

¹ Status of Yellowtail Rockfish (*Sebastes*
² *flavidus*) Along the U.S. Pacific Coast in 2017



³ Jean DeMarignac (SIMoN / MBNMS), Public Domain

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¹¹⁹ **Executive Summary**

executive-summary

¹²⁰ **Stock**

stock

¹²¹ This assessment reports the status of the Yellowtail Rockfish (*Sebastodes flavidus*) resource in
¹²² U.S. waters off the coast of California, Oregon, and Washington using data through 2016.

¹²³ The Pacific Fishery Management Council (PFMC) manages the U.S. fishery as two stocks
¹²⁴ separated at Cape Mendocino, California ($40^{\circ} 10'N$). This assessment analyzes those two
¹²⁵ areas as independent stocks, with the southern stock extending southward to the U.S./Mexico
¹²⁶ border and the northern stock extending northward to the U.S./Canada border.

¹²⁷ The previous assessment (Wallace and Lai [2005](#)), following the pattern of prior assessments,
¹²⁸ included only the Northern stock which it divided into three assessment areas with divisions
¹²⁹ at Cape Elizabeth ($47^{\circ} 20'N$) and Cape Falcon ($45^{\circ} 46'N$). However, a more recent genetic
¹³⁰ analysis (Hess et al. n.d.) found distinct stocks north and south of Cape Mendocino but
¹³¹ did not find stock differences within the northern area, with the genetic stock extending
¹³² northward through British Columbia, Canada to Southeast Alaska. However, Canada and
¹³³ Alaska are not included in this assessment. Since the previous assessment, reconstruction of
¹³⁴ historical catch by Washington and Oregon makes any border but the state line incompatible
¹³⁵ with the data. Additionally, much of the groundfish catch landed in northern Oregon is
¹³⁶ caught in Washington waters.

¹³⁷ **Catches**

catches

¹³⁸ Catches from the Northern stock were divided into four categories: commercial catch, bycatch
¹³⁹ in the at-sea hake fishery, recreational catch in Oregon and California (north of $40^{\circ} 10'N$),
¹⁴⁰ and recreational catch in Washington. The first three of these fleets were entered in metric
¹⁴¹ tons, but the recreational catch from Washington was entered in the model as numbers of
¹⁴² fish with the average weight calculated internally in the model.

¹⁴³ Catches from the Southern stock were divided into two categories: commercial and recreational
¹⁴⁴ catch, both of which were entered as metric tons.

¹⁴⁵ **Include: trends and current levels-include table for last ten years and graph with long term**
¹⁴⁶ **data**

¹⁴⁷ Catch figures: (Figures [a-b](#))

¹⁴⁸ Catch tables: (Tables [a-b](#))

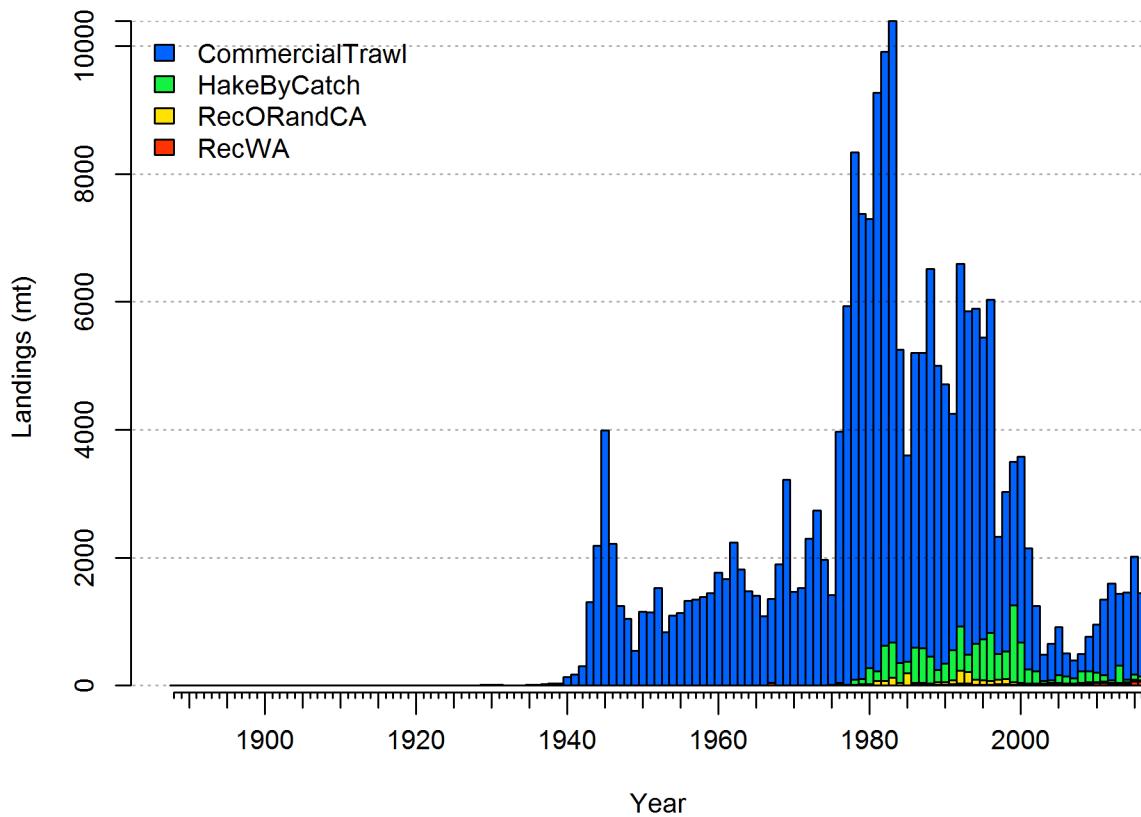


Figure a: Estimated catch history of Yellowtail Rockfish in the Northern model. Recreational catches in Washington are model estimates of total weight converted from input catch in numbers using model estimates of growth and selectivity.
fig:r4ss_catch_N

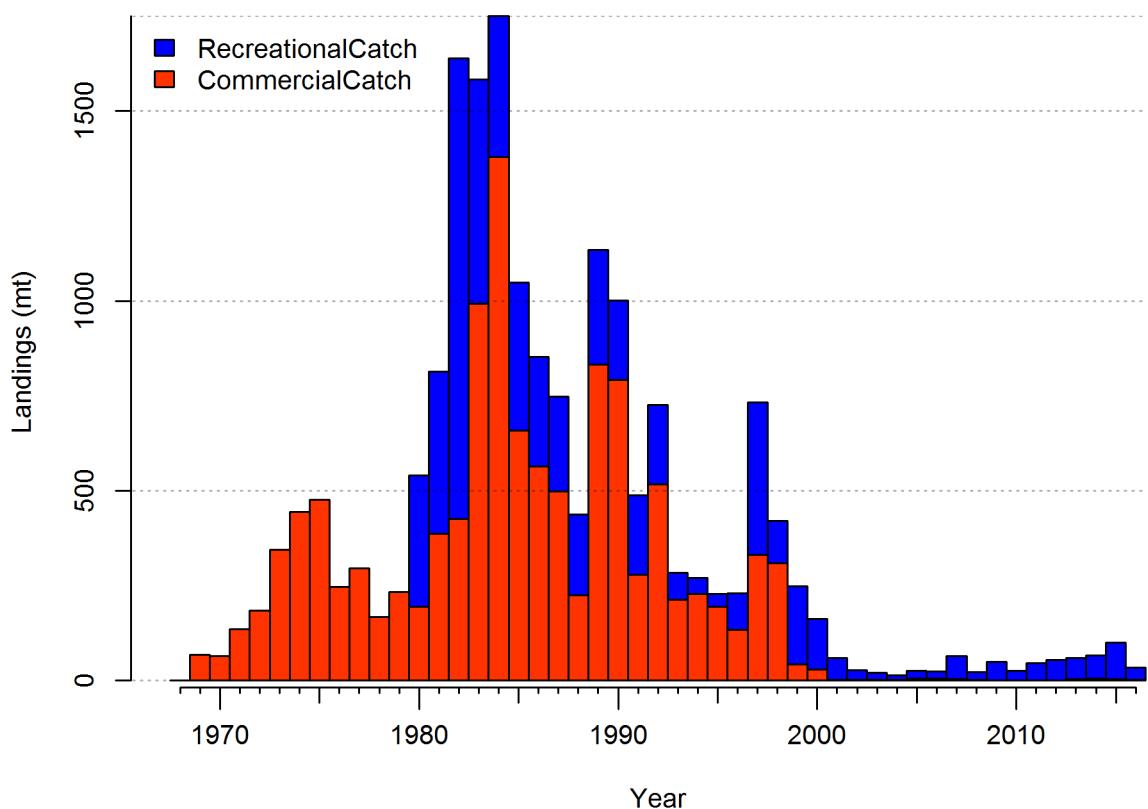


Figure b: Estimated catch history of Yellowtail Rockfish in the Southern model. [fig:r4ss_catch_S](#)

Table a: Recent Yellowtail Rockfish catch by fleet for the Northern stock (north of 40° 10'N).

tab:Exec_catch_N

Year	Commercial (t)	At-sea hake bycatch (t)	Recreational OR+CA (t)	Recreational WA (1000s)
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-

Table b: Recent Yellowtail Rockfish catch by fleet for the Southern stock (south of 40° 10'N).

tab:Exec_catch_S

Year	Recreational (t)	Commercial (t)
2007	-	-
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	-
2014	-	-
2015	-	-
2016	-	-

149 Data and Assessment

data-and-assessment

150 **Include:** date of last assessment, type of assessment model, data available, new information,
 151 and information lacking.

152 Yellowtail Rockfish was assessed.... This assessment uses the newest version of Stock
 153 Synthesis (3.xxx). The model begins in 1889, and assumes the stock was at an unfished
 154 equilibrium that year.

155 Map of assessment region: (Figure c).

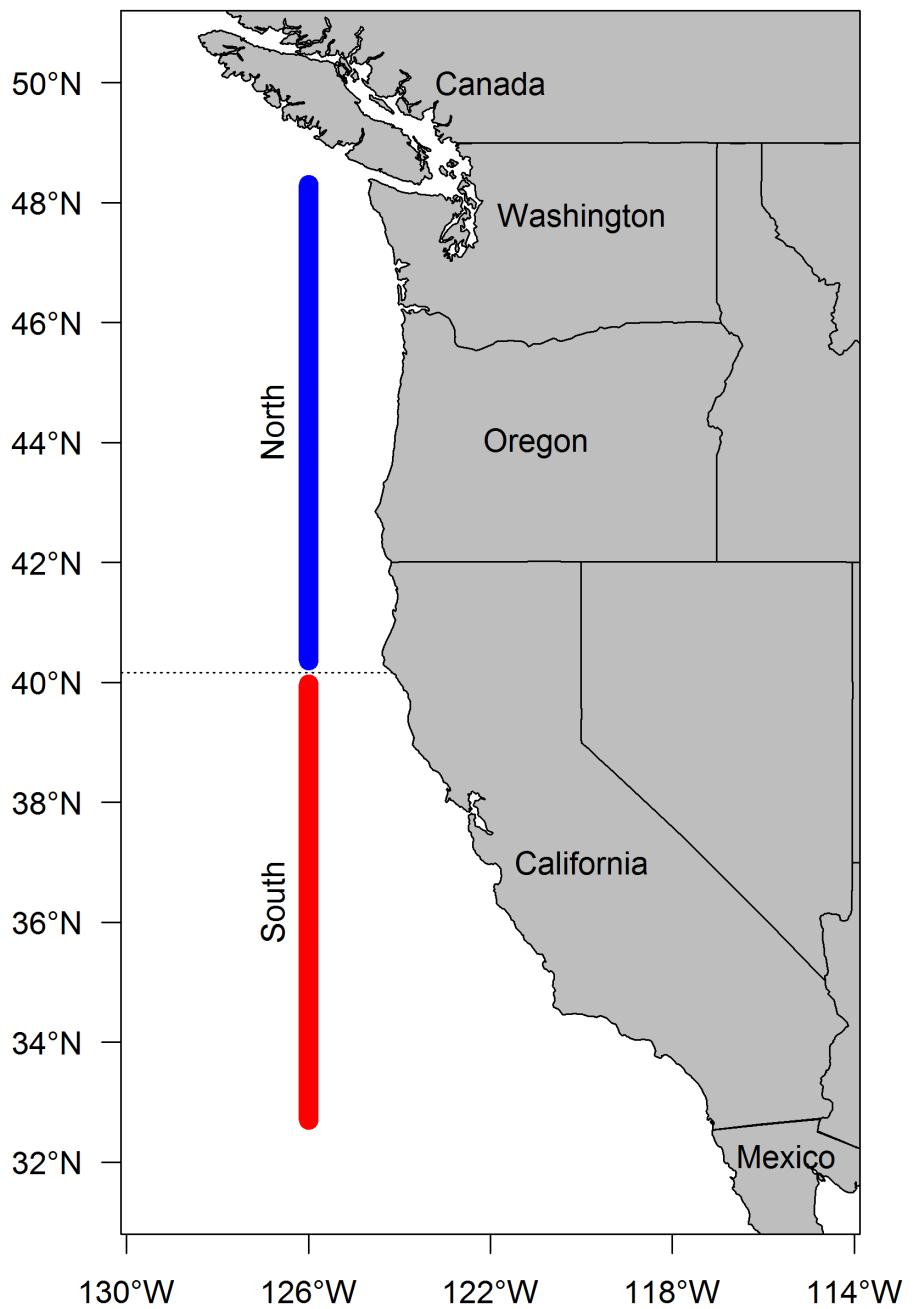


Figure c: Map depicting the boundaries for the base-case model. fig:assess_region_map

156 **Stock Biomass**

stock-biomass

157 Include: trends and current levels relative to virgin or historic levels, description of uncertainty-include table for last 10 years and graph with long term estimates.

159 Spawning output Figure: Figure [d](#)

160 Spawning output Table(s): Table [c](#)

161 Relative depletion Figure: Figure [e](#)

162 Example text (remove Models 2 and 3 if not needed - if using, remove the # in-line comments!!!)

163 The estimated relative depletion level (spawning output relative to unfished spawning output)

164 of the the base-case model in 2016 is 53% (~95% asymptotic interval: $\pm 41.3\%-64.8\%$) (Figure
165 [e](#)).

166 The estimated relative depletion level of model 2 in 2016 is 92.2% (~95% asymptotic interval:

167 $\pm 72.1\%-112\%$) (Figure [e](#)).

168 The estimated relative depletion level of model 3 in 2016 is (~95% asymptotic interval: \pm)
169 (Figure [e](#)).

Table c: Recent trend in beginning of the year spawning output and depletion for the Northern model for Yellowtail Rockfish.

Year	Spawning Output (trillion eggs)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2008	7.307	(5.31-9.3)	0.497	(0.368-0.627)
2009	7.713	(5.65-9.78)	0.525	(0.394-0.656)
2010	7.991	(5.87-10.12)	0.544	(0.412-0.676)
2011	8.105	(5.94-10.27)	0.552	(0.42-0.683)
2012	8.160	(5.98-10.34)	0.555	(0.426-0.685)
2013	8.101	(5.91-10.29)	0.551	(0.425-0.677)
2014	8.021	(5.83-10.21)	0.546	(0.423-0.669)
2015	7.943	(5.75-10.14)	0.541	(0.421-0.661)
2016	7.806	(5.6-10.02)	0.531	(0.413-0.65)
2017	7.791	(5.55-10.03)	0.530	(0.413-0.648)

Table d: Recent trend in beginning of the year spawning output and depletion for the Southern model for Yellowtail Rockfish.

Year	Spawning Output (trillion eggs)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2008	1.983	(-0.76-4.72)	0.588	(0.45-0.726)
2009	1.975	(-0.74-4.69)	0.586	(0.453-0.718)
2010	1.989	(-0.73-4.71)	0.590	(0.461-0.719)
2011	2.027	(-0.73-4.78)	0.601	(0.473-0.729)
2012	2.084	(-0.73-4.9)	0.618	(0.489-0.747)
2013	2.177	(-0.75-5.11)	0.646	(0.512-0.779)
2014	2.298	(-0.78-5.38)	0.682	(0.543-0.821)
2015	2.478	(-0.83-5.79)	0.735	(0.584-0.886)
2016	2.743	(-0.91-6.39)	0.814	(0.643-0.984)
2017	3.109	(-1.02-7.23)	0.922	(0.721-1.123)

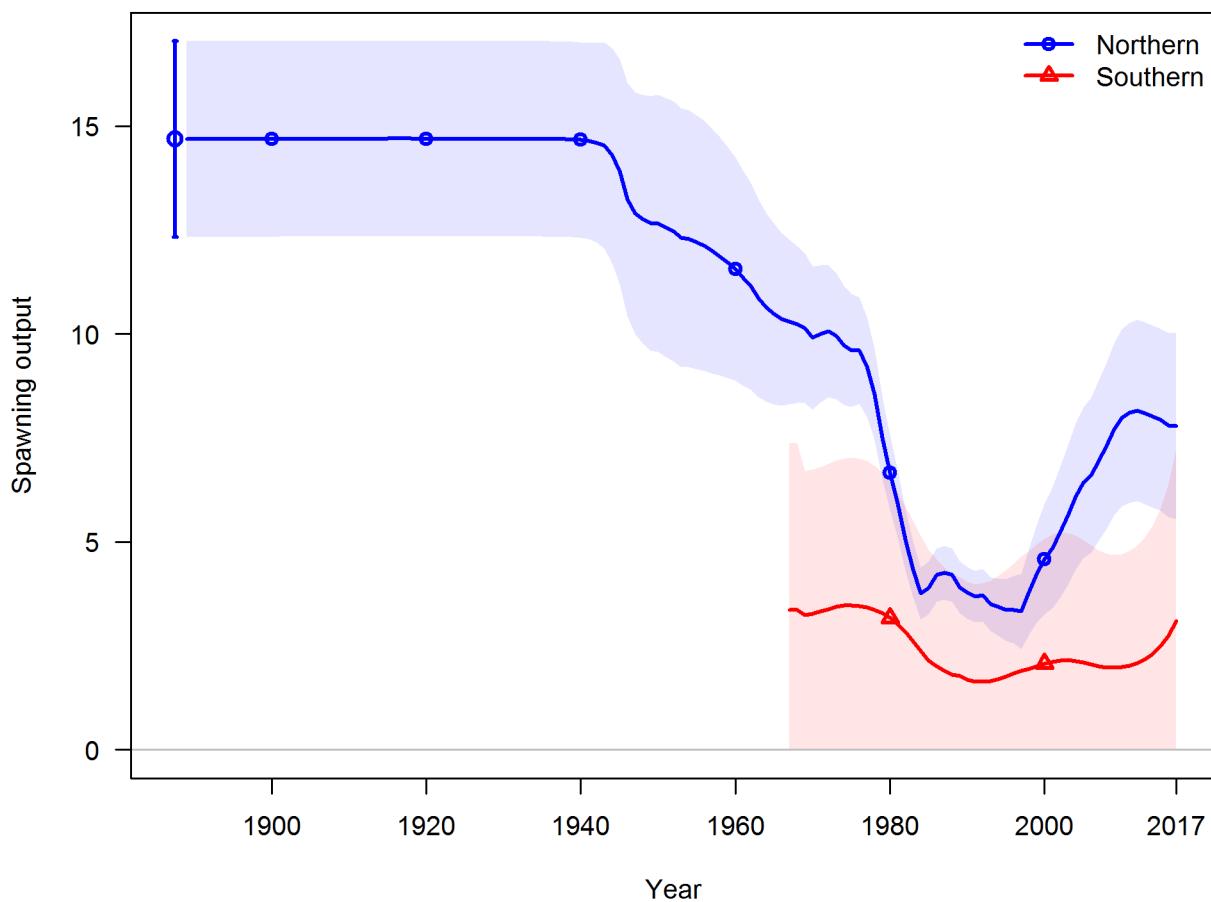


Figure d: Time series of spawning output trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model. [fig:Spawnbio_all](#)

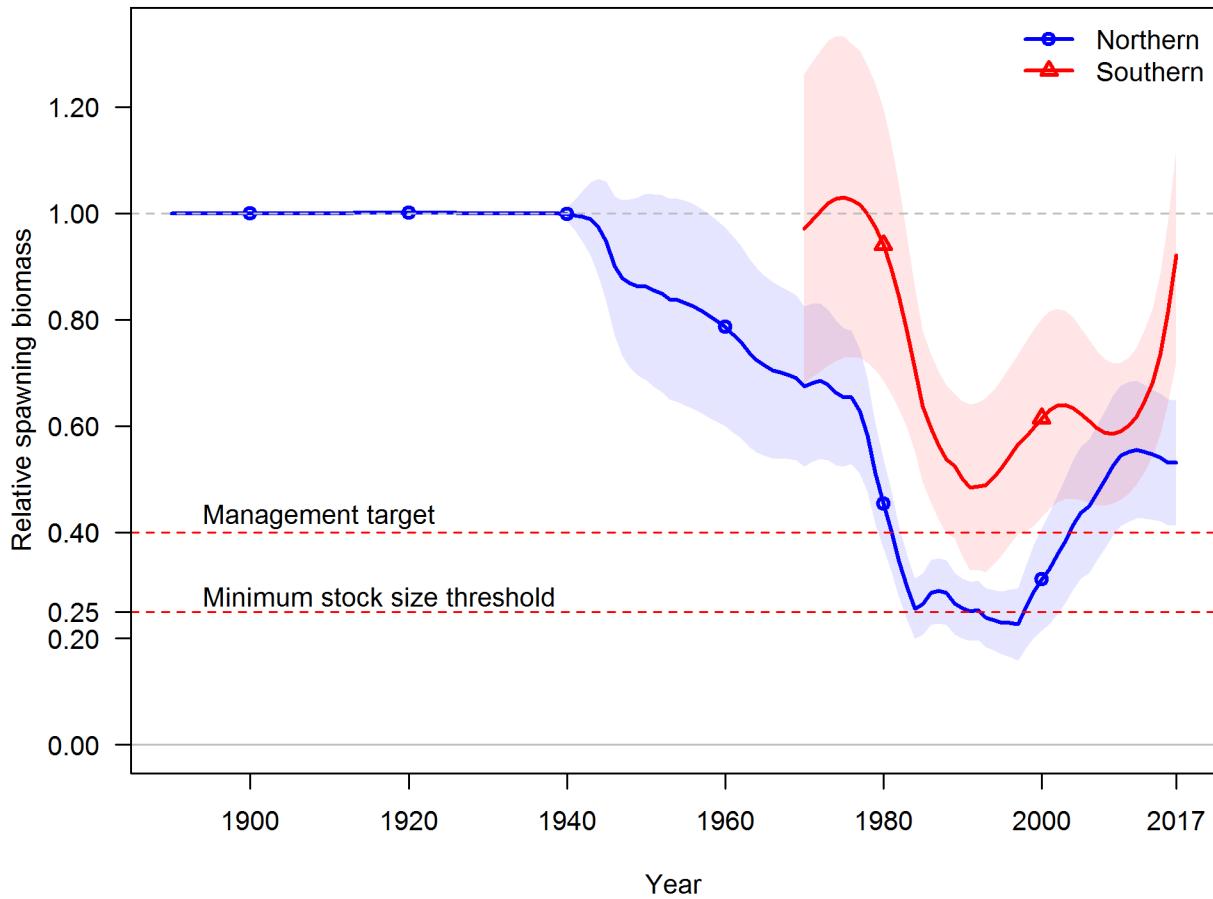


Figure e: Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model. [fig:RelDeplete_all](#)

170 **Recruitment**

recruitment

171 Include: trends and current levels relative to virgin or historic levels-include table for last 10
172 years and graph with long term estimates.

173 Recruitment Figure: (Figure f)

174 Recruitment Tables: (Tables e, f and ??)

Table e: Recent recruitment for the Northern model.

Year	Estimated Recruitment (millions)	~ 95% confidence interval
2008	34.46	(20.8 - 57.08)
2009	10.44	(5.04 - 21.65)
2010	22.11	(11.8 - 41.43)
2011	15.15	(6.89 - 33.31)
2012	15.95	(6.29 - 40.42)
2013	25.87	(8.87 - 75.43)
2014	24.05	(8.24 - 70.21)
2015	24.51	(8.62 - 69.71)
2016	24.35	(8.57 - 69.16)
2017	24.34	(8.57 - 69.13)

Table f: Recent recruitment for the Southern model.

Year	Estimated Recruitment (millions)	~ 95% confidence interval
2008	123.60	(31.9 - 478.95)
2009	61.44	(9.88 - 382.1)
2010	84.06	(14.63 - 483.13)
2011	68.11	(12.28 - 377.66)
2012	35.52	(6.07 - 207.89)
2013	41.50	(8.35 - 206.26)
2014	32.55	(6.23 - 170.09)
2015	25.26	(4.87 - 131.01)
2016	21.17	(3.94 - 113.89)
2017	21.81	(4.06 - 117.31)

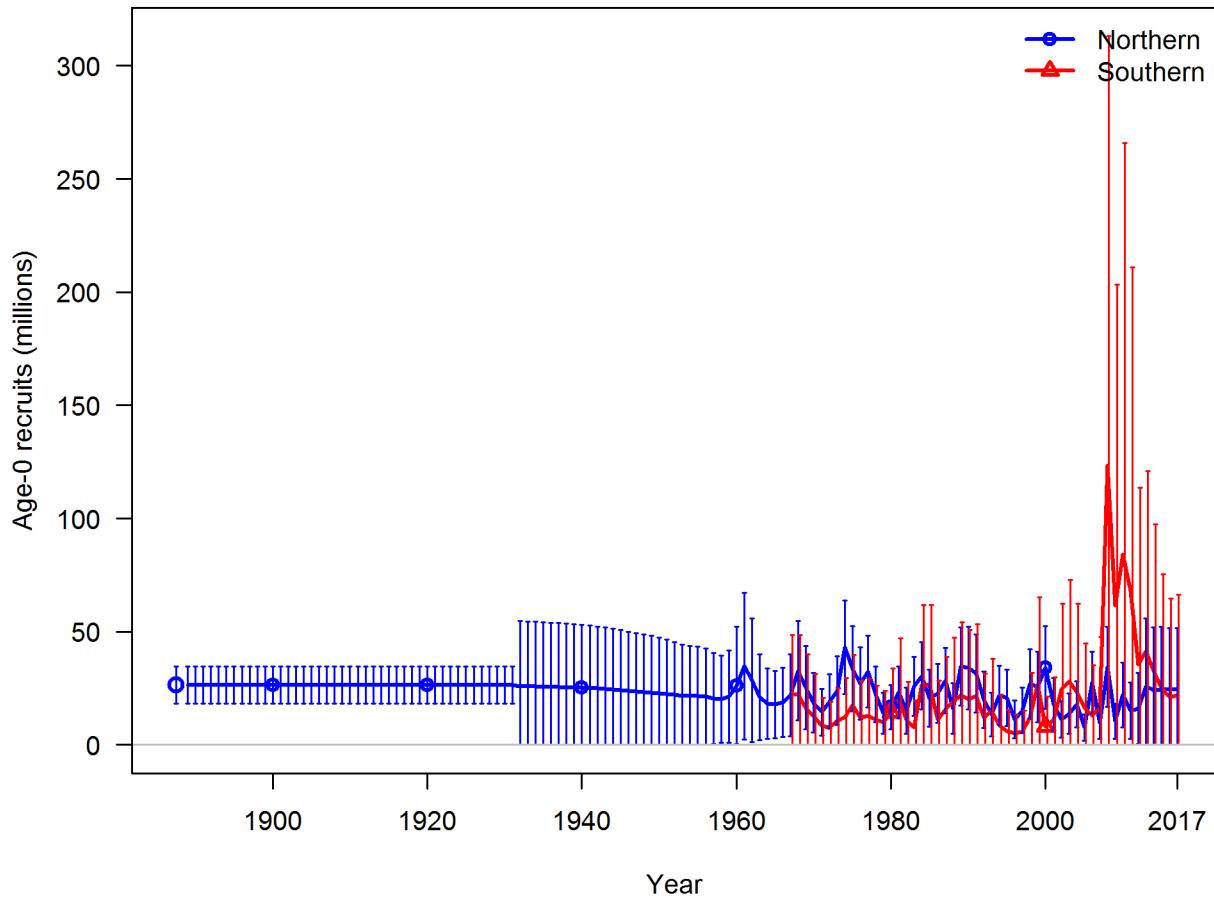


Figure f: Time series of estimated Yellowtail Rockfish recruitments for the base-case model with 95% confidence or credibility intervals. [fig:Recruits_all](#)

175 **Exploitation status**

exploitation-status

176 Include: exploitation rates (i.e., total catch divided by exploitable biomass, or the annual
177 SPR harvest rate) include a table with the last 10 years of data and a graph showing the
178 trend in fishing mortality relative to the target (y-axis) plotted against the trend in biomass
179 relative to the target (x-axis).

180 Exploitation Tables: Table [g](#), Table [h](#), Table ?? Exploitation Figure: Figure [g](#)).

181 A summary of Yellowtail Rockfish exploitation histories for base model is provided as Figure
182 [h](#).

Table g: Recent trend in spawning potential ratio and exploitation for Yellowtail Rockfish in the Northern model. Fishing intensity is (1-SPR) divided by 50% (the SPR target) and exploitation is F divided by F_{SPR} .

Year	Fishing intensity	~ 95% confidence interval	Exploitation rate	~ 95% confidence interval
2007	0.33	(0.12-0.55)	0.01	(0-0.02)
2008	0.21	(0.14-0.28)	0.01	(0-0.01)
2009	0.39	(0.24-0.54)	0.01	(0.01-0.02)
2010	0.52	(0.27-0.77)	0.02	(0.01-0.03)
2011	0.45	(0.33-0.58)	0.02	(0.01-0.02)
2012	0.52	(0.38-0.65)	0.02	(0.01-0.03)
2013	0.49	(0.36-0.62)	0.02	(0.01-0.02)
2014	0.49	(0.36-0.62)	0.02	(0.01-0.02)
2015	0.63	(0.48-0.79)	0.03	(0.02-0.03)
2016	0.50	(0.36-0.63)	0.02	(0.01-0.02)

Table h: Recent trend in spawning potential ratio and exploitation for Yellowtail Rockfish in the Southern model. Fishing intensity is $(1-SPR)$ divided by 50% (the SPR target) and exploitation is F divided by F_{SPR} .

Year	Fishing intensity	~ 95% confidence interval	Exploitation rate	~ 95% confidence interval	tab:SPR_Exploit_mod2
2007	0.04	(-0.01-0.1)	0.00	(0-0)	
2008	0.02	(0-0.04)	0.00	(0-0)	
2009	0.03	(-0.01-0.07)	0.00	(0-0)	
2010	0.01	(0-0.03)	0.00	(0-0)	
2011	0.02	(-0.01-0.05)	0.00	(0-0)	
2012	0.02	(-0.01-0.05)	0.00	(0-0)	
2013	0.02	(-0.01-0.05)	0.00	(0-0)	
2014	0.02	(-0.01-0.05)	0.00	(0-0)	
2015	0.03	(-0.01-0.07)	0.00	(0-0)	
2016	0.01	(0-0.02)	0.00	(0-0)	

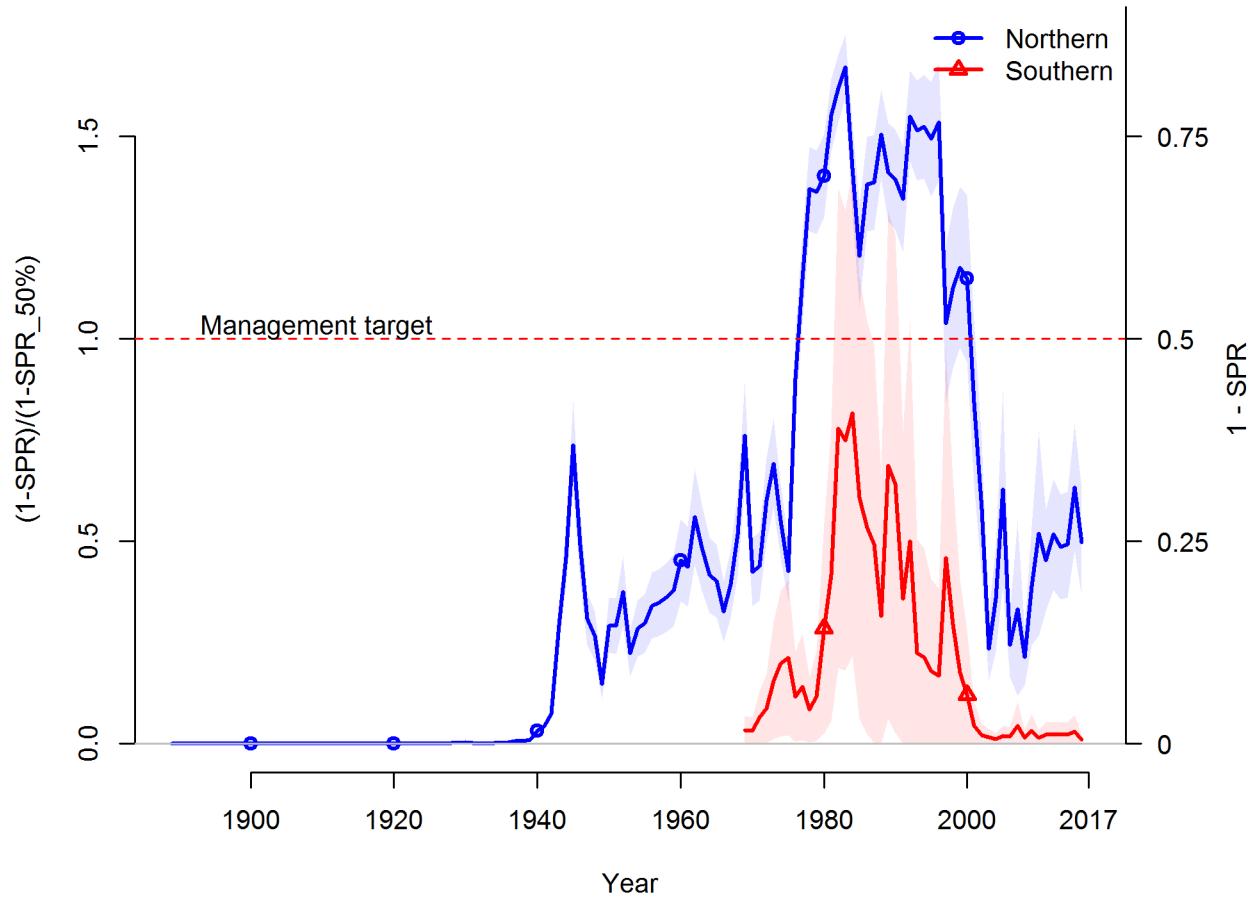


Figure g: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$ harvest rate. The last year in the time series is 2016. | [fig:SPR_all](#)

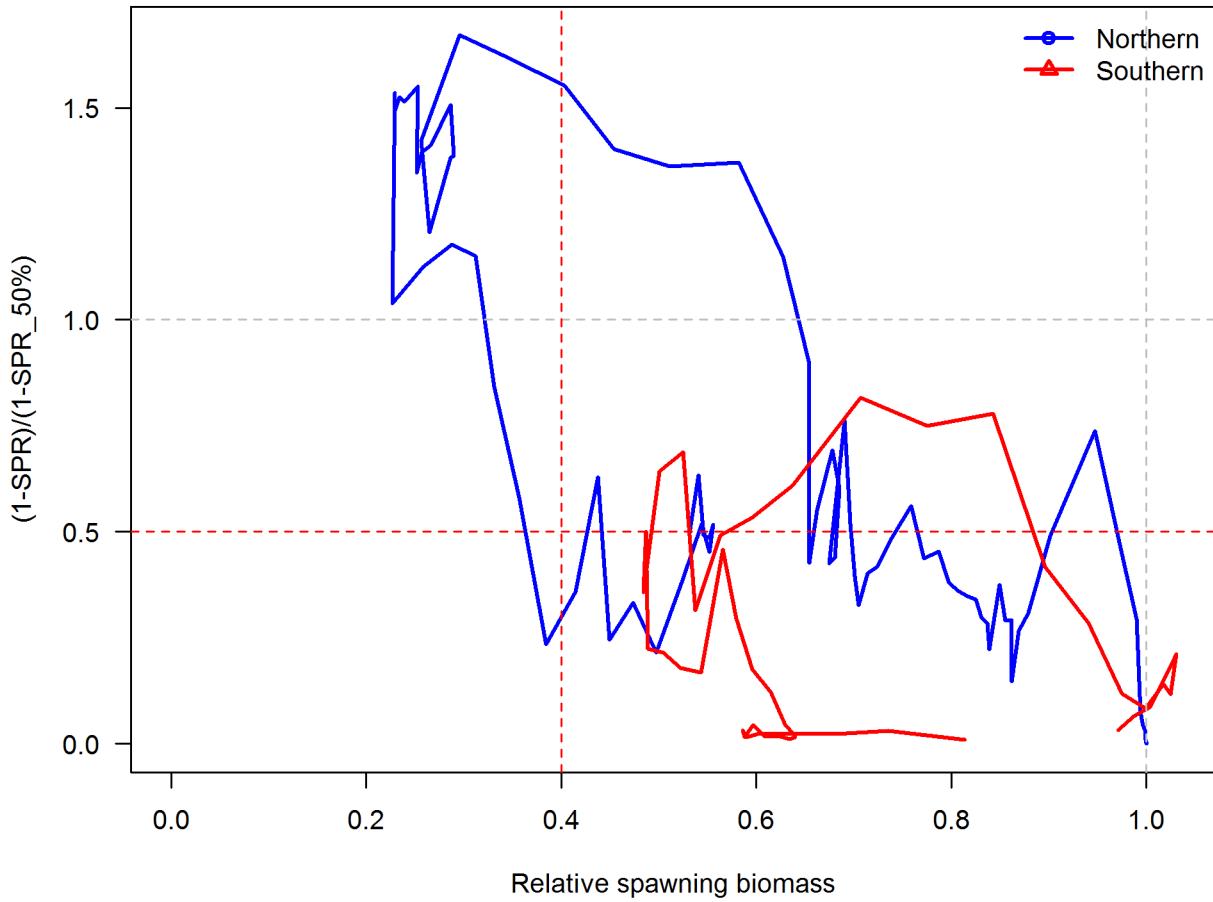


Figure h: Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base case model. The relative (1-SPR) is (1-SPR) divided by 50% (the SPR target). Relative depletion is the annual spawning biomass divided by the unfished spawning biomass. | [fig:Phase_all](#)

183 **Ecosystem Considerations**

ecosystem-considerations

184 In this assessment, ecosystem considerations were. . . .

185 **Reference Points**

reference-points

186 **Include:** management targets and definition of overfishing, including the harvest rate that
187 brings the stock to equilibrium at $B_{40\%}$ (the B_{MSY} proxy) and the equilibrium stock size
188 that results from fishing at the default harvest rate (the F_{MSY} proxy). Include a summary
189 table that compares estimated reference points for SSB, SPR, Exploitation Rate and Yield
190 based on SSBproxy for MSY, SPRproxy for MSY, and estimated MSY values

191 Write intro paragraph....and remove text for Models 2 and 3 if not needed

192 This stock assessment estimates that Yellowtail Rockfish in the Northern model are above
193 the biomass target, but above the minimum stock size threshold. Add sentence about
194 spawning output trend. The estimated relative depletion level for Model 1 in 2016 is 53%
195 (~95% asymptotic interval: $\pm 41.3\%-64.8\%$, corresponding to an unfished spawning output of
196 7.79131 trillion eggs (~95% asymptotic interval: 5.55-10.03 trillion eggs) of spawning output
197 in the base model (Table i). Unfished age 4+ biomass was estimated to be 128999 mt in the
198 base case model. The target spawning output based on the biomass target ($SB_{40\%}$) is 5.9
199 trillion eggs, which gives a catch of 3910.4 mt. Equilibrium yield at the proxy F_{MSY} harvest
200 rate corresponding to $SPR_{50\%}$ is 3691.6 mt.

201 This stock assessment estimates that Yellowtail Rockfish in the Southern model are above the
202 biomass target, but above the minimum stock size threshold. Add sentence about spawning
203 output trend. The estimated relative depletion level for Model 2 in 2016 is 92.2% (~95%
204 asymptotic interval: $\pm 72.1\%-112\%$), corresponding to an unfished spawning output of 3.10871
205 trillion eggs (~95% asymptotic interval:) of spawning output in the base model (Table j).
206 Unfished age 4+ biomass was estimated to be 71633.9 mt in the base case model. The target
207 spawning output based on the biomass target ($SB_{40\%}$) is 1.3 trillion eggs, which gives a catch
208 of mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 1890.2
209 mt.

210 This stock assessment estimates that Yellowtail Rockfish in the are

211 the biomass target, but
212 the minimum stock size threshold. Add sentence about spawning output trend. The estimated
213 relative depletion level or Model 3 in 2016 is (~95% asymptotic interval: \pm), corresponding
214 to an unfished spawning output of (~95% asymptotic interval:) of spawning output in the
215 base model (Table ??). Unfished age 4+ biomass was estimated to be mt in the base case
216 model. The target spawning output based on the biomass target ($SB_{40\%}$) is , which gives a
217 catch of mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is
218 mt.

Table i: Summary of reference points and management quantities for the base case Northern model.

Quantity	Estimate	<small>tab:Ref_pts_mod1</small> 95% Confidence Interval
Unfished spawning output (trillion eggs)	14.7	(12.3-17)
Unfished age 4+ biomass (mt)	128999	(110839.6-147158.4)
Unfished recruitment (R0, thousands)	26398.3	(18222.3-34574.3)
Spawning output(2016 trillion eggs)	7.8	(5.6-10)
Depletion (2016)	0.5313	(0.413-0.6496)
Reference points based on SB_{40%}		
Proxy spawning output ($B_{40\%}$)	5.9	(4.9-6.8)
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.4589	(0.4589-0.4589)
Exploitation rate resulting in $B_{40\%}$	0.0539	(0.0514-0.0564)
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	3910.4	(3265-4555.8)
Reference points based on SPR proxy for MSY		
Spawning output	6.5	(5.5-7.6)
SPR_{proxy}	0.5	
Exploitation rate corresponding to SPR_{proxy}	0.0477	(0.0455-0.05)
Yield with SPR_{proxy} at SB_{SPR} (mt)	3691.6	(3085.6-4297.5)
Reference points based on estimated MSY values		
Spawning output at MSY (SB_{MSY})	3.5	(2.9-4.1)
SPR_{MSY}	0.3118	(0.3067-0.3169)
Exploitation rate at MSY	0.0821	(0.0779-0.0863)
MSY (mt)	4347.6	(3612-5083.2)

Table j: Summary of reference points and management quantities for the base case Southern model.

Quantity	Estimate	<small>tab:Ref_pts_mod2</small> 95% Confidence Interval
Unfished spawning output (trillion eggs)	3.4	(-0.6265-7.4)
Unfished age 4+ biomass (mt)	71633.9	(-12564.9768-155832.8)
Unfished recruitment (R_0 , thousands)	22259.8	(-3949.6224-48469.2)
Spawning output(2016 trillion eggs)	2.7	(-0.9069-6.4)
Depletion (2016)	0.8136	(0.643-0.9843)
Reference points based on SB_{40%}		
Proxy spawning output ($B_{40\%}$)	1.3	(-0.2506-2.9)
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.4589	(0.4589-0.4589)
Exploitation rate resulting in $B_{40\%}$	0.0576	(0.0559-0.0593)
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	1997	(-354.5756-4348.5)
Reference points based on SPR proxy for MSY		
Spawning output	1.5	(-0.2791-3.3)
SPR_{proxy}	0.5	
Exploitation rate corresponding to SPR_{proxy}	0.0508	(0.0493-0.0522)
Yield with SPR_{proxy} at SB_{SPR} (mt)	1890.2	(-335.3679-4115.8)
Reference points based on estimated MSY values		
Spawning output at MSY (SB_{MSY})	0.8199	(-0.1516-1.8)
SPR_{MSY}	0.3175	(0.3141-0.3208)
Exploitation rate at MSY	0.0885	(0.0861-0.0909)
MSY (mt)	2197.8	(-391.3228-4786.9)

²¹⁹ **Management Performance**

management-performance

²²⁰ **Include:** catches in comparison to OFL, ABC and OY/ACL values for the most recent 10 years (when available), overfishing levels, actual catch and discard. Include OFL(encountered), OFL(retained) and OFL(dead) if different due to discard and discard mortality.

²²³ Management performance table: Table [k](#)

Table k: Recent trend in total catch and commercial landings (mt) relative to the management guidelines. Estimated total catch reflect the commercial landings plus the model estimated discarded biomass.

Year	OFL (mt; ABC prior to 2011)	ABC (mt)	ACL (mt; OY prior to 2011)	Estimated total catch (mt)
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-
2017	-	-	-	-
2018	-	-	-	-

²²⁴ **Unresolved Problems And Major Uncertainties**

unresolved-problems-and-major-uncertainties

²²⁵ TBD after STAR panel

²²⁶ **Decision Table(s) (groundfish only)**

decision-tables-groundfish-only

²²⁷ **Include:** projected yields (OFL, ABC and ACL), spawning biomass, and stock depletion levels for each year. Not required in draft assessments undergoing review.

²²⁹ OFL projection table: Table [l](#)

²³⁰ Decision table(s) Table [m](#), Table [n](#), Table ??

²³¹ Yield curve: Figure \ref{fig:Yield_all}

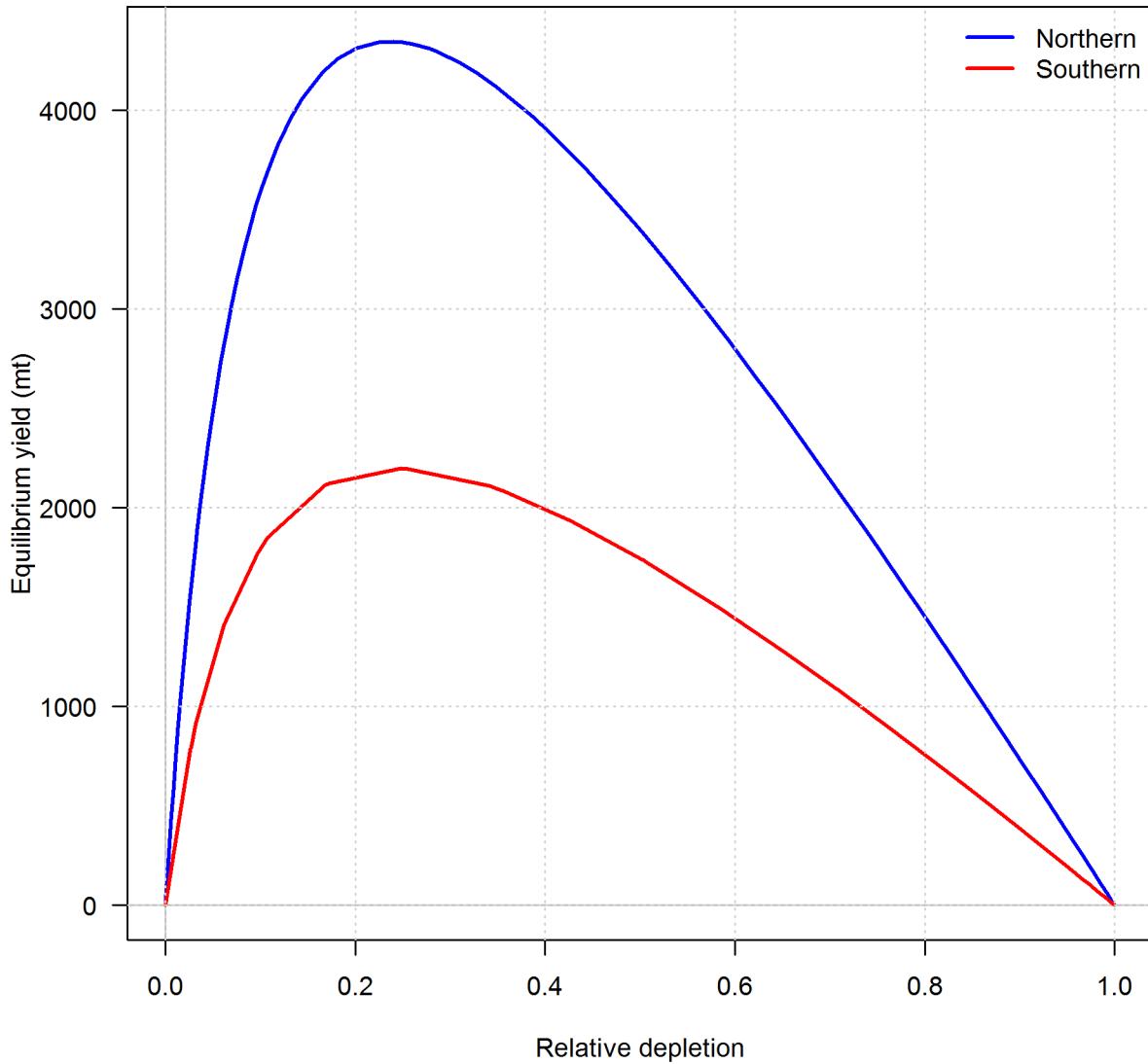


Figure i: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at... Fig:Yield_all

Table 1: Projections of potential OFL (mt) for each model, using the base model forecast.
tab:OFL_projection

Year	Model 1	Model 2	Total
2017	3988.81	5152.74	9141.55
2018	3840.38	5006.04	8846.42
2019	3712.42	4801.18	8513.60
2020	3611.38	4566.83	8178.21
2021	3544.46	4324.17	7868.63
2022	3513.29	4085.35	7598.64
2023	3512.56	3857.50	7370.06
2024	3532.98	3645.03	7178.01
2025	3564.86	3450.44	7015.30
2026	3600.46	3274.82	6875.28
2027	3634.58	3118.20	6752.78
2028	3664.30	2979.81	6644.11

Table m: Summary of 10-year projections beginning in 2018 for alternate states of nature based on an axis of uncertainty for the Northern model. Columns range over low, mid, and high states of nature, and rows range over different assumptions of catch levels. An entry of “–” indicates that the stock is driven to very low abundance under the particular scenario.

tab:Decision_table_mod1
States of nature

	Year	Catch	Low M 0.05		Base M 0.07		High M 0.09	
			Spawning Output	Depletion	Spawning Output	Depletion	Spawning Output	Depletion
40-10 Rule, Low M	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
40-10 Rule	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
40-10 Rule, High M	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
Average Catch	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-

Table n: Summary of 10-year projections beginning in 2018 for alternate states of nature based on an axis of uncertainty for the Southern model. Columns range over low, mid, and high states of nature, and rows range over different assumptions of catch levels. An entry of “–” indicates that the stock is driven to very low abundance under the particular scenario.

		States of nature					
		Low M 0.05		Base M 0.07		High M 0.09	
	Year	Catch	Spawning Output	Depletion	Spawning Output	Depletion	Spawning Output
40-10 Rule, Low M	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-
40-10 Rule	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-
40-10 Rule, High M	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-
Average Catch	2019	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2021	-	-	-	-	-	-
	2022	-	-	-	-	-	-
	2023	-	-	-	-	-	-
	2024	-	-	-	-	-	-
	2025	-	-	-	-	-	-
	2026	-	-	-	-	-	-
	2027	-	-	-	-	-	-
	2028	-	-	-	-	-	-

Table o: Yellowtail Rockfish base case results summary.

Model Region	Quantity	2008		2009		2010		2011		2012		2013		2014		2015		2016		2017			
		Landings (mt)		Total Est. Catch (mt)		OFL (mt)		ACL (mt)		(1-SPR)(1-SPR _{90%})		Base Case		Age 4+ biomass (mt)		Spawning Output		95% CI		Depletion		Recruits	
Model 1	(1-SPR)(1-SPR _{90%})	0.21	0.39	0.52	0.45	0.52	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.50	
Base Case	Exploitation rate	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	Age 4+ biomass (mt)	76365.3	77111.1	76466.7	77313.9	75707.8	77354.4	76340.3	76340.3	76340.3	76340.3	76683.8	76683.8	76683.8	76683.8	76683.8	76683.8	76683.8	76683.8	76683.8	76683.8	76683.8	75174.0
	OFL (mt)	7.3	7.7	8.0	8.1	8.2	8.1	8.0	8.0	8.0	8.0	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.8
	ACL (mt)	(5.31-9.3)	(5.65-9.78)	(5.87-10.12)	(5.94-10.27)	(5.98-10.34)	(5.98-10.34)	(5.91-10.29)	(5.91-10.29)	(5.91-10.29)	(5.91-10.29)	(5.83-10.21)	(5.75-10.14)	(5.75-10.14)	(5.75-10.14)	(5.75-10.14)	(5.75-10.14)	(5.75-10.14)	(5.75-10.14)	(5.75-10.14)	(5.75-10.14)	(5.75-10.14)	(5.75-10.14)
	Spawning Output	95% CI	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Depletion	95% CI	(0.368-0.627)	(0.394-0.656)	(0.412-0.676)	(0.426-0.683)	(0.426-0.685)	(0.426-0.685)	(0.425-0.677)	(0.425-0.677)	(0.423-0.669)	(0.423-0.669)	(0.421-0.661)	(0.421-0.661)	(0.421-0.661)	(0.421-0.661)	(0.421-0.661)	(0.421-0.661)	(0.421-0.661)	(0.421-0.661)	(0.421-0.661)	(0.421-0.661)	(0.421-0.661)
	Recruits	34.46	10.44	22.11	15.15	15.95	25.87	24.05	24.05	24.05	24.05	24.51	24.35	24.35	24.35	24.35	24.35	24.35	24.35	24.35	24.35	24.35	24.34
	95% CI	(20.8 - 57.08)	(5.04 - 21.65)	(11.8 - 41.43)	(6.89 - 33.31)	(6.29 - 40.42)	(8.87 - 75.43)	(8.24 - 70.21)	(8.87 - 75.43)	(8.87 - 75.43)	(8.87 - 75.43)	(8.62 - 69.71)	(8.57 - 69.16)	(8.57 - 69.16)	(8.57 - 69.16)	(8.57 - 69.16)	(8.57 - 69.16)	(8.57 - 69.16)	(8.57 - 69.16)	(8.57 - 69.16)	(8.57 - 69.16)	(8.57 - 69.16)	(8.57 - 69.16)
Model 2	(1-SPR)(1-SPR _{90%})	0.02	0.03	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	
Base Case	Exploitation rate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Age 4+ biomass (mt)	41317.6	43306.9	44211.0	44337.0	44909.1	63175.4	72683.3	72683.3	72683.3	72683.3	85860.8	85860.8	85860.8	85860.8	85860.8	85860.8	85860.8	85860.8	85860.8	85860.8	85860.8	
	OFL (mt)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
	Spawning Output	95% CI	(-0.76-4.72)	(-0.74-4.69)	(-0.73-4.71)	(-0.73-4.78)	(-0.73-4.78)	(-0.73-4.78)	(-0.73-4.78)	(-0.73-4.78)	(-0.73-4.78)	(-0.73-4.78)	(-0.75-5.11)	(-0.75-5.11)	(-0.75-5.11)	(-0.75-5.11)	(-0.75-5.11)	(-0.75-5.11)	(-0.75-5.11)	(-0.75-5.11)	(-0.75-5.11)	(-0.75-5.11)	(-0.75-5.11)
	Depletion	95% CI	(0.45-0.726)	(0.433-0.718)	(0.461-0.719)	(0.473-0.729)	(0.489-0.747)	(0.489-0.747)	(0.489-0.747)	(0.489-0.747)	(0.512-0.779)	(0.512-0.779)	(0.543-0.821)	(0.543-0.821)	(0.543-0.821)	(0.543-0.821)	(0.543-0.821)	(0.543-0.821)	(0.543-0.821)	(0.543-0.821)	(0.543-0.821)	(0.543-0.821)	(0.543-0.821)
	Recruits	123.60	61.44	84.06	68.11	35.52	41.50	32.55	25.26	25.26	25.26	21.17	21.17	21.17	21.17	21.17	21.17	21.17	21.17	21.17	21.17	21.17	
	95% CI	(31.9 - 478.95)	(9.88 - 382.1)	(14.63 - 483.13)	(12.28 - 377.66)	(6.07 - 207.89)	(8.35 - 206.26)	(6.23 - 170.09)	(6.23 - 170.09)	(6.23 - 170.09)	(6.23 - 170.09)	(6.23 - 170.09)	(3.94 - 113.91)	(3.94 - 113.91)	(3.94 - 113.91)	(3.94 - 113.91)	(3.94 - 113.91)	(3.94 - 113.91)	(3.94 - 113.91)	(3.94 - 113.91)	(3.94 - 113.91)	(3.94 - 113.91)	(3.94 - 113.91)

²³² **Research And Data Needs**

research-and-data-needs

²³³ Include: identify information gaps that seriously impede the stock assessment.

²³⁴ We recommend the following research be conducted before the next assessment:

²³⁵ 1. List item No. 1 in the list

²³⁶ 2. List item No. 2 in the list, etc.

²³⁷ **Rebuilding Projections**

rebuilding-projections

²³⁸ Include: reference to the principal results from rebuilding analysis if the stock is overfished.

²³⁹ This section should be included in the Final/SAFE version assessment document but is not

²⁴⁰ required for draft assessments undergoing review. See Rebuilding Analysis terms of reference

²⁴¹ for detailed information on rebuilding analysis requirements.

242 **1 Introduction**

introduction

243 **1.1 Basic Information**

basic-information

244 Include: Scientific name, distribution, the basis of the choice of stock structure, including
245 regional differences in life history or other biological characteristics that should form the
246 basis of management units.

247 **1.2 Map**

map

248 A map showing the scope of the assessment and depicting boundaries for fisheries or data
249 collection strata is provided in Figure ??.

250 **1.3 Life History**

life-history

251 Include: Important features of life history that affect management (e.g., migration, sexual
252 dimorphism, bathymetric demography).

253 **1.4 Ecosystem Considerations**

ecosystem-considerations-1

254 Include: Ecosystem considerations (e.g., ecosystem role and trophic relationships of the
255 species, habitat requirements/preferences, relevant data on ecosystem processes that may
256 affect stock or parameters used in the stock assessment, and/or cross-FMP interactions with
257 other fisheries). This section should note if environmental correlations or food web interactions
258 were incorporated into the assessment model. The length and depth of this section would
259 depend on availability of data and reports from the IEA, expertise of the STAT, and whether
260 ecosystem factors are informational to contribute quantitative information to the assessment.

261 **1.5 Fishery Information**

fishery-information

262 Include: Important features of current fishery and relevant history of fishery.

263 Rockfish example: The rockfish fishery off the U.S. Pacific coast first developed off California
264 in the late 19th century as a hook-and-line fishery (Love et al. 2002).

265 The rockfish trawl fishery was established in the early 1940s, when the United States became
266 involved in World War II and wartime shortage of red meat created an increased demand for
267 other sources of protein (Harry and Morgan 1961, Alverson et al. 1964). Etc....

268 **1.6 Summary of Management History**

summary-of-management-history

269 Include: Summary of management history (e.g., changes in mesh sizes, trip limits, or other
270 management actions that may have significantly altered selection, catch rates, or discards).

271 **1.7 Management Performance**

management-performance-1

272 Include: Management performance, including a table or tables comparing Overfishing Limit
273 (OFL), Annual Catch Limit (ACL), Harvest Guideline (HG) [CPS only], landings, and catch
274 (i.e., landings plus discard) for each area and year.

275 Management performance table: (Table [k](#))

276 A summary of these values as well as other base case summary results can be found in Table
277 [O](#).

278 **1.8 Fisheries off Canada, Alaska, and/or Mexico**

fisheries-off-canada-alaska-andor-mexico

279 Include if necessary.

280 **2 Data**

data

281 Data used in the Northern and Southern yellowtail rockfish assessments are summarized in
282 Figures [8](#) and [8](#).

283 Data sources for the two models are largely distinct. Northern fisheries and surveys had very
284 sparse data (if any) for the south and vice-versa. Among the 12 data sources referenced
285 below, only 2 data sources are common to both models. These are the MRFSS/RecFIN
286 recreational dockside survey, which focuses on California and Oregon, and the CalCOM
287 California commercial dataset, which contributed data from the northern-most California
288 counties (Eureka and Del Norte) to the Northern model. The CalCOM data account for less
289 than five percent of the commercial landings in the Northern model, and less than 1% of the
290 biological samples.

291 Commercial landings are not differentiated in either model. For the Northern model, this is
292 due to the very small portion (1.15 %) of the landings that are attributed to non-trawl gear.
293 For the Southern model, this is due to the paucity of data.

294 A description of each model's data sources follows.

295 **2.1 Northern Model Data**

northern-model-data

Table 1: Summary of the data source in the Northern model.

Source	Landings	Lengths	Ages	Indices	Discard	Type
PacFIN	Y	Y	Y	Y		Commercial
WCGOP		Y			Y	Commercial Discards
Hake Bycatch	Y	Y	Y	Y		Commercial
CalCOM	Y	Y	Y			Commercial
WaSport	Y	Y	Y			Recreational
MRFSS	Y	Y				Recreational
RecFIN	Y	Y				Recreational
Triennial		Y	Y	Y		Survey
NWFSCcombo		Y	Y	Y		Survey
Pikitch		Y			Y	Commercial Study
ODFW	Y					Historical data
WDFW	Y					Historical data

296 **2.1.1 Commercial Fishery Landings**

commercial-fishery-landings

297 **Washington and Oregon Landings** The bulk of the commercial landings for Washington
298 and Oregon came from the from the Pacific Fisheries Information Network (**PacFIN**)
299 database.

300 **Washington Catch Information**

301 The Washington Department of Fisheries and Wildlife (**WDFW**) provided historical yellow-
302 tail catch for 1889–1980. Landings for 1981-2016 came from the PacFIN database. WDFW
303 also provided catches for the period 1981 – 2016 to include the re-distribution of the un-
304 speciated “URCK” landings in PacFIN; this information is currently not available from
305 PacFIN.

306 **Oregon Catch Information**

307 The Oregon Department of Fisheries and Wildlife (**ODFW**) provided historical yellowtail
308 catch from 1892-1985. ODFW also provided estimates of yellowtail rockfish in the in the
309 un-speciated PacFIN “URCK” and “POP1” catch categories for recent years, and those
310 estimates were combined with PacFIN landings for 1986-2016.

311 **Northern California Catch**

312 The California Commercial Fishery Database (**CalCOM**) provided landings for the Northern
313 model for the two counties north of 40.10 (Eureka and Del Norte) for 1969-2016.

314 **Hake Bycatch**

315 The Alaska Fisheries Science Center (**AFSC**) provided data for yellowtail bycatch in the
316 hake fishery from 1976-2016.

317 **2.1.2 Sport Fishery Removals**

sport-fishery-removals

318 **Washington Sport Catch**

319 WDFW provided recreational catches for 1967 and 1975-2016.

320 **Oregon Sport Catch**

321 ODFW provided recreational catch data for 1979-2016.

322 **MRFSS and RecFIN** Data from Northern California came from the Marine Recreational Fisheries Statistical Survey (**MRFSS**) and from the Recreational Fisheries Information Network (**RecFIN). These are dockside surveys focused on California and Oregon. MRFSS was conducted from 1980-1989 and 1993-2003, RecFIN from 2004 to the present.

326 **2.1.3 Estimated Discards**

estimated-discards

327 **Commercial Discards**

328 The West Coast Groundfish Observing Program (**WCGOP**) is an onboard observer program
329 that has extensively surveyed fishing practices since 2002, with nearly 100% observer coverage
330 in the trawl sector in recent years. WCGOP provided discard ratios for yellowtail rockfish
331 from 2002 to 2015.

332 **Pikitch Study**

333 The Pikitch study was conducted between 1985 and 1987 (Pikitch et al. [1988](#)). The northern
334 and southern boundaries of the study were 48°42' N latitude and 42°60' N. latitude respectively,
335 which is primarily within the Columbia INPFC area (Pikitch et al. [1988](#), Rogers and Pikitch
336 [1992](#)).

337 Participation in the study was voluntary and included vessels using bottom, midwater, and
338 shrimp trawl gears.

339 Observers of normal fishing operations on commercial vessels collected the data, estimated
340 the total weight of the catch by tow and recorded the weight of species retained and discarded
341 in the sample.

342 Pikitch study discards were aggregated due to small sample size and included in the data as
343 representing a single year mid-way through the study.

344 **2.1.4 Abundance Indices**

abundance-indices

345 **Commercial Logbook CPUE**

346 The commercial logbook (fish-ticket) data in PacFIN was used to generate an index for the

³⁴⁷ years 1987-1998, a period in which management of the fishery was stable, i.e., regulations
³⁴⁸ weren't changing fishery practices.

³⁴⁹ The data were modeled with a modified Stephens-MacCall approach (Stephens and MacCall
³⁵⁰ 2004). This approach uses the species composition of the catch to evaluate the per-haul
³⁵¹ probability of encountering a particular species; in this case, yellowtail rockfish. The intent
³⁵² of the analysis is to eliminate all hauls from the index that could not encounter yellowtail.
³⁵³ Usually, the Stephens-MacCall approach is a simple binomial model for presence-absence of
³⁵⁴ the predictive species and the target, however a generalized linear mixed-effects approach –
³⁵⁵ modeling the species as binomial and adding random effects for year, vessel, and haul-duration
³⁵⁶ improved the model fit.

³⁵⁷ The hauls identified with a reasonable probability of encountering yellowtail were then
³⁵⁸ modeled in a delta-lognormal glm to produce an index of abundance.

³⁵⁹ Hake Bycatch Index

³⁶⁰ The Hake bycatch data provided by the Alaska Fisheries Science Center (AFSC) was used to
³⁶¹ generate an index of abundance for 1985-1999.

³⁶² Data on haul-by-haul catch of Yellowtail Rockfish and Pacific Hake for the period 1976-2016
³⁶³ were obtained from the At-Sea Hake Observer Program along associated information including
³⁶⁴ the location of each tow and the duration. Previous Yellowtail assessments used an index
³⁶⁵ of abundance for the years 1978-1999. The most recent assessment (Wallace and Lai, 2005)
³⁶⁶ stated that the index was not updated to include years beyond 1999 “because subsequent
³⁶⁷ changes in fishery regulations and behavior have altered the statistical properties of these
³⁶⁸ abundance indices”. The ending year of 1999 was retained for this analysis. However, the
³⁶⁹ years up to 1984 have relatively few tows with adequate information for CPUE analysis, and
³⁷⁰ fishing effort off the coast of Washington where yellowtail are most commonly encountered
³⁷¹ (Figure X1). Therefore, for this new analysis, 1985 was chosen as the starting year.

³⁷² The hake fishery was evolving during the chosen 15 year period (1985-1999), which included a
³⁷³ transition from foreign to domestic fleets fishing for Pacific Hake (Figure X2). The index from
³⁷⁴ the at-sea hake fishery used in previous assessments standardized for changes in catchability
³⁷⁵ by using a ratio estimator relating yellowtail catch to hake catch and then scaling by an
³⁷⁶ estimate of fishing effort for hake (Equation 1 in Wallace and Lai, 2005). However, that
³⁷⁷ approach does not take into account differences in the spatial distribution of the at-sea hake
³⁷⁸ fishery relative to the distributions of hake and yellowtail.

³⁷⁹ For this new analysis, changes in catchability were estimated by comparing an index based
³⁸⁰ on a geostatistical analysis of the hake CPUE from VAST (Thorson et al. YYYY) to the
³⁸¹ estimated available hake biomass from the most recent stock assessment (Berger et al. 2017).
³⁸² The relative catchability was then used to adjust an independent geostatistical index of
³⁸³ yellowtail CPUE (Figure X3). In order to capture the general trend in catchability, reducing
³⁸⁴ the variability among years, linear, exponential, and locally smoothed (LOWESS) models
³⁸⁵ were fit to the time series of individual estimates of hake index to available biomass (Figure

³⁸⁶ X3b). Of these, the LOWESS model best captured the pattern of fastest change in the middle
³⁸⁷ of the time series. The average rate of increase in the resulting estimated catchability time
³⁸⁸ series is 13% per year.

³⁸⁹ VAST was then used to conduct a geostatistical standardization of the CPUE of yellowtail
³⁹⁰ caught as bycatch in the at-sea hake fishery. The resulting yellowtail index after adjustment by
³⁹¹ the estimated changes in catchability is qualitatively more similar to the index used in previous
³⁹² assessments (Figure X4) than the index resulting from assuming constant catchability.

³⁹³ **Pikitch Study**

³⁹⁴ The Pikitch data referenced above provided an index for years 1981-91.

³⁹⁵ **2.1.5 Fishery-Independent Data**

fishery-independent-data

³⁹⁶ **Northwest Fisheries Science Center (NWFSC) shelf-slope survey**

³⁹⁷ This survey, referred to as the **NWFSCcombo Survey**, has been conducted annually since
³⁹⁸ 2003.

³⁹⁹ The survey consistently covers depths between 30 and 700 fm.

⁴⁰⁰ Data from this survey for yellowtail rockfish was available for 2003-2016, and provided an
⁴⁰¹ index in addition to length and age data.

⁴⁰² **Alaska Fisheries Science Center (AFSC) Triennial shelf survey**

⁴⁰³ The **Triennial Survey** was conducted by the AFSC every third year between 1977 and 2001,
⁴⁰⁴ (and was conducted in 2004 by the NWFSC using the same protocols). The Triennial Survey
⁴⁰⁵ trawled in depths of 30 to 275 fm.

⁴⁰⁶ The Triennial Survey provided yellowtail rockfish length and age data, as well as an index of
⁴⁰⁷ abundance from 1997-2004.

⁴⁰⁸ **2.1.6 Biological Samples**

biological-samples

⁴⁰⁹ **Length And Age Compositions**

⁴¹⁰ Length composition data were compiled from PacFIN for Oregon and Washington for the
⁴¹¹ Northern model and combined with raw (unexpanded) length data from CalCOM for the
⁴¹² two California counties north of 40.10 (Eureka and Del Norte counties).

⁴¹³ Length compositions were provided from the following sources:

⁴¹⁴ Model input sample-sizes for age data were calculated according to the same algorithm as
⁴¹⁵ for lengths, except that the conditional age-at-length sample sizes are the number of fish,
⁴¹⁶ regardless of the source of the data.

⁴¹⁷ Age structure data were available from the following sources:

Table 2: Summary of the time series of lengths used in the stock assessment.

Source	Type	Lengths	Tows	Years	tab:Length_sources
PacFIN	commercial	186161	3830	1968-2016	
CalCOM	commercial	2340		1978-2015	
MRFSS	recreational	4125		1980-2003	
RecFIN	recreational	432		2004-2016	
WASport	recreational	11099		1975-2015	
Triennial	survey	16262	465	1977-2004	
NWFSCcombo	survey	940	564	2004-2016	

Table 3: Summary of the time series of age data used in the stock assessment.

Source	Type	Ages	Tows	Years	tab:Age_sources
PacFIN	commercial	138854		1972-2016	
CalCOM	commercial	3546		1980-2002	
WASport	recreational	4027		1997-2016	
Triennial	survey	6553	278	1997-2004	
NWFSCcombo	survey	2990	544	2003-2016	

418 2.2 Southern Model Data

southern-model-data

Table 4: Summary of the data source in the Northern model.

Source	Landings	Lengths	Ages	Indices	Discard	Type	tab:Data_sources
CalCOM	Y	Y	Y			Commercial	
MRFSS	Y	Y				Recreational	
RecFIN	Y	Y				Recreational	
HookandLine		Y	Y	Y		Survey	
Onboard		Y	Y	Y		Survey	
SmallResearch	Y	Y				Study	

419 2.2.1 Commercial Fishery Landings

commercial-fishery-landings-1

420 California Commercial Landings

421 The California Commercial Fishery Database (**CalCOM**) provided landings in California
422 south of 40.10 for 1969-2016.

423 2.2.2 Sport Fishery Removals

sport-fishery-removals-1

424 MRFSS Estimates and RecFIN

425 The California Department of Fish and Wildlife (**CDFW**) provided estimated yellowtail

⁴²⁶ removals for the Marine Recreational Fisheries Statistical Survey (**MRFSS**) from 1980-1989,
⁴²⁷ 1993-2003. The Recreational FIsheries Information Network, (**RecFIN**) provided landings
⁴²⁸ for 2004-2016.

⁴²⁹ **Small Research Study** A small number of fish were collected from the recreational fishery
⁴³⁰ by the Southwest Fisheries Science Center (**SWFSC**) and are included in the data for
⁴³¹ 1978-1984.

⁴³² **2.2.3 Estimated Discards**

`estimated-discards-1`

⁴³³ No discard data were available for the Southern model.

⁴³⁴ **2.2.4 Abundance Indices**

`abundance-indices-1`

⁴³⁵ **MRFSS Index**

⁴³⁶ An index of abundance was developed from trip-aggregated MRFSS data for the years
⁴³⁷ 1980-1989, 1992-2003.

⁴³⁸ **California Onboard Survey**

⁴³⁹ An Onboard recreational survey conducted by provided data for an index of abundance
⁴⁴⁰ provided by the SWFSC for 1987-2016.

⁴⁴¹ **2.2.5 Fishery-Independent Data**

`fishery-independent-data-1`

⁴⁴² **Hook and Line Survey**

⁴⁴³ The NWFSC Hook and Line survey provided data for an index in the Southern California
⁴⁴⁴ Bight from 2004-2016.

⁴⁴⁵ **2.2.6 Biological Samples**

`biological-samples-1`

⁴⁴⁶ Length composition samples were available for the Southern model from 5 sources, and ages
⁴⁴⁷ from 3.

⁴⁴⁸ Length compositions were provided from the following sources:

⁴⁴⁹ Model input sample-sizes for age data were calculated according to the same algorithm as
⁴⁵⁰ for lengths, except that the conditional age-at-length sample sizes are the number of fish,
⁴⁵¹ regardless of the source of the data.

⁴⁵² Age structure data were available from the following sources:

Table 5: Summary of the time series of lengths used in the stock assessment.

Source	Type	Lengths	Tows	Years
CalCOM	commercial	16160	1543	1978-2015
MRFSS	recreational	39425		1980-2003
RecFIN	recreational	49136		2004-2016
Onboard	recreational	76740		1987-2016
Small Study	recreational	909		1978-1984
Hook and Line	survey	1339	174	2004-2016

Table 6: Summary of the time series of age data used in the stock assessment.

Source	Type	Ages	Years
CalCOM	commercial	7875	1980-2004
Small Study	recreational	400	1978-1984
Hook and Line	survey	248	2004

453 2.3 Biological Parameters Common to Both Models

biological-parameters-common-to-both-models

454 Aging Precision And Bias

455 Age error matrices were developed for double-reads at the PFMC aging lab in Newport, OR
 456 and for double reads within the WDFW aging lab. The Newport lab has done all of the
 457 Survey aging for the NWFSC, along with some commercial ages and the 400 fish from the
 458 Small Study. WDFW provided the bulk of recreational and commercial ages. Between-lab
 459 differences in aging were minute, as were within-lab differences.

460 Weight-Length

461 The weight-length relationship is based on the standard power function: $W = \alpha(L^\beta)$ where
 462 W is individual weight (kg), L is length (cm), and α and β are coefficients used as constants.

463 To estimate this relationship, 12,778 samples with both weight and length measurements
 464 from the fishery independent surveys were analyzed. These included 6,354 samples from
 465 the NWFSC Combo survey, 5,085 from the Triennial survey, and 1,339 from the Hook and
 466 Line survey. All Hook and Line survey samples were from the Southern area, along with
 467 910 samples from the other two surveys (Figure 5). A single weight-length relationship was
 468 chosen for females and males in both areas after examining various factors that may influence
 469 this relationships, including sex, area, year, and season. None of these factors had a strong
 470 influence in the overall results. Season was one of the bigger factors, with fish sampled later
 471 in the year showing a small increase in weight at a given length (2-6% depending on the
 472 other factors considered). However, season was confounded with area because most of the
 473 samples from the Southern area were collected from the Hook and Line survey which takes

474 place later in the year (mid-September to mid-November) and the resolution of other data in
475 the model do not support modeling the stock at a scale finer than a annual time step. Males
476 and females did not show strong differences in either area, and the estimated differences were
477 in opposite directions for the two areas, suggesting that this might be a spurious relationship
478 or confounded with differences timing of the sampling relative to spawning.

479 The estimated coefficients resulting from this analysis were $\alpha = 1.1843e - 05$ and $\beta = 3.0672$.

480 **Maturity And Fecundity** Maturity was estimated from histological analysis of

481 141 samples collected in 2016. These include 96 from the NWFSC Combo survey, 25 from
482 mid-water catches in the NWFSC acoustic/trawl survey, 13 from the Hook and Line survey,
483 and 7 from Oregon Department of Fish and Wildlife. The sample sizes were not adequate to
484 estimate differences in maturity by area. Length at 50% maturity was estimated at 42.49cm
485 (Figure ??) which was consistent with the range 37-45cm cited in the previous assessment
486 (Wallace and Lai 2005).

487 **Natural Mortality**

488 Natural mortality estimates used as priors for the Northern model and as fixed values for the
489 Southern model were provided by Owen Hamel (pers. comm.).

490 **Sex ratios**

491 The largest fish seen in the data are females, however the oldest are males. The sex ratio
492 falls off differently in each model, as can be seen in Figs(x,y).

493 **2.3.1 Environmental Or Ecosystem Data Included In The Assessment** environmental-or-ecosystem-data-included-in-the-assessment

494 No environmental index is present in either model.

495 **3 Assessment**

assessment

496 **3.1 History Of Modeling Approaches Used For This Stock** history-of-modeling-approaches-used-for-this-stock

497 Yellowtail rockfish was previously modeled as a 3-area stock north of 40.10 using ADMB in 1999
498 Need citation, with an update assessment in 2004(Wallace and Lai 2005). That assessment

499 divided the stock into 3 INPFC areas which are not coincident with state boundaries; this is
500 a concern in that recent reconstructions of historical catch are state-by-state along the West
501 Coast, therefor we have made no effort to reproduce the previous model.

502 **3.1.1 Previous Assessment Recommendations**

previous-assessment-recommendations

503 Include: Response to STAR panel recommendations from the most recent previous assessment.

504 **Recommendation 1: More data needed.**

505

506 STAT response: Got some.

507 **Recommendation 2: blah blah blah.**

508

509 STAT response: blah blah blah....

510 **Recommendation 3: blah blah blah., etc.**

511

512 STAT response: Continue recommendations as needed

513 **3.2 Model Description**

model-description

514 **3.2.1 Transition To The Current Stock Assessment**

transition-to-the-current-stock-assessment

515 These are the main changes from the previous model, and our rationale for them:

- 516 1. Transition to Stock Synthesis. *Rationale*: The Pacific Fishery Management Council's
517 preferred modeling platform for stock assessments is Stock Synthesis (Methot 2015),
518 developed since the last full assessment of yellowtail rockfish.
- 519 2. Addition of Southern model. *Rationale*: Hess, et al. determined that the West Coast
520 yellowtail stocks show a genetic cline occurring near Cape Mendocino, which is roughly
521 40.10 north latitude (Hess et al. n.d.). This divides the stock into two genetically
522 distinct substocks which we model independently.
- 523 3. Availability of recent data. *Rationale*: Ten years of data collection have occurred since
524 the last update assessment.
- 525 4. Historical catch reconstructions. *Rationale*: Reconstruction of catch timeseries in
526 California, Washington and Oregon clarify stock history as far back as 1898.

527 **3.2.2 Definition of Fleets and Areas**

definition-of-fleets-and-areas

528 **Northern Model**

529 *Commercial*: The commercial fleet consists primarily of bottom and midwater trawl.

530 *Recreational*: The recreational fleet includes data from sport fisheries off Washington, Oregon,
531 and northern California (Eureka and Del Norte counties)

532 *Research*: Research derived-data include observations from the West Coast Groundfish
533 Observing Program (WCGOP) which documents discarding in the commercial fishery, the
534 Alaska Fisheries Science Center's Triennial Trawl survey, and the Northwest Fisheries Science
535 Center's NWFSCcombo survey.

536 **Southern Model**

537 *Commercial*: The commercial fleet consists primarily of hook and line and trawl gear. Hook
538 and line gear account for 78% of the landings by weight in the recent period (1978-2016).

539 *Recreational*: The recreational fleet includes data from sport fishery off the California coast
540 south of Cape Mendocino.

541 *Research*: Research derived-data include observations from the Northwest Fisheries Science
542 Center's NWFSCcombo survey, and California Onboard recreational survey.

543 **3.2.3 Modeling Software**

modeling-software

544 The STAT team used Stock Synthesis 3 version 3.3 (Methot 2015).

545 **3.2.4 Data Weighting**

data-weighting

546 Commercial and survey length composition and marginal age composition data are weighted
547 according to the method of Ian Stewart (pers.comm):

548 Sample Size = $0.138 * \text{Nfish} + \text{Ntows}$ if $\text{Nfish}/\text{Ntows} < 44$, and $\text{Ntows} * 7.06$ otherwise.

549 Age-at-Length samples are unwieghted; that is, each fish is assumed to represesnt an inde-
550 pendent sample.

551 Recreational tows are difficult to define in most cases. Since much of the recreational data
552 are from the dockside interview Marine Recreational Fisheries Statics Survey (MRFSS, 1980-
553 2003), which provided notoriously poor data with respect to aggregating samples to “trip”,

554 we chose to use all recreational data “as-is”, with the initial weights entered as number of
555 fish.

556 Stock Synthesis does internal re-weighting between years within fleets to adjust for sample size.
557 Weighting among fleets uses either the Francis method (Francis 2011) or the Ianelli-McAllister
558 harmonic mean method (McAllister and Ianelli 1997). The Francis method was used for all
559 fleets, except for the Southern model’s Hook and Line age data, which is a single year of data
560 to which we applied the Ianelli-McAllister method.

561 3.2.5 Priors

priors

562 Natural Mortality (M) priors were provided by Owen Hamel prior on natural mortality (Hamel
563 2015). We used the Hamel prior as a fixed value in the Southern model, however the Northern
564 model was able to estimate M. In both models, male M was estimated as an offset from
565 female M. The Southern female M is 0.18; the Northern female M prior is 0.12.

566 The prior for steepness (h, 0.718) was provided by James Thorson and used as a fixed
567 parameter in both models. <TOADS: Citation>

568 3.2.6 General Model Specifications

general-model-specifications

569 Citation for posterior predictive fecundity relationship from Dick (2009)

570 Model data, control, starter, and forecast files can be found at <https://DEVORE> .

571 3.2.7 Estimated And Fixed Parameters

estimated-and-fixed-parameters

572 A full list of all estimated and fixed parameters is provided in Tables.... Estimated and fixed
573 parameters tables currently read in from .csv file, EXAMPLE: Table ??

574 3.3 Model Selection and Evaluation

model-selection-and-evaluation

575 3.3.1 Key Assumptions and Structural Choices

key-assumptions-and-structural-choices

576 Include: Evidence of search for balance between model realism and parsimony.

577 Comparison of key model assumptions, include comparisons based on nested models (e.g.,
578 asymptotic vs. domed selectivities, constant vs. time-varying selectivities).

579 Selectivity in both models is asymptotic, with the exception of the OR-CA MRFSS recreational
580 fleet in the Northern model, and the Onboard recreational fleet in the Southern model.

581 **3.3.2 Alternate Models Considered**

alternate-models-considered

582 Include: Summary of alternate model configurations that were tried but rejected.

583 **3.3.3 Convergence**

convergence

584 Include: Randomization run results or other evidence of search for global best estimates.

585 Convergence testing through use of dispersed starting values often requires extreme values
586 to actually explore new areas of the multivariate likelihood surface. Jitter is a Stock
587 Synthesis option that generates random starting values from a normal distribution logically
588 transformed into each parameter's range (Methot 2015). Table 9 shows the results of running
589 100 jitters for each pre-STAR base model....

590 **3.4 Response To The Current STAR Panel Requests**

response-to-the-current-star-panel-requests

591 **Request No. 1: Add after STAR panel.**

592

593 **Rationale:** Add after STAR panel.

594

STAT Response: Add after STAR panel.

595 **Request No. 2: Add after STAR panel.**

596

597 **Rationale:** Add after STAR panel.

598

STAT Response: Add after STAR panel.

599 **Request No. 3: Add after STAR panel.**

600

601 **Rationale:** Add after STAR panel.

602

STAT Response: Add after STAR panel.

603 **Request No. 4: Example of a request that may have a list:**

604

- 605 • **Item No. 1**
- 606 • **Item No. 2**
- 607 • **Item No. 3, etc.**

608 **Rationale:** Add after STAR panel.

609 **STAT Response:** Continue requests as needed.

610 **3.5 Model 1**

model-1

611 **3.5.1 Model 1 Base Case Results**

model-1-base-case-results

612 Table ??

613 **3.5.2 Model 1 Uncertainty and Sensitivity Analyses**

model-1-uncertainty-and-sensitivity-analyses

614 Table 10

615 **3.5.3 Model 1 Retrospective Analysis**

model-1-retrospective-analysis

616 **3.5.4 Model 1 Likelihood Profiles**

model-1-likelihood-profiles

617 **3.5.5 Model 1 Harvest Control Rules (CPS only)**

model-1-harvest-control-rules-cps-only

618 **3.5.6 Model 1 Reference Points (groundfish only)**

model-1-reference-points-groundfish-only

619 Intro sentence or two....(Table 11).

620 Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 3691.6 mt.
621 Table i shows the full suite of estimated reference points for the northern area model and
622 Figure i shows the equilibrium yield curve.

623 **3.6 Model 2** model-2

624 **3.6.1 Model 2 Base Case Results** model-2-base-case-results

625 **3.6.2 Model 2 Uncertainty and Sensitivity Analyses** model-2-uncertainty-and-sensitivity-analyses

626 **3.6.3 Model 2 Retrospective Analysis** model-2-retrospective-analysis

627 **3.6.4 Model 2 Likelihood Profiles** model-2-likelihood-profiles

628 **3.6.5 Model 2 Harvest Control Rules (CPS only)** model-2-harvest-control-rules-cps-only

629 **3.6.6 Model 2 Reference Points (groundfish only)** model-2-reference-points-groundfish-only

630 **3.7 Model 3** model-3

631 **3.7.1 Model 3 Base Case Results** model-3-base-case-results

632 **3.7.2 Model 3 Uncertainty and Sensitivity Analyses** model-3-uncertainty-and-sensitivity-analyses

633 **3.7.3 Model 3 Retrospective Analysis** model-3-retrospective-analysis

634 **3.7.4 Model 3 Likelihood profiles** model-3-likelihood-profiles

635 **3.7.5 Model 3 Harvest Control Rules (CPS only)** model-3-harvest-control-rules-cps-only

636 **3.7.6 Model 3 Reference Points (groundfish only)** model-3-reference-points-groundfish-only

637 **4 Harvest Projections and Decision Tables** harvest-projections-and-decision-tables

638 Table [k](#)

639 Model 1 Projections and Decision Table (groundfish only) (Table [12](#))

640 Table [m](#)

641 Model 2 Projections and Decision Table (groundfish only)

642 Model 3 Projections and Decision Table (groundfish only)

643 5 Regional Management Considerations

regional-management-considerations

- 644 1. For stocks where current practice is to allocate harvests by management area, a
- 645 recommended method of allocating harvests based on the distribution of biomass should
- 646 be provided. The MT advisor should be consulted on the appropriate management
- 647 areas for each stock.
- 648 2. Discuss whether a regional management approach makes sense for the species from a
- 649 biological perspective.
- 650 3. If there are insufficient data to analyze a regional management approach, what are the
- 651 research and data needs to answer this question?

652 6 Research Needs

research-needs

- 653 1. Research need No. 1
- 654 2. Research need No. 2
- 655 3. Research need No. 3
- 656 4. etc.

657 7 Acknowledgments

acknowledgments

658 Include: STAR panel members and affiliations as well as names and affiliations of persons
659 who contributed data, advice or information but were not part of the assessment team. Not
660 required in draft assessment undergoing review.

₆₆₁ 8 Tables

tables

Table 7: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
1	NatM_p_1_Fem_GP_1	0.141	2	(0.02, 0.25) (1, 25)	OK	0.009	None
2	Lat_Amin_Fem_GP_1	14.879	3	(1, 25)	OK	0.575	None
3	Lat_Amax_Fem_GP_1	53.827	2	(35, 70)	OK	0.235	None
4	VonBert_K_Fem_GP_1	0.137	3	(0.1, 0.4)	OK	0.004	None
5	CV_young_Fem_GP_1	0.101	5	(0.03, 0.16)	OK	0.010	None
6	CV_old_Fem_GP_1	0.043	5	(0.03, 0.16)	OK	0.003	None
7	Wtlen_1_Fem	0.000	-50	(0, 3)	None	None	None
8	Wtlen_2_Fem	3.067	-50	(2, 4)	None	None	None
9	Mat50%_Fem	42.490	-50	(30, 56)	None	None	None
10	Mat_slope_Fem	-0.401	-50	(-2, 1)	None	None	None
11	Eggs_scalar_Fem	0.000	-50	(0, 6)	None	None	None
12	Eggs_exp_len_Fem	4.590	-50	(2, 7)	OK	0.017	None
13	NatM_p_1_Mal_GP_1	-0.142	2	(-3, 3)	OK	0.017	None
14	Lat_Amin_Mal_GP_1	0.000	-2	(-1, 1)	OK	0.005	None
15	Lat_Amax_Mal_GP_1	-0.148	2	(-1, 1)	OK	0.027	None
16	VonBert_K_Mal_GP_1	0.369	3	(-1, 1)	OK	0.027	None
17	CV_young_Mal_GP_1	0.000	-5	(-1, 1)	OK	0.070	None
18	CV_old_Mal_GP_1	0.172	5	(-1, 1)	OK	0.070	None
19	Wtlen_1_Mal	0.000	-50	(0, 3)	None	None	None
20	Wtlen_2_Mal	3.067	-50	(2, 4)	None	None	None
24	CohortGrowDev	1.000	-50	(0, 2)	None	None	None
25	FracFemale_GP_1	0.500	-99	(0.001, 0.999)	None	None	None
26	SR_LN(R0)	10.181	1	(5, 20)	OK	0.158	None
27	SR_BH_stEEP	0.718	-6	(0.2, 1)	None	None	None
28	SR_sigmar	0.546	-6	(0.5, 1.2)	None	None	None
29	SR_regime	0.000	-50	(-5, 5)	None	None	None

Continued on next page

Table 7: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
30	SR.autocorr	0.000	-50	(0, 2)			None
140	LnQ_base_CommercialTrawl(1)	-4.397	-1	(-30, 15)			None
141	LnQ_base_HakeByCatch(2)	-9.820	-1	(-30, 15)			None
142	Q_extraSD_HakeByCatch(2)	0.278	1	(0, 0.5)	OK	0.083	None
143	LnQ_base_Triennial(5)	-1.003	-1	(-30, 15)			None
144	LnQ_base_NWFSCombo(6)	-0.559	-1	(-30, 15)			None
145	SizeSel_P1_CommercialTrawl(1)	48.717	1	(20, 55)	OK	0.724	None
146	SizeSel_P2_CommercialTrawl(1)	70.000	-4	(-20, 70)			None
147	SizeSel_P3_CommercialTrawl(1)	4.296	3	(-5, 20)	OK	0.095	None
148	SizeSel_P4_CommercialTrawl(1)	70.000	-4	(-5, 70)			None
149	SizeSel_P5_CommercialTrawl(1)	-999.000	-99	(-999, 25)			None
150	SizeSel_P6_CommercialTrawl(1)	-999.000	-99	(-999, 25)			None
151	Retain_P1_CommercialTrawl(1)	24.506	3	(20, 55)	OK	3.272	None
152	Retain_P2_CommercialTrawl(1)	1.597	3	(0.1, 40)	OK	0.700	None
153	Retain_P3_CommercialTrawl(1)	3.070	3	(-10, 20)	OK	0.706	None
154	Retain_P4_CommercialTrawl(1)	0.000	-4	(-3, 3)			None
155	SizeSel_P1_HakeByCatch(2)	52.341	1	(20, 55)	OK	0.878	None
156	SizeSel_P2_HakeByCatch(2)	70.000	-4	(-20, 70)			None
157	SizeSel_P3_HakeByCatch(2)	4.301	3	(-5, 20)	OK	0.113	None
158	SizeSel_P4_HakeByCatch(2)	70.000	-4	(-5, 70)			None
159	SizeSel_P5_HakeByCatch(2)	-999.000	-99	(-999, 25)			None
160	SizeSel_P6_HakeByCatch(2)	-999.000	-99	(-999, 25)			None
161	SizeSel_P1_RecORandCA(3)	30.578	1	(20, 55)	OK	0.710	None
162	SizeSel_P2_RecORandCA(3)	-19.161	4	(-20, 7)	OK	3239.790	None
163	SizeSel_P3_RecORandCA(3)	3.117	3	(-5, 20)	OK	0.237	None
164	SizeSel_P4_RecORandCA(3)	6.734	4	(-5, 20)	OK	0.566	None
165	SizeSel_P5_RecORandCA(3)	-999.000	-99	(-999, 25)			None

Continued on next page

Table 7: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
166	SizeSel_P6_RecORandCA(3)	-999.000	-99	(-999, 25)			None
167	SizeSel_P1_RecWA(4)	28.338	6	(20, 55)	OK	0.950	None
168	SizeSel_P2_RecWA(4)	70.000	-4	(-20, 70)	OK	2.463	None
169	SizeSel_P3_RecWA(4)	-1.407	6	(-5, 20)	OK		None
170	SizeSel_P4_RecWA(4)	70.000	-4	(-5, 70)	OK		None
171	SizeSel_P5_RecWA(4)	-999.000	-99	(-999, 25)	OK		None
172	SizeSel_P6_RecWA(4)	-999.000	-99	(-999, 25)	OK		None
173	SizeSel_P1_Triennial(5)	54.364	1	(20, 55)	OK	3.966	None
174	SizeSel_P2_Triennial(5)	70.000	-4	(-20, 70)	OK		None
175	SizeSel_P3_Triennial(5)	5.128	3	(-5, 20)	OK	0.308	None
176	SizeSel_P4_Triennial(5)	70.000	-4	(-5, 70)	OK		None
177	SizeSel_P5_Triennial(5)	-999.000	-99	(-999, 25)	OK		None
178	SizeSel_P6_Triennial(5)	-999.000	-99	(-999, 25)	OK		None
179	SizeSel_P1_NWFSCCombo(6)	49.696	1	(20, 55)	OK	2.906	None
180	SizeSel_P2_NWFSCCombo(6)	70.000	-4	(-20, 70)	OK		None
181	SizeSel_P3_NWFSCCombo(6)	4.551	3	(-5, 20)	OK	0.433	None
182	SizeSel_P4_NWFSCCombo(6)	70.000	-4	(-5, 70)	OK		None
183	SizeSel_P5_NWFSCCombo(6)	-999.000	-99	(-999, 25)	OK		None
184	SizeSel_P6_NWFSCCombo(6)	-999.000	-99	(-999, 25)	OK		None
185	Retain_P3_CommercialTrawl(1)_BLK1repL2002	2.228	6	(-10, 20)	OK	0.457	None
186	Retain_P3_CommercialTrawl(1)_BLK1repL2003	3.708	6	(-10, 20)	OK	0.756	None
187	Retain_P3_CommercialTrawl(1)_BLK1repL2004	1.128	6	(-10, 20)	OK	0.522	None
188	Retain_P3_CommercialTrawl(1)_BLK1repL2005	-0.115	6	(-10, 20)	OK	0.400	None
189	Retain_P3_CommercialTrawl(1)_BLK1repL2006	1.760	6	(-10, 20)	OK	0.260	None
190	Retain_P3_CommercialTrawl(1)_BLK1repL2007	-0.516	6	(-10, 20)	OK	0.625	None
191	Retain_P3_CommercialTrawl(1)_BLK1repL2008	2.373	6	(-10, 20)	OK	0.820	None
192	Retain_P3_CommercialTrawl(1)_BLK1repL2009	0.480	6	(-10, 20)	OK	0.495	None

Continued on next page

Table 7: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD)).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
193	Retain.P3_CommercialTrawl(1)_BLK1rep1.2010	0.159	6	(-10, 20)	OK	0.678	None
194	Retain.P3_CommercialTrawl(1)_BLK1rep1.2011	7.327	6	(-10, 20)	OK	0.670	None

tab-model-params

Table 8: Summary of the biomass/abundance time series used in the stock assessment.

Region	ID	Fleet	Years	Name	Fishery ind.	Filtering	Method	Endorsed
WA	1	4	1981- 2014	Dockside CPUE	No	trip, area, month, Stephens- MacCall	delta-GLM (bin- gamma)	SSC
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

Table 9: Results from 100 jitters from each of the three models.

Status	Model.1	Model.2	Model.3	tab:jitter
Returned to base case	-	-	-	
Found local minimum	-	-	-	
Found better solution	-	-	-	
Error in likelihood	-	-	-	
Total	100	100	100	

Table 11: Time-series of population estimates from the base-case model.

Yr	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative ex- ploitation rate	SPR
1889	128998	15	0.00	26416	0	0.00	1.00
1890	128998	15	1.00	26416	0	0.00	1.00
1891	128997	15	1.00	26416	0	0.00	1.00
1892	128977	15	1.00	26416	2	0.00	1.00
1893	128980	15	1.00	26416	2	0.00	1.00
1894	128980	15	1.00	26416	2	0.00	1.00
1895	128994	15	1.00	26416	1	0.00	1.00
1896	128998	15	1.00	26416	0	0.00	1.00
1897	128998	15	1.00	26416	0	0.00	1.00
1898	128998	15	1.00	26416	0	0.00	1.00
1899	128998	15	1.00	26416	0	0.00	1.00
1900	128997	15	1.00	26416	0	0.00	1.00
1901	128997	15	1.00	26416	0	0.00	1.00
1902	128996	15	1.00	26416	0	0.00	1.00
1903	128996	15	1.00	26416	0	0.00	1.00
1904	128993	15	1.00	26416	1	0.00	1.00
1905	128995	15	1.00	26416	0	0.00	1.00
1906	128995	15	1.00	26417	1	0.00	1.00
1907	128994	15	1.00	26417	1	0.00	1.00
1908	128992	15	1.00	26417	1	0.00	1.00
1909	128993	15	1.00	26417	1	0.00	1.00
1910	128993	15	1.00	26417	1	0.00	1.00
1911	128992	15	1.00	26417	1	0.00	1.00
1912	128992	15	1.00	26417	1	0.00	1.00
1913	128991	15	1.00	26417	1	0.00	1.00
1914	128991	15	1.00	26417	1	0.00	1.00
1915	128989	15	1.00	26417	1	0.00	1.00
1916	128989	15	1.00	26417	1	0.00	1.00
1917	128988	15	1.00	26417	1	0.00	1.00
1918	128963	15	1.00	26417	4	0.00	1.00
1919	128979	15	1.00	26417	2	0.00	1.00
1920	128980	15	1.00	26417	2	0.00	1.00
1921	128981	15	1.00	26417	2	0.00	1.00
1922	128983	15	1.00	26417	2	0.00	1.00
1923	128982	15	1.00	26417	2	0.00	1.00
1924	128976	15	1.00	26417	3	0.00	1.00
1925	128972	15	1.00	26417	3	0.00	1.00
1926	128963	15	1.00	26417	4	0.00	1.00
1927	128955	15	1.00	26417	5	0.00	1.00
1928	128948	15	1.00	26417	6	0.00	1.00

Table 11: Time-series of population estimates from the base-case model.

Yr	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative ex- ploitation rate	SPR
1929	128895	15	1.00	26417	12	0.00	1.00
1930	128855	15	1.00	26417	16	0.00	1.00
1931	128906	15	1.00	26416	11	0.00	1.00
1932	128972	15	1.00	25869	3	0.00	1.00
1933	128961	15	1.00	25816	4	0.00	1.00
1934	128936	15	1.00	25755	7	0.00	1.00
1935	128911	15	1.00	25686	10	0.00	1.00
1936	128873	15	1.00	25606	14	0.00	1.00
1937	128765	15	1.00	25516	27	0.00	1.00
1938	128739	15	1.00	25415	30	0.00	1.00
1939	128664	15	1.00	25306	38	0.00	1.00
1940	127810	15	1.00	25186	137	0.00	0.98
1941	127419	15	1.00	25051	182	0.00	0.98
1942	126278	15	0.99	24902	316	0.00	0.96
1943	118201	15	0.99	24735	1363	0.01	0.85
1944	111879	14	0.97	24527	2291	0.02	0.77
1945	101159	14	0.95	24284	4177	0.03	0.63
1946	110770	13	0.90	23931	2315	0.02	0.75
1947	117634	13	0.88	23608	1304	0.01	0.85
1948	119213	13	0.87	23335	1094	0.01	0.87
1949	123621	13	0.86	23082	570	0.01	0.93
1950	118250	13	0.86	22821	1208	0.01	0.85
1951	118297	13	0.86	22467	1194	0.01	0.85
1952	115125	12	0.85	22053	1594	0.01	0.81
1953	120832	12	0.84	21672	870	0.01	0.89
1954	118529	12	0.84	21493	1141	0.01	0.86
1955	118066	12	0.83	21469	1189	0.01	0.85
1956	116427	12	0.82	21229	1382	0.01	0.83
1957	116142	12	0.82	20596	1403	0.01	0.83
1958	115689	12	0.81	20155	1444	0.01	0.82
1959	115004	12	0.80	21249	1512	0.01	0.81
1960	112205	12	0.79	26215	1850	0.02	0.77
1961	112783	11	0.77	34817	1743	0.02	0.78
1962	108082	11	0.76	28452	2342	0.02	0.72
1963	111006	11	0.74	20940	1897	0.02	0.76
1964	113580	11	0.72	18139	1548	0.02	0.79
1965	114117	10	0.71	17896	1466	0.02	0.80
1966	116975	10	0.70	18720	1135	0.01	0.84
1967	114315	10	0.70	21822	1420	0.01	0.80
1968	109723	10	0.70	32764	1985	0.02	0.74

Table 11: Time-series of population estimates from the base-case model.

Yr	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative ex- ploitation rate	SPR
1969	100189	10	0.69	25306	3364	0.03	0.62
1970	113265	10	0.67	18555	1530	0.02	0.79
1971	112767	10	0.68	14419	1598	0.02	0.78
1972	106461	10	0.68	19106	2400	0.03	0.70
1973	102941	10	0.68	23959	2865	0.03	0.65
1974	108465	10	0.66	43111	2055	0.02	0.72
1975	113173	10	0.65	33612	1480	0.02	0.79
1976	94517	10	0.65	27068	4151	0.05	0.55
1977	84114	9	0.63	32309	6205	0.07	0.43
1978	73977	9	0.58	22366	8721	0.10	0.31
1979	74340	8	0.51	13972	7712	0.09	0.32
1980	72474	7	0.45	16706	7625	0.09	0.30
1981	64605	6	0.40	23192	9692	0.12	0.22
1982	61042	5	0.34	15076	10338	0.14	0.19
1983	57786	4	0.30	25907	10842	0.16	0.16
1984	71611	4	0.26	30505	5477	0.09	0.29
1985	81228	4	0.26	20605	3751	0.06	0.40
1986	73723	4	0.29	22826	5412	0.09	0.31
1987	73504	4	0.29	28515	5419	0.09	0.31
1988	67338	4	0.29	16021	6800	0.11	0.25
1989	71983	4	0.27	34522	5227	0.09	0.29
1990	72925	4	0.26	33940	4916	0.08	0.30
1991	75372	4	0.25	31514	4418	0.07	0.33
1992	64703	4	0.25	19984	6857	0.11	0.22
1993	66430	4	0.24	13490	6104	0.10	0.24
1994	66346	3	0.23	21921	6140	0.10	0.24
1995	68115	3	0.23	20802	5657	0.09	0.25
1996	65907	3	0.23	11261	6275	0.10	0.23
1997	89311	3	0.23	15130	2412	0.04	0.48
1998	85488	4	0.26	26917	3142	0.05	0.44
1999	84144	4	0.29	25511	3599	0.06	0.41
2000	84704	5	0.31	34151	3716	0.06	0.43
2001	97218	5	0.33	17903	2236	0.04	0.58
2002	107616	5	0.36	11227	1356	0.02	0.71
2003	120377	6	0.38	13806	491	0.01	0.88
2004	115717	6	0.41	17951	839	0.01	0.82
2005	105479	6	0.44	7619	1753	0.02	0.69
2006	120140	7	0.45	27431	565	0.01	0.88
2007	116755	7	0.47	9802	852	0.01	0.83
2008	121368	7	0.50	34459	520	0.01	0.89

Table 11: Time-series of population estimates from the base-case model.

Yr	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative ex- ploitation rate	SPR
2009	114737	8	0.53	10442	1095	0.01	0.80
2010	109749	8	0.54	22111	1600	0.02	0.74
2011	112174	8	0.55	15149	1348	0.02	0.77
2012	109683	8	0.56	15950	1593	0.02	0.74
2013	111229	8	0.55	25871	1432	0.02	0.76
2014	110627	8	0.55	24047	1460	0.02	0.75
2015	105097	8	0.54	24513	2017	0.03	0.68
2016	110396	8	0.53	24346			

`tab:Timeseries_mod1`

Table 10: Sensitivity of the base model to dropping or down-weighting data sources and alternative assumptions about growth.

Label	Base (Francis weights)	Harmonic weights)	Drop index	Drop ages	Down- weight lengths	Free size Age0	Free CV Amin	External growth
TOTAL_like	-	-	-	-	-	-	-	-
Catch_like	-	-	-	-	-	-	-	-
Equil_catch_like	-	-	-	-	-	-	-	-
Survey_like	-	-	-	-	-	-	-	-
Length_comp_like	-	-	-	-	-	-	-	-
Age_comp_like	-	-	-	-	-	-	-	-
Parm_priors_like	-	-	-	-	-	-	-	-
SSB_Umfished_thousand_mt	-	-	-	-	-	-	-	-
TotBio_Umfished	-	-	-	-	-	-	-	-
SmryBio_Umfished	-	-	-	-	-	-	-	-
Recr_Umfished_billions	-	-	-	-	-	-	-	-
SSB_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SPR_Btgt	-	-	-	-	-	-	-	-
Fstd_Btgt	-	-	-	-	-	-	-	-
TotYield_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
Fstd_SPRtgt	-	-	-	-	-	-	-	-
TotYield_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_MSY_thousand_mt	-	-	-	-	-	-	-	-
SPR_MSY	-	-	-	-	-	-	-	-
Fstd_MSY	-	-	-	-	-	-	-	-
TotYield_MSY_thousand_mt	-	-	-	-	-	-	-	-
RetYield_MSY	-	-	-	-	-	-	-	-
Bratio_2015	-	-	-	-	-	-	-	-
F_2015	-	-	-	-	-	-	-	-
SPRratio_2015	-	-	-	-	-	-	-	-
Recr_2015	-	-	-	-	-	-	-	-
Recr_Virgin_billions	-	-	-	-	-	-	-	-
L_at_Amin_Fem_GP_1	-	-	-	-	-	-	-	-
L_at_Amax_Fem_GP_1	-	-	-	-	-	-	-	-
VonBert_K_Fem_GP_1	-	-	-	-	-	-	-	-
CV_young_Fem_GP_1	-	-	-	-	-	-	-	-
CV_old_Fem_GP_1	-	-	-	-	-	-	-	-

Table 12: Projection of potential OFL, spawning biomass, and depletion for the base case model.

Yr	OFL contribution (mt)	ACL landings (mt)	Age 5+ biomass (mt)	Spawning Biomass (mt)	<small>tab:Forecast_mod1</small>
2017	3988.81	3660.21	75949.10	7.79	0.53
2018	3840.38	3524.14	74683.90	7.43	0.51
2019	3712.42	3406.90	74047.40	7.11	0.48
2020	3611.38	3314.36	73875.00	6.83	0.46
2021	3544.46	3253.15	74067.80	6.60	0.45
2022	3513.29	3224.88	74487.30	6.43	0.44
2023	3512.56	3224.60	75022.20	6.34	0.43
2024	3532.98	3243.48	75582.80	6.32	0.43
2025	3564.86	3272.58	76107.30	6.34	0.43
2026	3600.46	3304.98	76561.10	6.38	0.43
2027	3634.58	3336.05	76932.40	6.44	0.44
2028	3664.30	3363.16	77224.20	6.49	0.44

662 **9 Figures**

figures

663 **9.1 Catch History**

catch-history

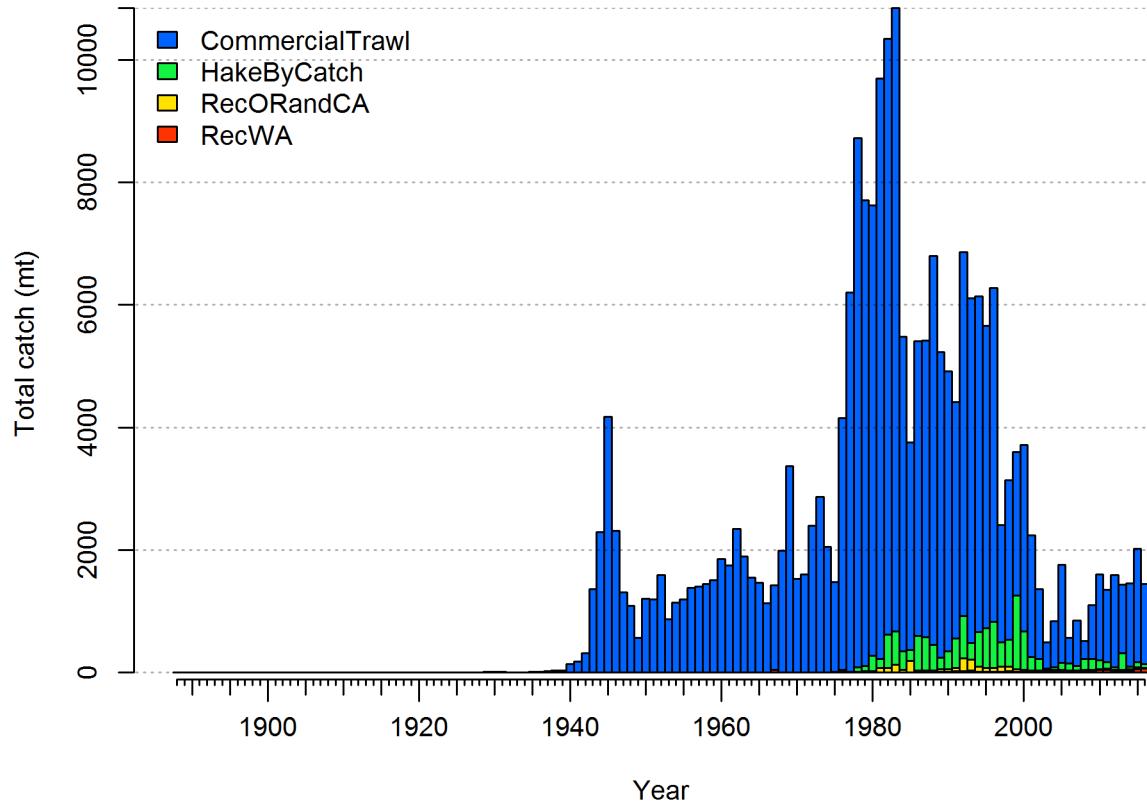


Figure 1: Estimated catch history of Yellowtail Rockfish in the Northern model. Recreational catches in Washington are model estimates of total weight converted from input catch in numbers using model estimates of growth and selectivity. Catches for the Commercial Fishery include estimated discards.
fig:r4ss_total_catch_N

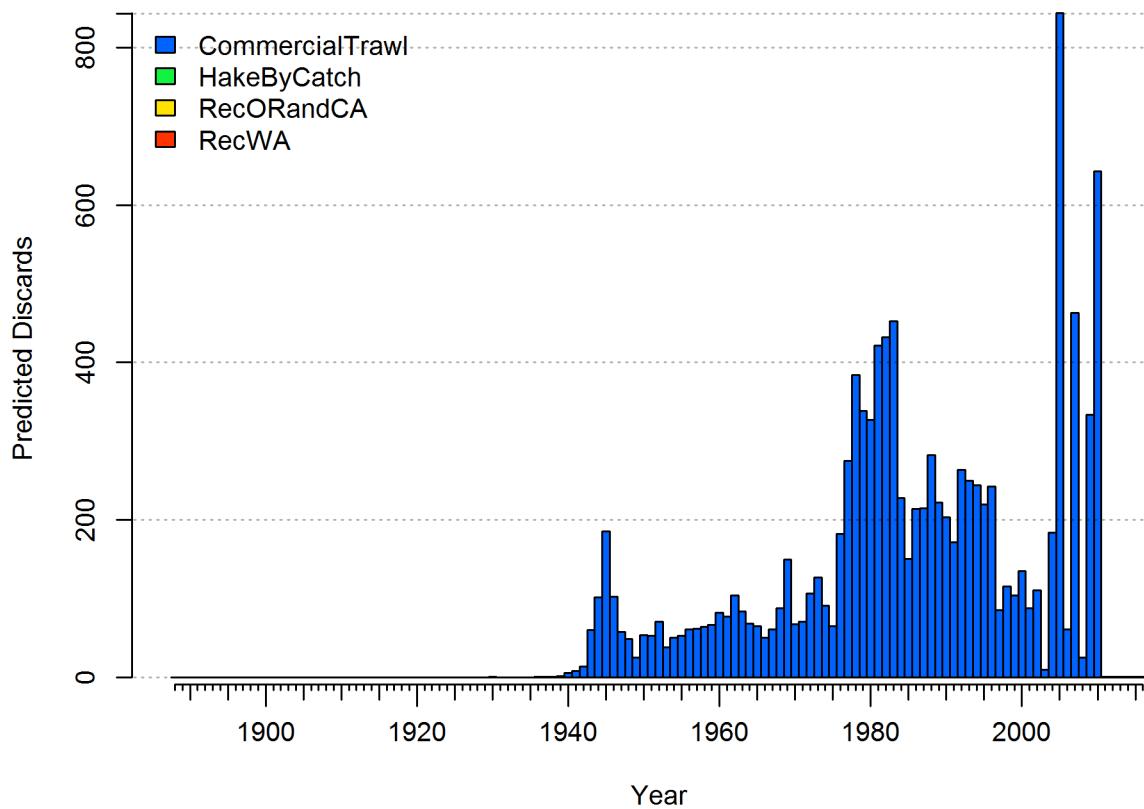


Figure 2: Estimated discards in the Commercial Fishery in the Northern model. Estimates are influenced by the data for landings, discard ratios, and discard length combines and depend on the estimated parameters controlling selectivity and retention.^{fig:r4ss_discard_N}

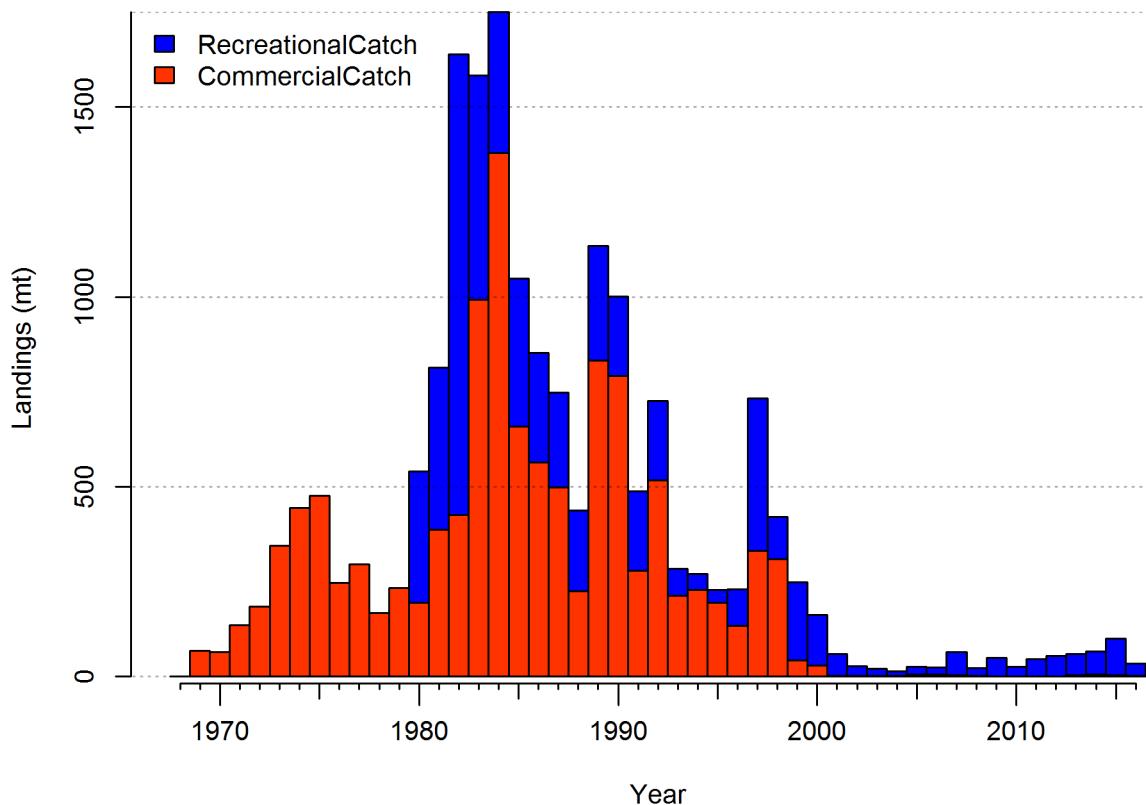


Figure 3: Estimated catch history of Yellowtail Rockfish in the Southern model. fig:r4ss_catch2_S

664 9.2 Life History (Maturity, Fecundity, Weight-Length, and
665 Growth)

life-history-maturity-fecundity-weight-length-and-growth

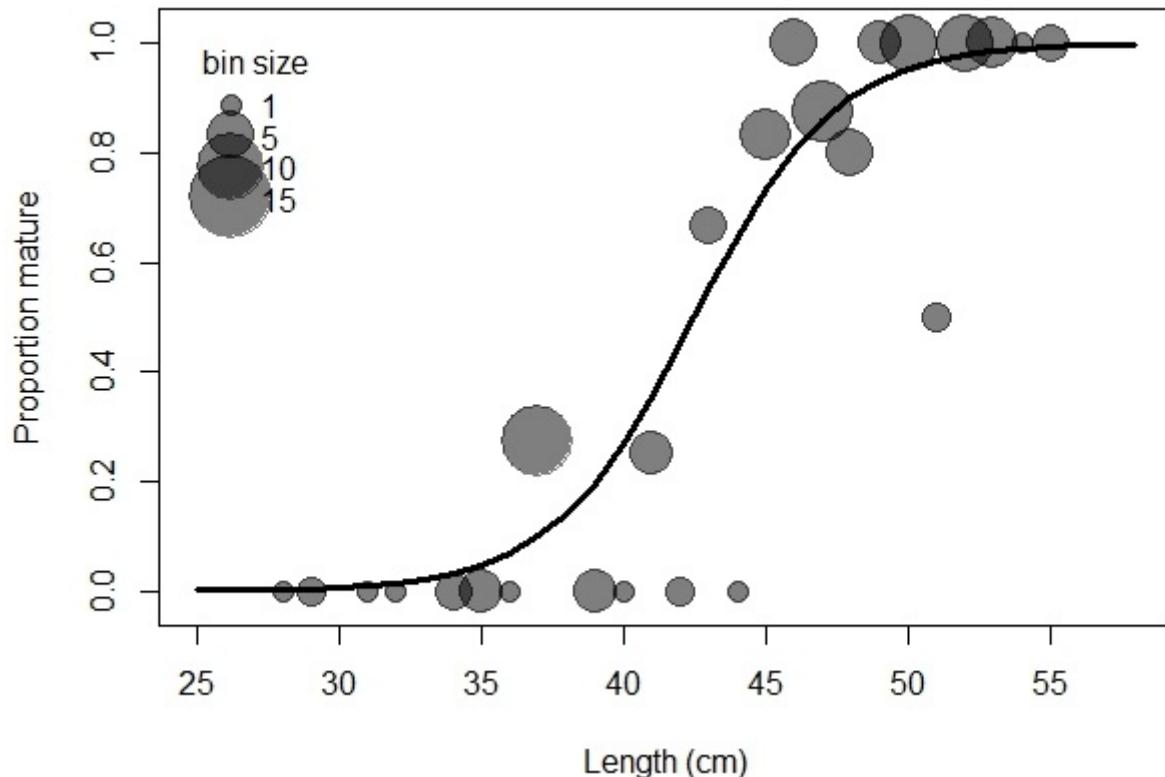


Figure 4: Estimated maturity relationship for Yellowtail Rockfish used in both models. Gray points indicate average observed functional maturity within each length bin with point size proportional to the number of samples.
fig:maturity

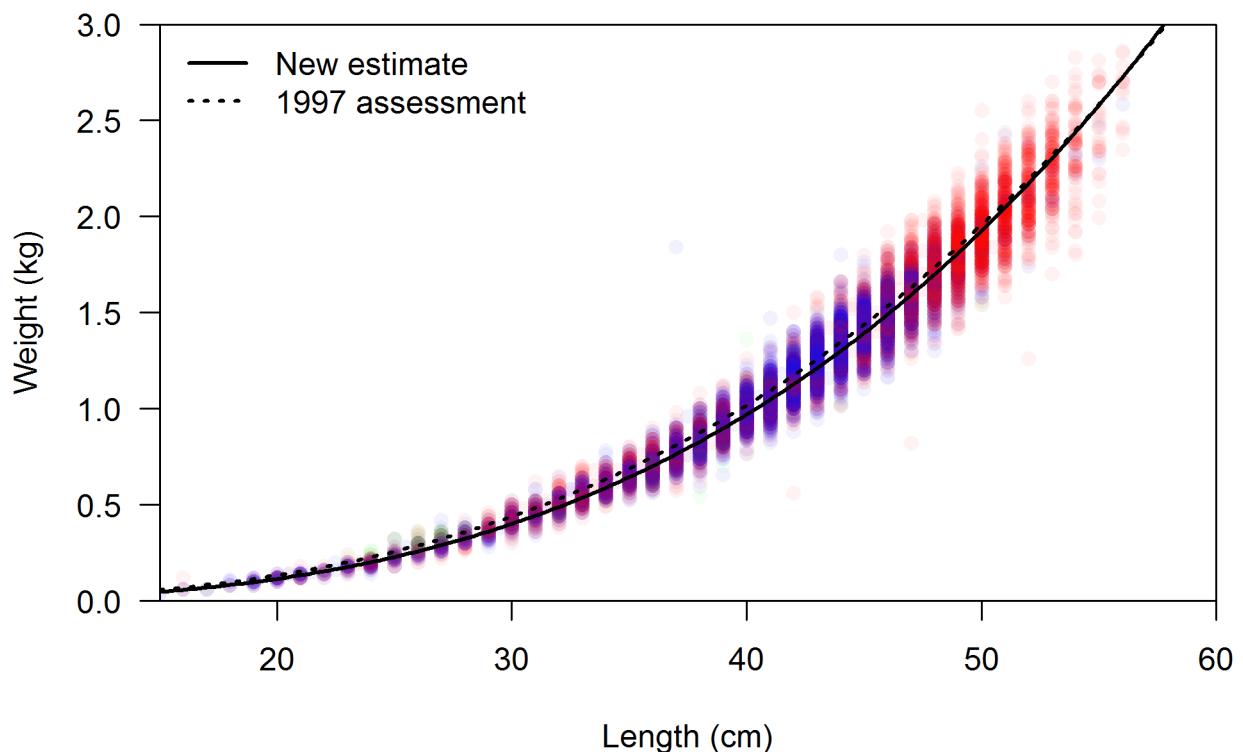


Figure 5: Estimated weight-length relationship for Yellowtail Rockfish used in both models. Colored points show observed values (red for females, blue for males, and green for unsexed). The black line indicates the estimated relationship $W = 0.000011843L^{3.0672}$.
fig:weight-length

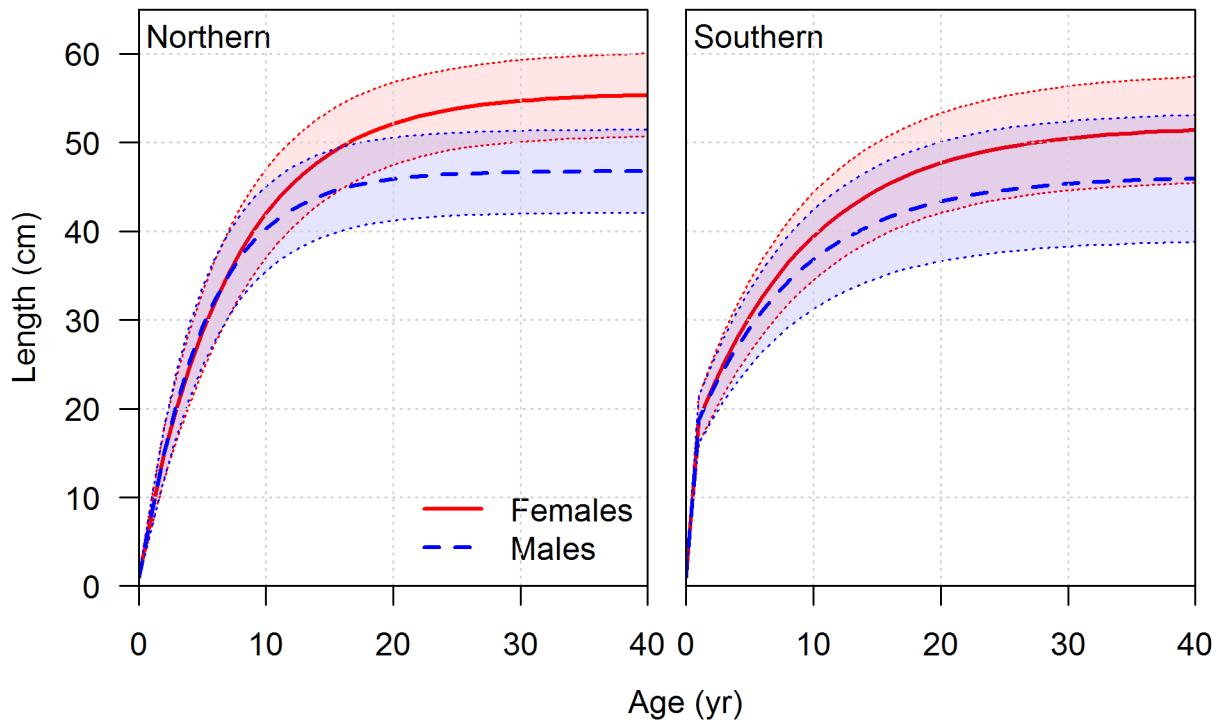


Figure 6: Estimated length-at-age for female and male Yellowtail Rockfish in each model. Shaded areas indicate 95% intervals for distribution of lengths at each age. Values represent beginning-of-year growth. [fig:growth](#)

666 9.3 Data and model fits

data-and-model-fits

667 9.3.1 Data summary

data-summary

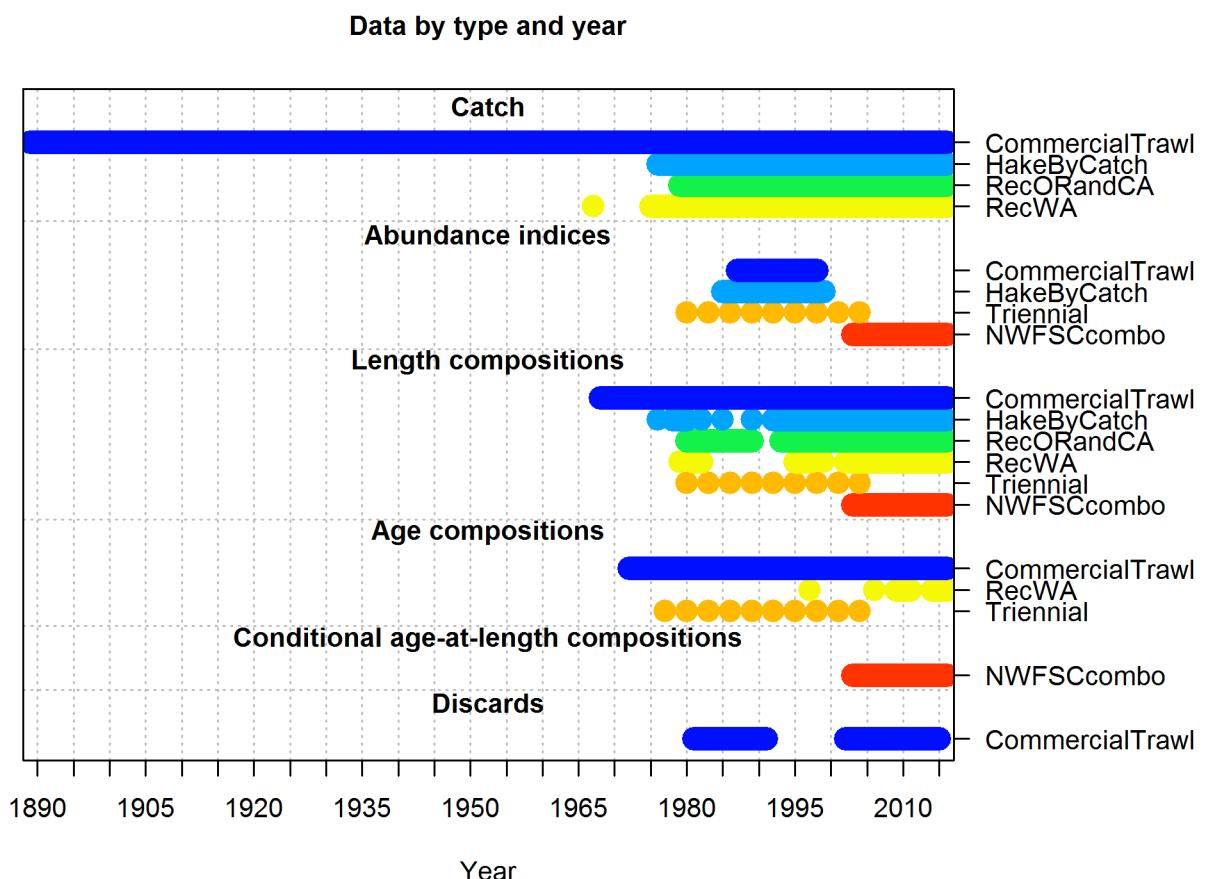


Figure 7: Summary of data sources used in the Northern model. [fig: data_plot](#)

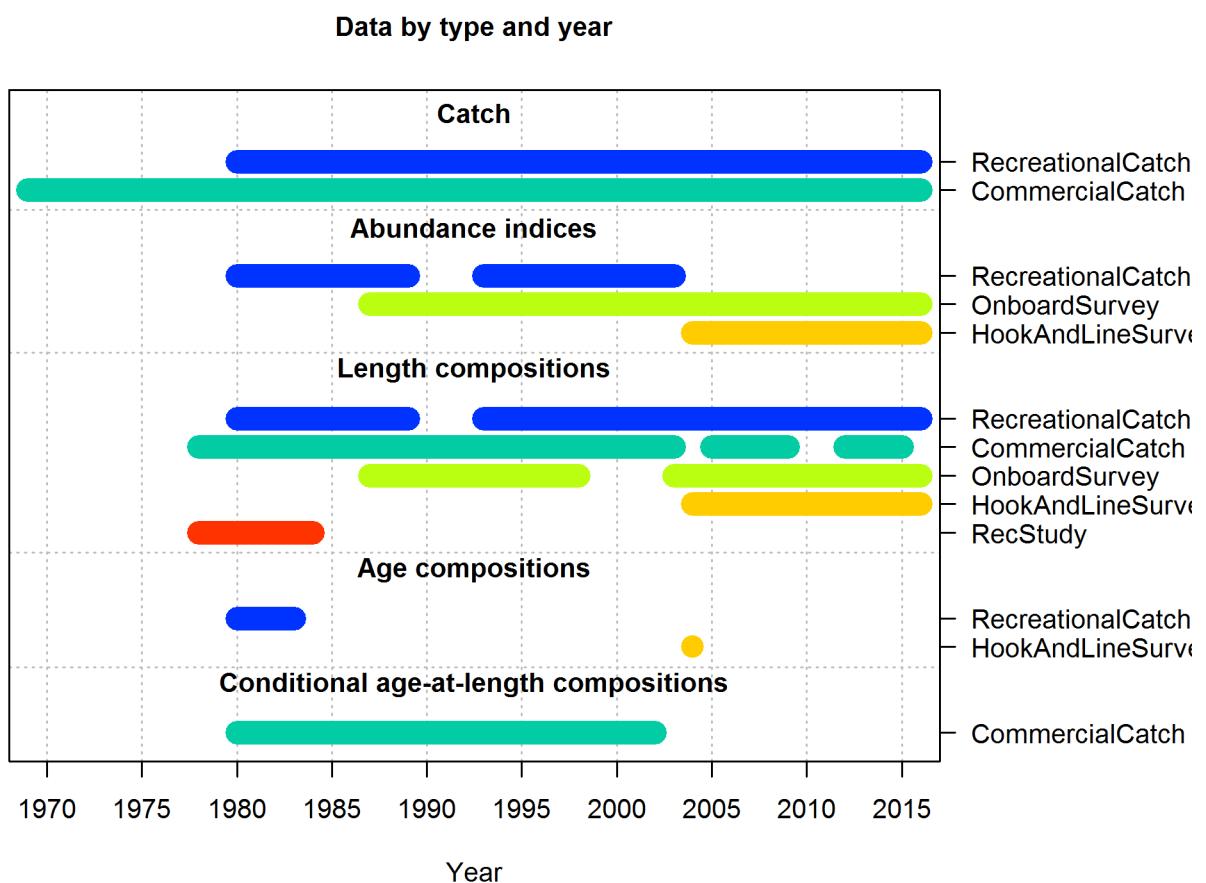


Figure 8: Summary of data sources used in the Southern model. fig:data_plot

668 9.3.2 Selectivity, retention, and discards

selectivity-retention-and-discards

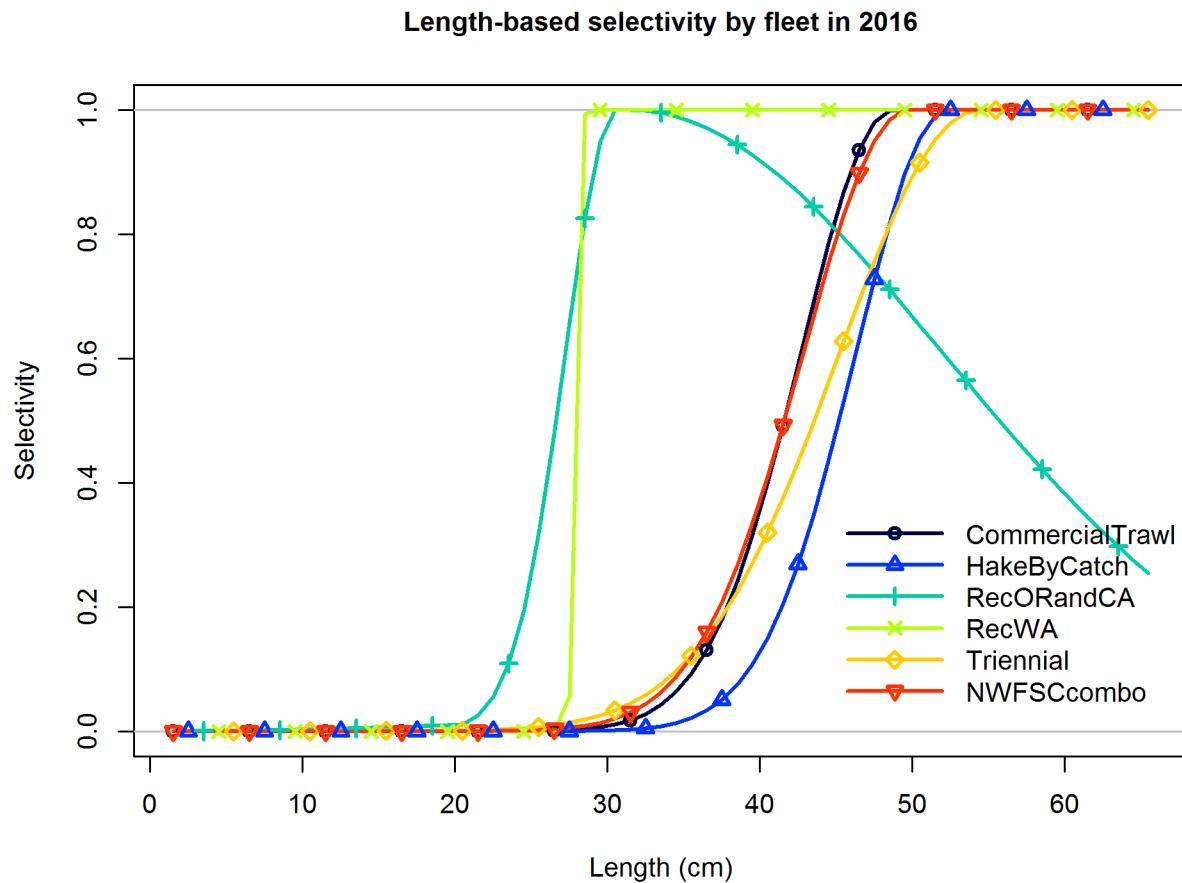


Figure 9: Estimated selectivity by length by each fishery and survey in the Northern model. fig:selex

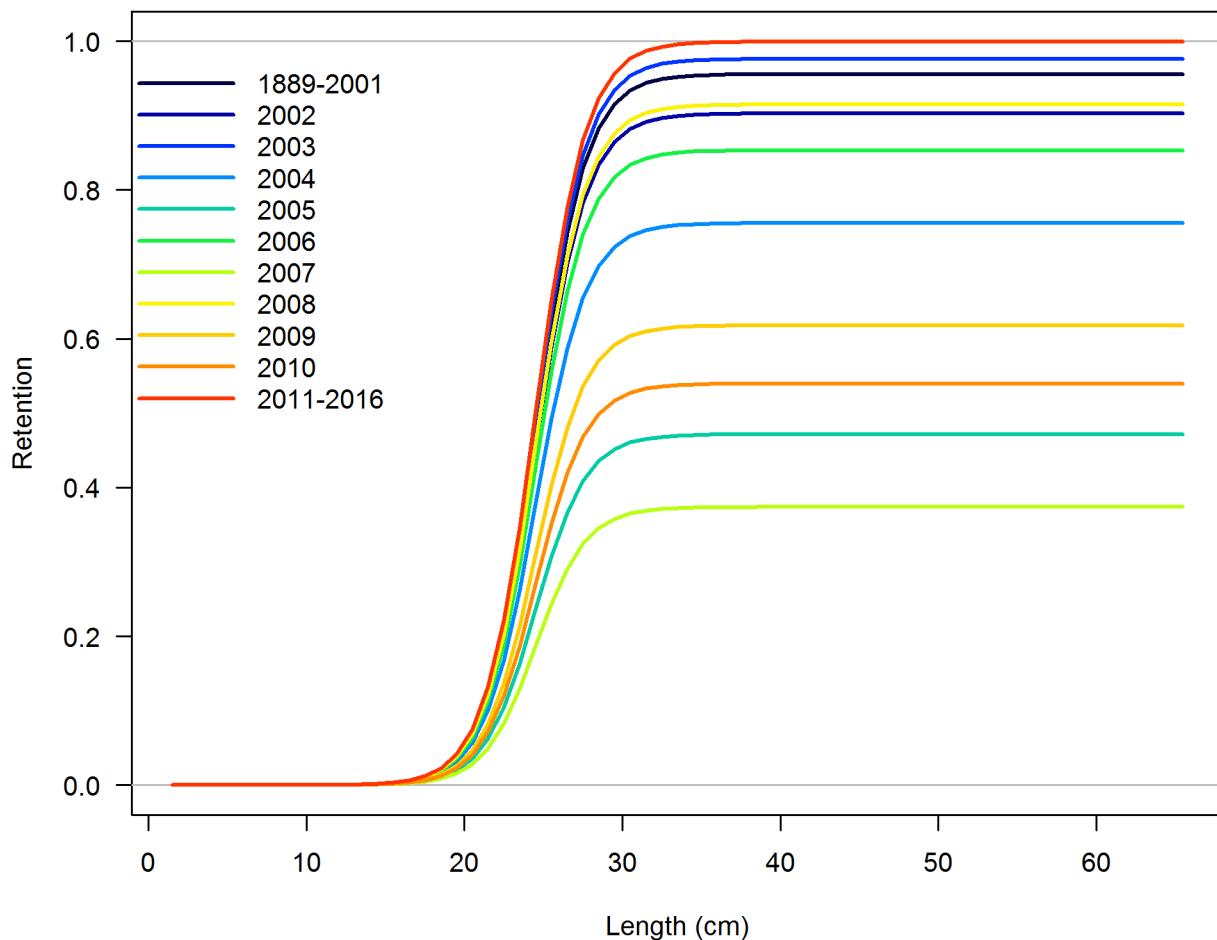


Figure 10: Estimated retention by length by the Commercial Fishery in the Northern model. `fig:retention`

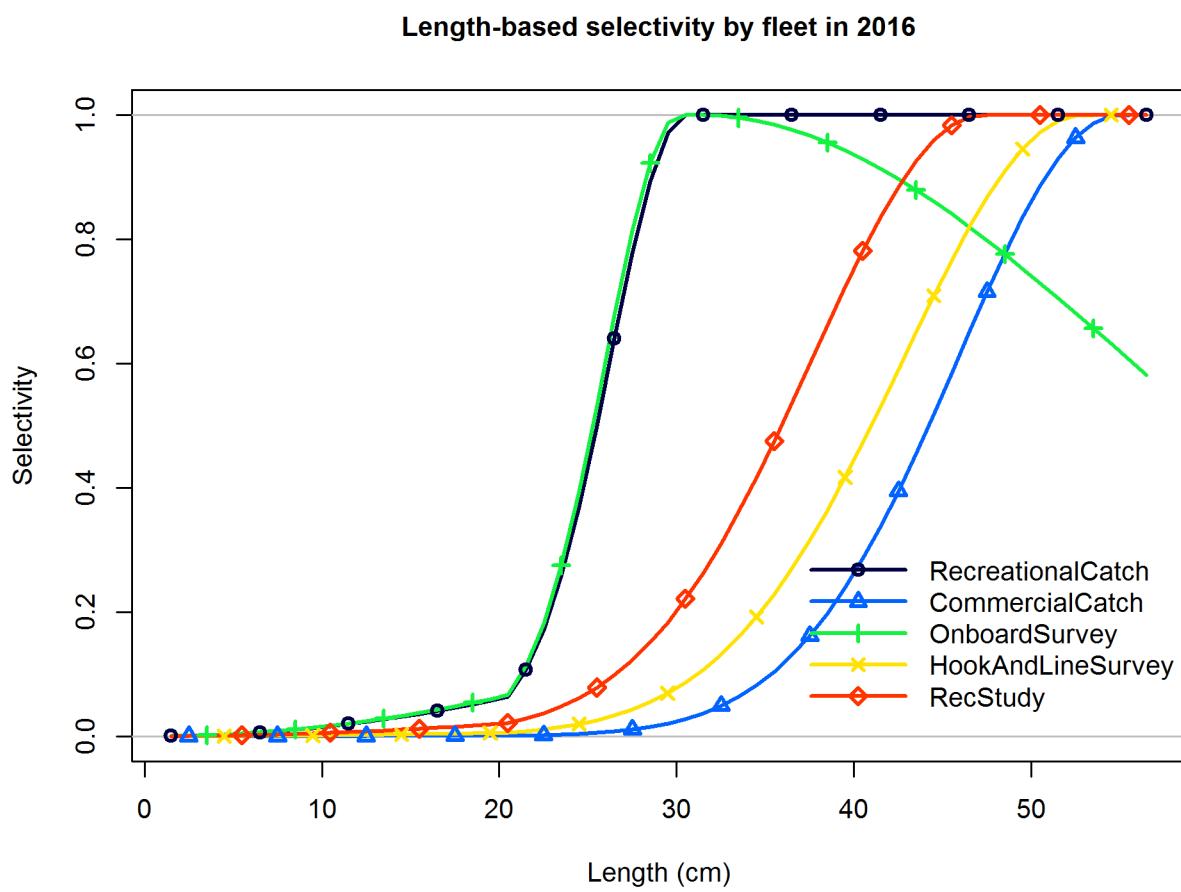


Figure 11: Estimated selectivity by length by each fishery and survey in the Southern model.
`fig:sellex`

Discard fraction for CommercialTrawl

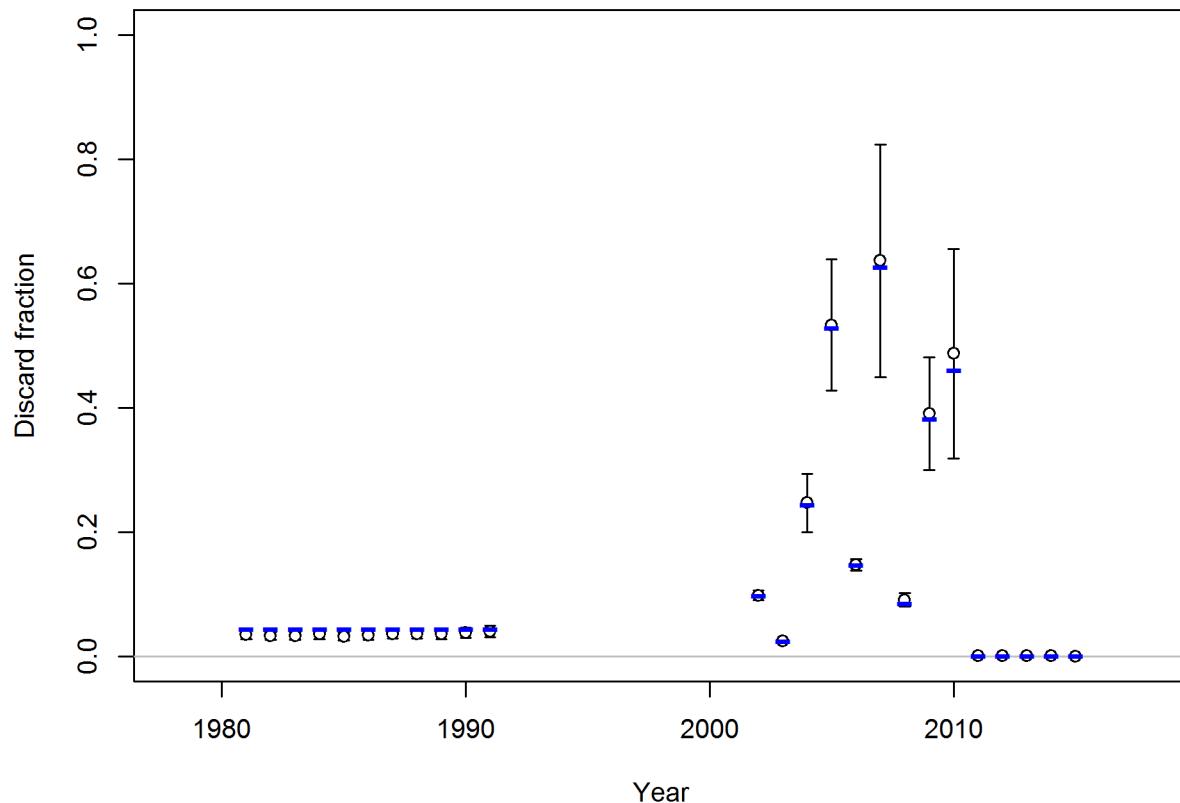


Figure 12: Fit to discard fractions for the commercial fishery in the Northern model.^{fig:r4ss_discard}

669 9.3.3 Fits to indices of abundance

fits-to-indices-of-abundance

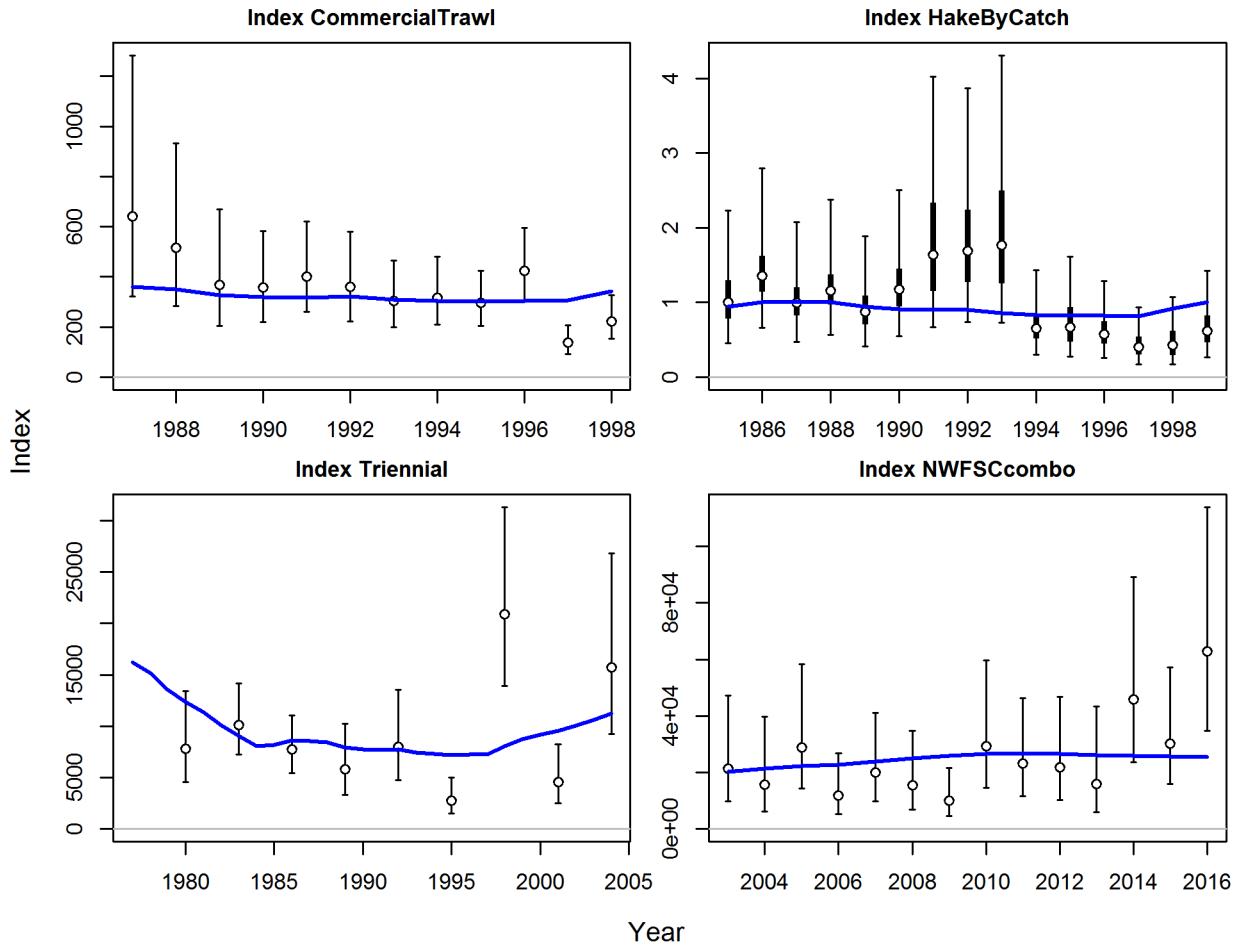


Figure 13: Estimated fits to the CPUE and survey indices for the Northern model. `fig:index_fits1`

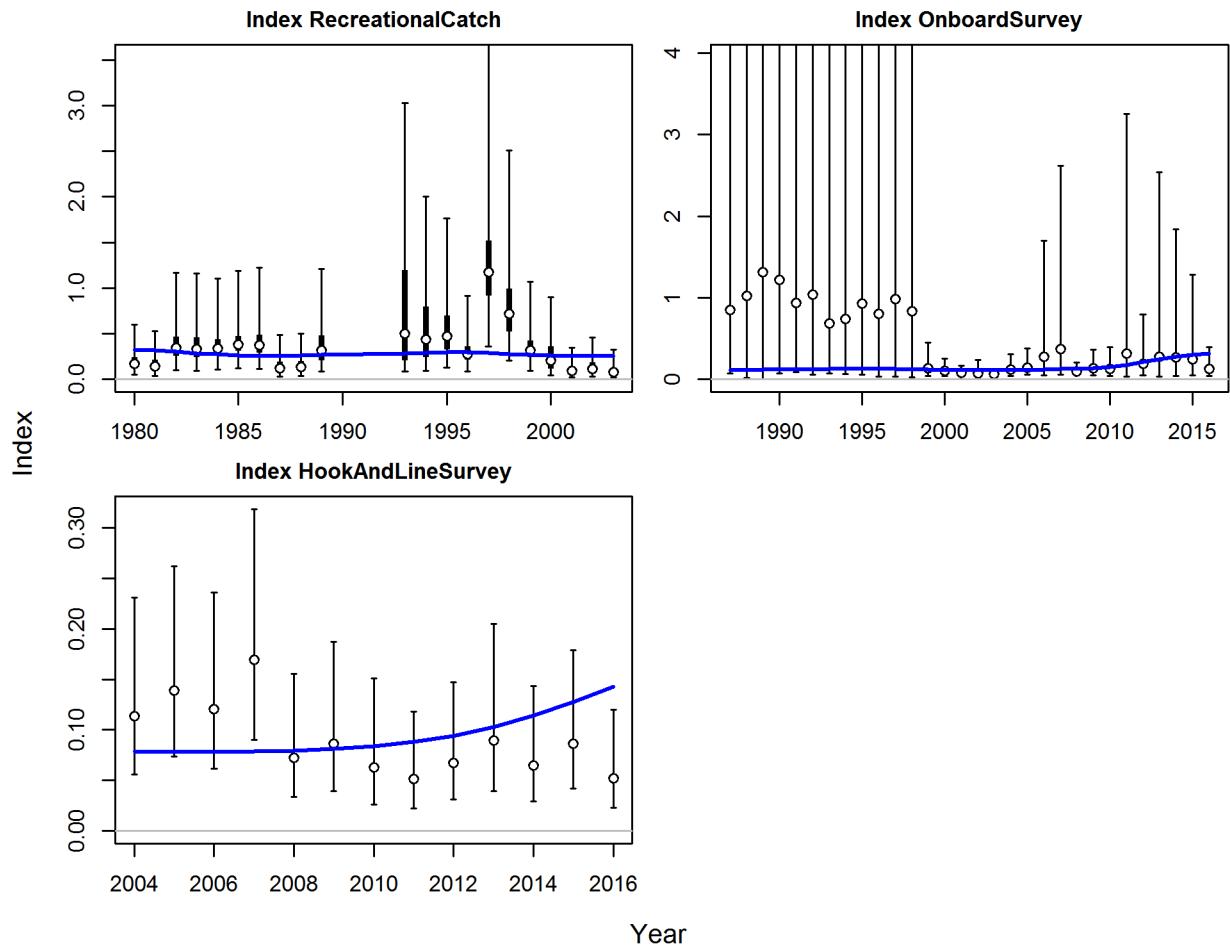


Figure 14: Estimated fits to the CPUE and survey indices for the Southern model. `fig:index_fits2`

670 9.3.4 Fits to length compositions for Northern model
 fits-to-length-compositions-for-northern-model

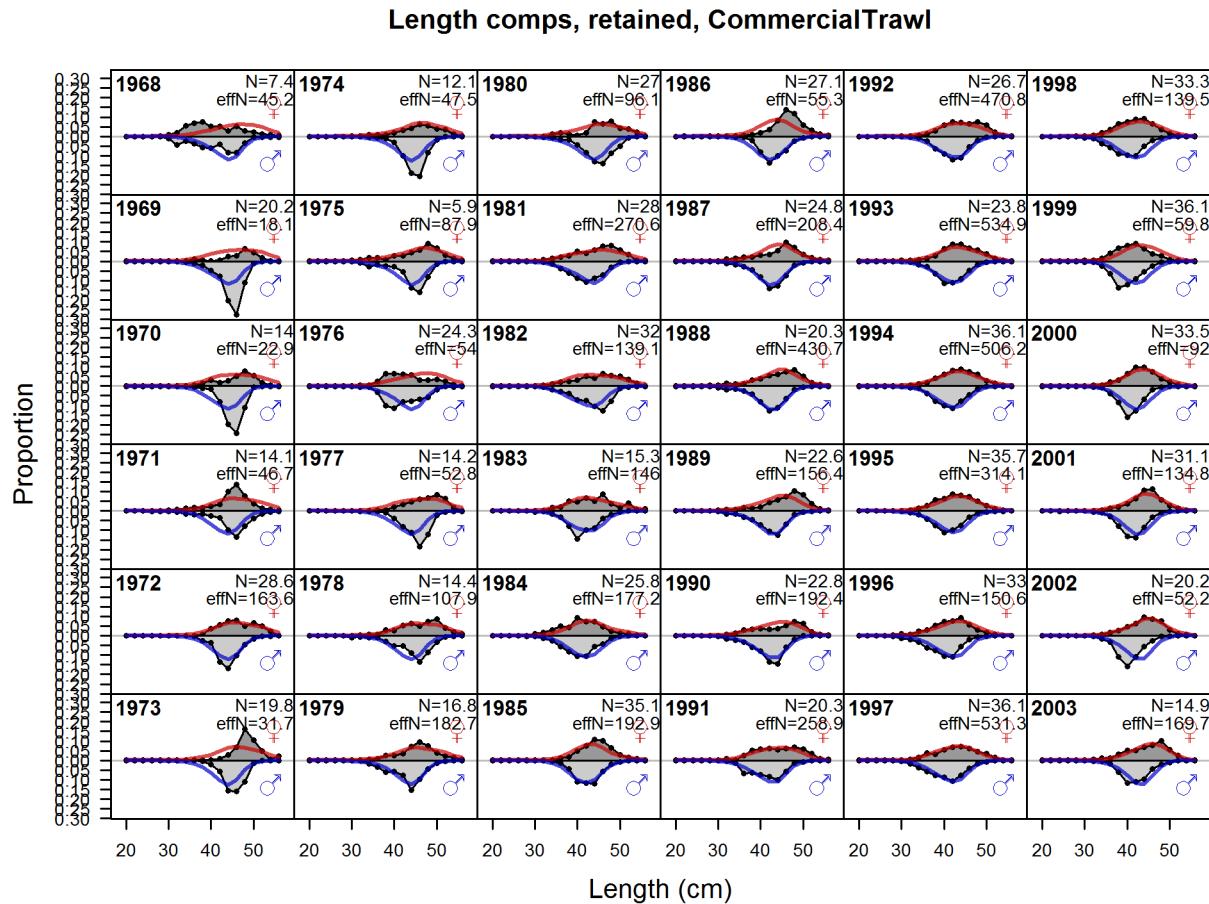
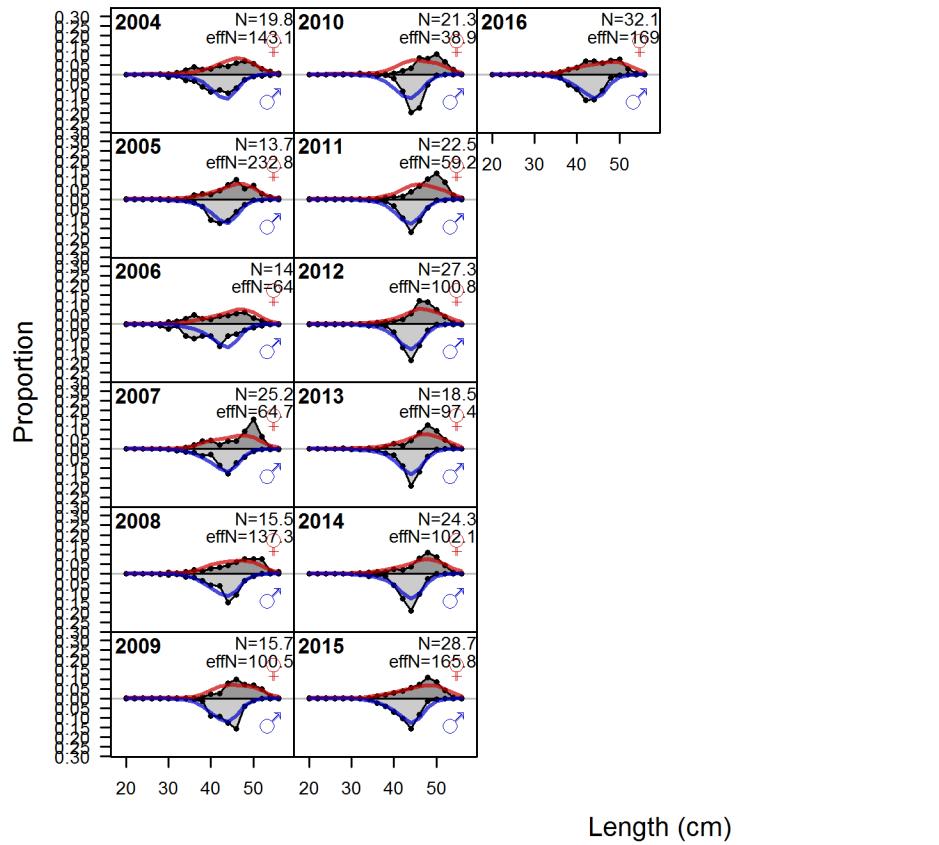


Figure 15: Northern model Length comps, retained, CommercialTrawl (plot 1 of 2) fig:mod1_1_comp

Length comps, retained, CommercialTrawl

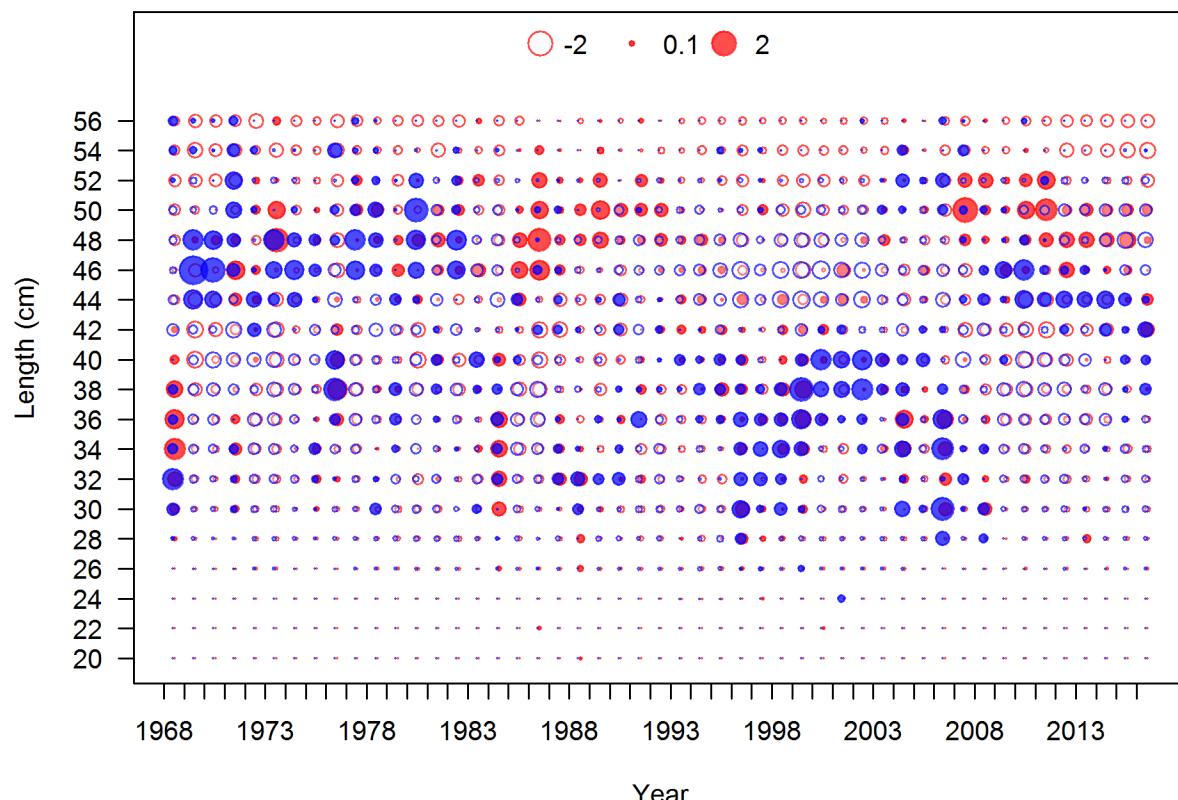


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Figure continued from previous page

Pearson residuals, retained, CommercialTrawl (max=2.68)



673

674

Figure continued from previous page

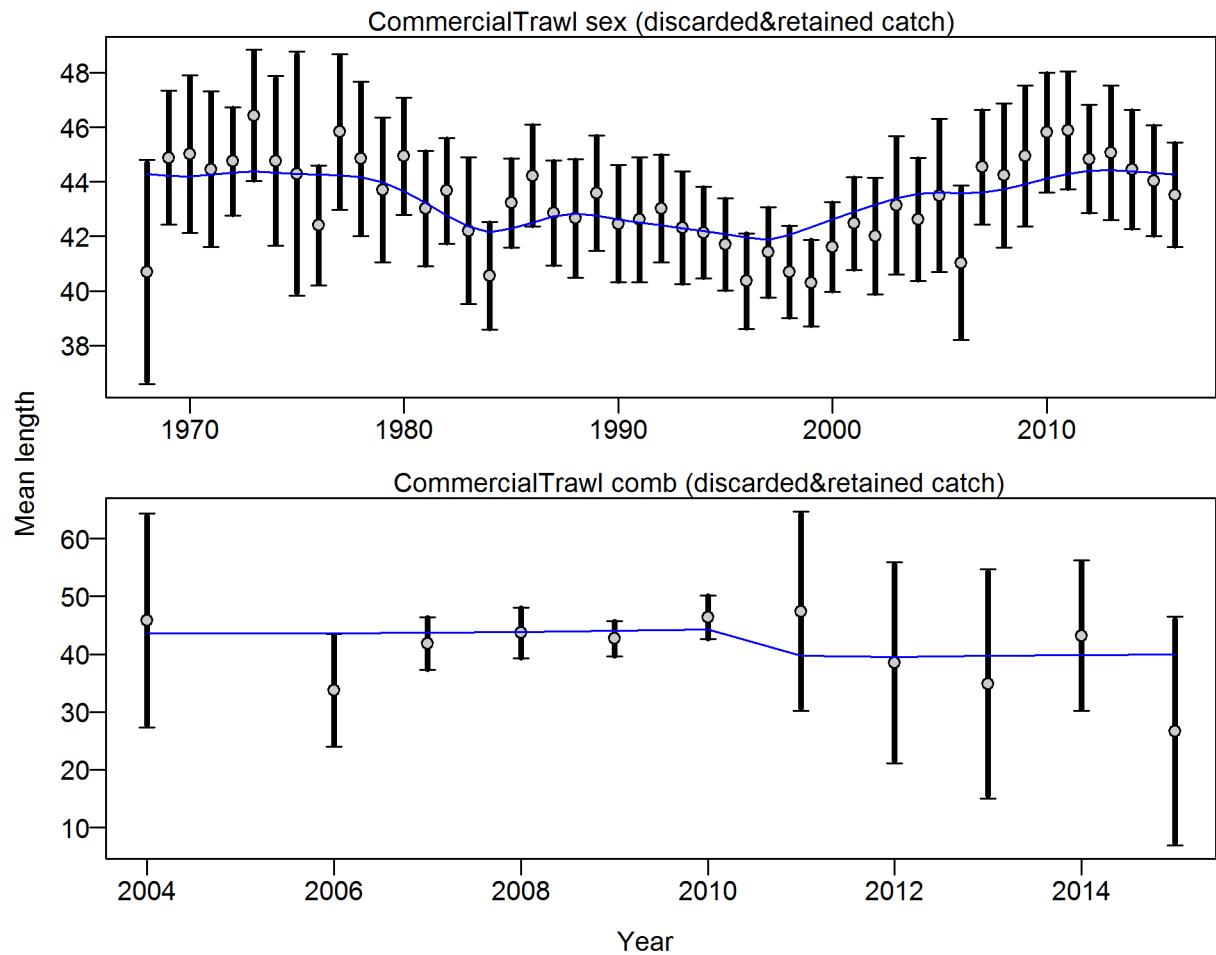


Figure 16: **Northern model** Francis data weighting method TA1.8: CommercialTrawl Suggested sample size adjustment (with 95% interval) for len data from CommercialTrawl: 0.9488 (0.7164_1.4056) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. [Fig:mod1_5_comp](#)

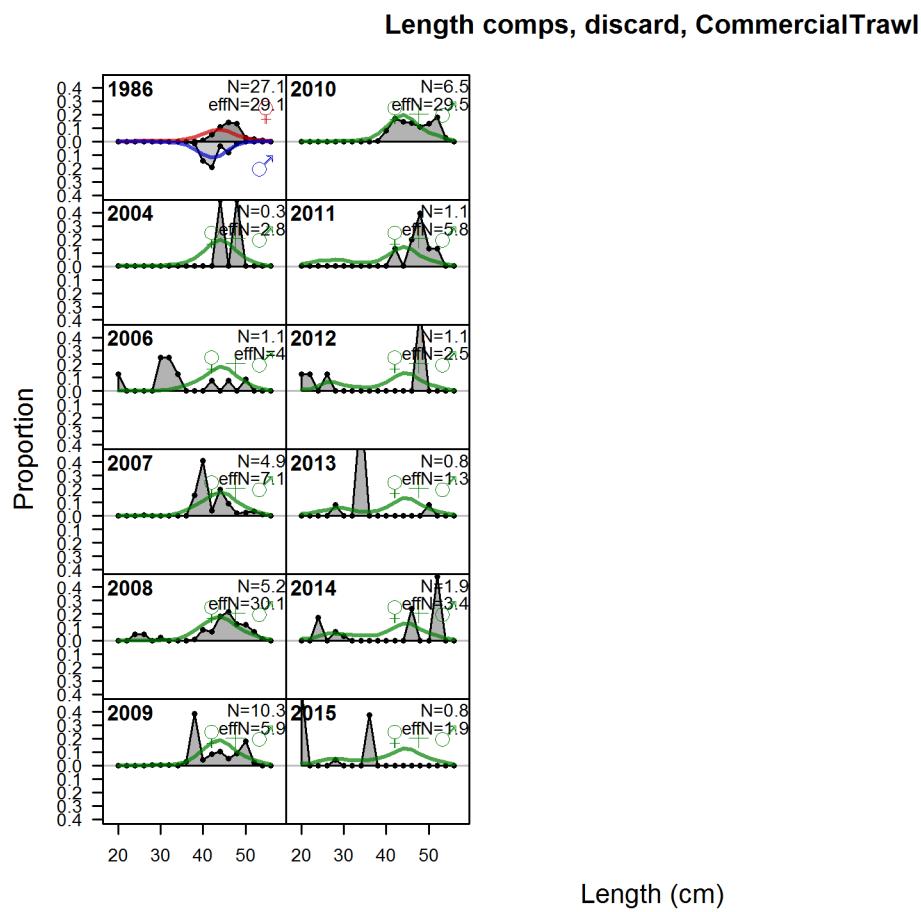


Figure 17: **Northern model** Length comps, discard, CommercialTrawl fig:mod1_6_comp_lenfi

Pearson residuals, discard, CommercialTrawl (max=4.18)



Figure 18: **Northern model** Pearson residuals, discard, CommercialTrawl (max=4.18)
Closed bubbles are positive residuals (observed $>$ expected) and open bubbles are negative residuals (observed $<$ expected). [fig:mod1_7_comp_lenfit_residsfitlmkt1](#)

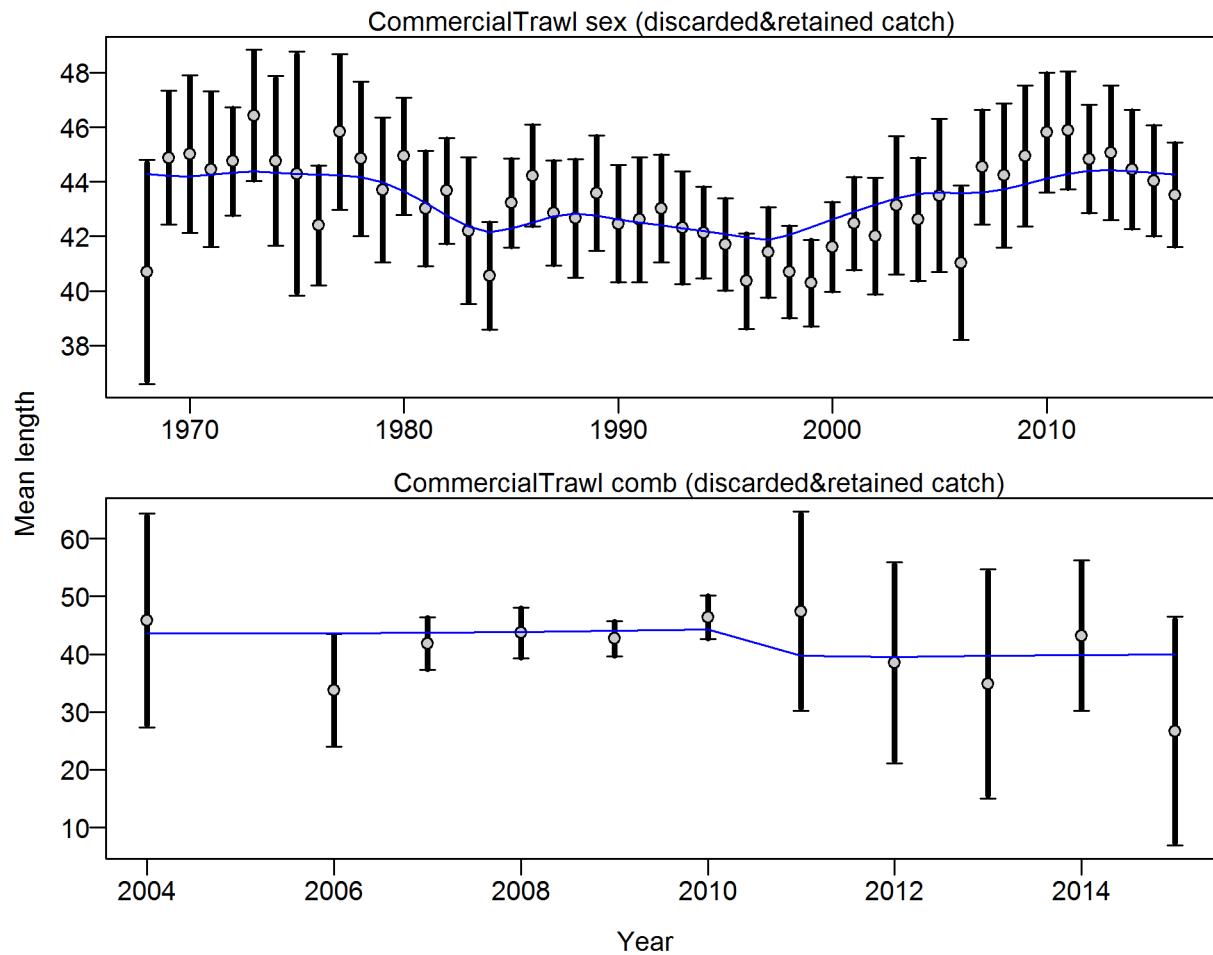


Figure 19: **Northern model** Francis data weighting method TA1.8: CommercialTrawl Suggested sample size adjustment (with 95% interval) for len data from CommercialTrawl: 0.9488 (0.7195_1.4058) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. [Fig:mod1_9_comp](#)

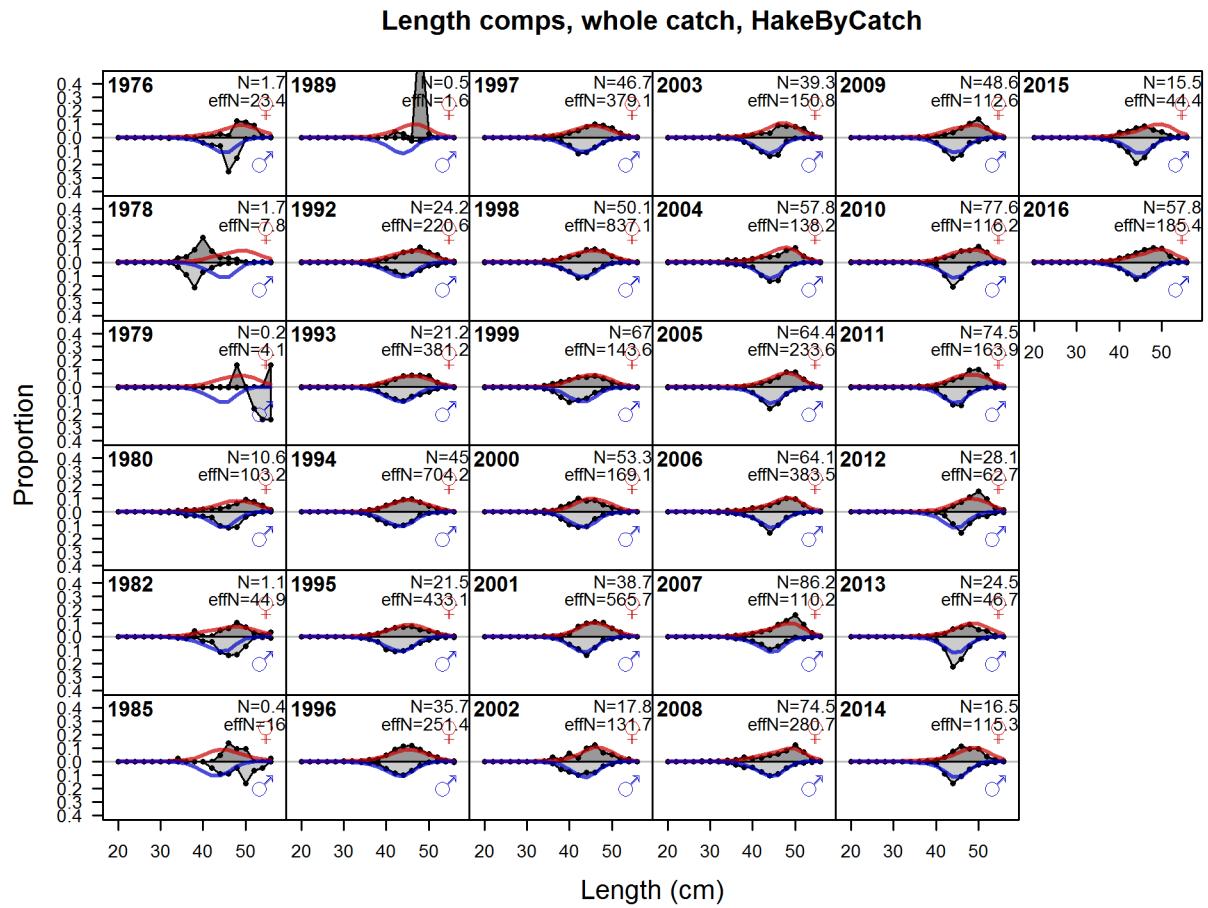


Figure 20: **Northern model** Length comps, whole catch, HakeByCatch fig:mod1_10_comp_lenf

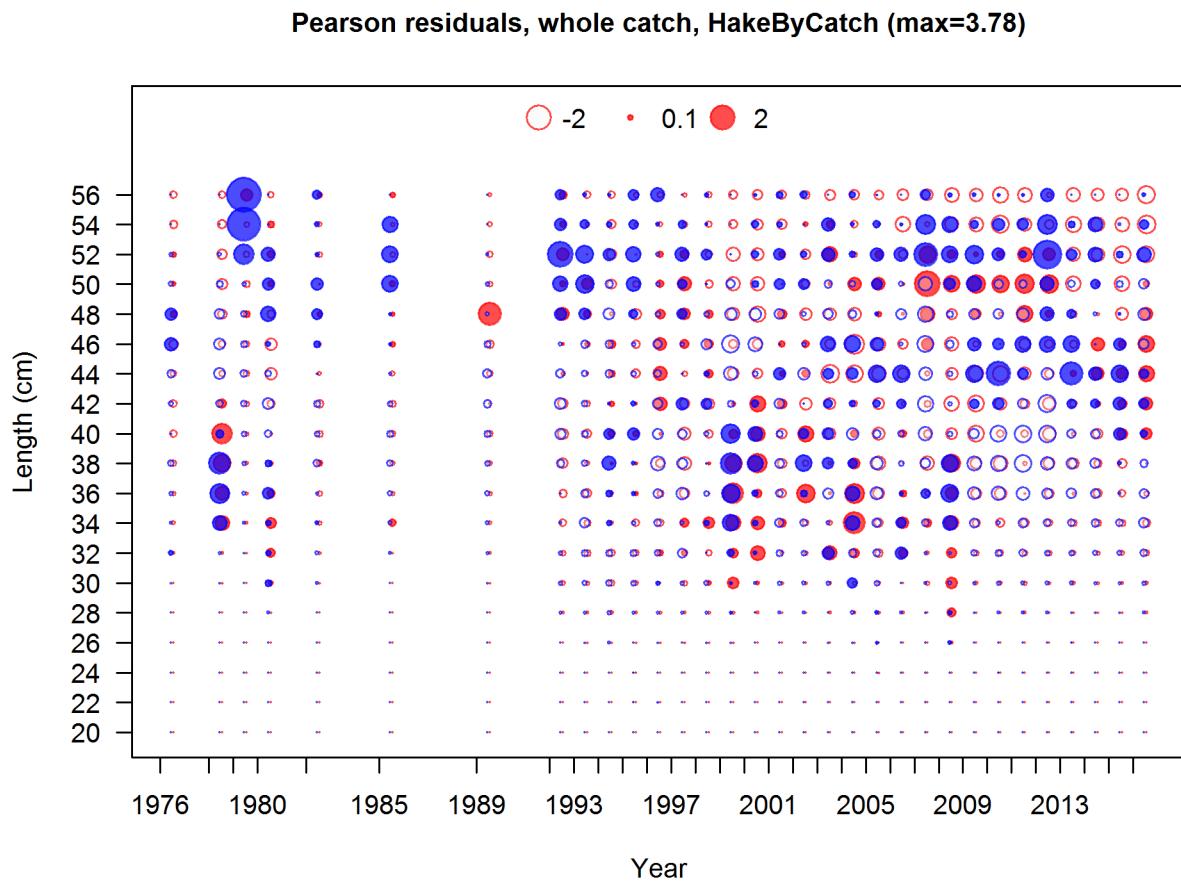


Figure 21: **Northern model** Pearson residuals, whole catch, HakeByCatch (max=3.78)
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_11_comp_lenfit_residsfit2mkt0

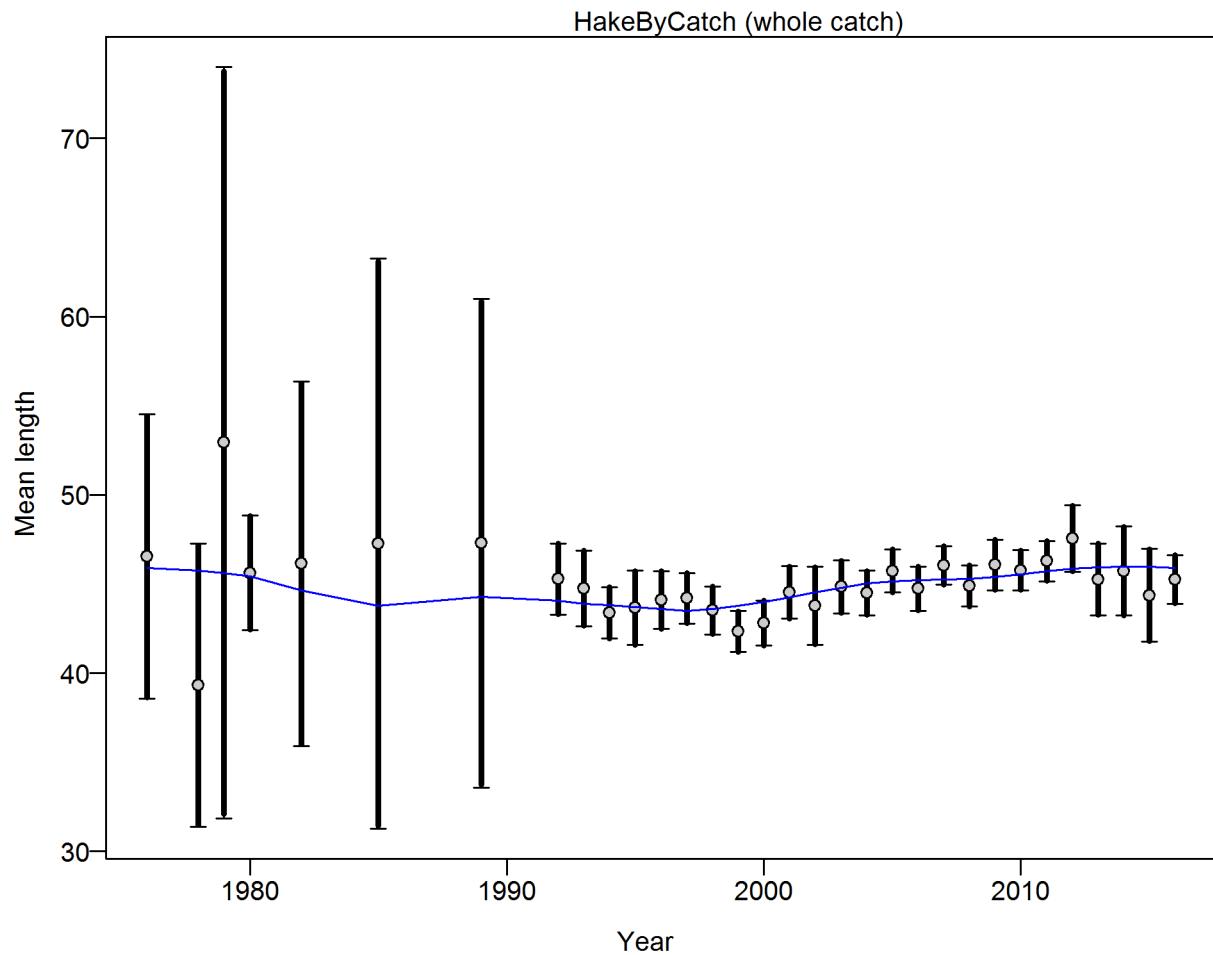


Figure 22: **Northern model** Francis data weighting method TA1.8: HakeByCatch Suggested sample size adjustment (with 95% interval) for len data from HakeByCatch: 0.9774 (0.6751_1.6973) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_13_comp_lenfit_da

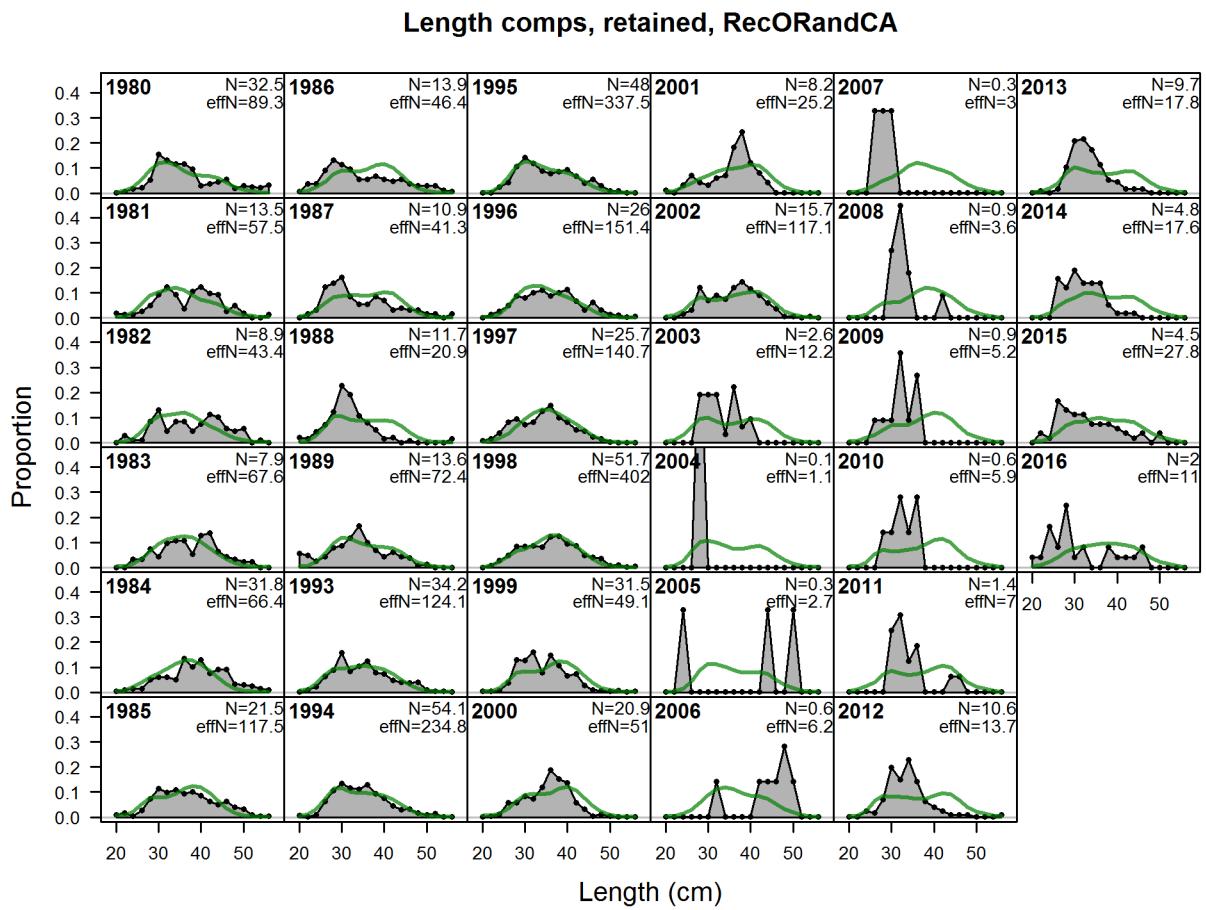


Figure 23: Northern model Length comps, retained, RecORandCA fig:mod1_14_comp_lenfi

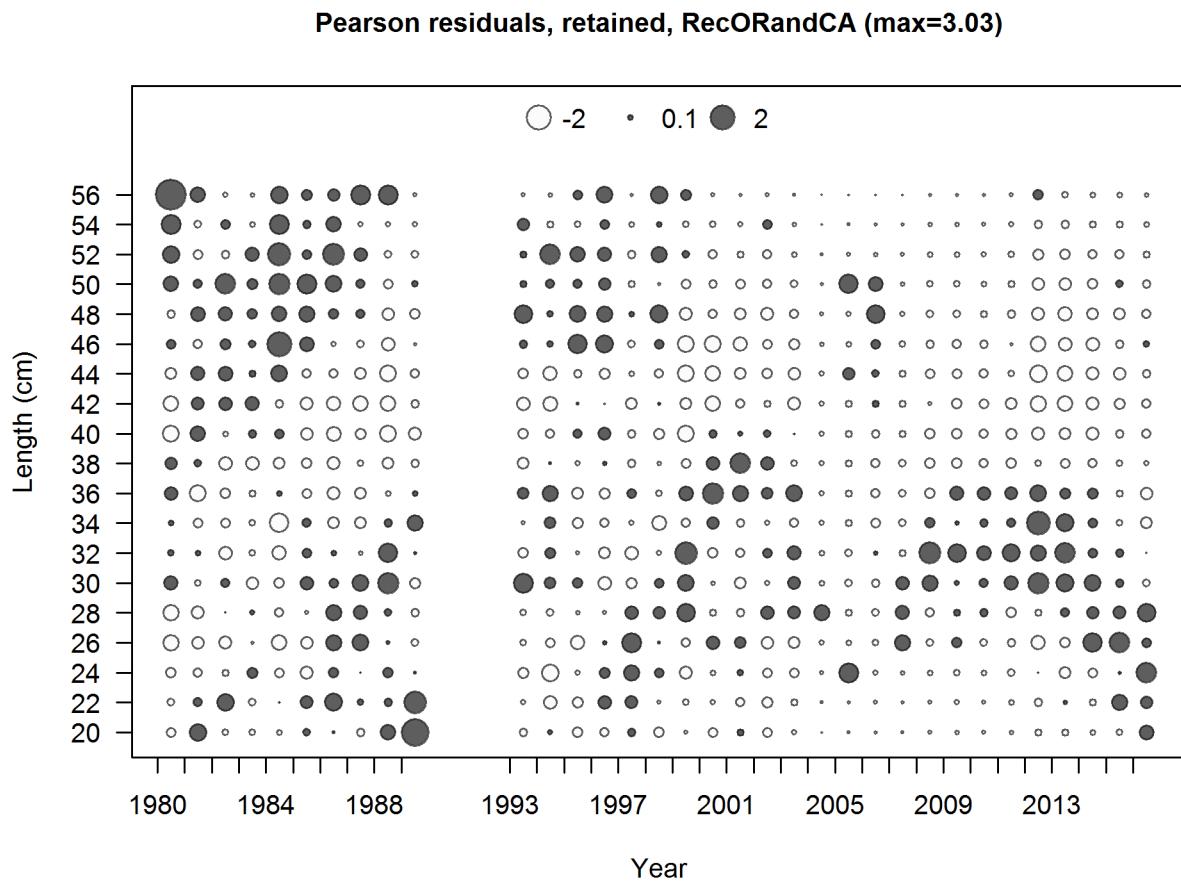


Figure 24: **Northern model** Pearson residuals, retained, RecORandCA (max=3.03)
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_15_comp_lenfit_residsfit3mkt2](#)

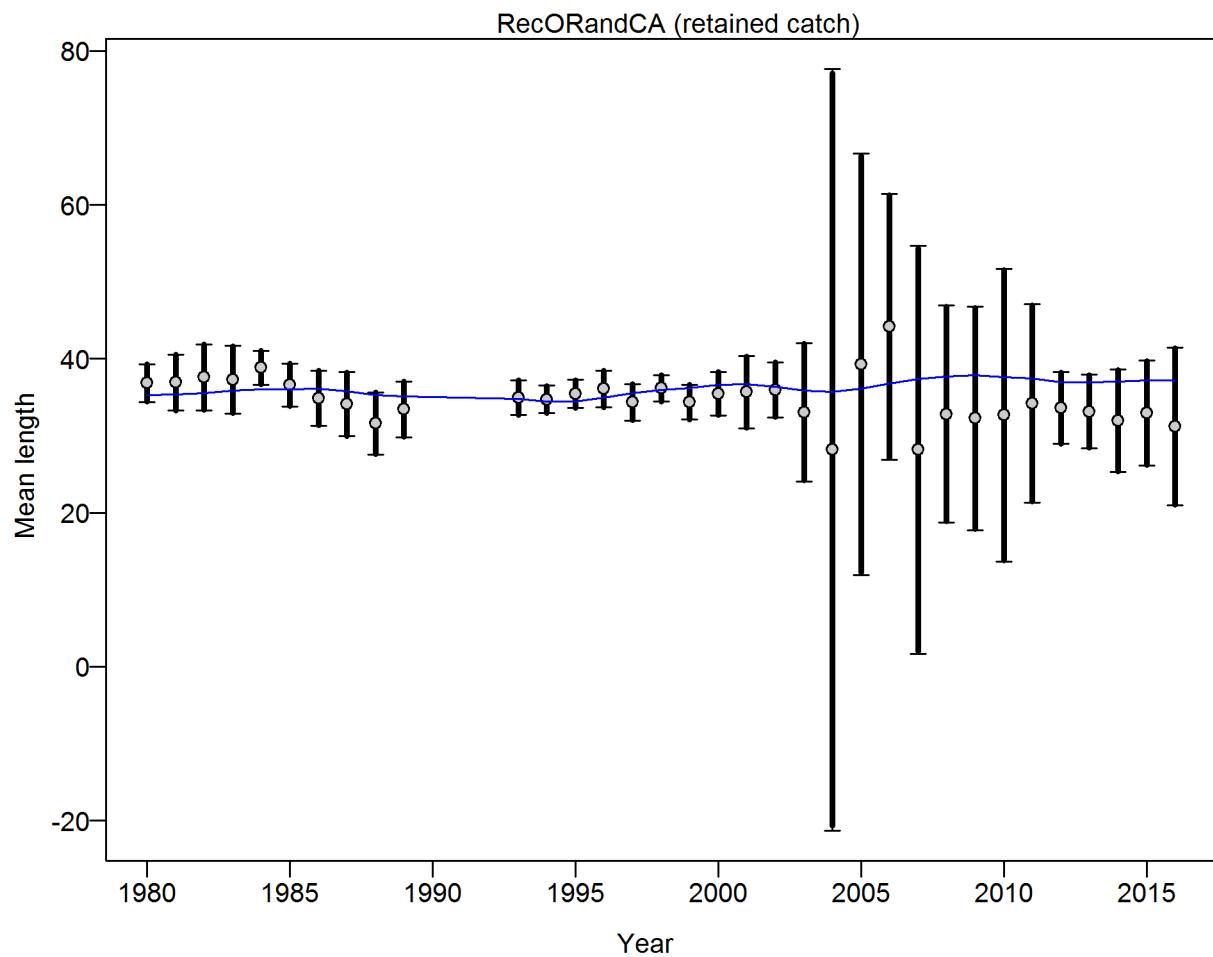


Figure 25: **Northern model** Francis data weighting method TA1.8: RecORandCA Suggested sample size adjustment (with 95% interval) for len data from RecORandCA: 0.9761 (0.6621_1.774) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_17_comp_lenfit_da

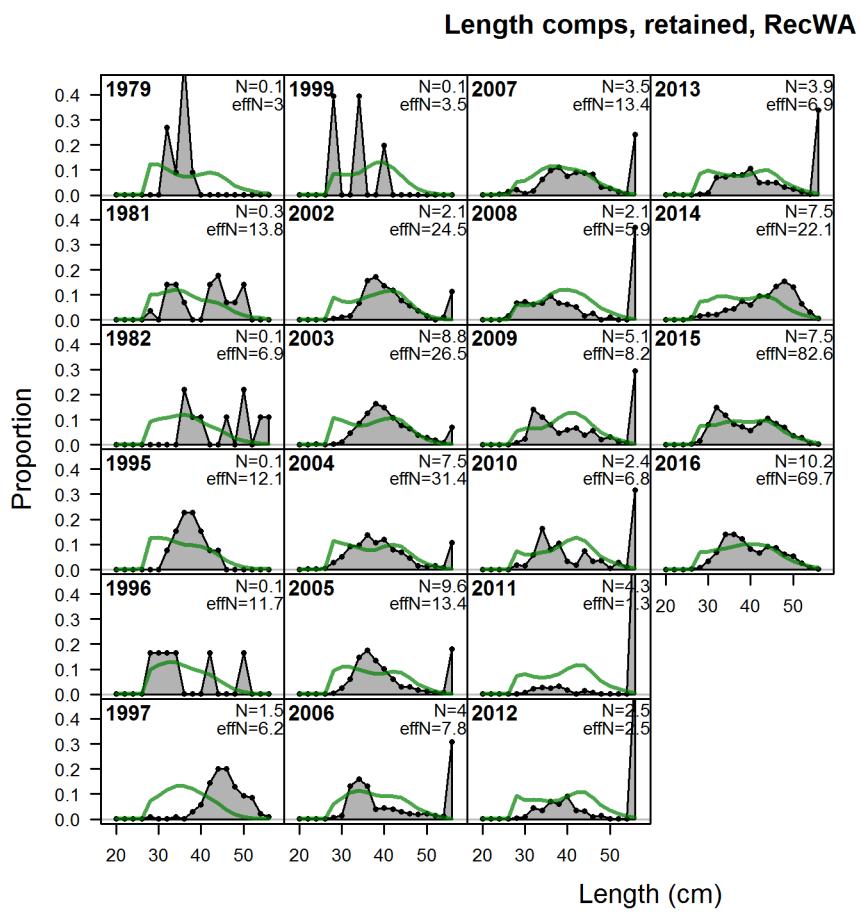


Figure 26: Northern model Length comps, retained, RecWA fig:mod1_18_comp_lenfit_f

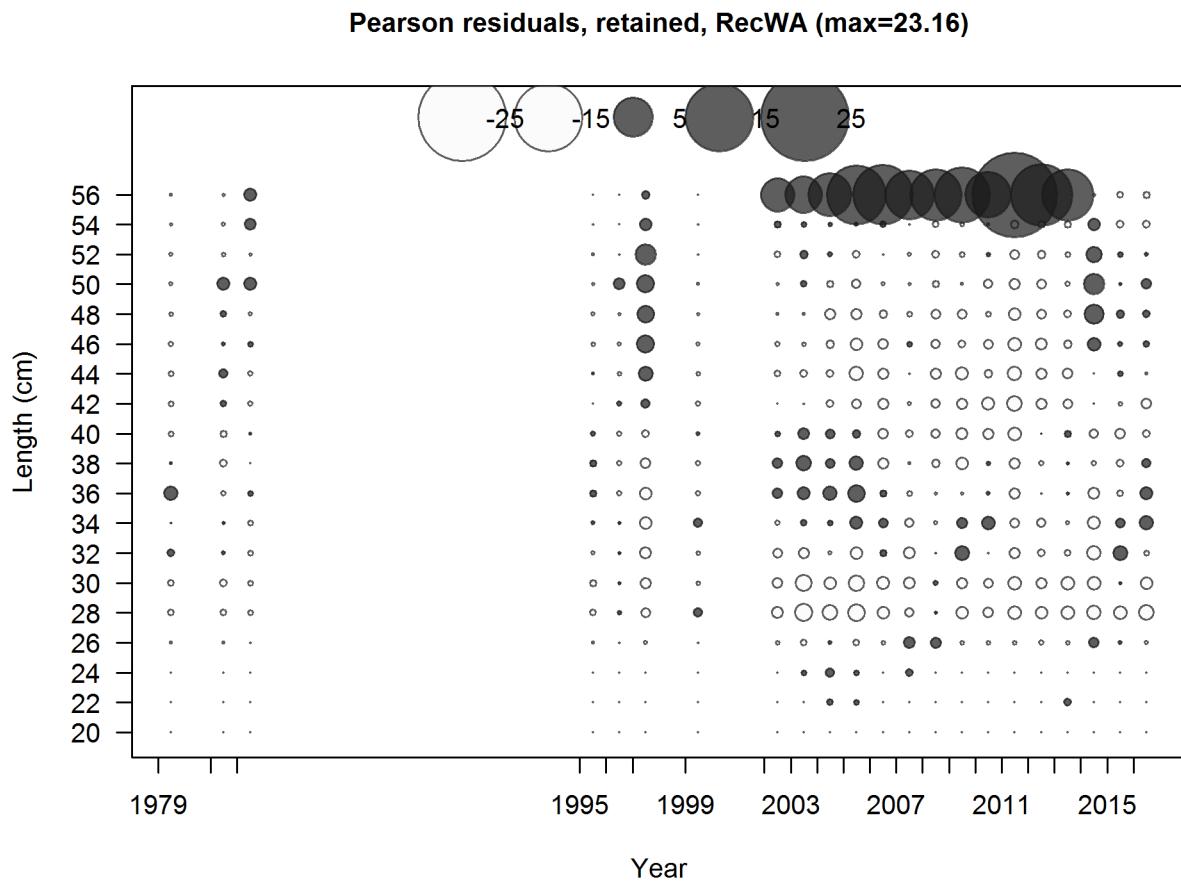


Figure 27: **Northern model** Pearson residuals, retained, RecWA (max=23.16)
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_19_comp_lenfit_residsfit4mkt2](#)

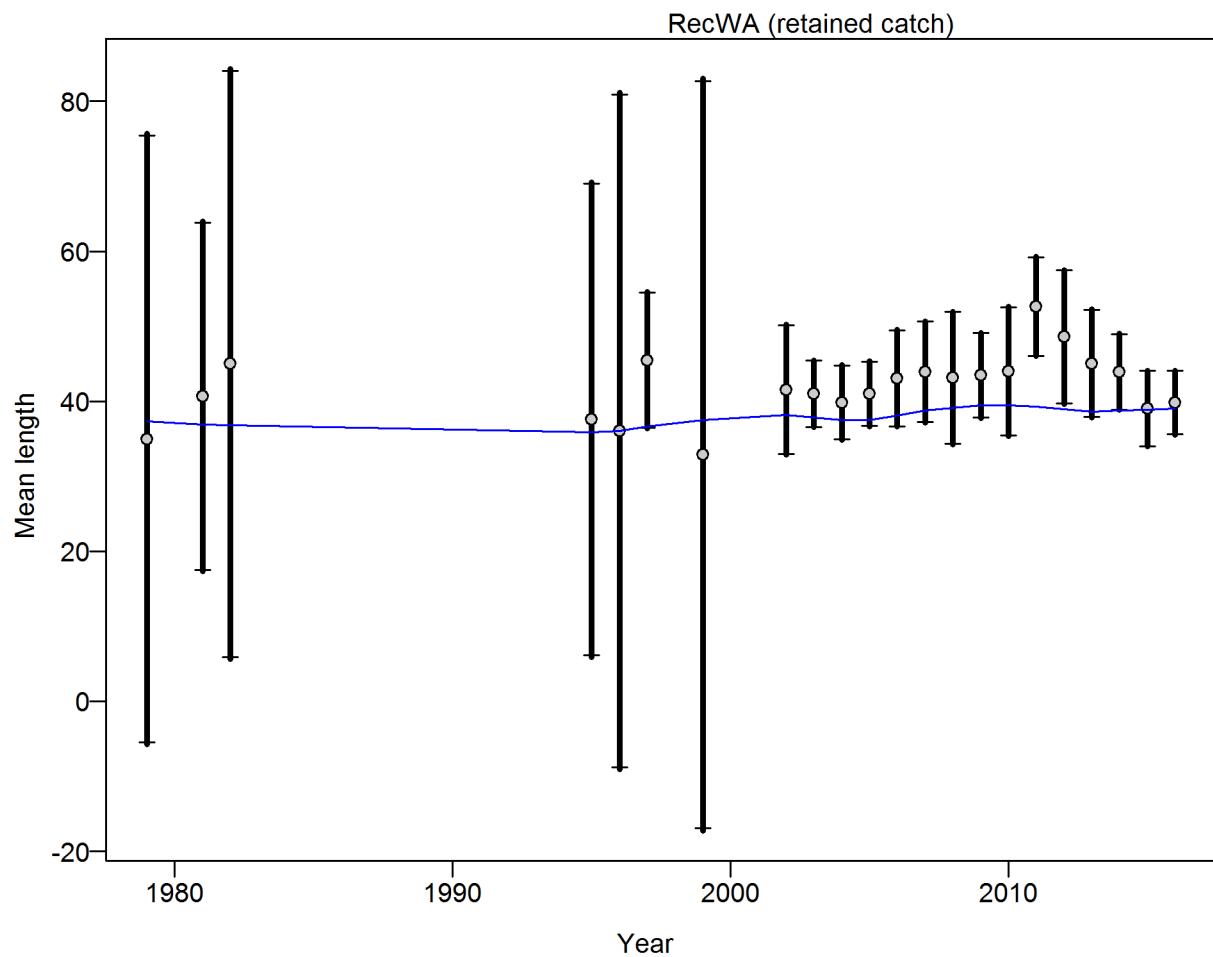


Figure 28: **Northern model** Francis data weighting method TA1.8: RecWA Suggested sample size adjustment (with 95% interval) for len data from RecWA: 1.0134 (0.5588_2.3419)
For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. [fig:mod1_21_comp_lenfit_data_weighting](#)

Length comps, retained, Triennial

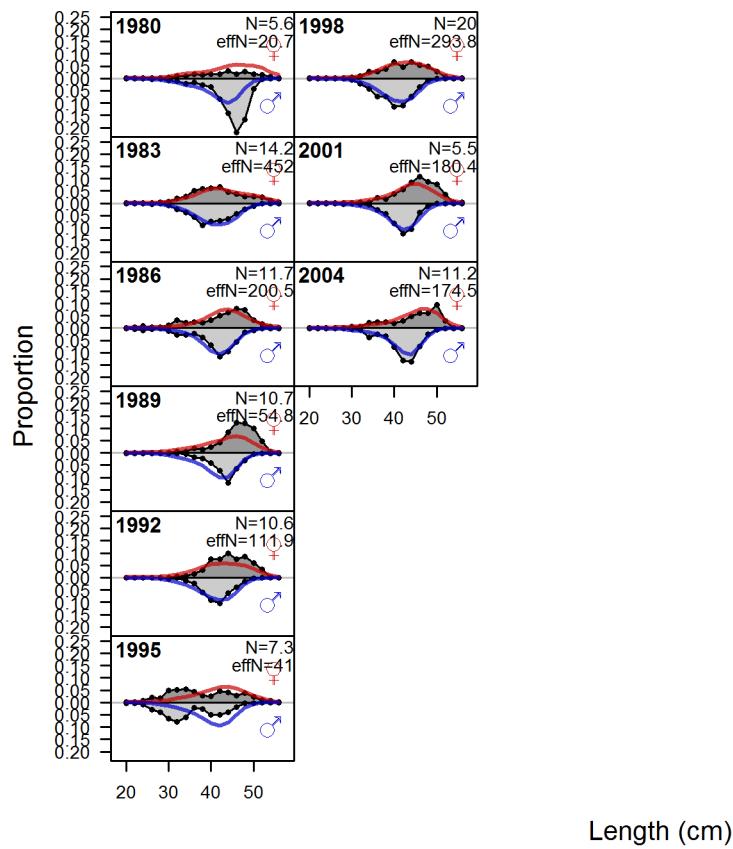


Figure 29: Northern model Length comps, retained, Triennial fig:mod1_22_comp_lenfit_1

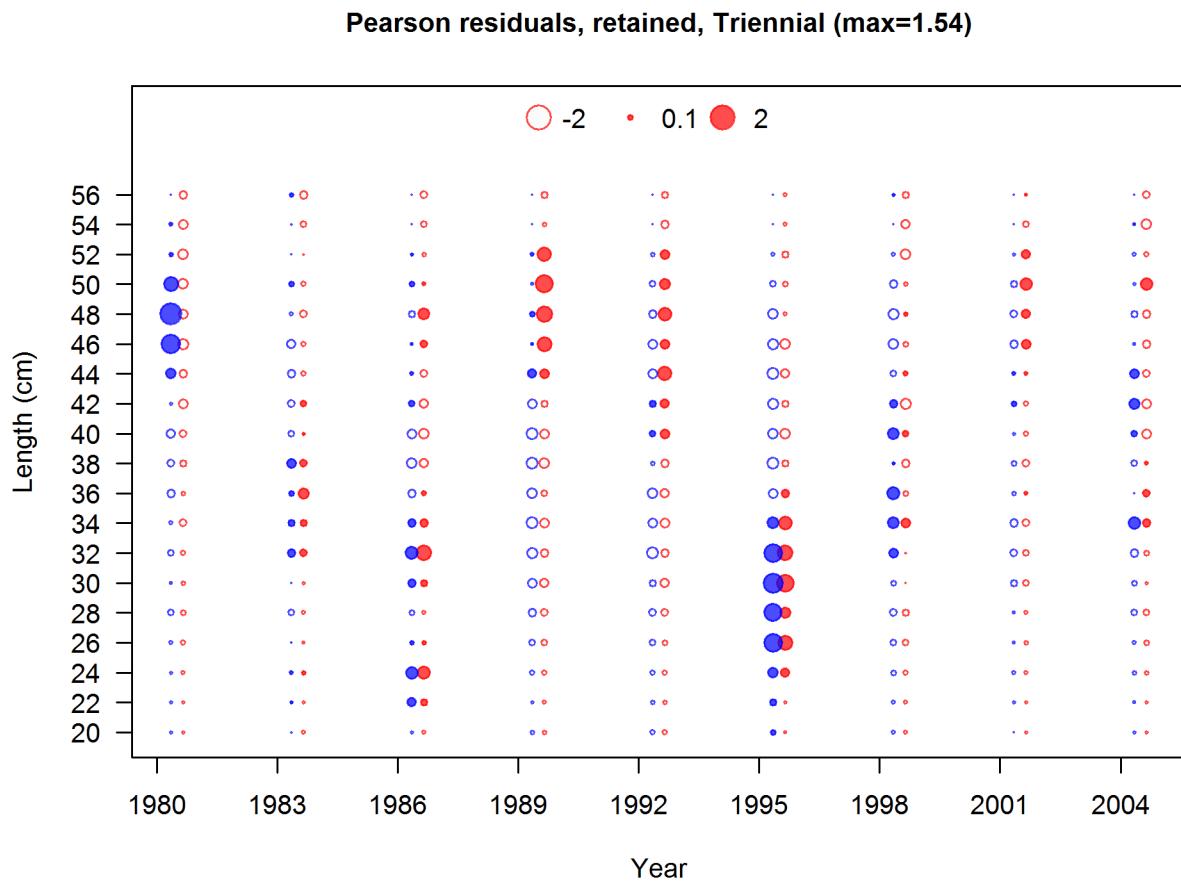


Figure 30: **Northern model** Pearson residuals, retained, Triennial (max=1.54)
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_23_comp_lenfit_residsflt5mkt2](#)

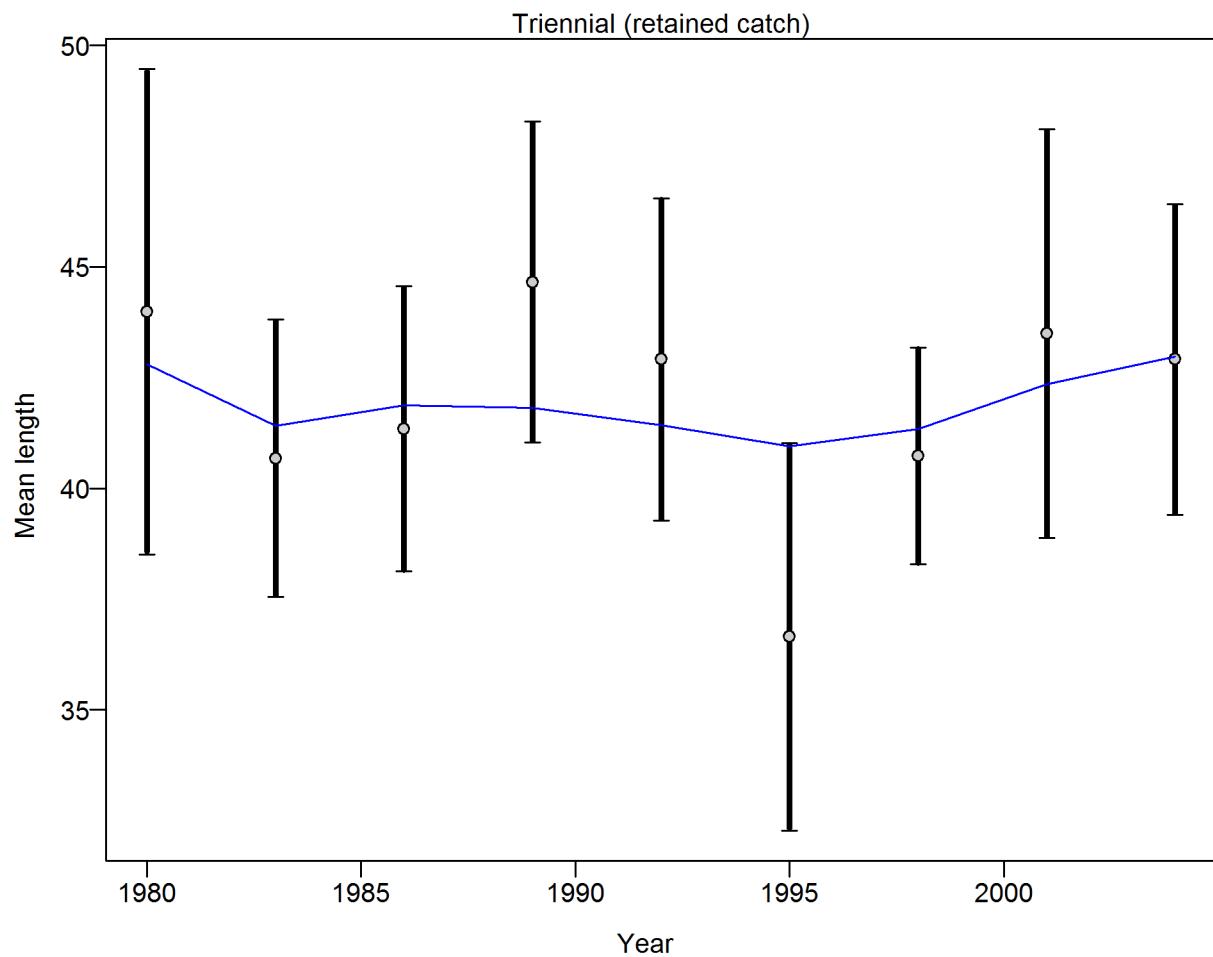


Figure 31: **Northern model** Francis data weighting method TA1.8: Triennial Suggested sample size adjustment (with 95% interval) for len data from Triennial: 0.9781 (0.5131_5.1969)
 For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. [fig:mod1_25_comp_lenfit_data_weighting](#)

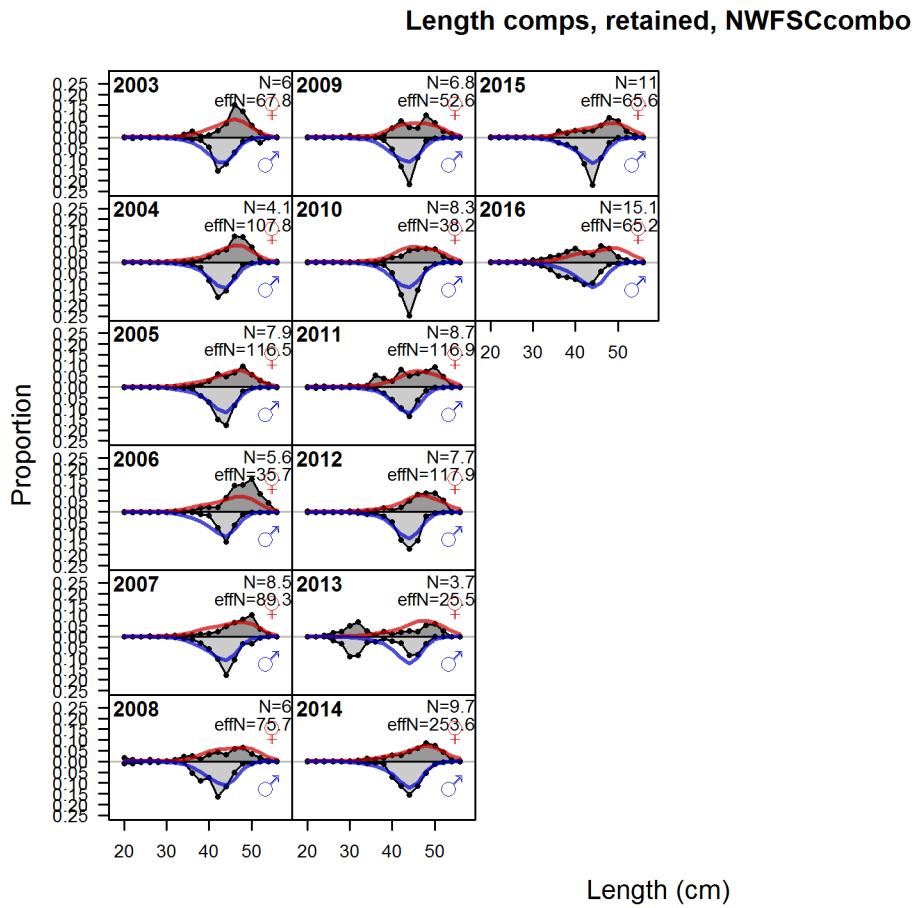


Figure 32: **Northern model** Length comps, retained, NWFSCcombo fig:mod1_26_comp_lenfi

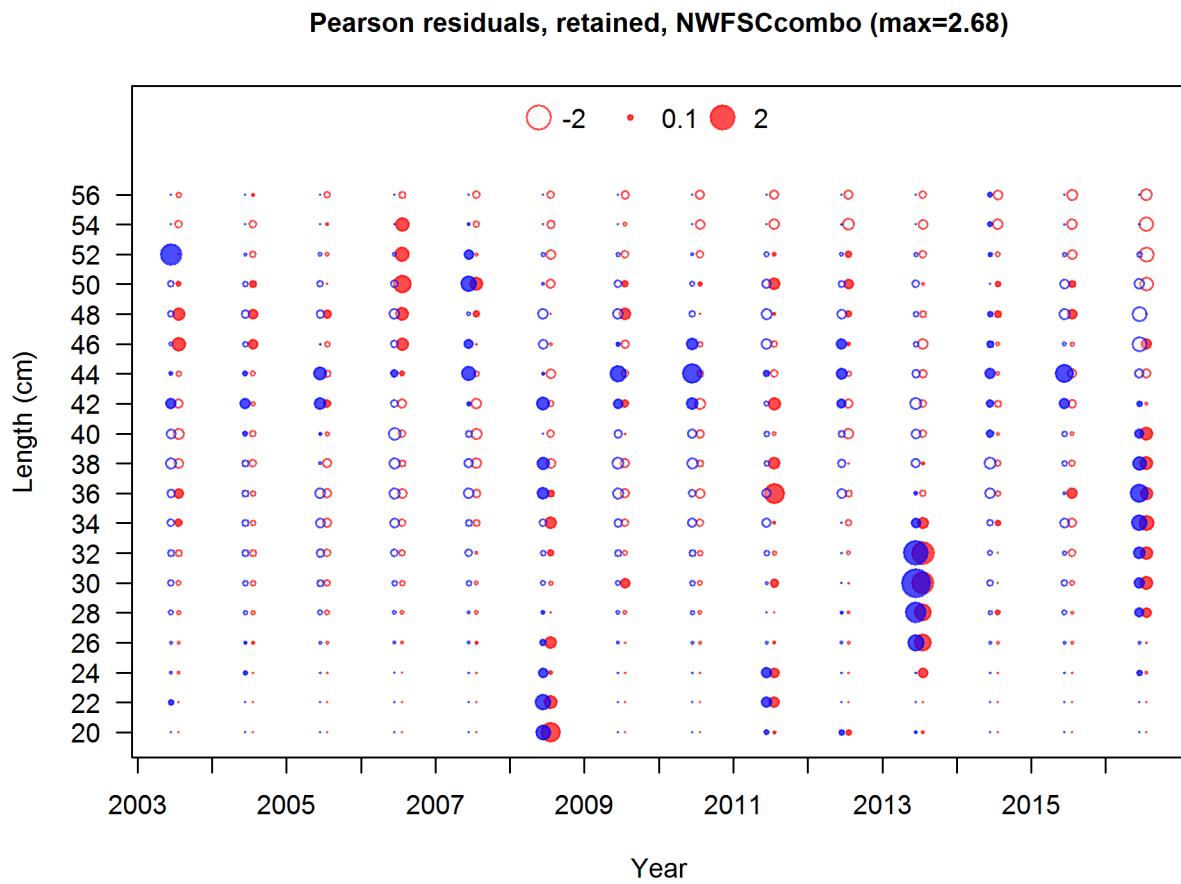


Figure 33: **Northern model** Pearson residuals, retained, NWFSCcombo (max=2.68)
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_27_comp_lenfit_residsflt6mkt2](#)

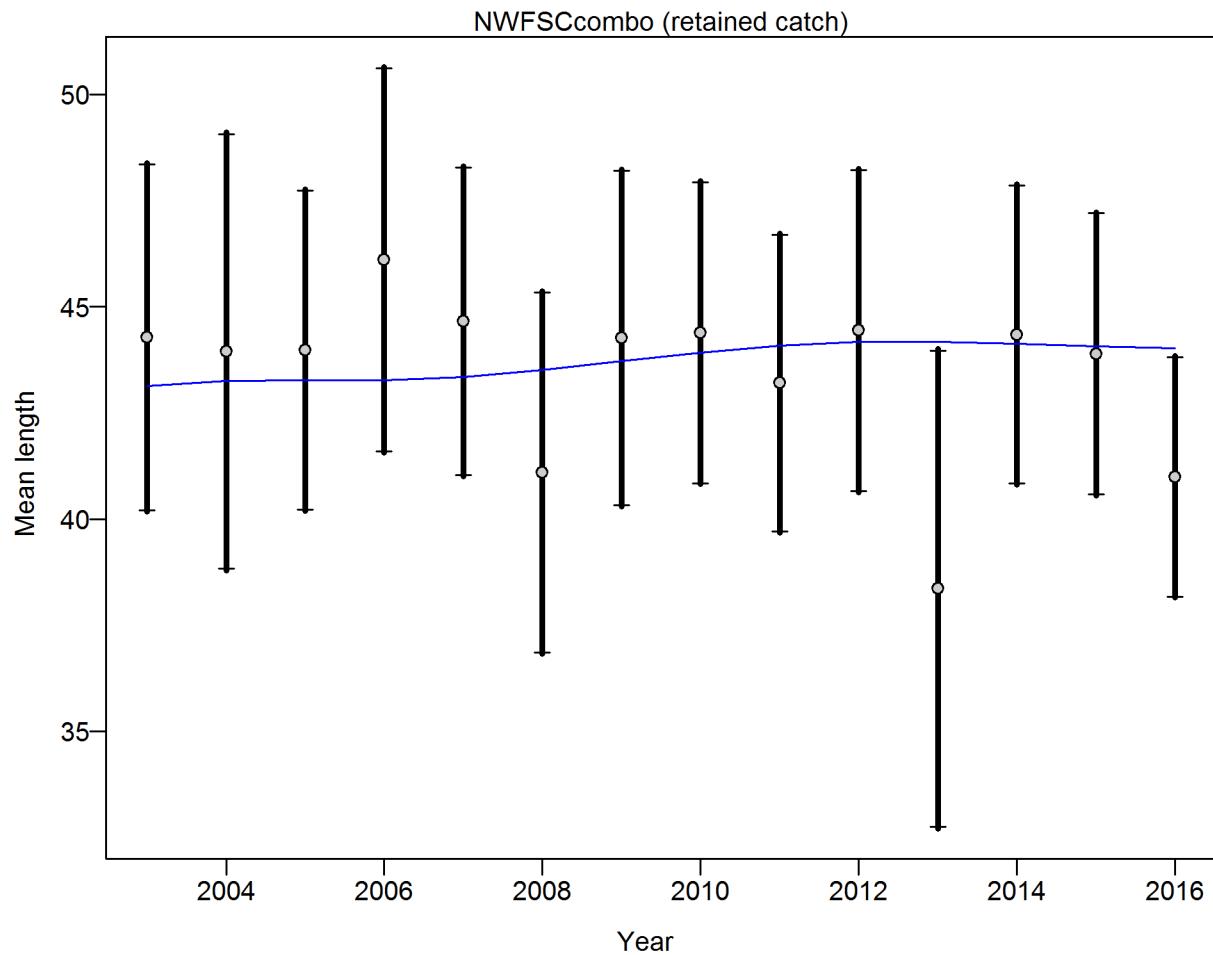


Figure 34: **Northern model** Francis data weighting method TA1.8: NWFSCcombo Suggested sample size adjustment (with 95% interval) for len data from NWFSCcombo: 1.0144 (0.6332_5.1343) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_29_comp_lenfit_da

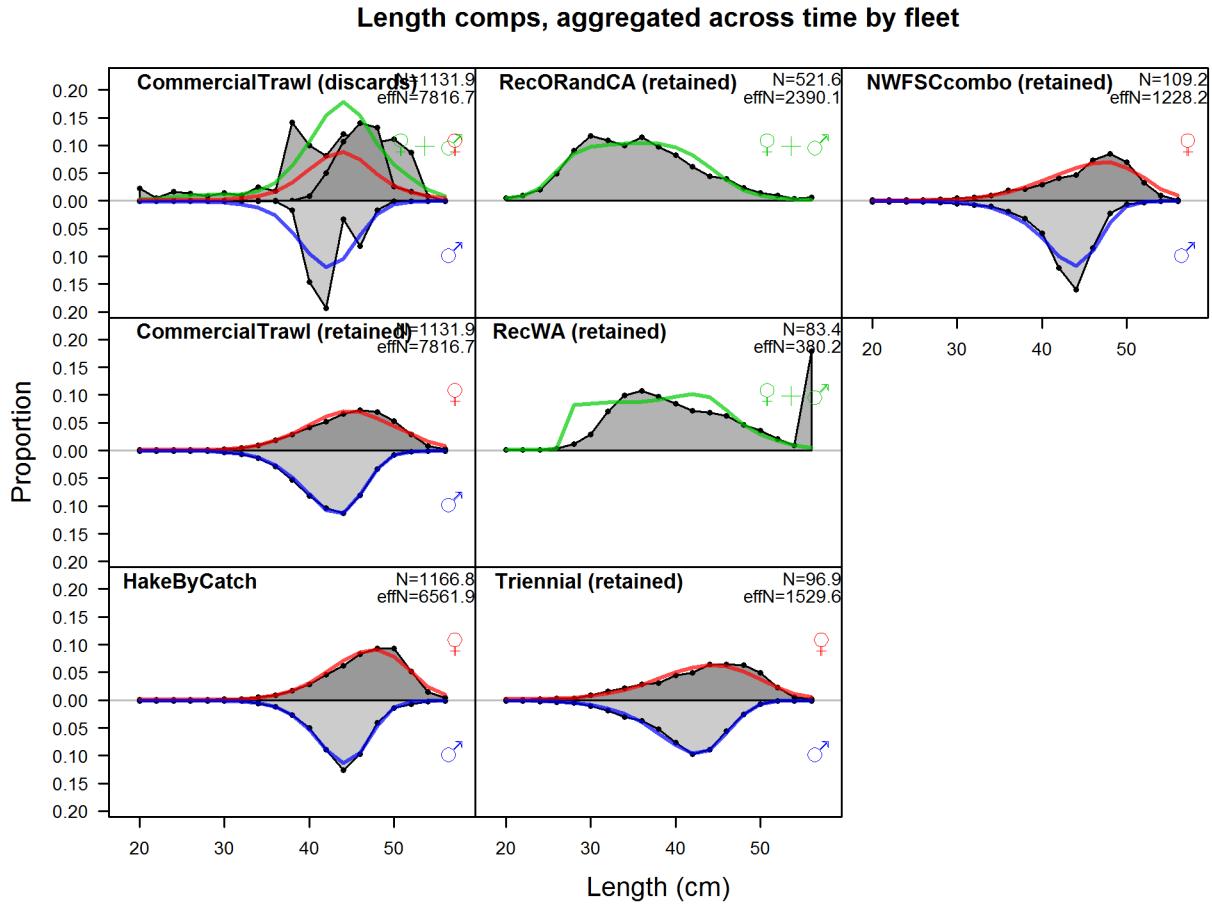


Figure 35: **Northern model** Length comps, aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch. | [fig:mod1_30_comp_lensfit_aggregated_across_time](#)

Pearson residuals, sexes combined, discard, comparing across fleets

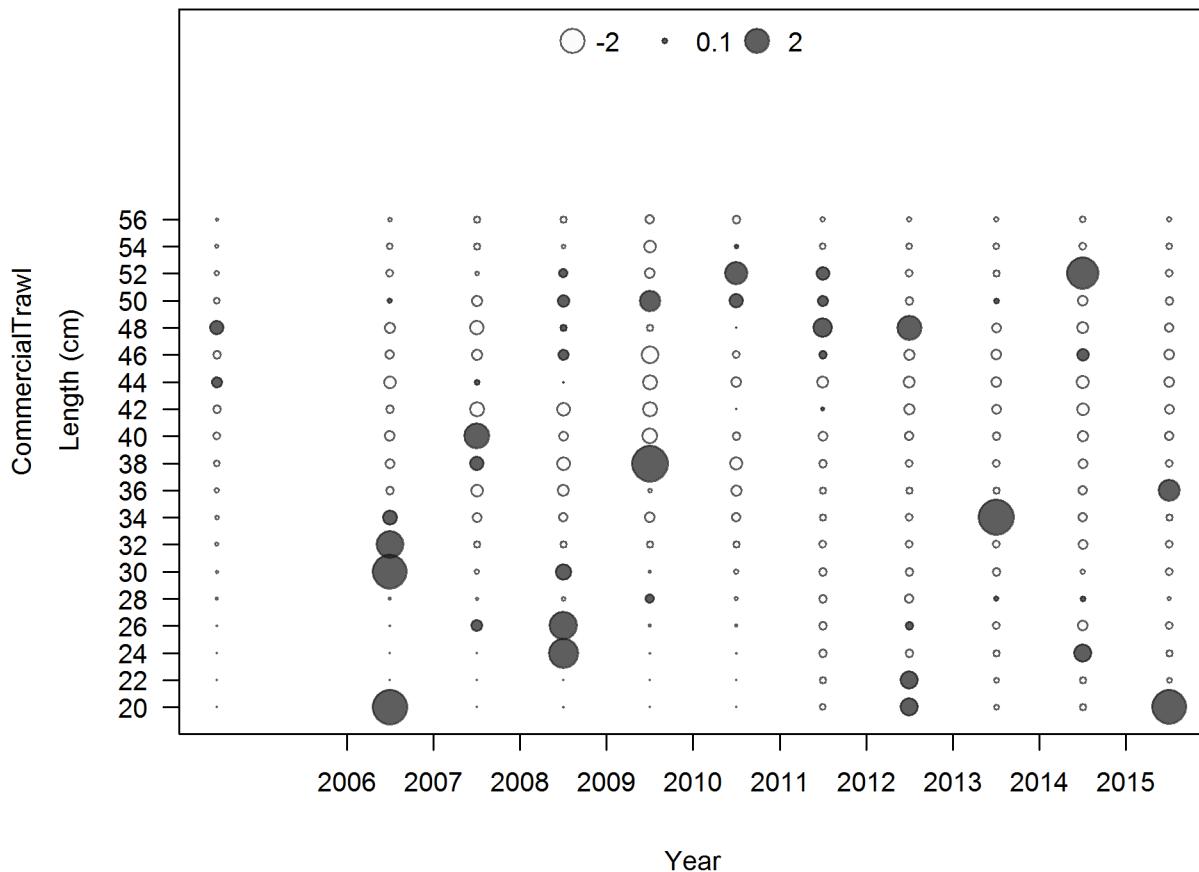


Figure 36: **Northern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, sexes combined, discard, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_31_comp_lenfit_seximkt1_multi-fleet_comparison](#)

Pearson residuals, sexes combined, retained, comparing across fleets

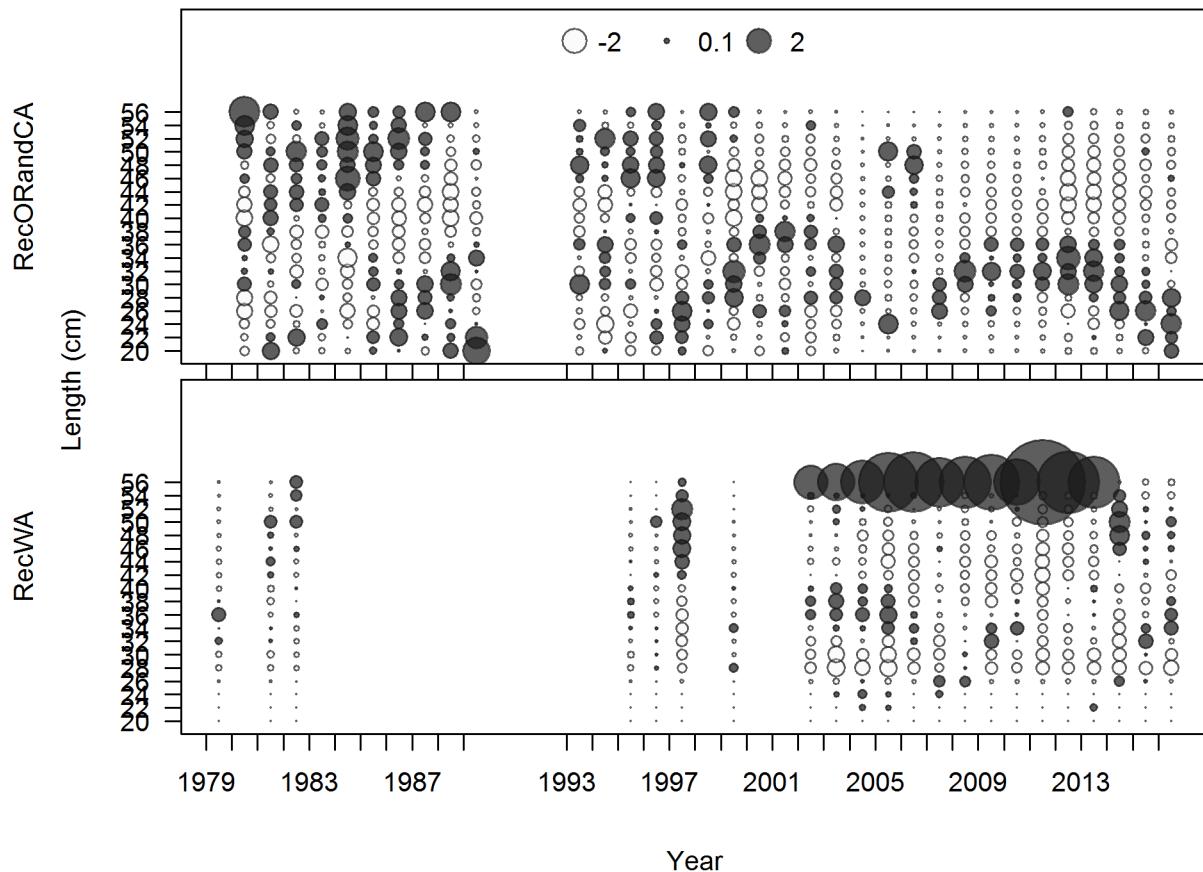


Figure 37: **Northern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, sexes combined, retained, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_32_comp_lenfit_seximkt2_multi-fleet_comparison](#)

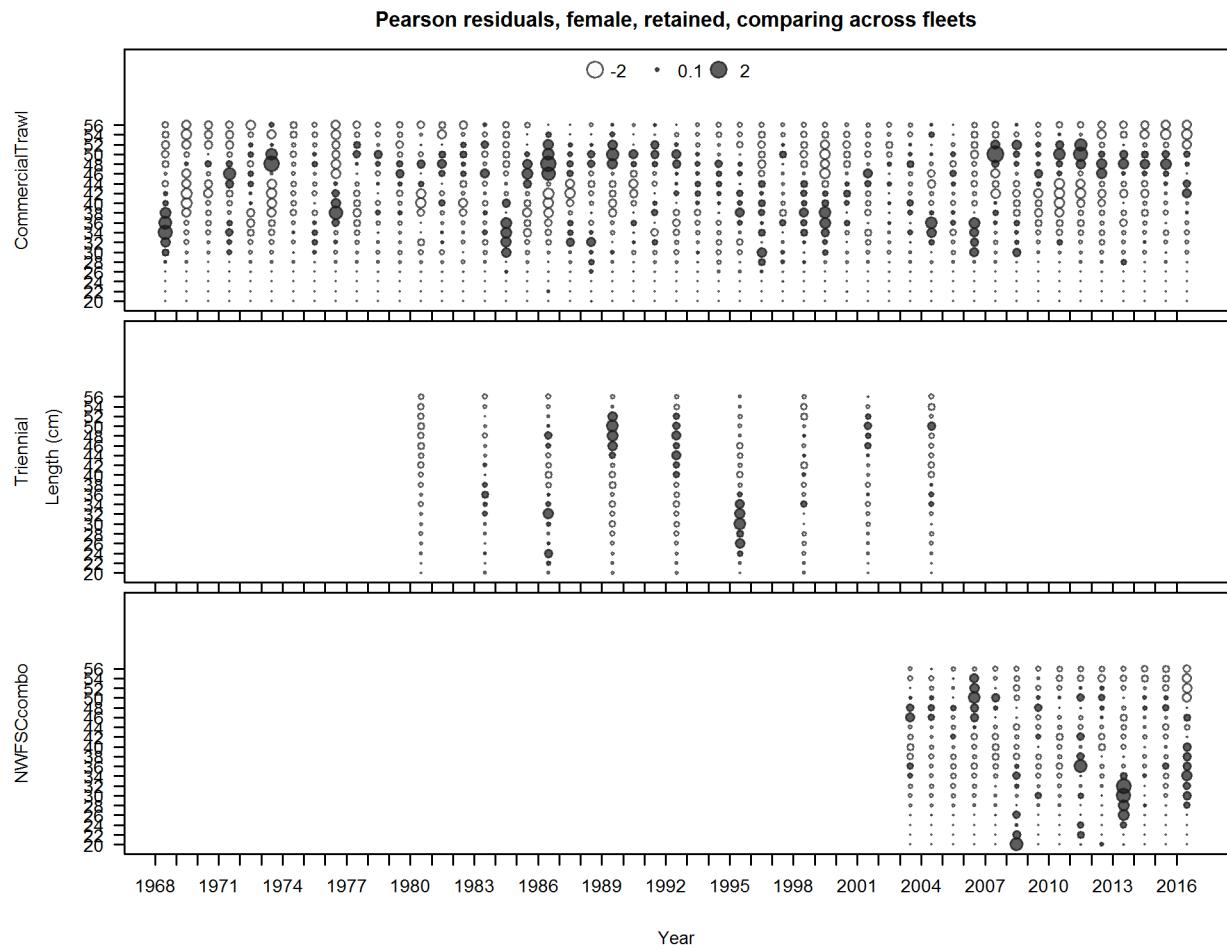


Figure 38: **Northern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, female, retained, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_33_comp_lenfit_sex2mkt2_multi-fleet_comparison](#)

Pearson residuals, female, discard, comparing across fleets

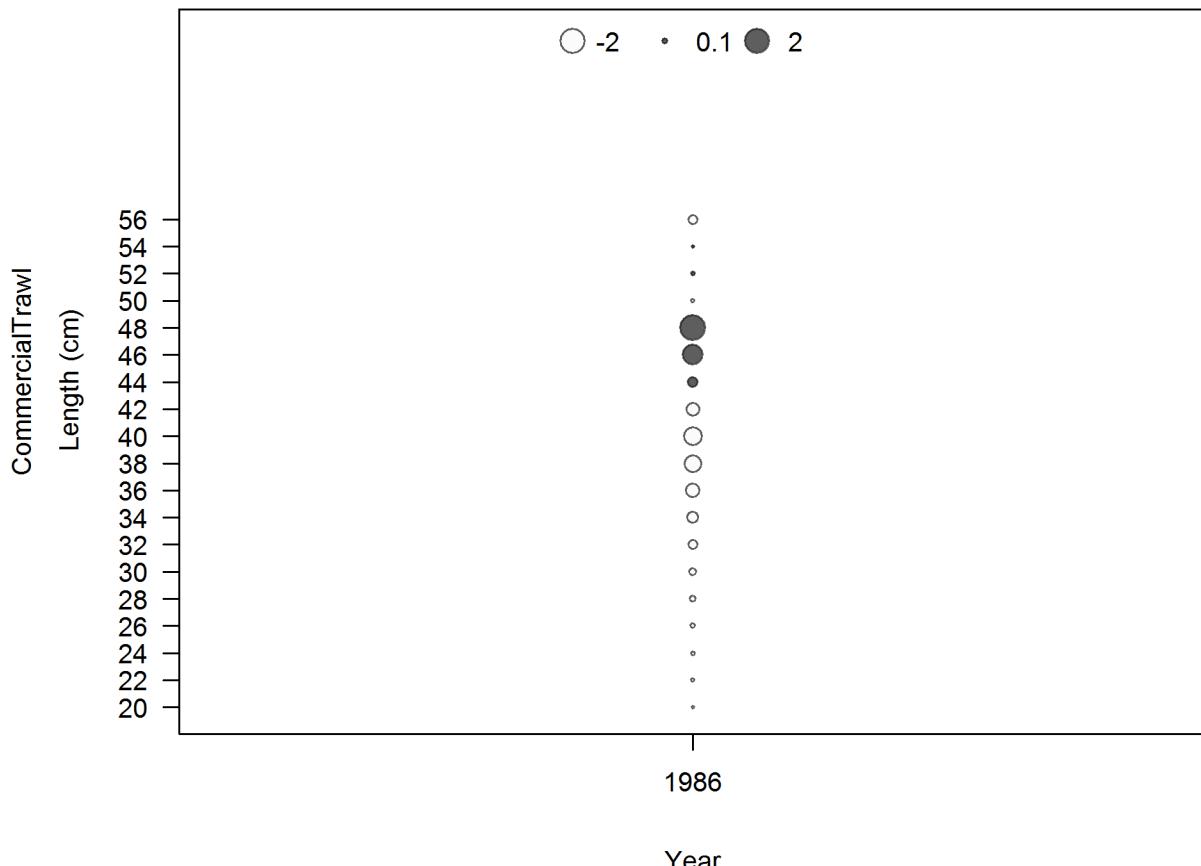


Figure 39: **Northern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, female, discard, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_34_comp_1enfit_sex2mkt1_multi-fleet_comparison](#)

Pearson residuals, female, whole catch, comparing across fleets

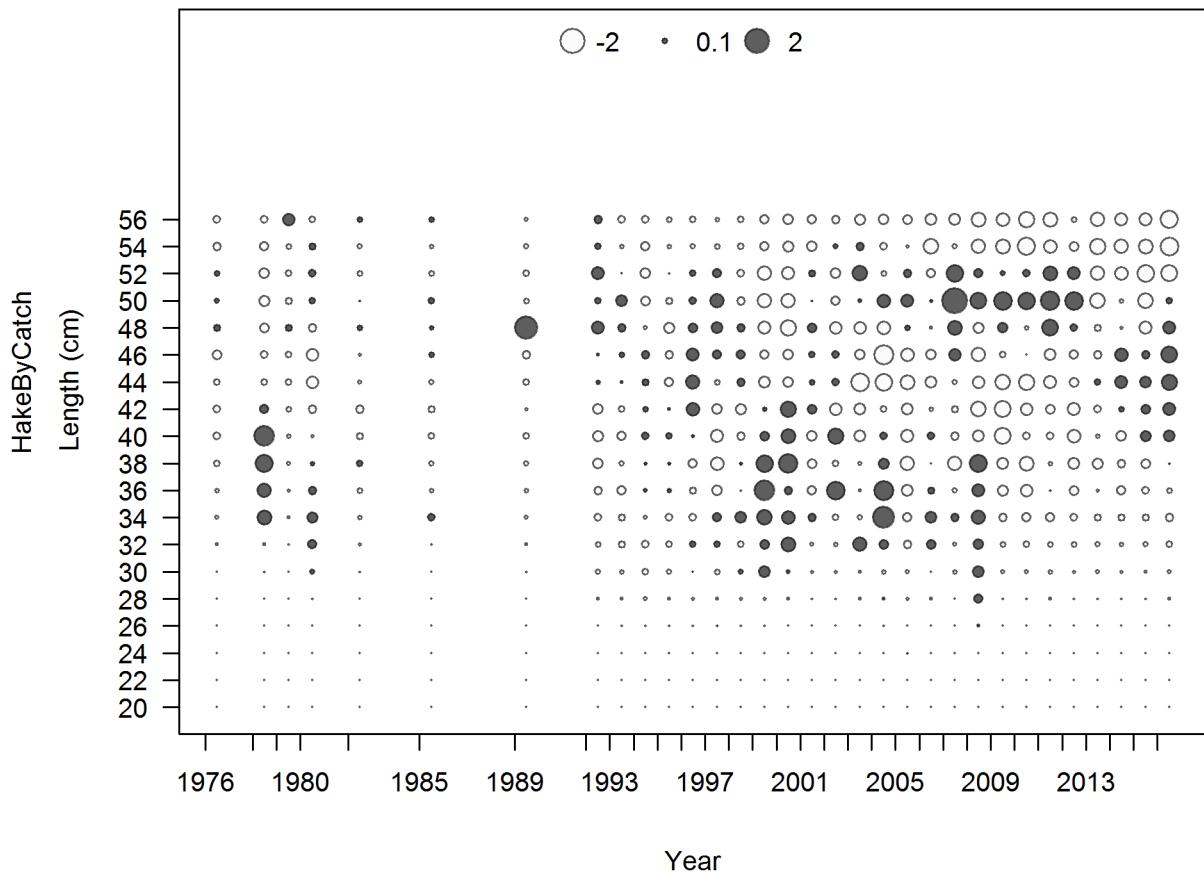


Figure 40: **Northern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, female, whole catch, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_35_comp_lenfit_sex2mkt0_multi-fleet_comparison](#)

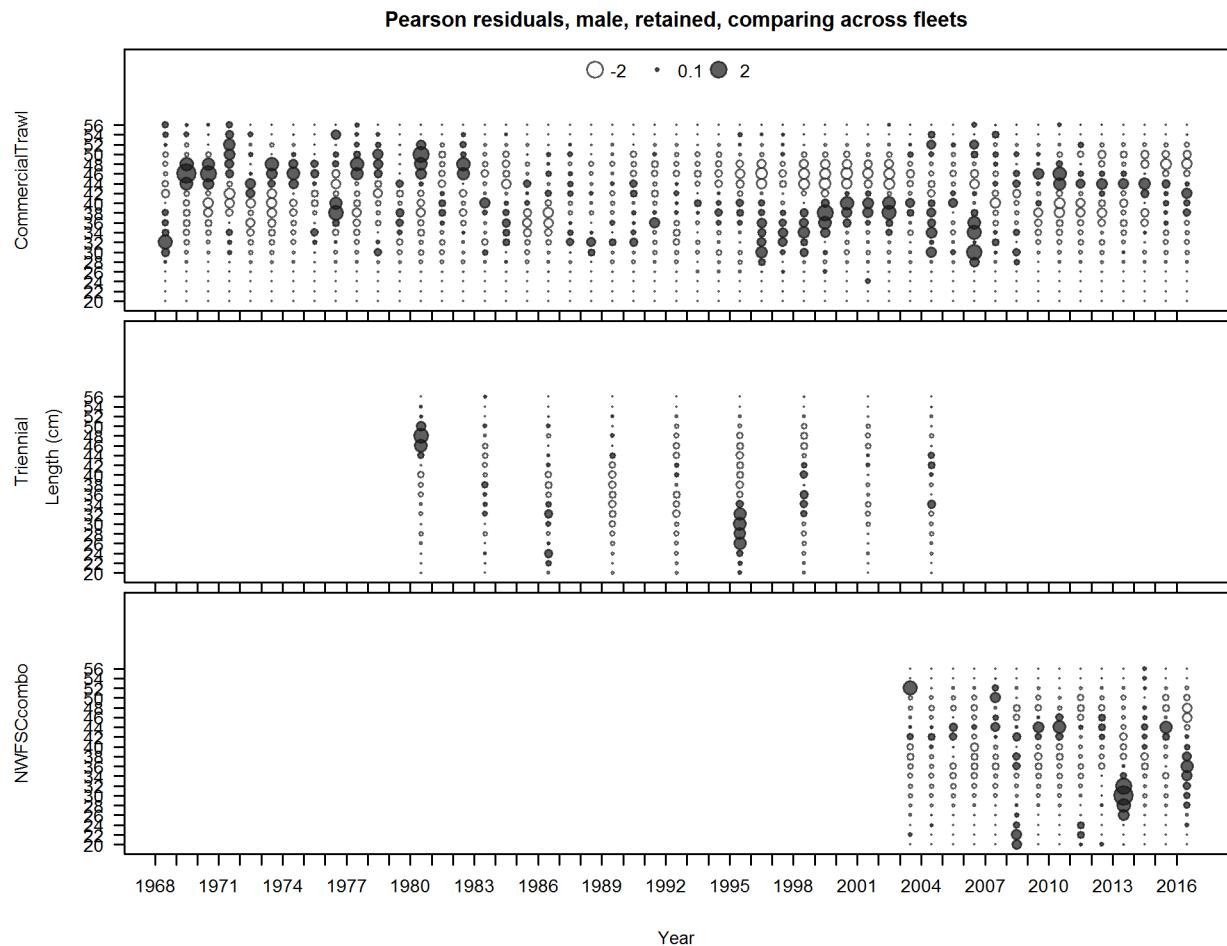


Figure 41: **Northern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, male, retained, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_36_comp_lenfit_sex3mkt2_multi-fleet_comparison](#)

Pearson residuals, male, discard, comparing across fleets

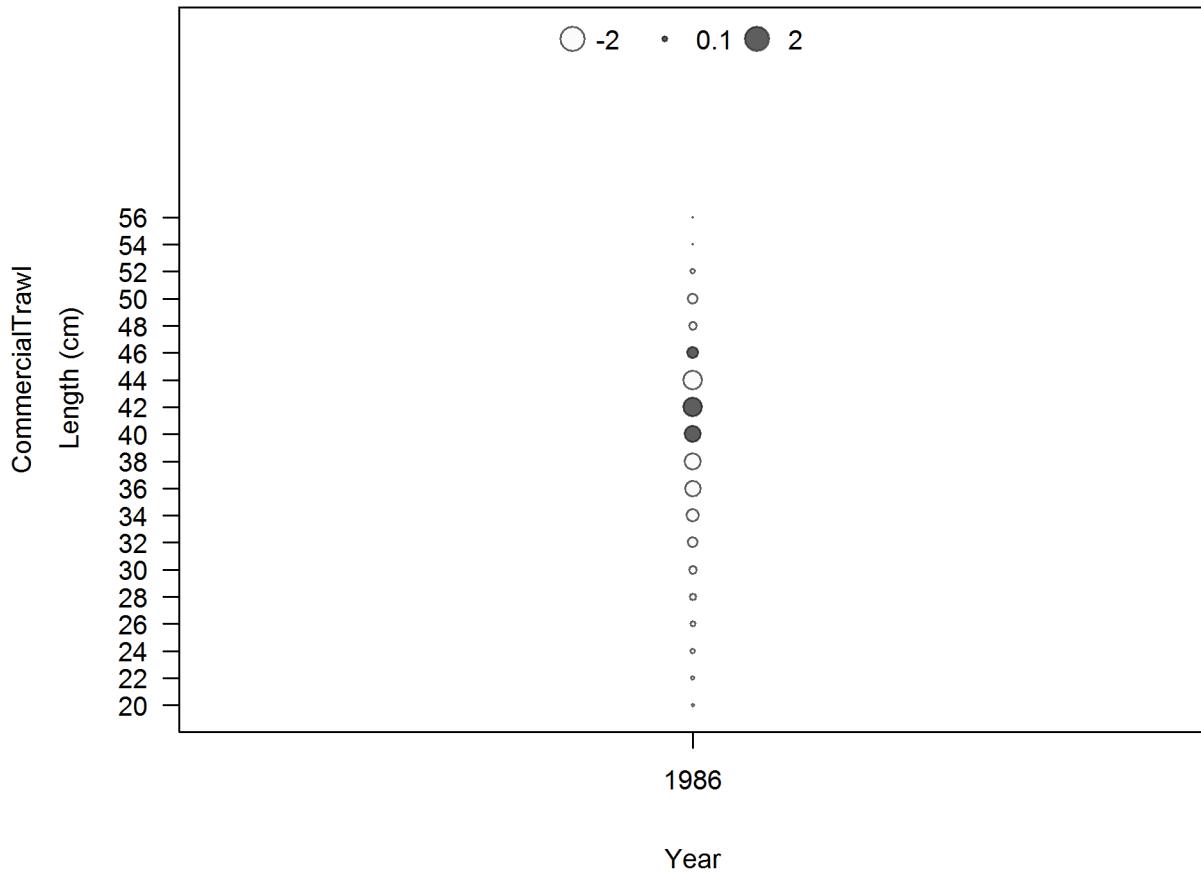


Figure 42: **Northern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, male, discard, comparing across fleets
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_37_comp_lenfit_sex3mkt1_multi-fleet_comparison](#)

Pearson residuals, male, whole catch, comparing across fleets

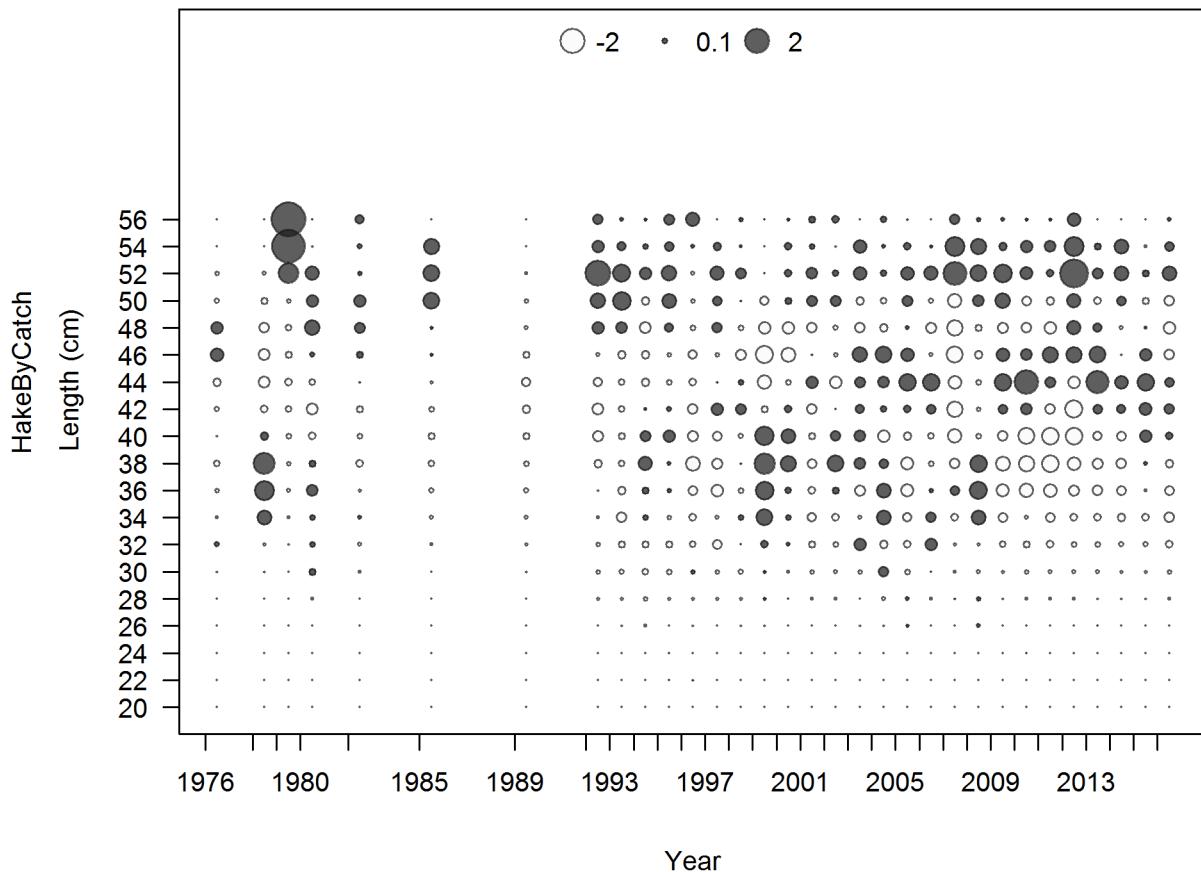


Figure 43: **Northern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, male, whole catch, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_38_comp_lensfit_sex3mkt0_multi-fleet_comparison](#)

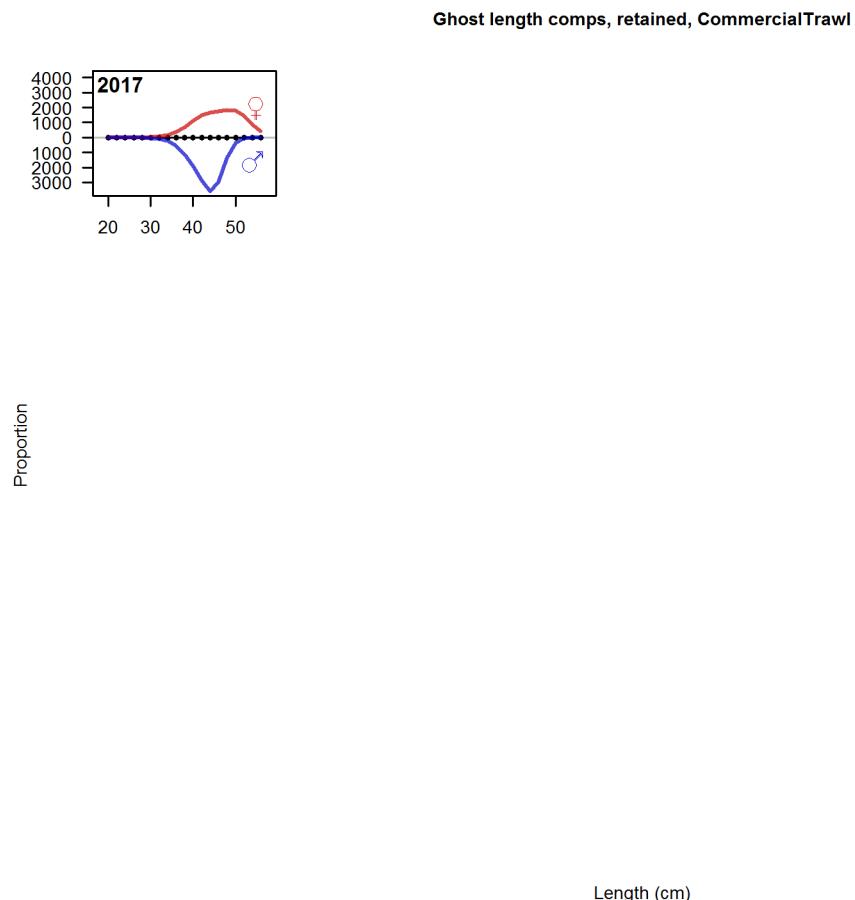


Figure 44: Northern model Ghost length comps, retained, CommercialTrawl fig:mod1_39_comp-g

Figure 45: **Northern model** Pearson residuals, retained, CommercialTrawl (max=NA)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative
residuals (observed < expected). 

675 9.3.5 Fits to length compositions for Southern model
 fits-to-length-compositions-for-southern-model

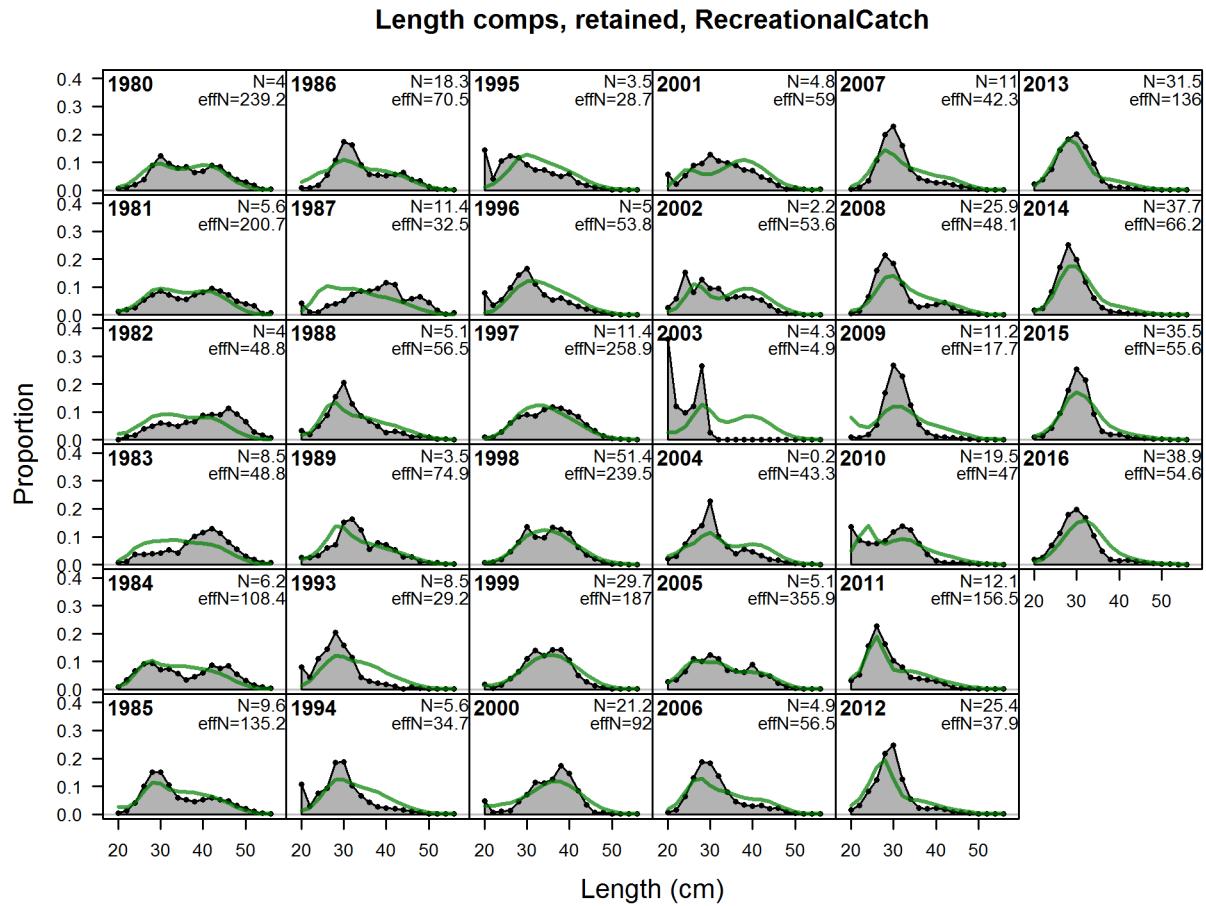


Figure 46: **Southern model** Length comps, retained, RecreationalCatch fig:mod2_1_comp_lenf

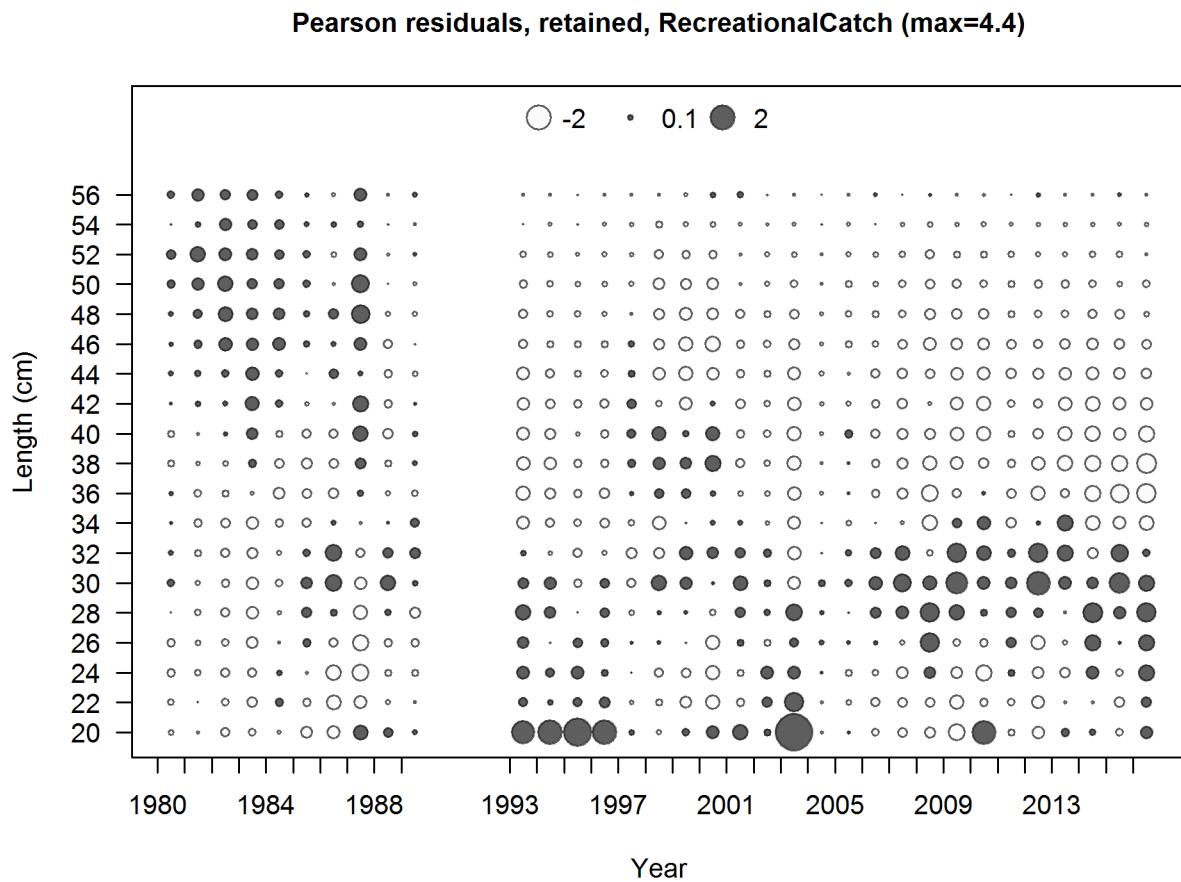


Figure 47: **Southern model** Pearson residuals, retained, RecreationalCatch (max=4.4)
 Closed bubbles are positive residuals (observed $>$ expected) and open bubbles are negative residuals (observed $<$ expected). [fig:mod2_2_comp_lenfit_residsfitmkt2](#)

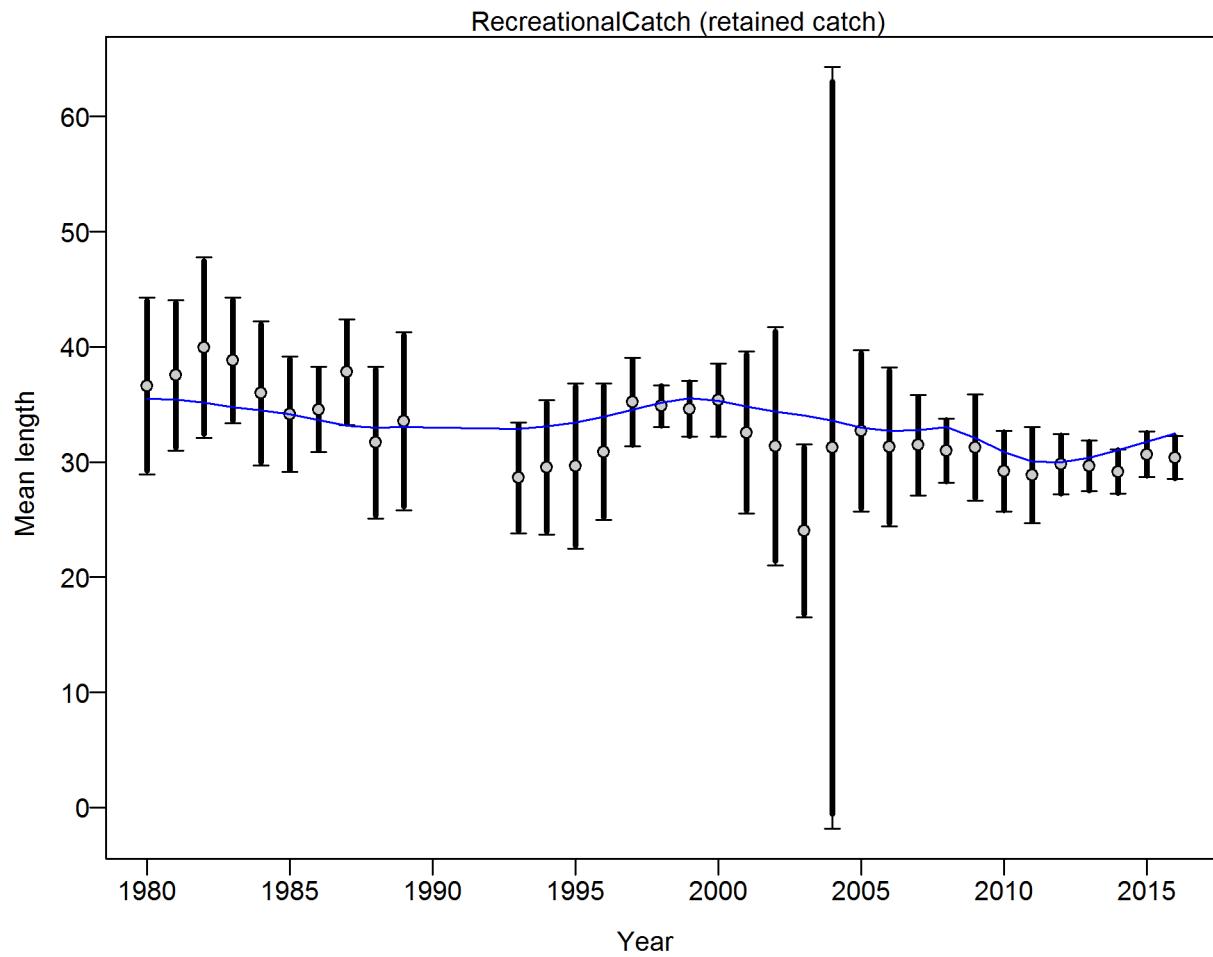


Figure 48: **Southern model** Francis data weighting method TA1.8: RecreationalCatch Suggested sample size adjustment (with 95% interval) for len data from RecreationalCatch: 0.9238 (0.6097_1.7877) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod2_4_comp

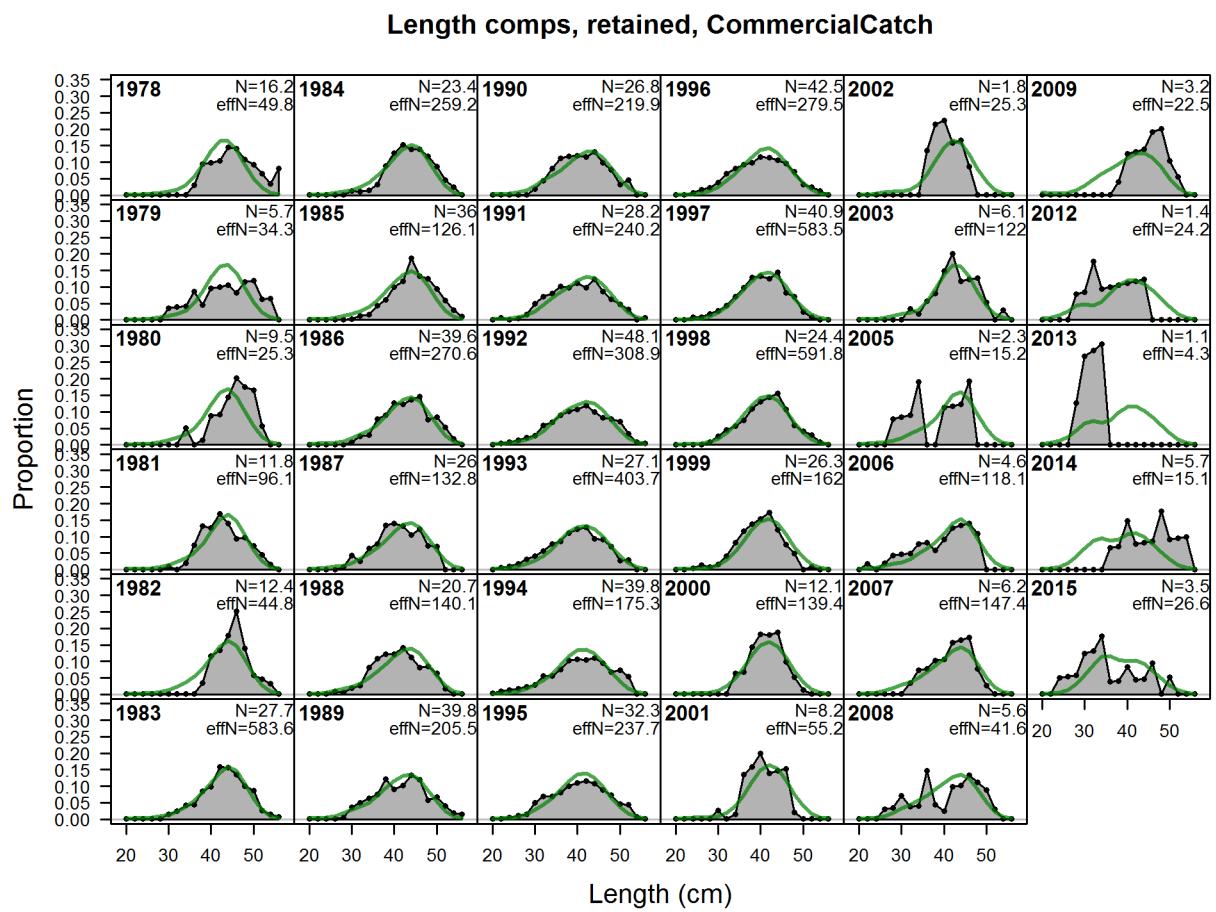


Figure 49: Southern model Length comps, retained, CommercialCatch fig:mod2_5_comp_lenfi

Pearson residuals, retained, CommercialCatch (max=5.72)

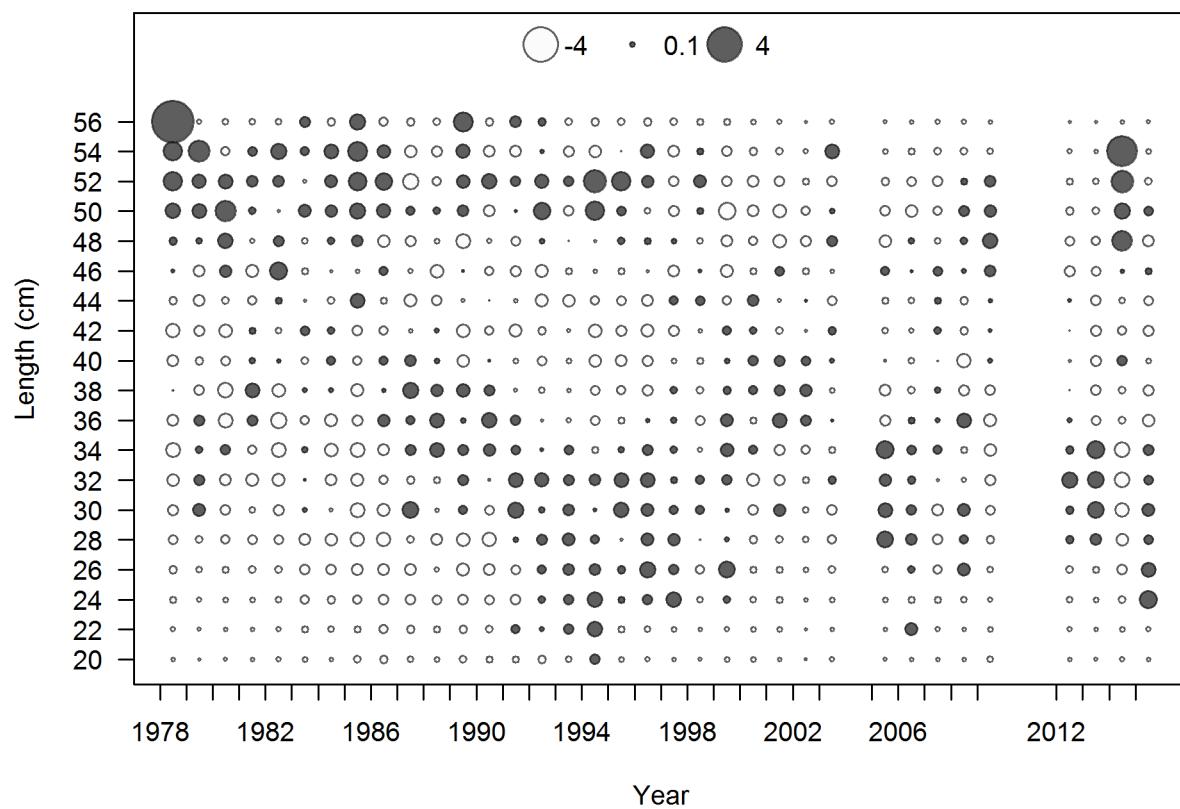


Figure 50: **Southern model** Pearson residuals, retained, CommercialCatch (max=5.72)
Closed bubbles are positive residuals (observed $>$ expected) and open bubbles are negative residuals (observed $<$ expected). [fig:mod2_6_comp_lenfit_residsfit2mkt2](#)

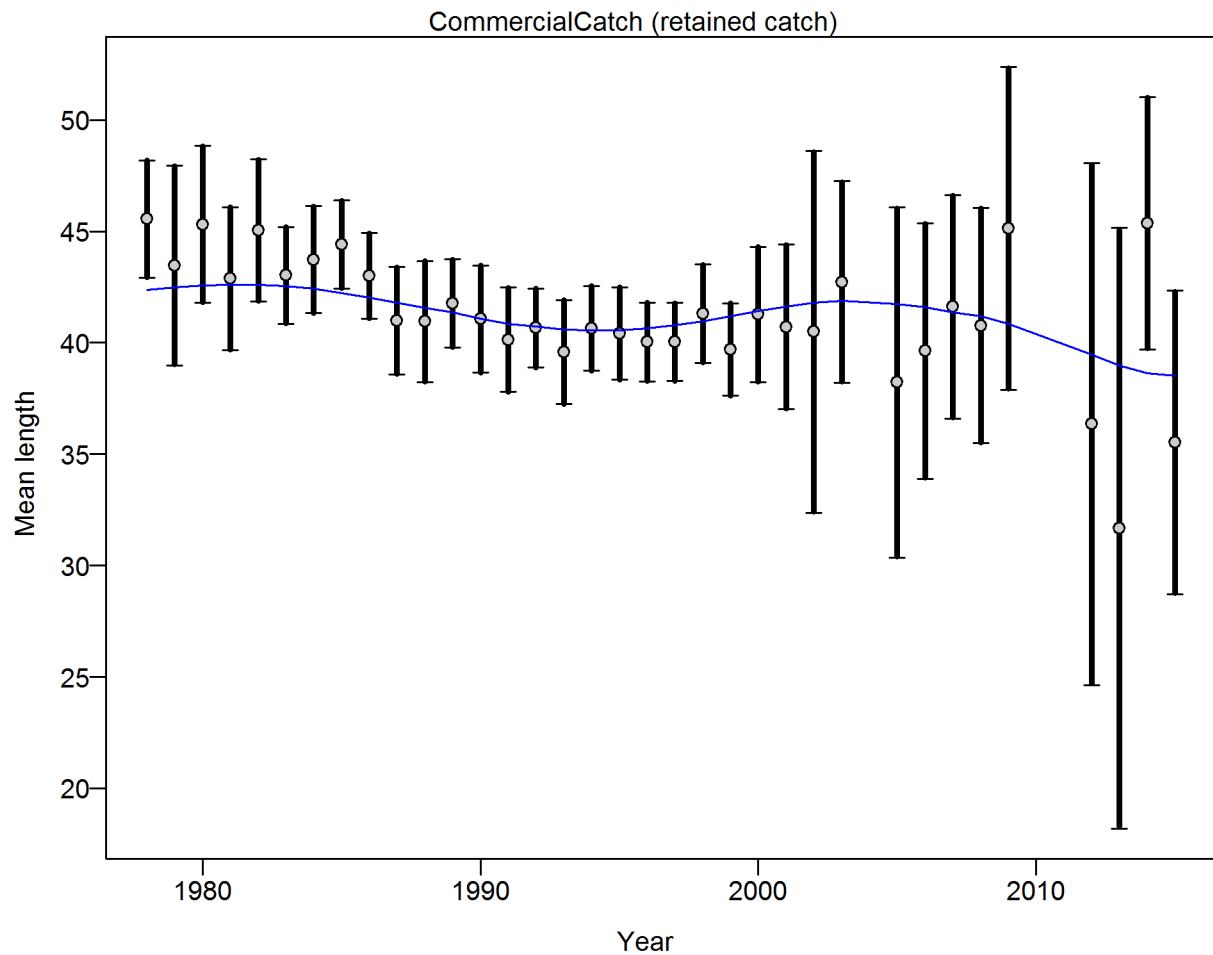


Figure 51: **Southern model** Francis data weighting method TA1.8: CommercialCatch Suggested sample size adjustment (with 95% interval) for len data from CommercialCatch: 0.9835 (0.6829_1.8164) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. [fig:mod2_8_comp](#)

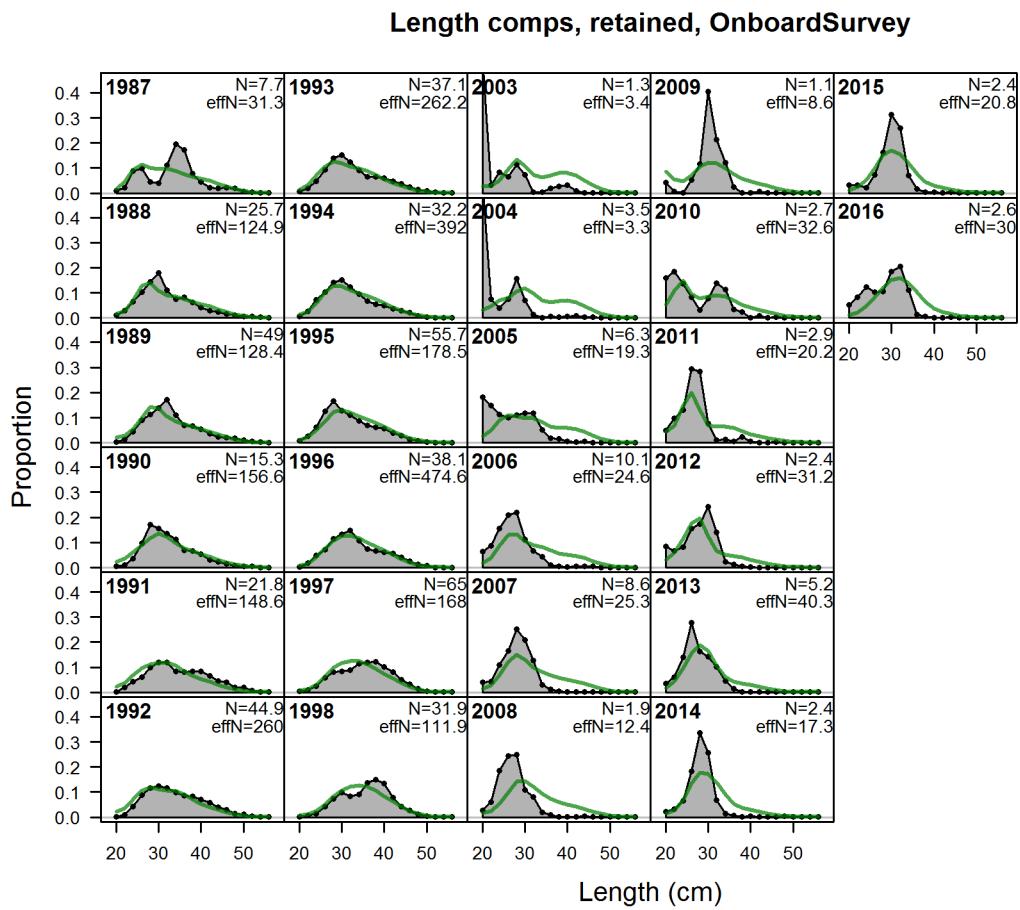


Figure 52: **Southern model** Length comps, retained, OnboardSurvey fig:mod2_9_comp_lenfit

Pearson residuals, retained, OnboardSurvey (max=5.23)

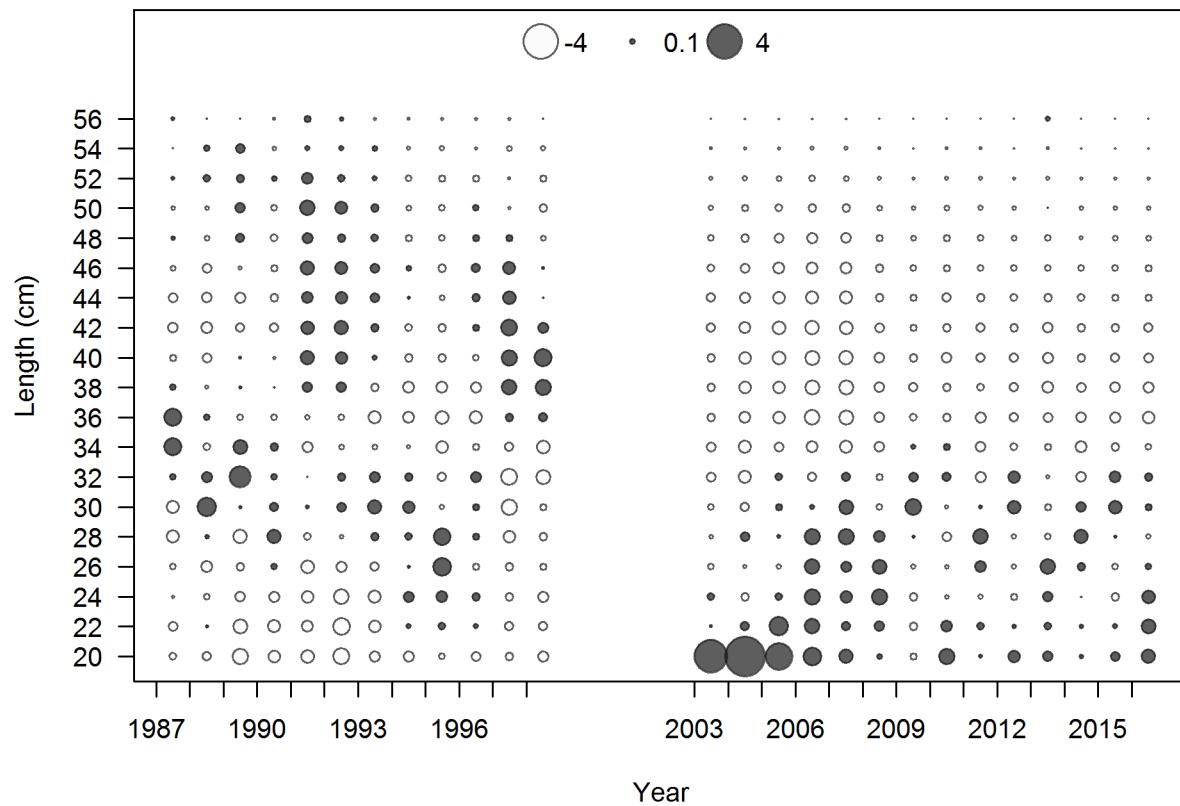


Figure 53: **Southern model** Pearson residuals, retained, OnboardSurvey (max=5.23)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative
residuals (observed < expected). [fig:mod2_10_comp_lenfit_residsfit3mkt2](#)

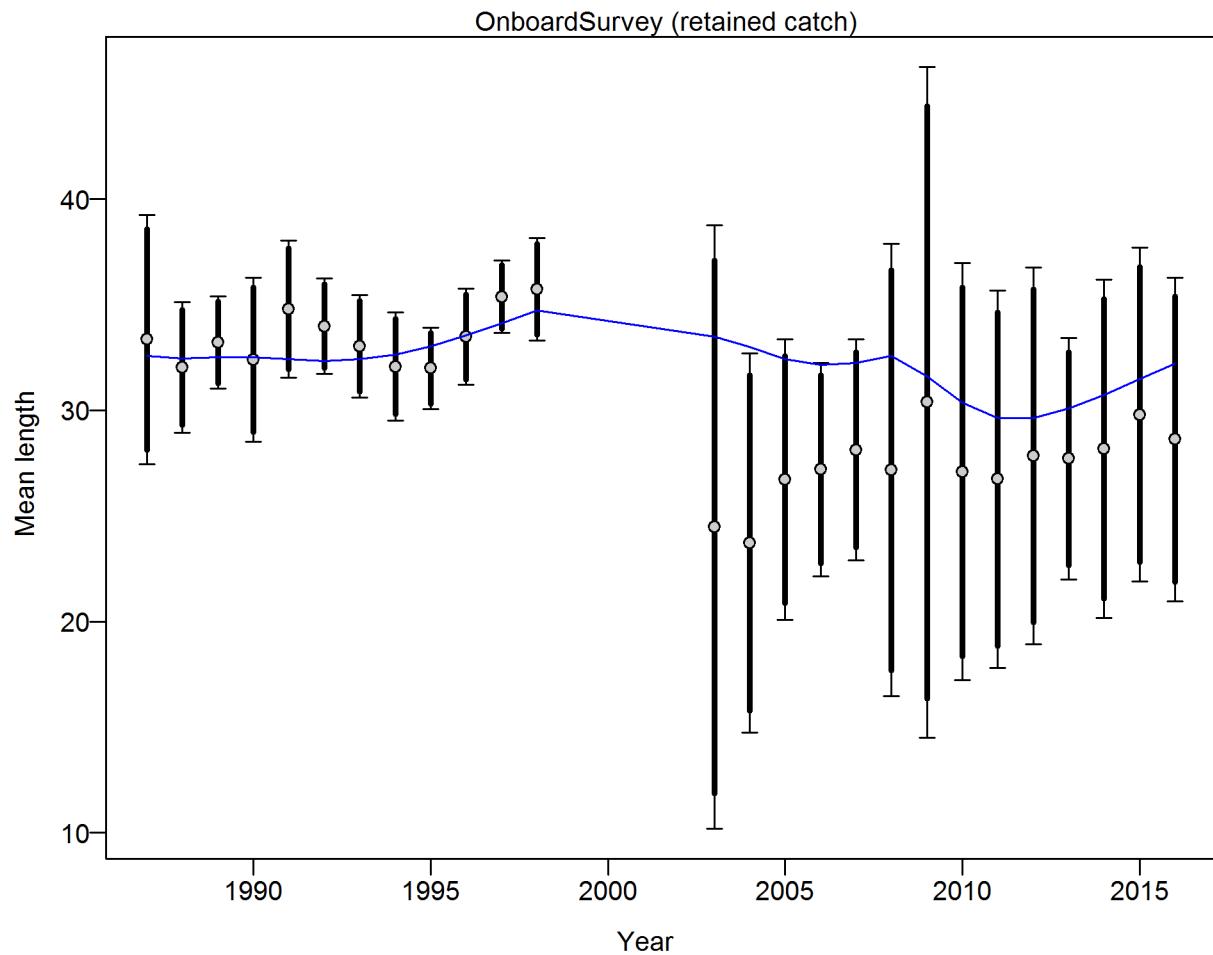


Figure 54: **Southern model** Francis data weighting method TA1.8: OnboardSurvey Suggested sample size adjustment (with 95% interval) for len data from OnboardSurvey: 0.7823 (0.5494, 1.4862) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124–1138. [fig:mod2_12_comp_lenfit_da](#)

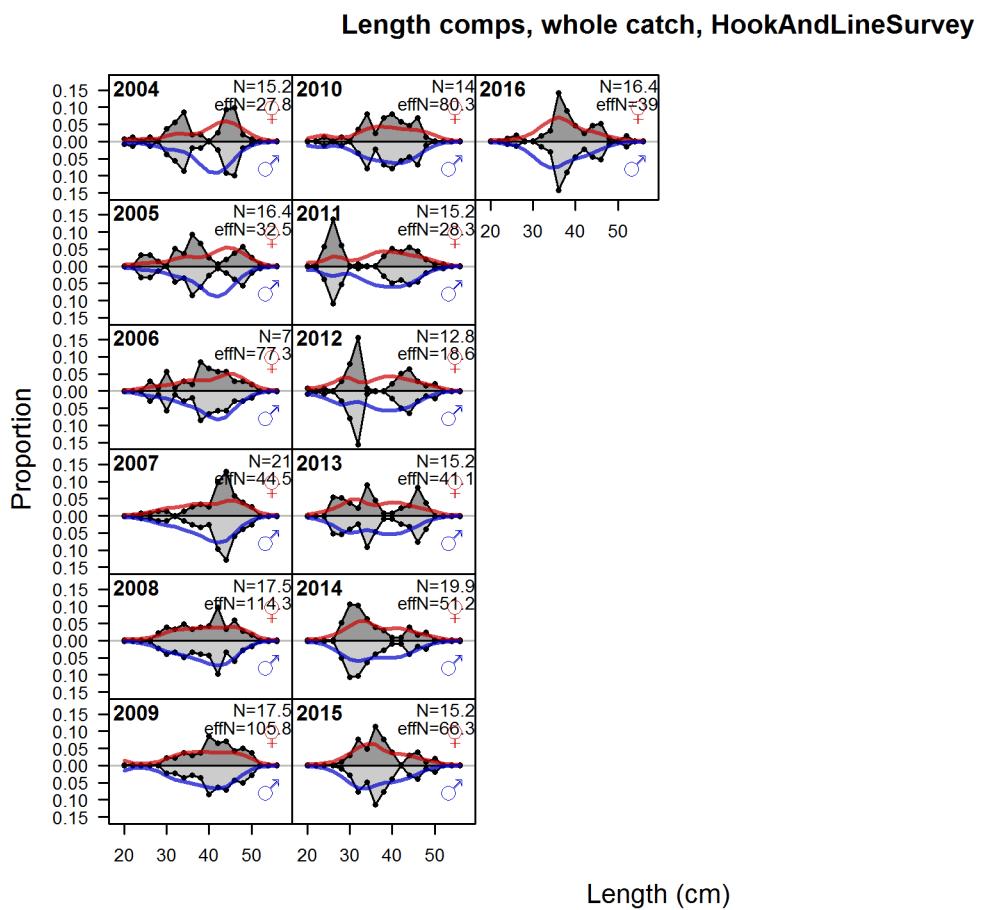


Figure 55: **Southern model** Length comps, whole catch, HookAndLineSurvey fig:mod2_13_comp_1

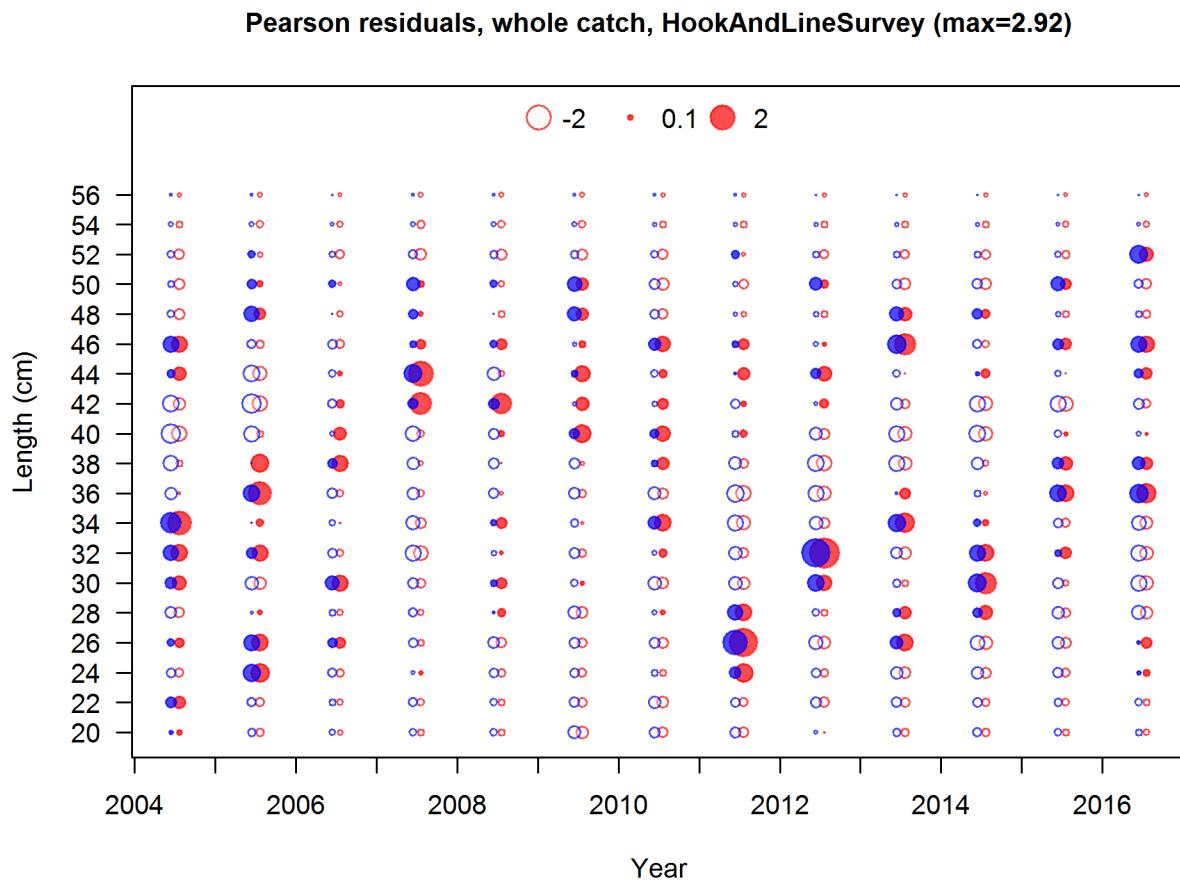


Figure 56: **Southern model** Pearson residuals, whole catch, HookAndLineSurvey (max=2.92)

Closed bubbles are positive residuals ($\text{observed} > \text{expected}$) and open bubbles are negative residuals ($\text{observed} < \text{expected}$). [fig:mod2_14_comp_lenfit_residsflt4mkt0](#)

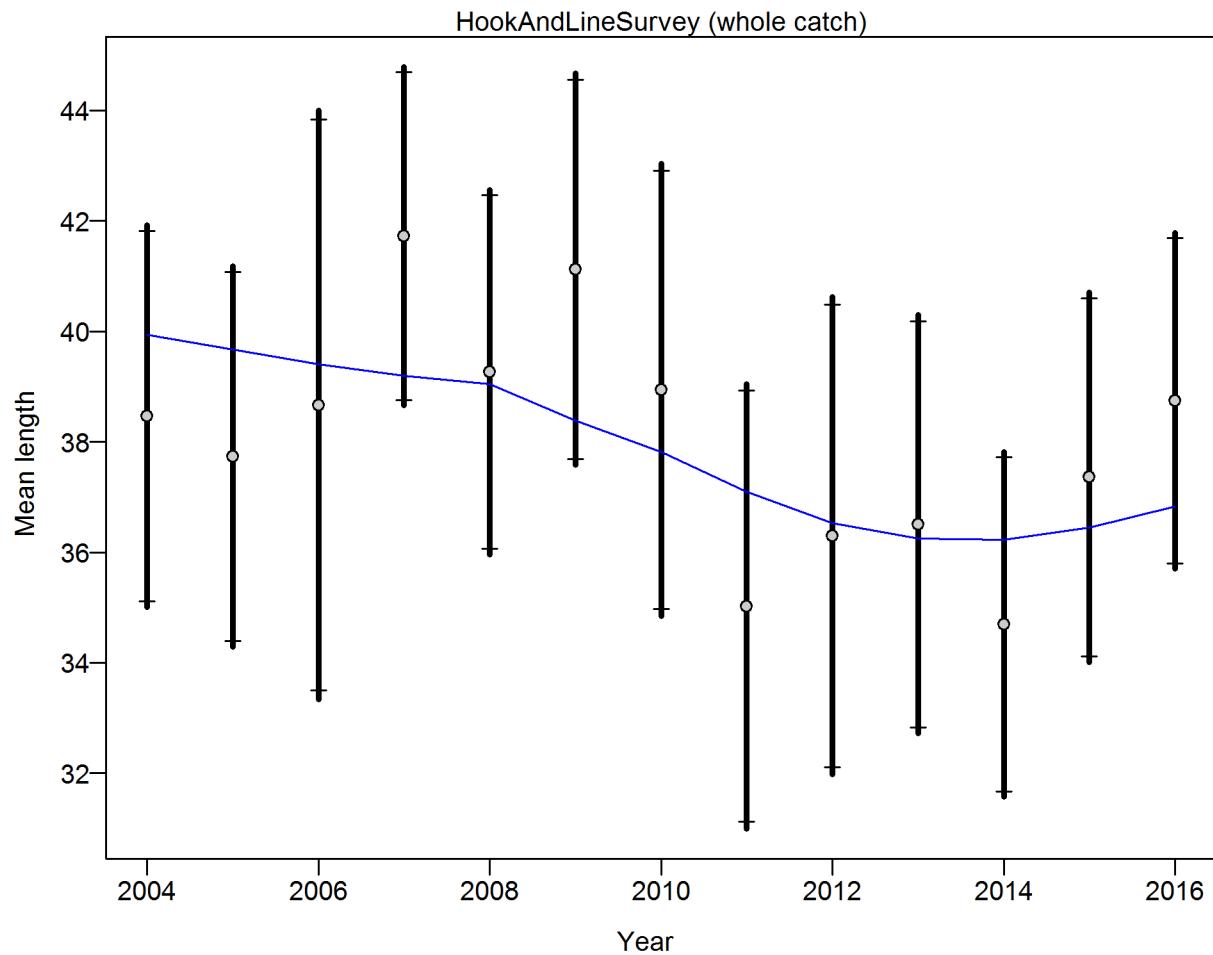


Figure 57: **Southern model** Francis data weighting method TA1.8: HookAndLineSurvey Suggested sample size adjustment (with 95% interval) for len data from HookAndLineSurvey: 1.0633 (0.74_2.6995) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. [fig:mod2_16_comp_lenfit_da](#)

Length comps, retained, RecStudy

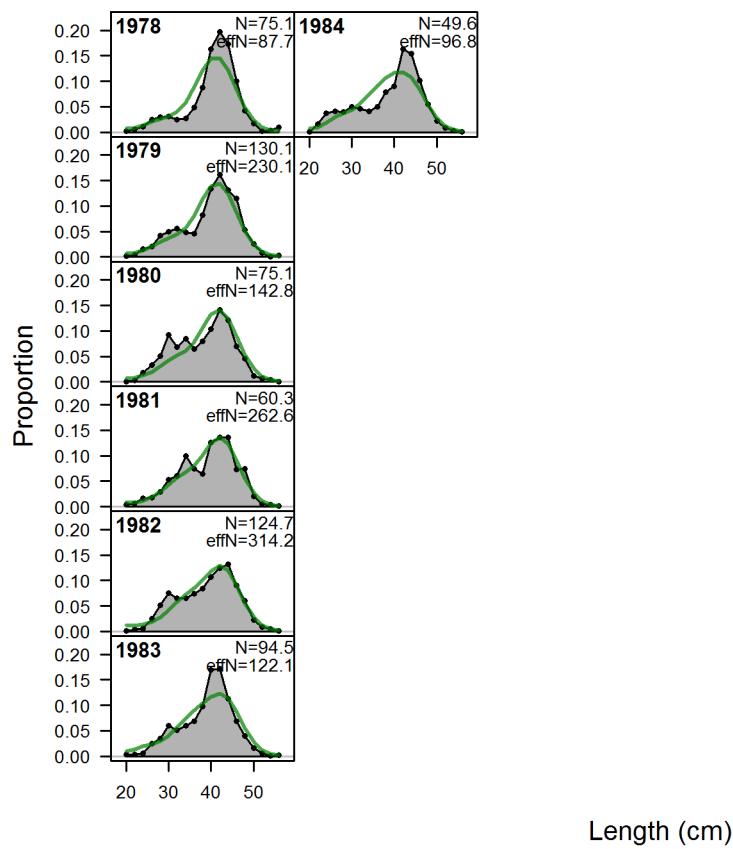


Figure 58: **Southern model** Length comps, retained, RecStudy fig:mod2_17_comp_lenfit...

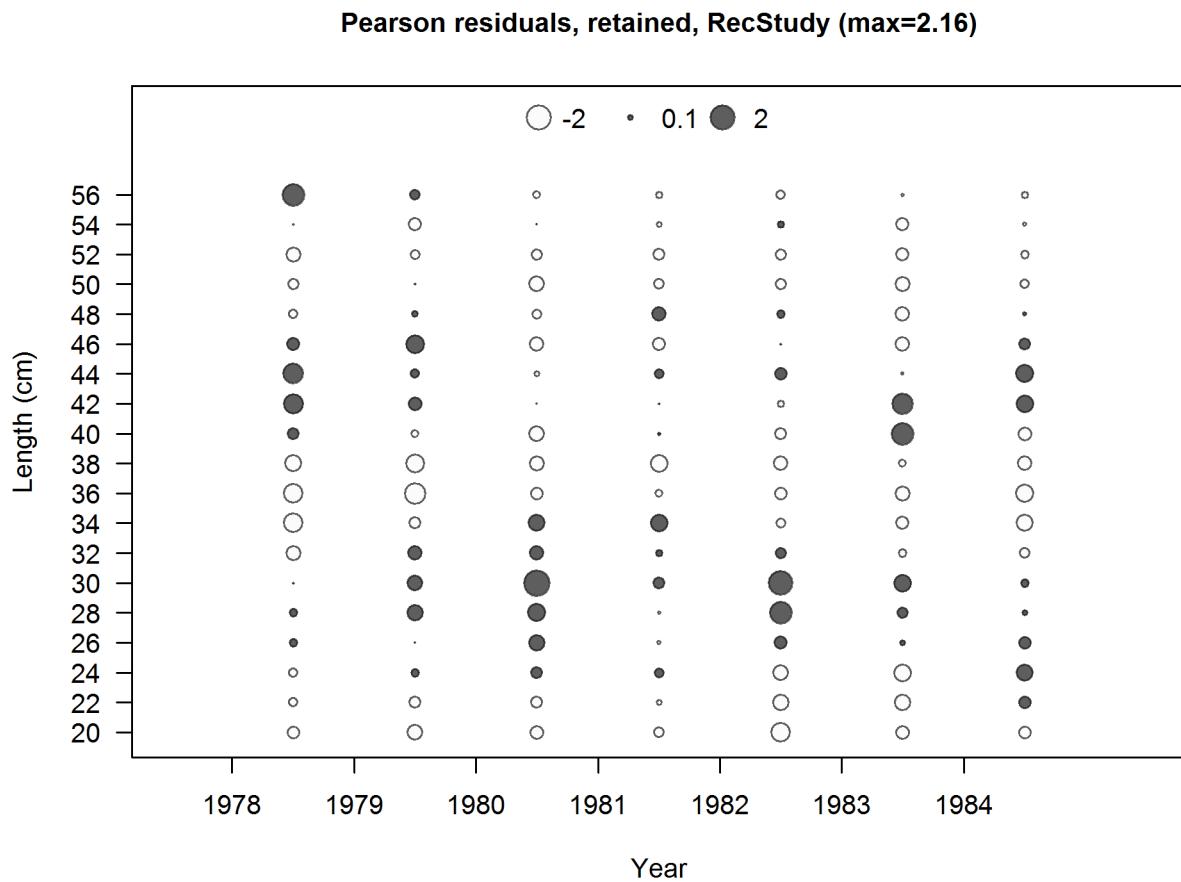


Figure 59: **Southern model** Pearson residuals, retained, RecStudy (max=2.16)
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod2_18_comp_lenfit_residsfit5mkt2

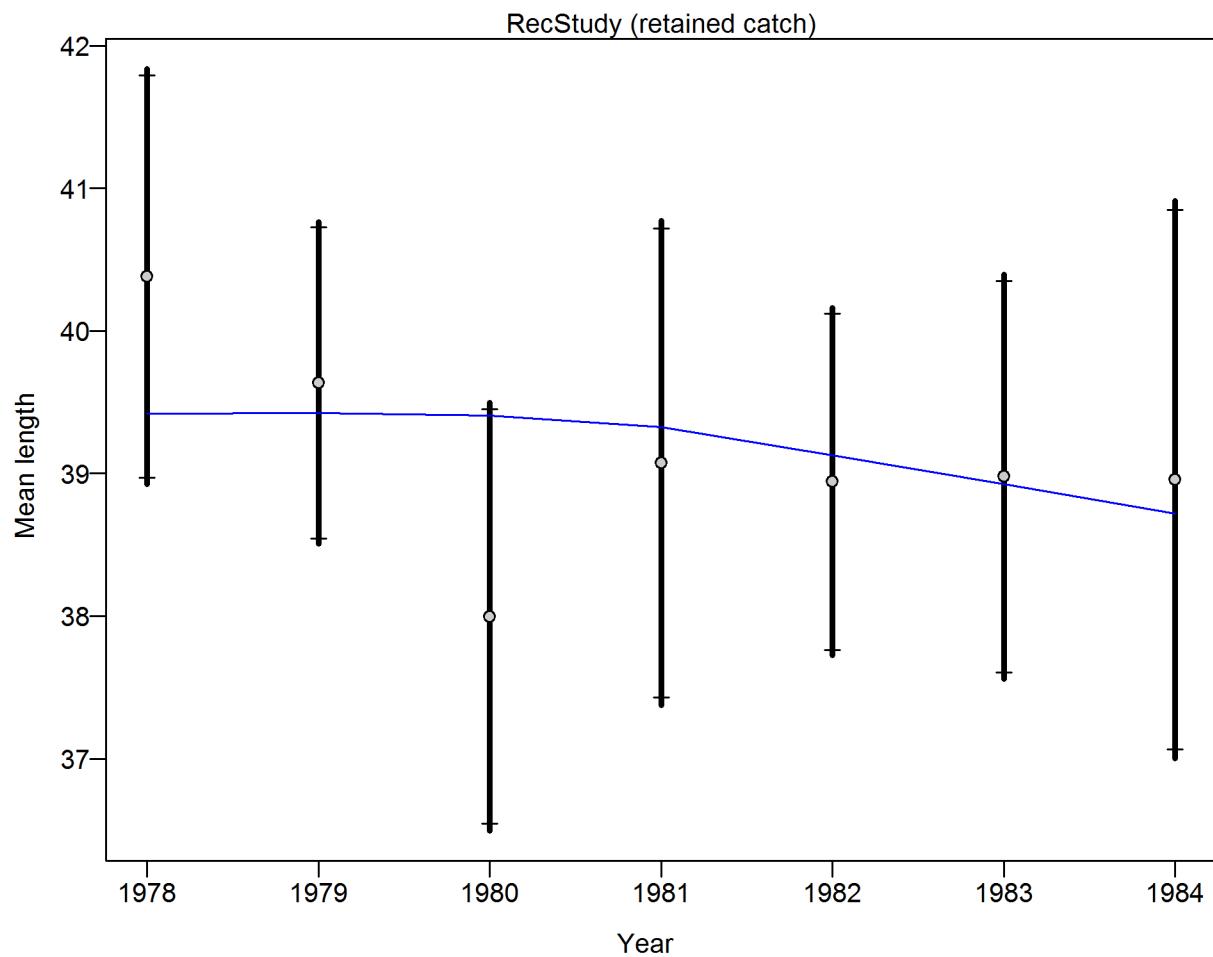


Figure 60: **Southern model** Francis data weighting method TA1.8: RecStudy Suggested sample size adjustment (with 95% interval) for len data from RecStudy: 1.0664 (0.5599_16.048)
For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. [fig:mod2_20_comp_lenfit_data_weighting](#)

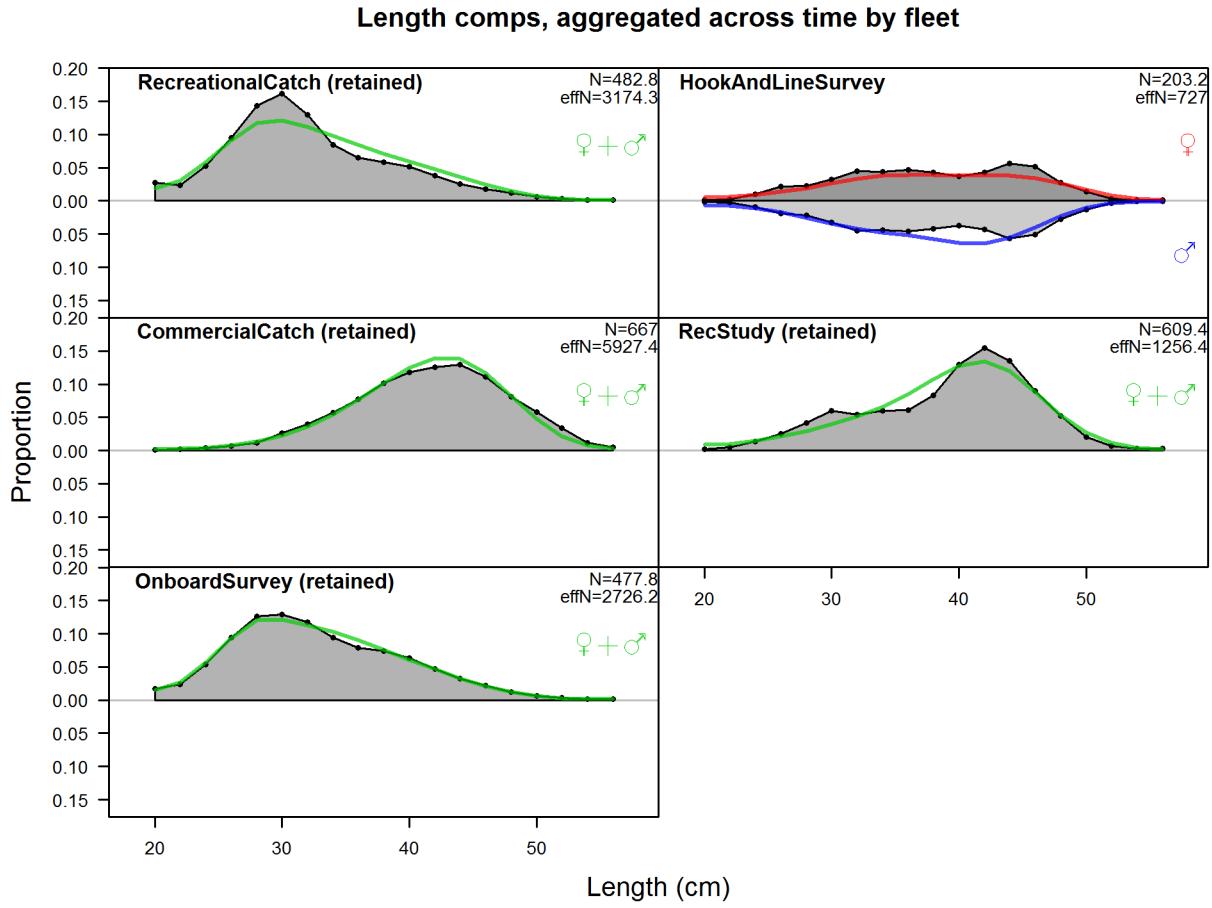


Figure 61: **Southern model** Length comps, aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate discarded or retained samples for each fleet. Panels without this designation represent the whole catch. [fig:mod2_21_comp_lenfit__aggregated_across_time](#)

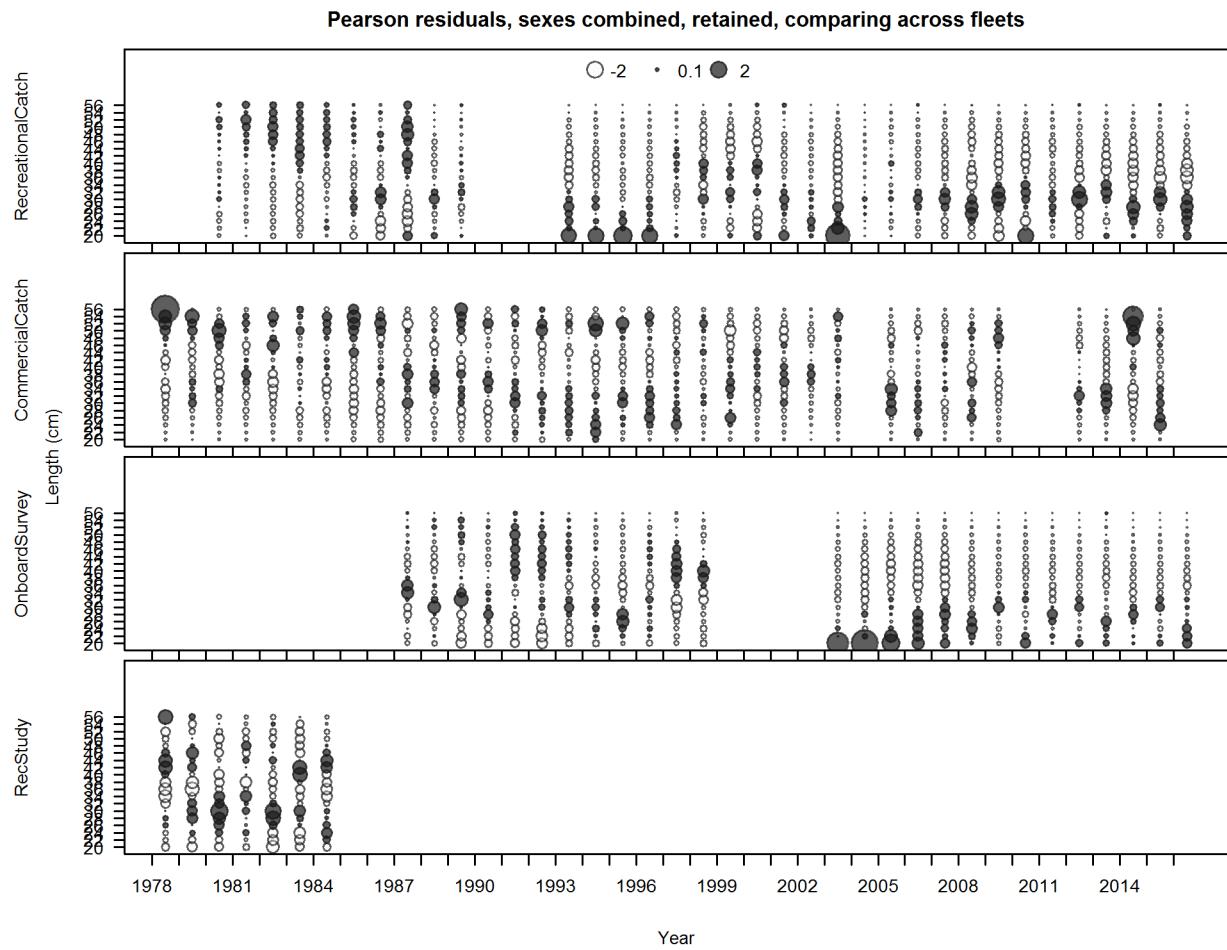


Figure 62: Southern model Note: this plot doesn't seem to be working right for some models. Pearson residuals, sexes combined, retained, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). | [fig:mod2_22_comp_lenfit_seximkt2_multi-fleet_comparison](#)

Pearson residuals, female, whole catch, comparing across fleets

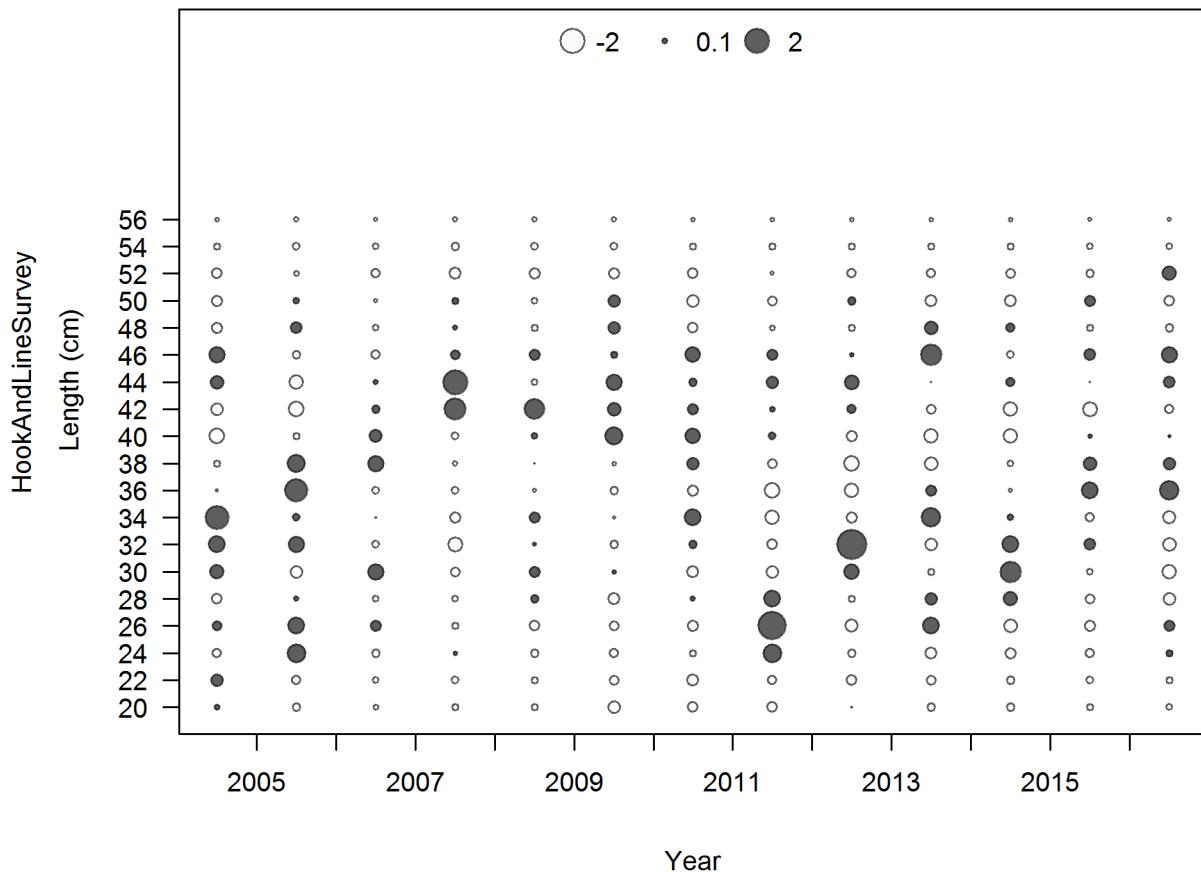


Figure 63: **Southern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, female, whole catch, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod2_23_comp_1enfit_sex2mkt0_multi-fleet_comparison](#)

Pearson residuals, male, whole catch, comparing across fleets

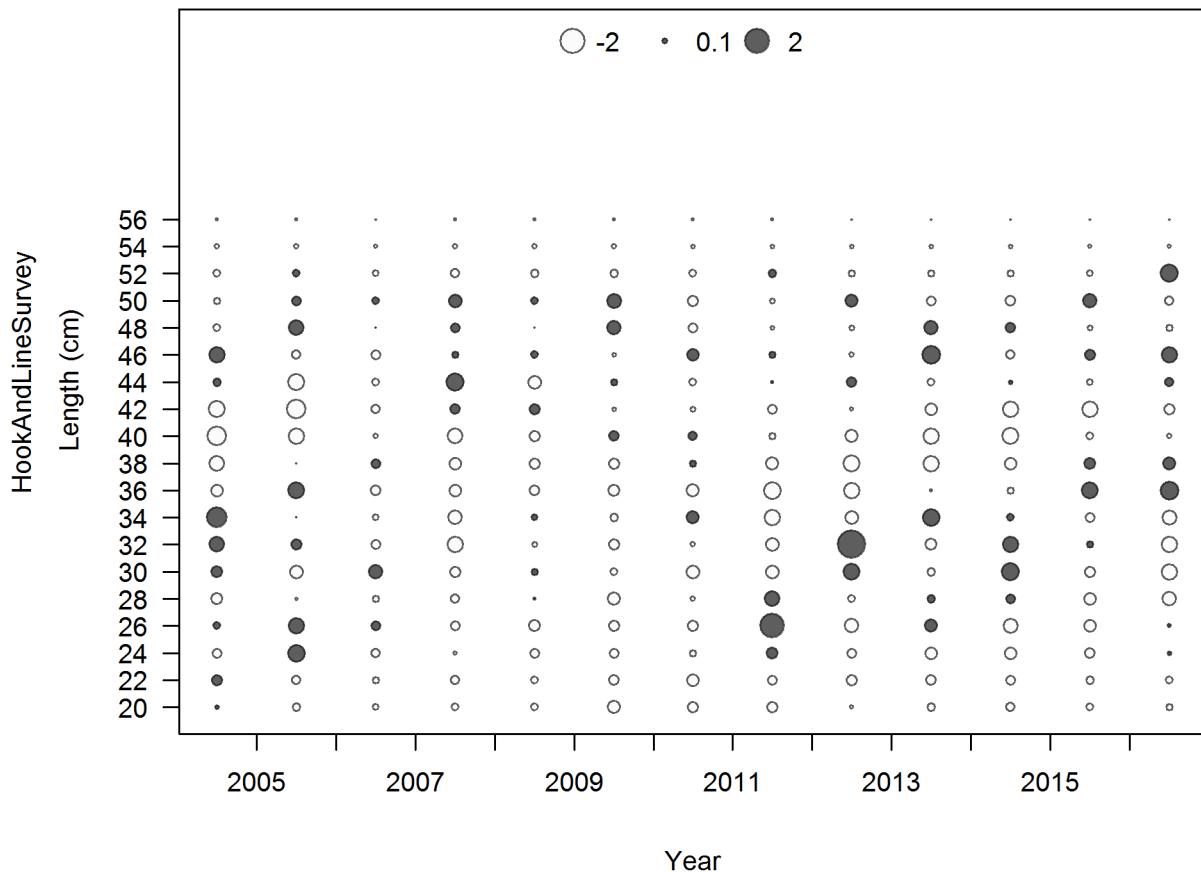


Figure 64: **Southern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, male, whole catch, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod2_24_comp_lenfit_sex3mkt0_multi-fleet_comparison](#)

676 9.3.6 Fits to age compositions for Northern model

[fits-to-age-compositions-for-northern-model](#)

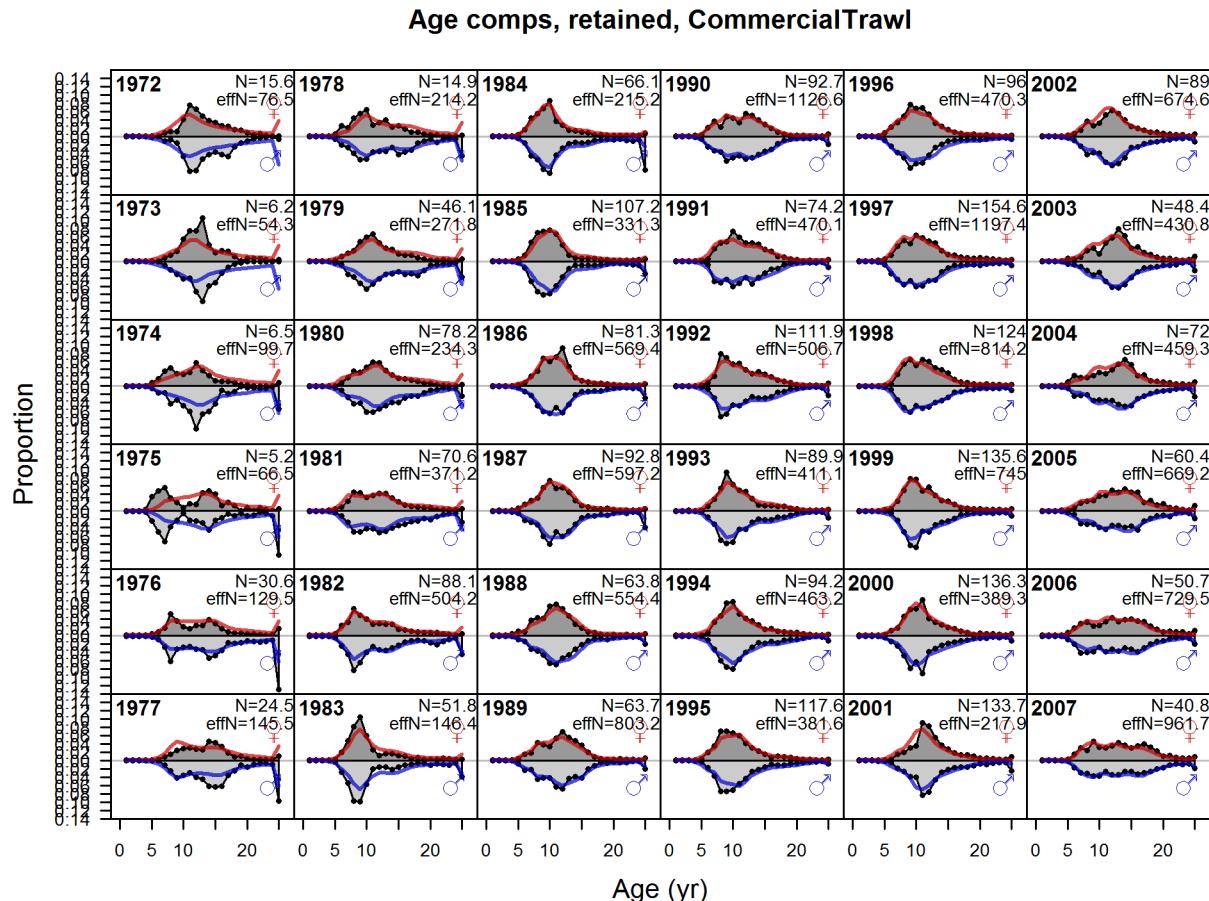
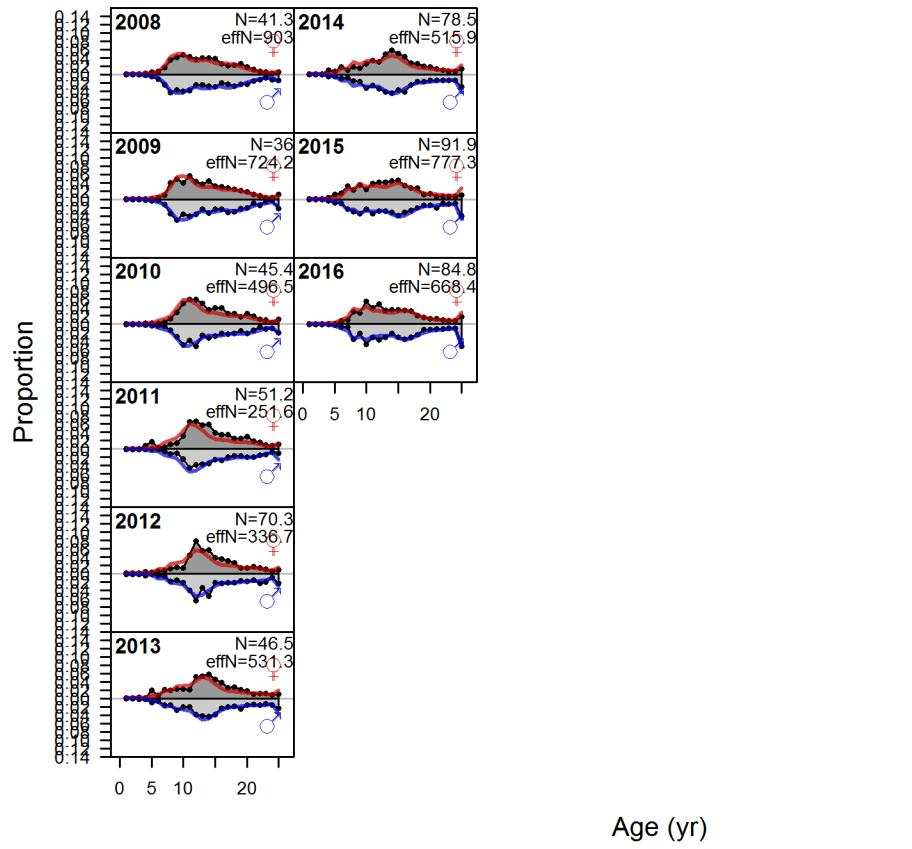


Figure 65: **Northern model** Age comps, retained, CommercialTrawl (plot 1 of 2) [fig:mod1_1_comp](#)

Age comps, retained, CommercialTrawl

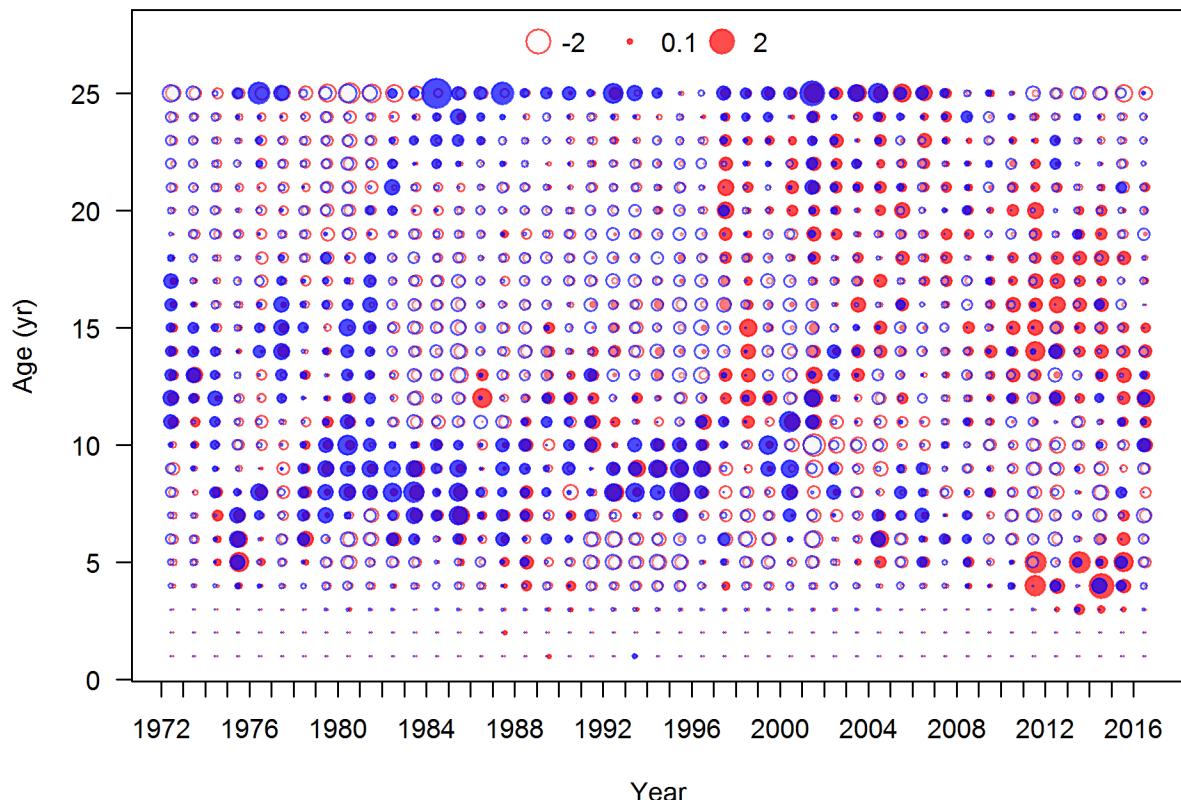


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Pearson residuals, retained, CommercialTrawl (max=2.88)



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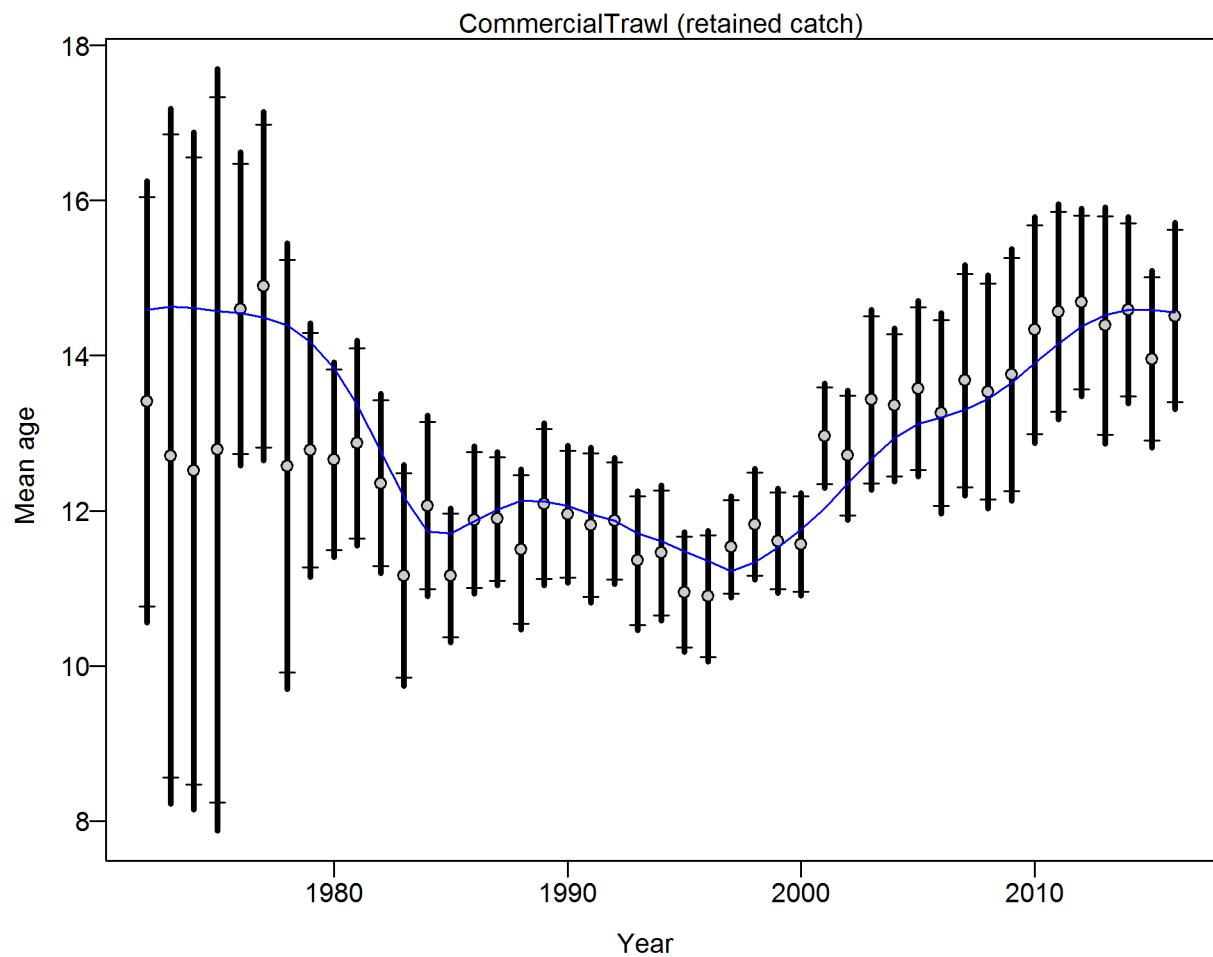


Figure 66: **Northern model** Francis data weighting method TA1.8: CommercialTrawl Suggested sample size adjustment (with 95% interval) for age data from CommercialTrawl: 1.1663 (0.7554_2.1133) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_5_comp

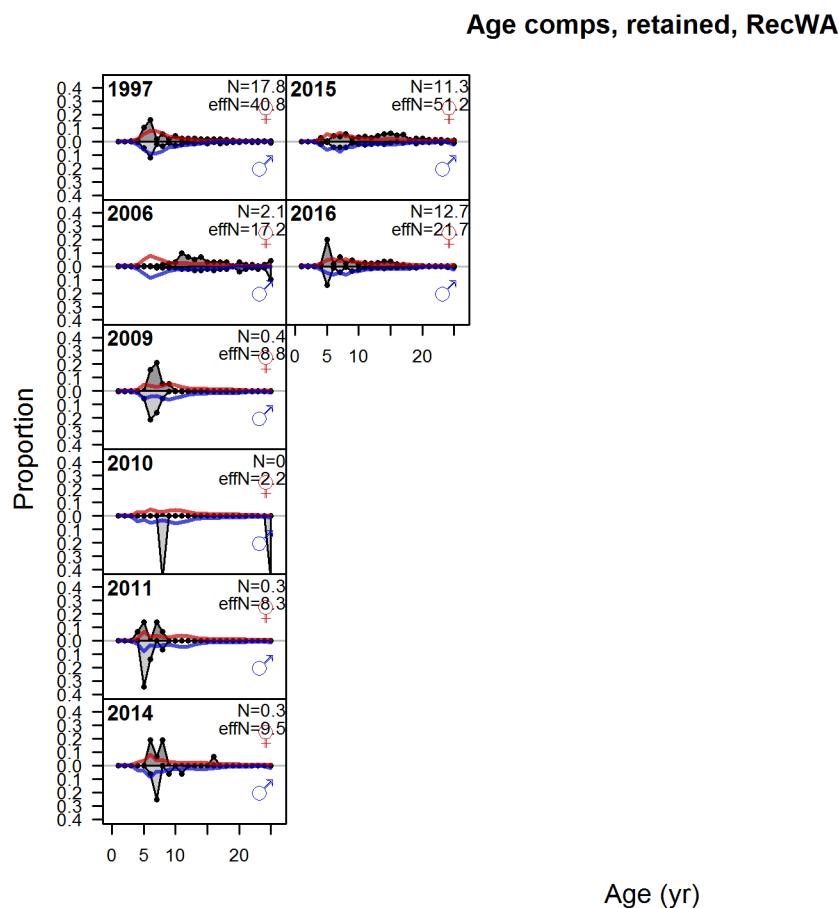


Figure 67: **Northern model** Age comps, retained, RecWA

`fig:mod1_6_comp_agefit_flt4`

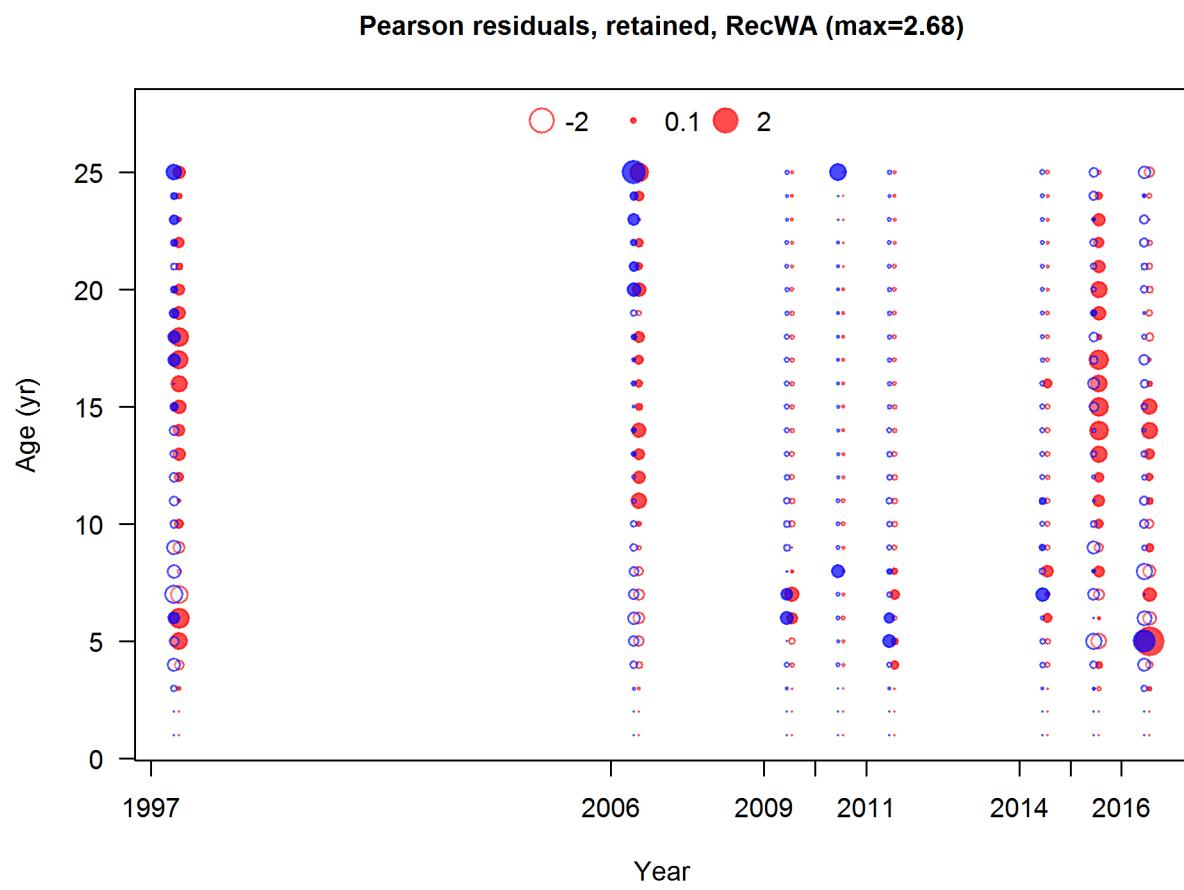


Figure 68: **Northern model** Pearson residuals, retained, RecWA (max=2.68)
 Closed bubbles are positive residuals (observed $>$ expected) and open bubbles are negative residuals (observed $<$ expected). [fig:mod1_7_comp_agefit_residsfit4mkt2](#)

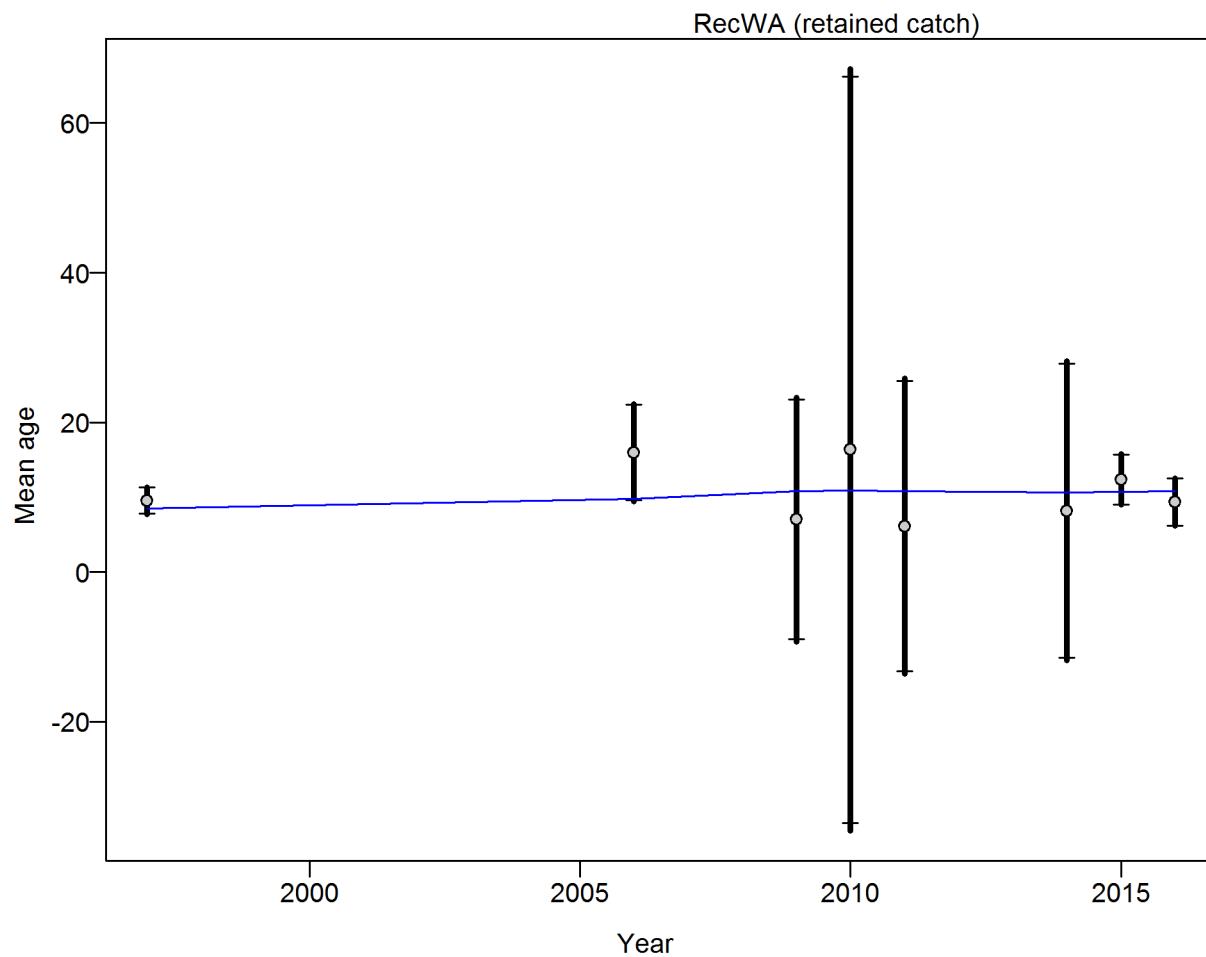


Figure 69: **Northern model** Francis data weighting method TA1.8: RecWA Suggested sample size adjustment (with 95% interval) for age data from RecWA: 1.0396 (0.6753_3.901)
For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. [fig:mod1_9_comp_agefit_data_weighting_T](#)

Age comps, retained, Triennial

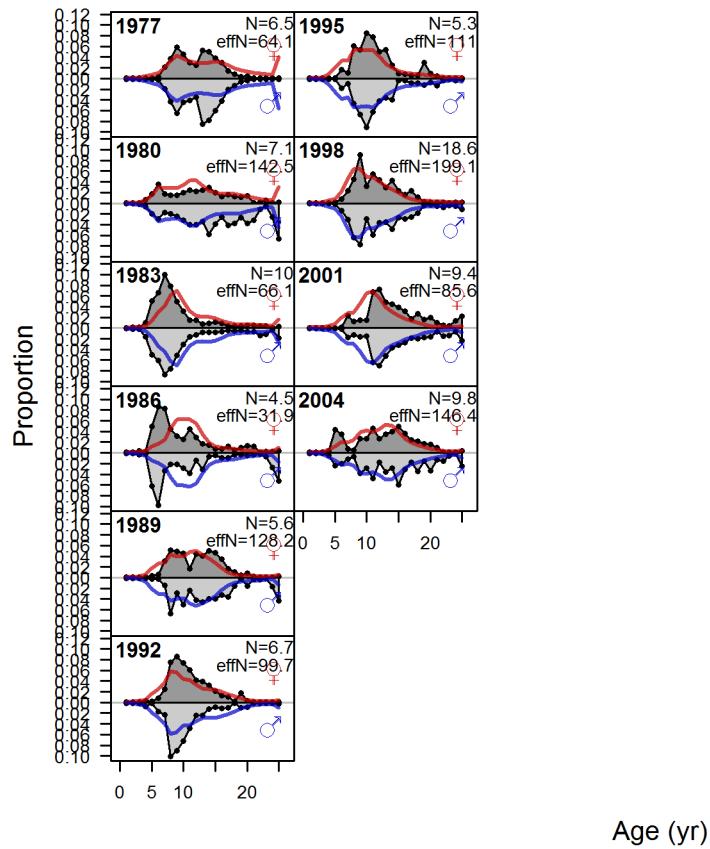


Figure 70: Northern model Age comps, retained, Triennial

`fig:mod1_10_comp_agefit_f1`

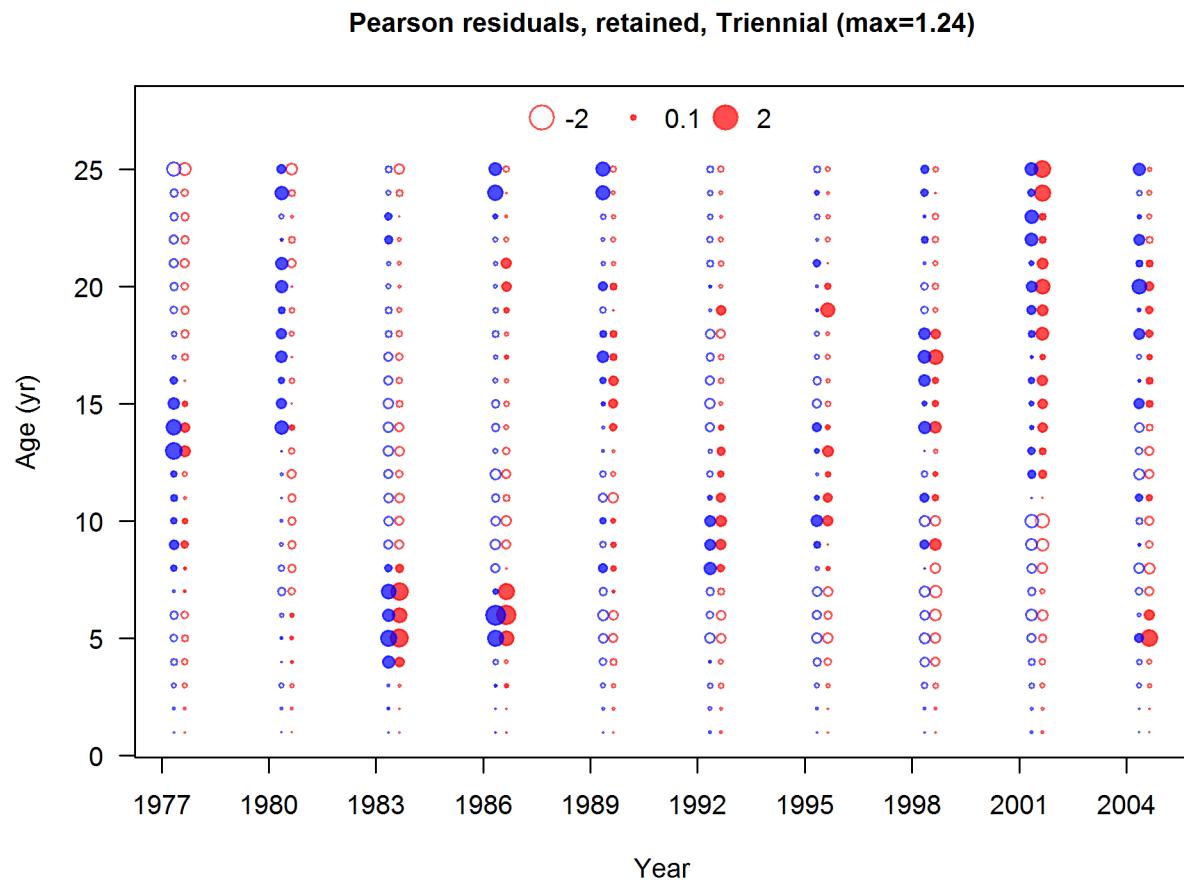


Figure 71: **Northern model** Pearson residuals, retained, Triennial (max=1.24)
 Closed bubbles are positive residuals (observed $>$ expected) and open bubbles are negative residuals (observed $<$ expected). [fig:mod1_11_comp_agefit_residsfit5mkt2](#)

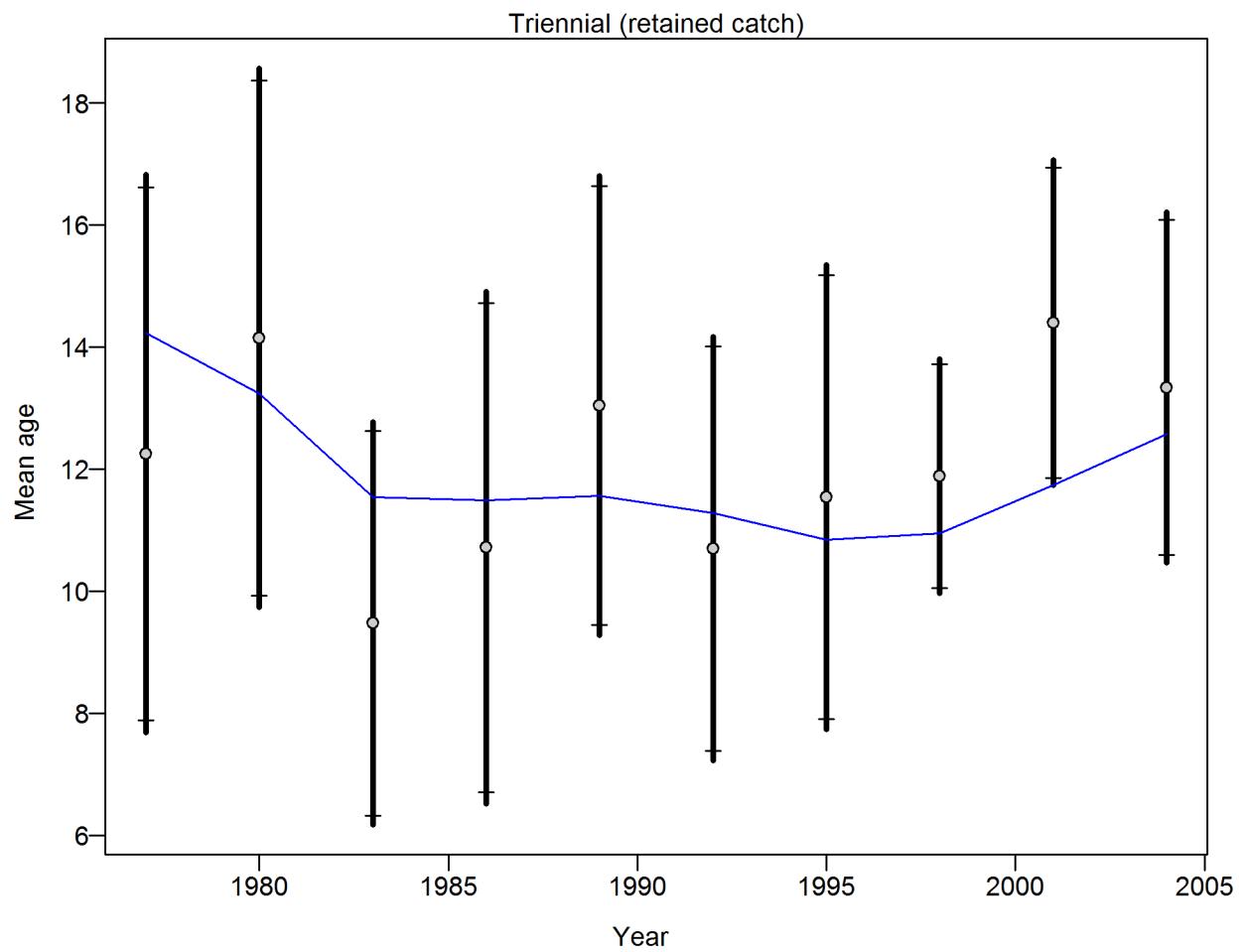


Figure 72: **Northern model** Francis data weighting method TA1.8: Triennial Suggested sample size adjustment (with 95% interval) for age data from Triennial: 1.0944 (0.6476_3.7348)
For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. [fig:mod1_13_comp_agefit_data_weighting](#)

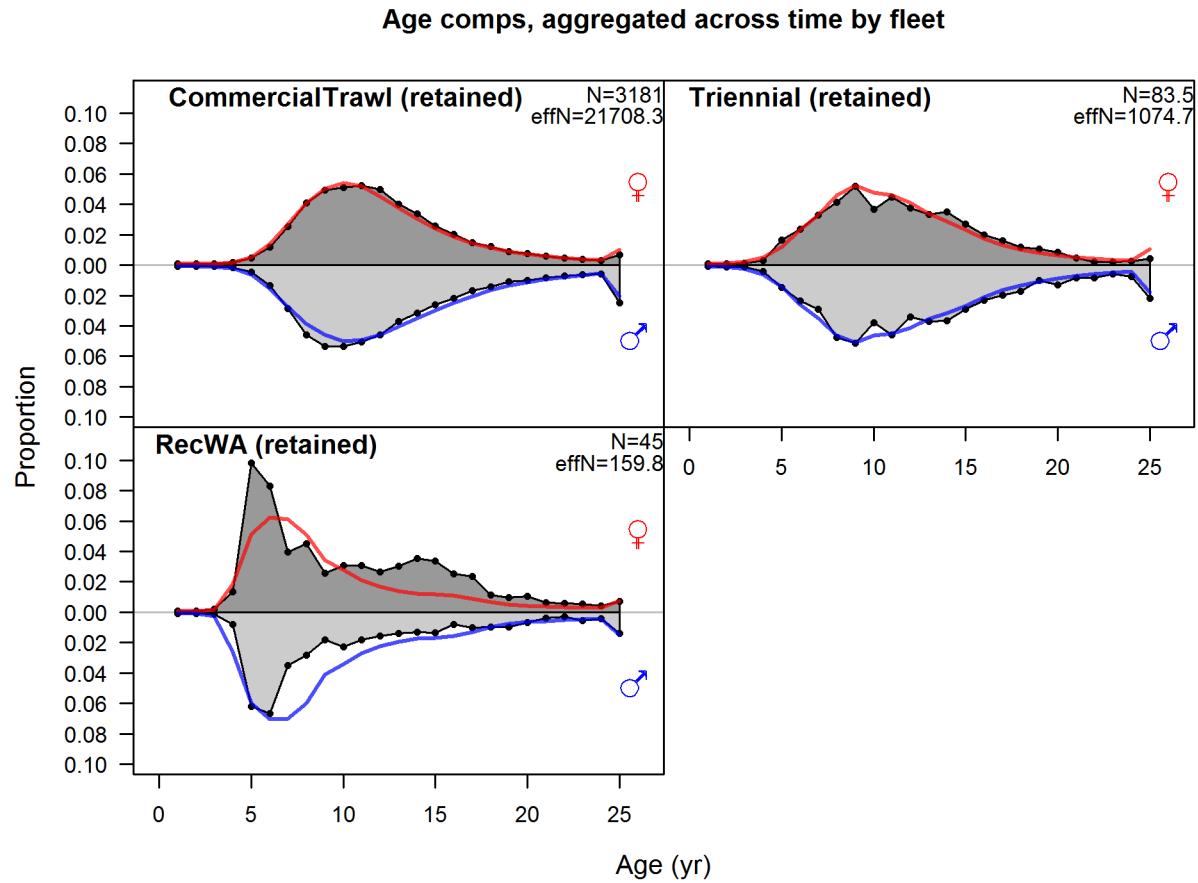


Figure 73: **Northern model** Age comps, aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch. [fig:mod1_14_comp_agefit__aggregated_across_time](#)

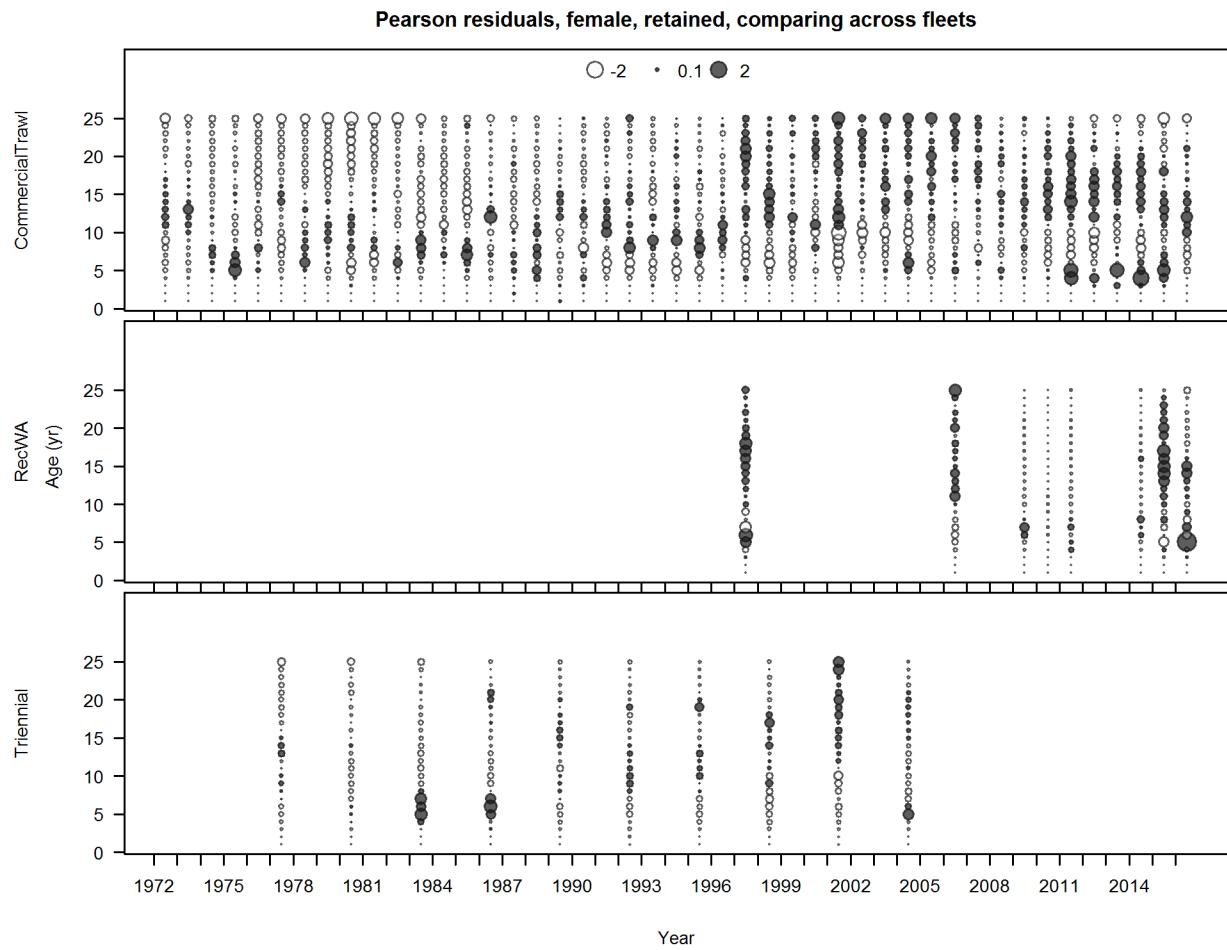


Figure 74: **Northern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, female, retained, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_15_comp_agefit_sex2mkt2_multi-fleet_comparison](#)

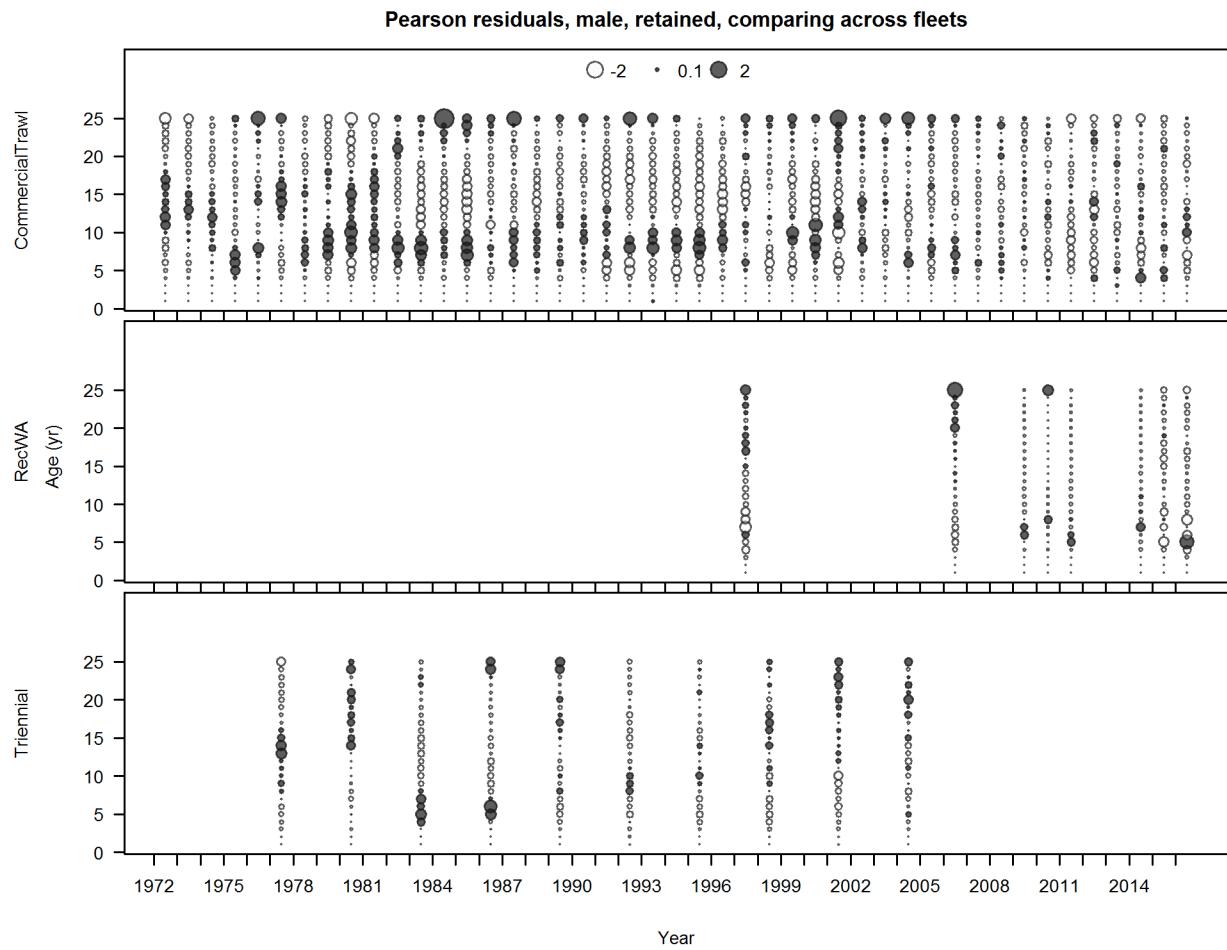


Figure 75: **Northern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, male, retained, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod1_16_comp_agefit_sex3mkt2_multi-fleet_comparison](#)

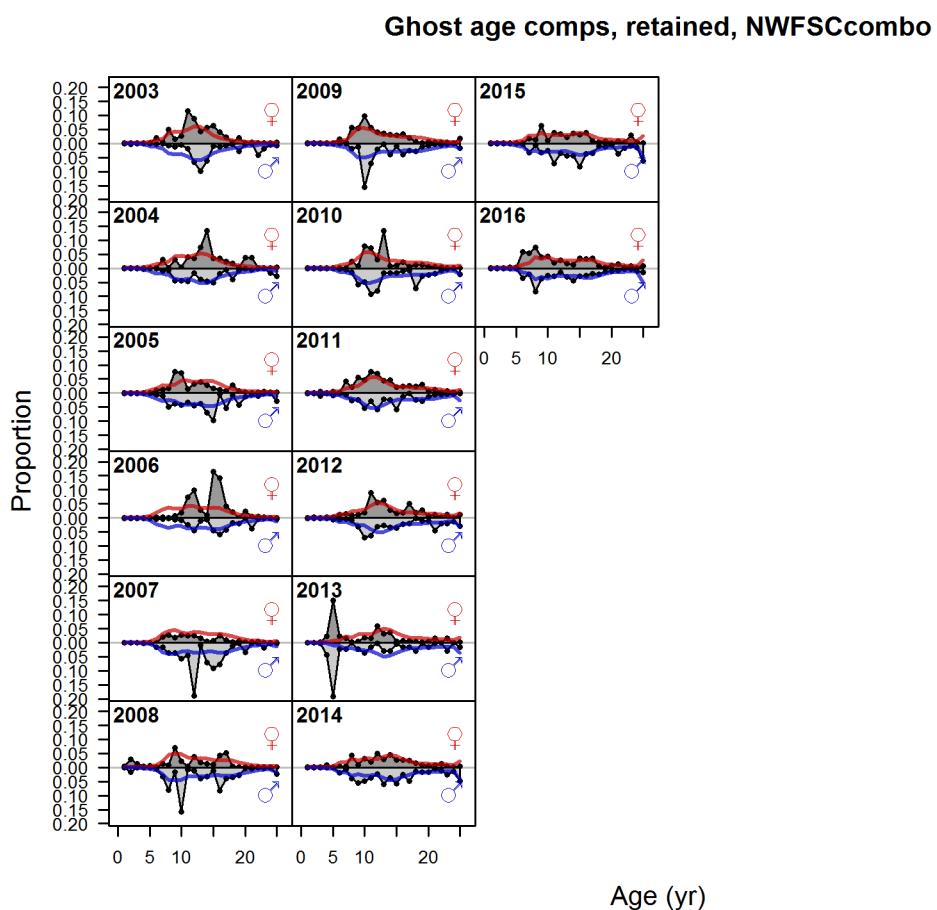


Figure 76: **Northern model** Ghost age comps, retained, NWFSCcombo fig:mod1_17_comp_gsta

Figure 77: **Northern model** Pearson residuals, retained, NWFSCcombo (max=NA)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative
residuals (observed < expected). 

681 9.3.7 Fits to conditional-age-at-length compositions for Northern model
fits-to-conditional-age-at-length-compositions-for-northern-model

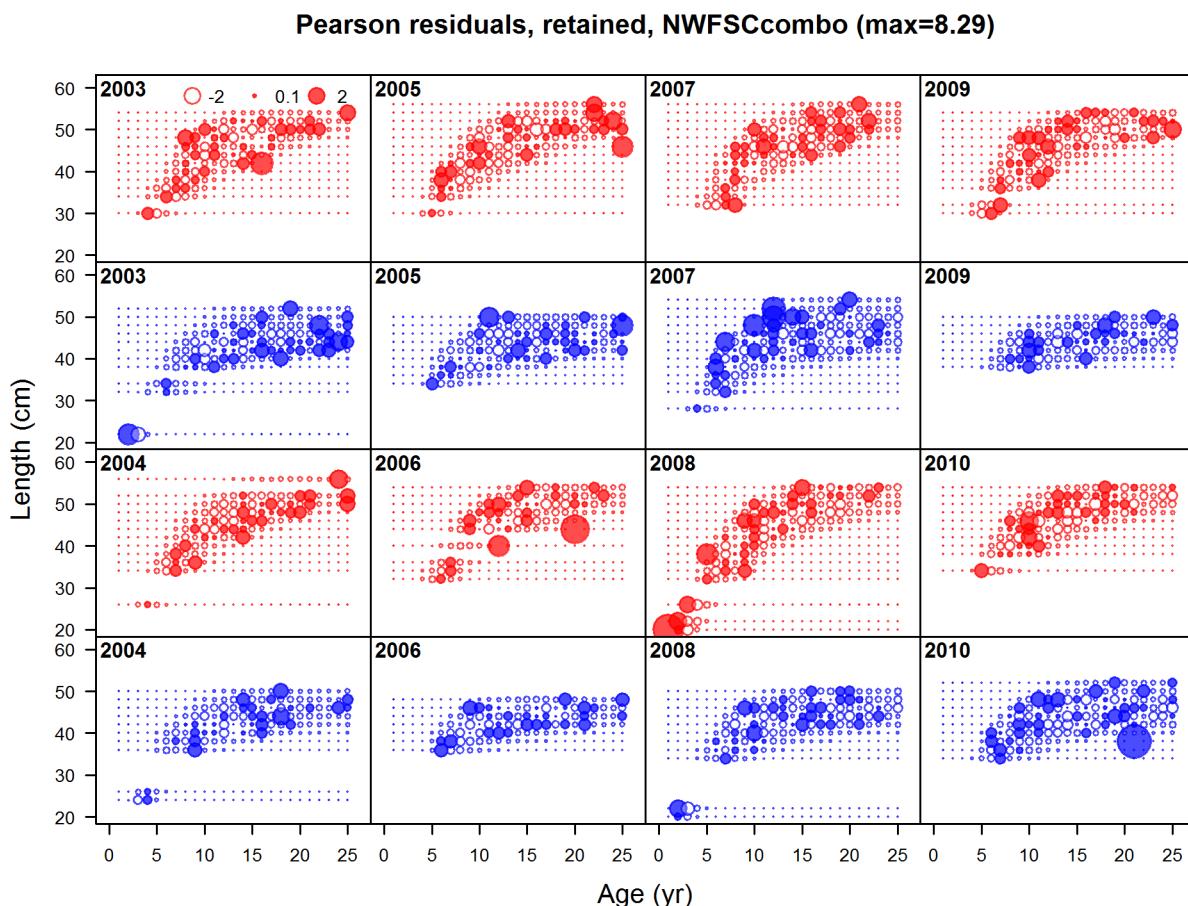
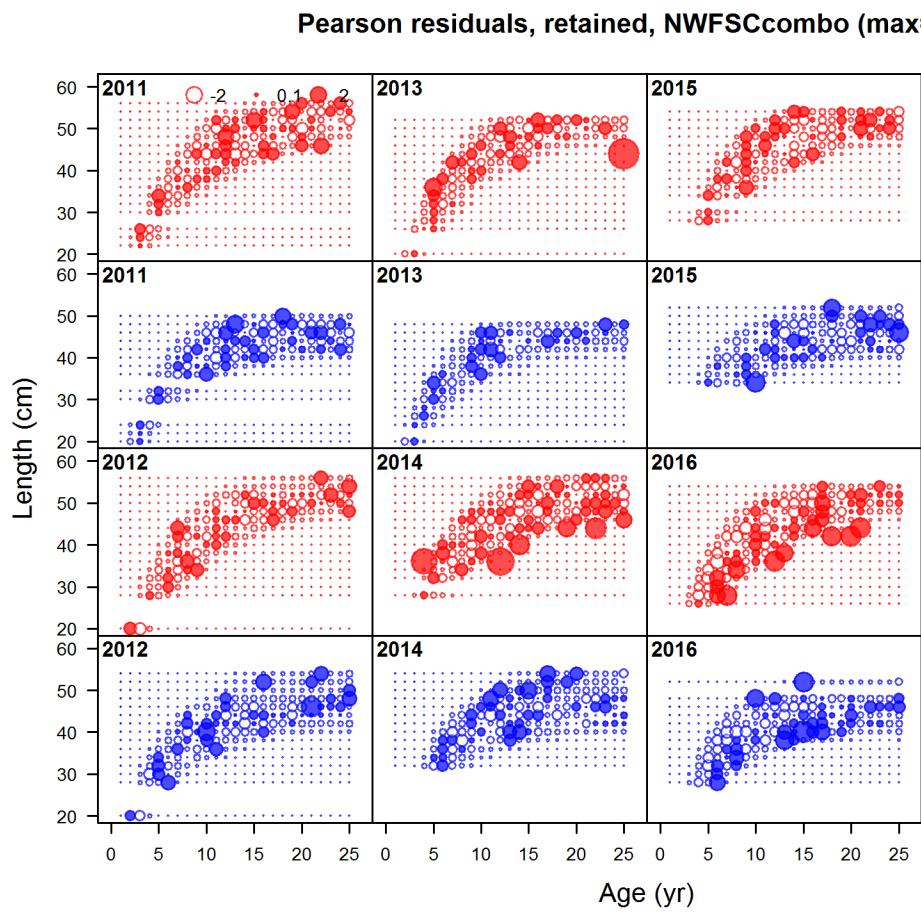


Figure 78: Northern model Pearson residuals, retained, NWFSCcombo (max=8.29) (plot 1 of 2)
fig:mod1_1_comp_condAALfit_residsfit6mkt2_page1



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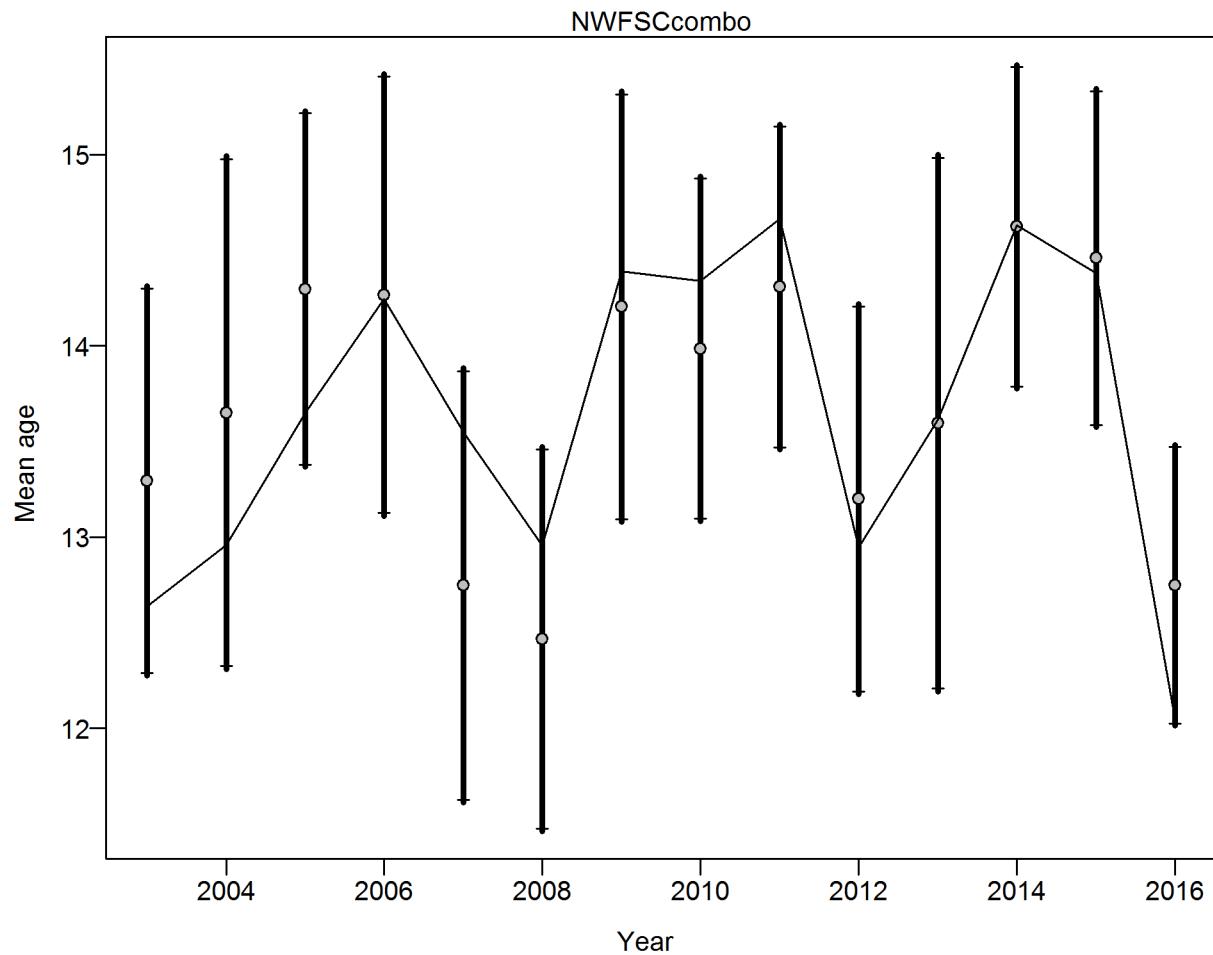


Figure 79: **Northern model** Francis data weighting method TA1.8 for conditional age data:NWFSCcombo Suggested sample size adjustment (with 95% interval) for conditional age_at_length data from NWFSCcombo: 1.0265 (0.6887_2.3764) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. | fig:mod1_3_comp_condAALfit_data_weighting_TA1.8_condAgeNWFSCcombo

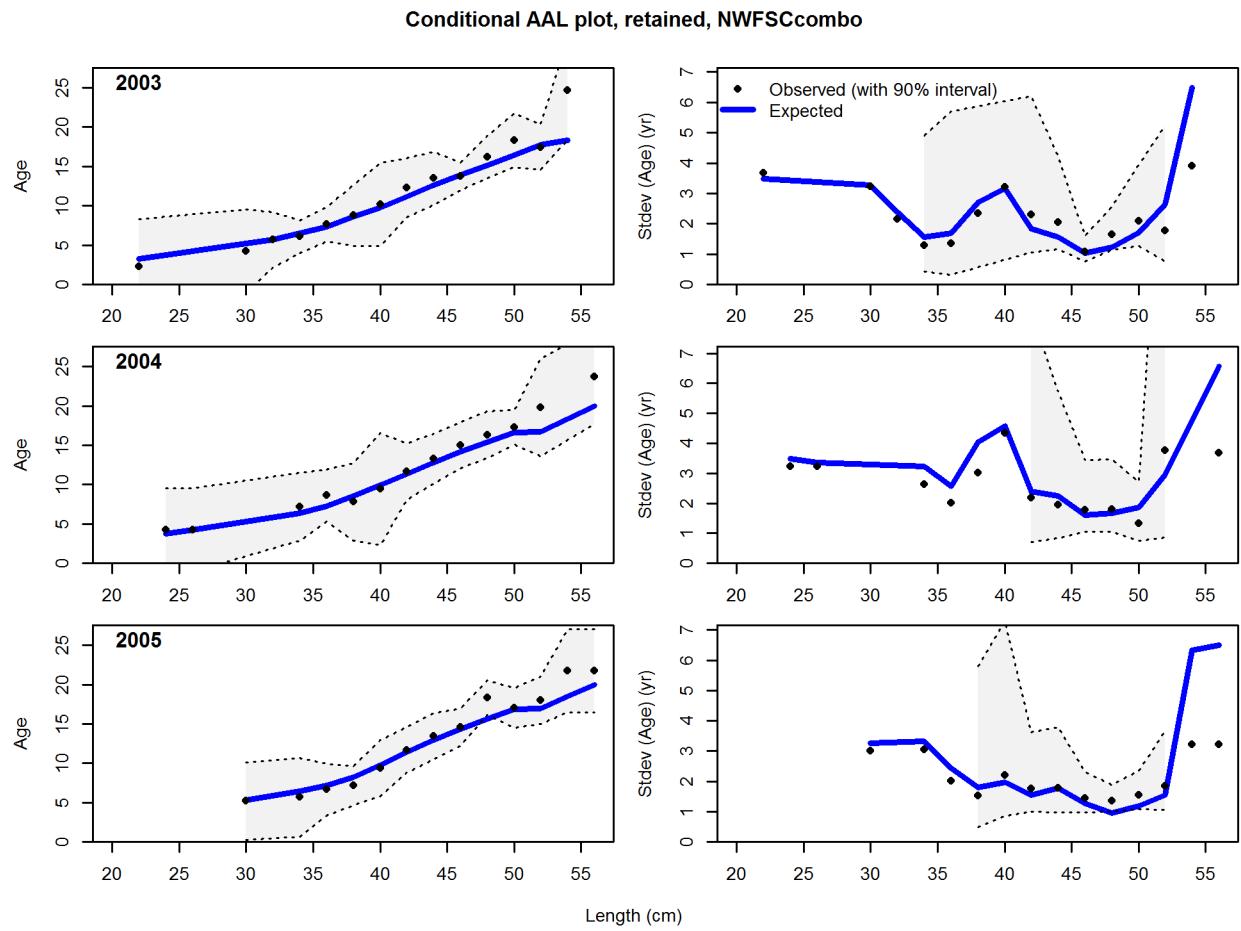
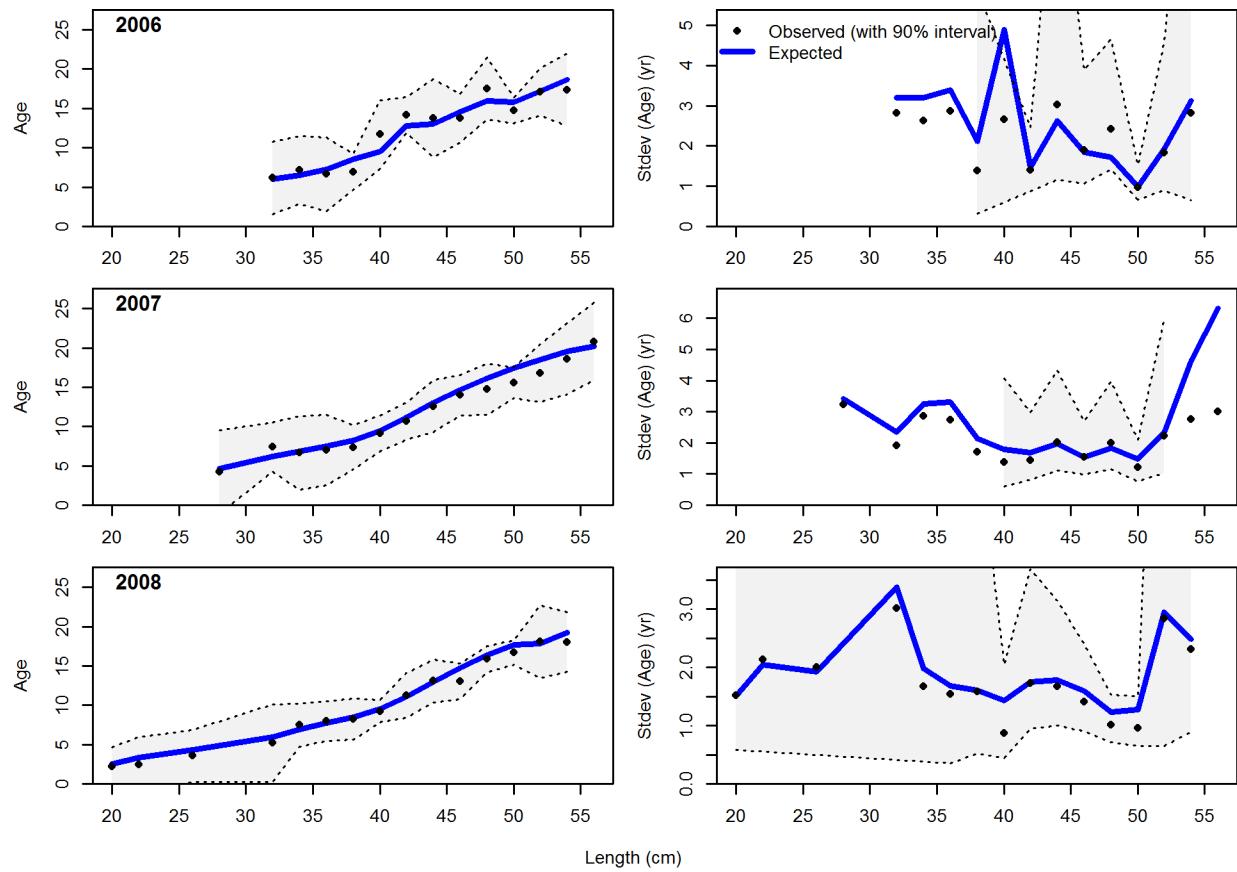


Figure 80: **Northern model** Conditional AAL plot, retained, NWFSCcombo (plot 1 of 5)
 These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution. | [fig:mod1_4_comp_condAALfitAndre_plotsf1t6mkt2_page1](#)

Conditional AAL plot, retained, NWFSCcombo

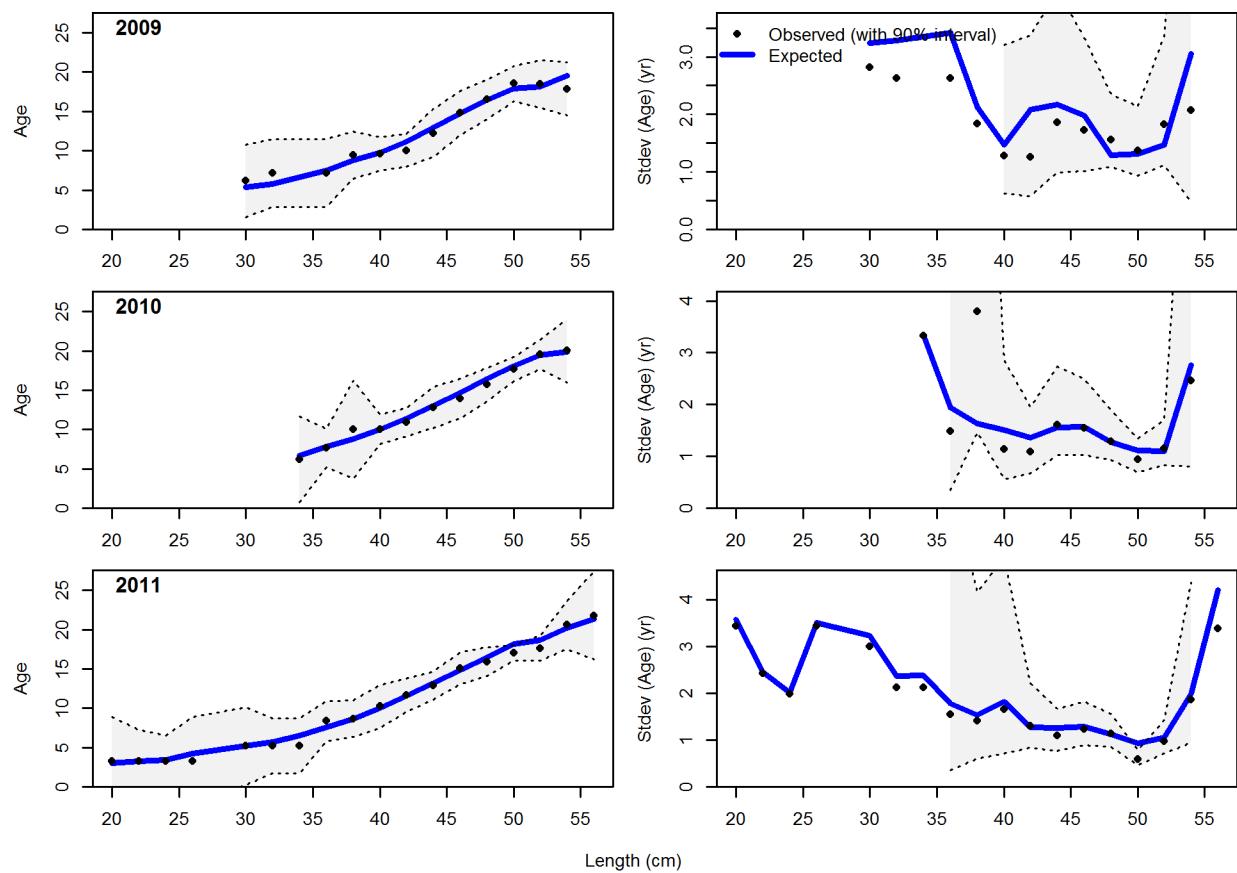


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Conditional AAL plot, retained, NWFSCcombo

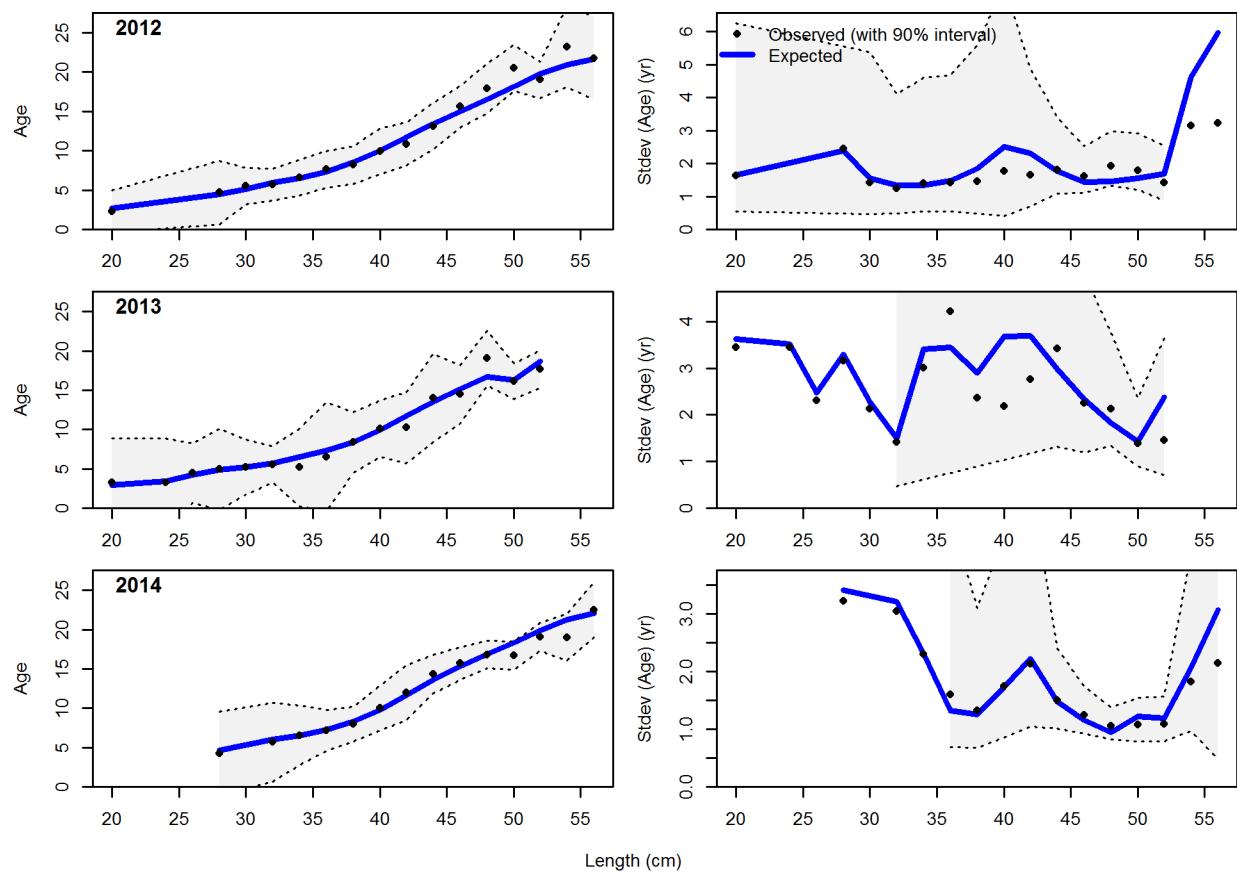


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Conditional AAL plot, retained, NWFSCcombo

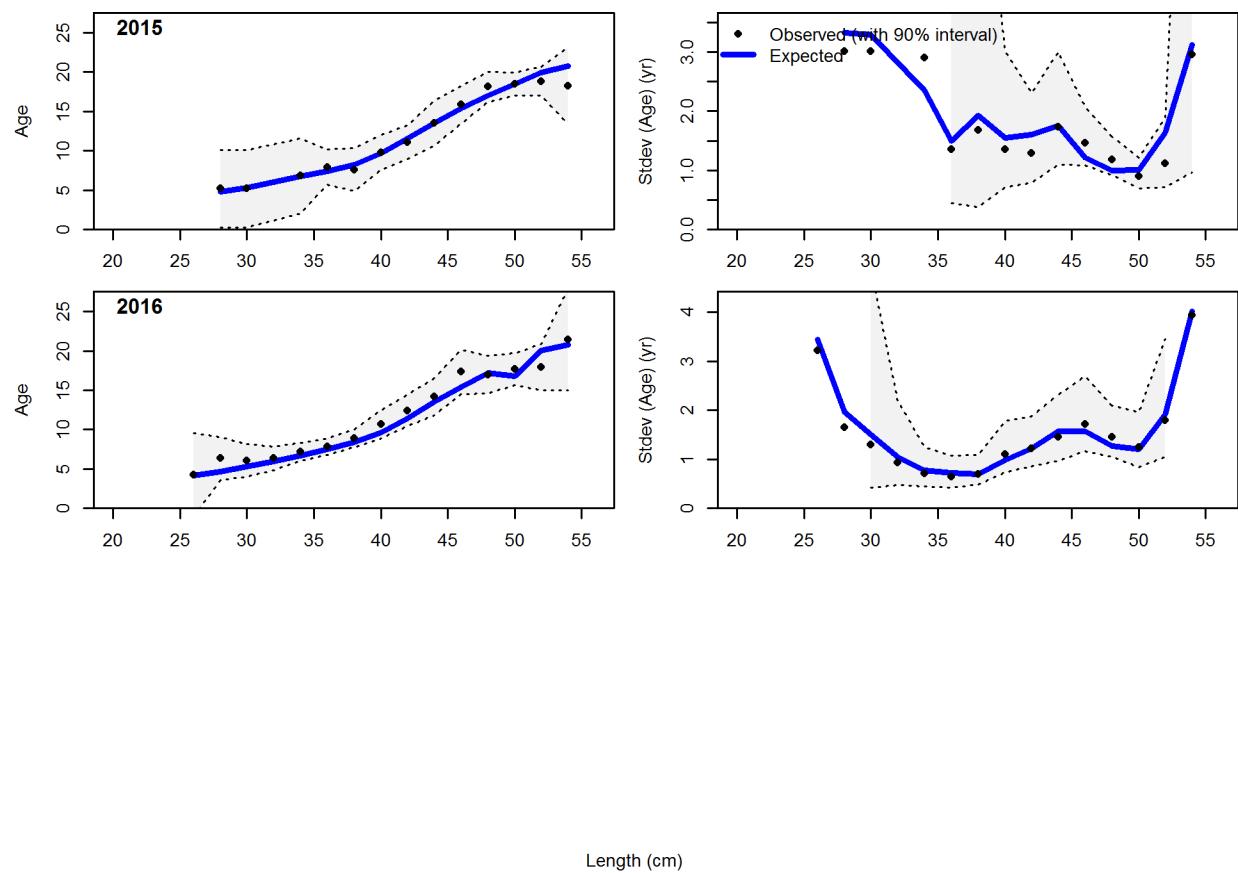


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Conditional AAL plot, retained, NWFSCcombo



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692 9.3.8 Fits to age compositions for Southern model

fits-to-age-compositions-for-southern-model

Age comps, retained, RecreationalCatch

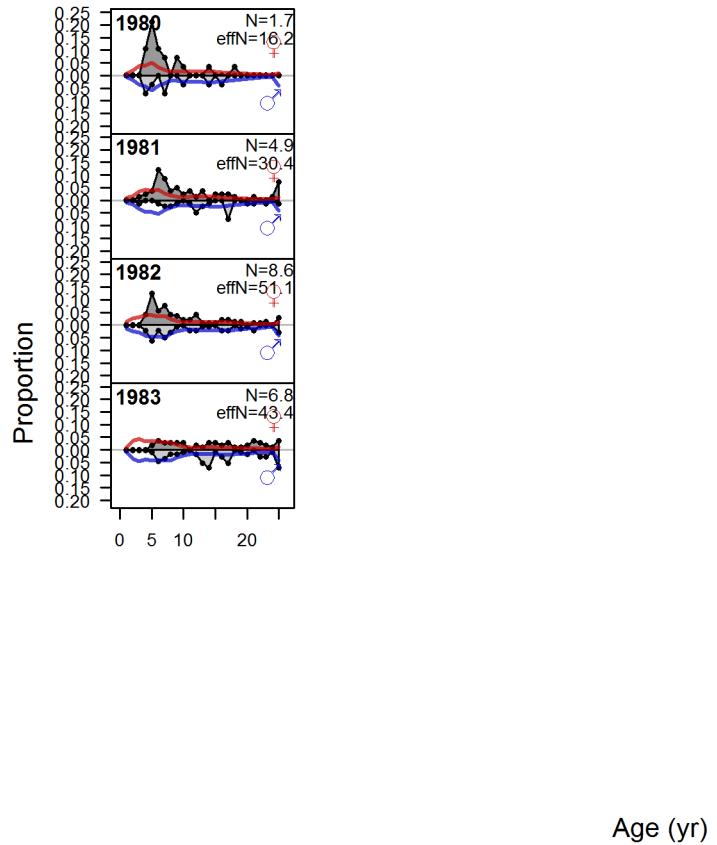


Figure 81: Southern model Age comps, retained, RecreationalCatch fig:mod2_1_comp_agefit

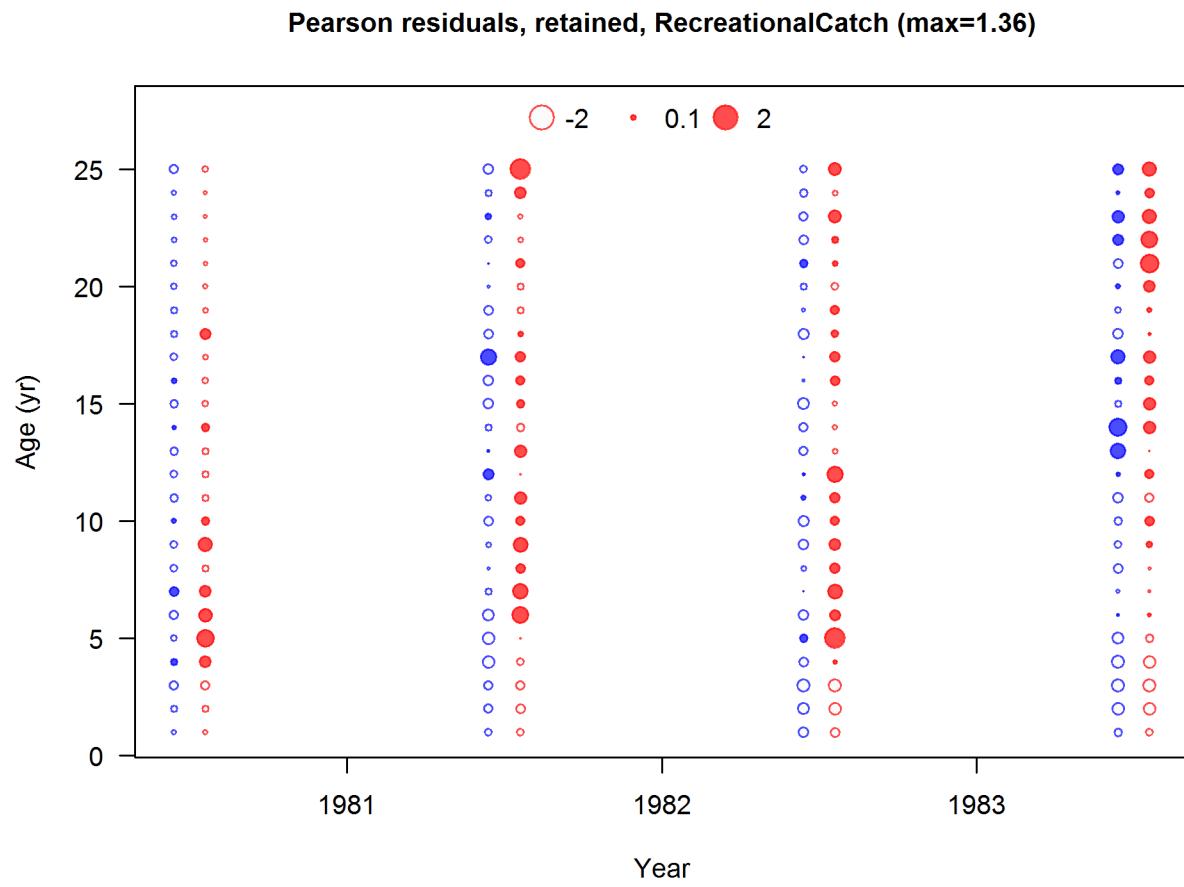


Figure 82: **Southern model** Pearson residuals, retained, RecreationalCatch (max=1.36)
 Closed bubbles are positive residuals (observed $>$ expected) and open bubbles are negative residuals (observed $<$ expected). [fig:mod2_2_comp_agefit_residsfit1mkt2](#)

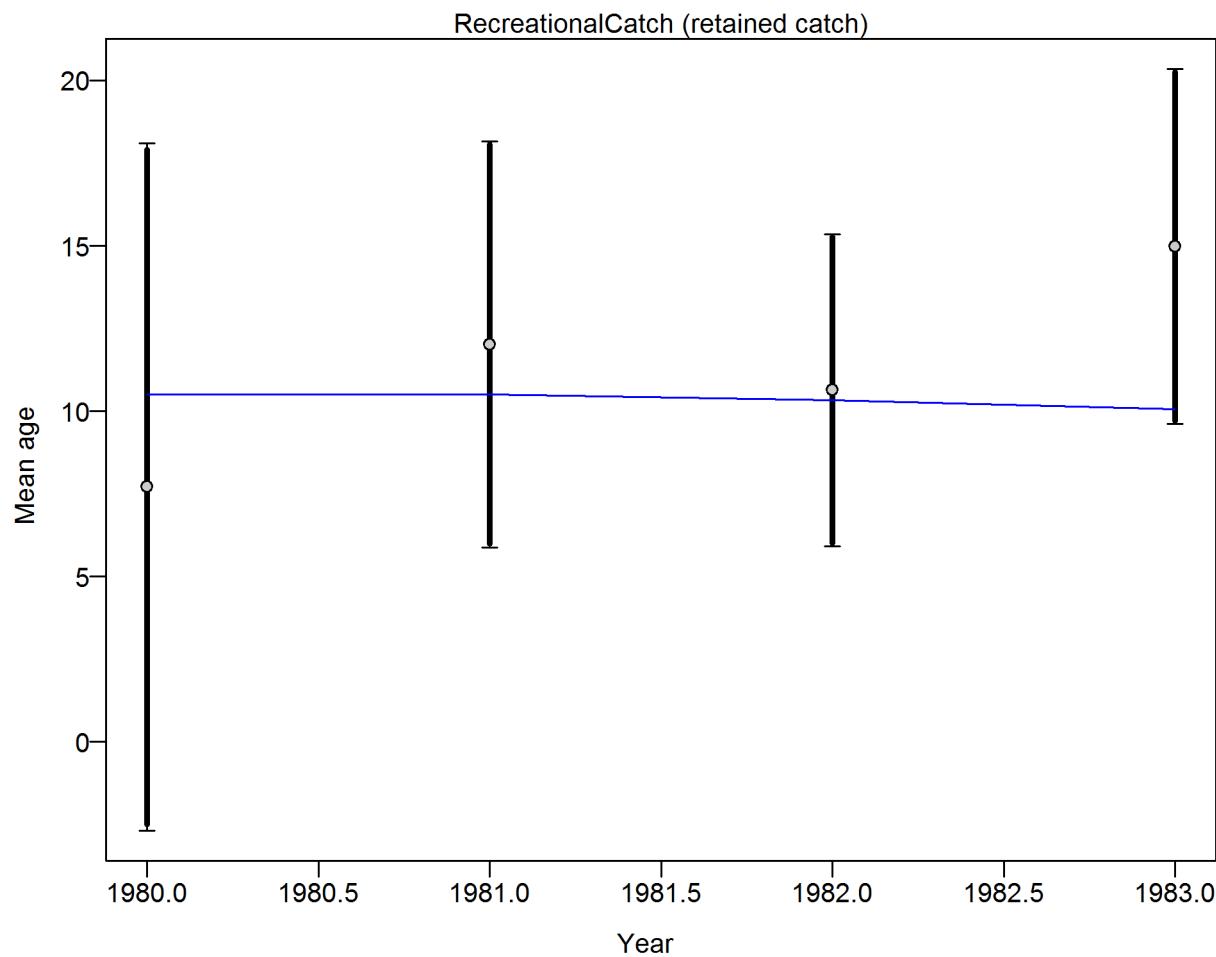


Figure 83: **Southern model** Francis data weighting method TA1.8: RecreationalCatch Suggested sample size adjustment (with 95% interval) for age data from RecreationalCatch: 0.9648 (0.5135_28.2193) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod2_4_comp

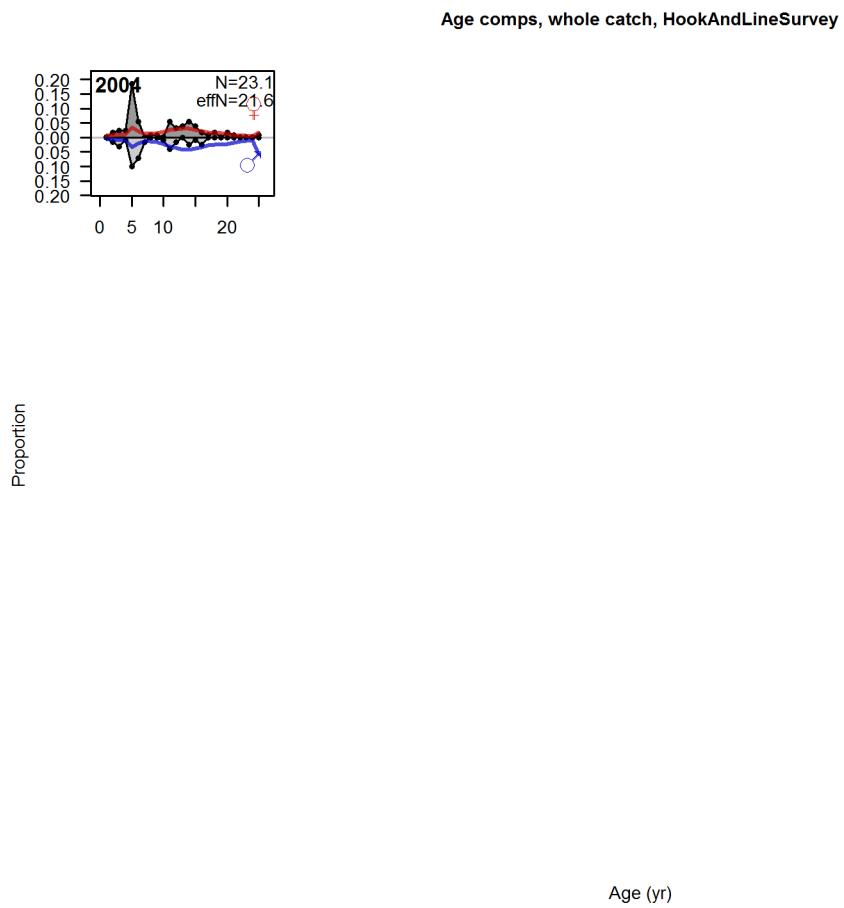


Figure 84: **Southern model** Age comps, whole catch, HookAndLineSurvey `fig:mod2_5_comp_age`

Pearson residuals, whole catch, HookAndLineSurvey (max=4.02)

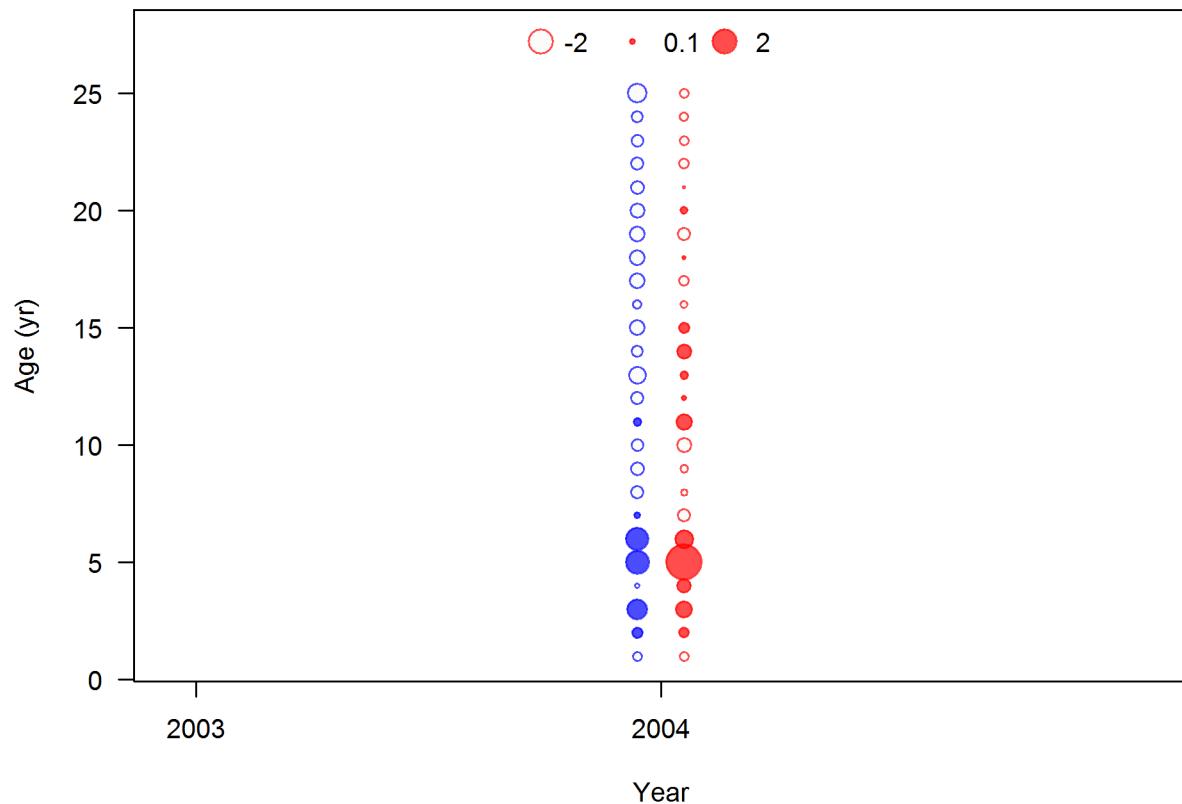


Figure 85: **Southern model** Pearson residuals, whole catch, HookAndLineSurvey (max=4.02)

Closed bubbles are positive residuals ($\text{observed} > \text{expected}$) and open bubbles are negative residuals ($\text{observed} < \text{expected}$). [fig:mod2_6_comp_agefit_residsflt4mkt0](#)

Figure 86: **Southern model** Francis data weighting method TA1.8: HookAndLineSurvey
Too few points to calculate adjustments For more info, see Francis, R.I.C.C. (2011). Data
weighting in statistical fisheries stock assessment models. *Can. J. Fish. Aquat. Sci.* 68:
[fig:mod2_8_comp_agefit_data_weighting_TA1.8_HookAndLineSurvey](#)
1124–1138. |

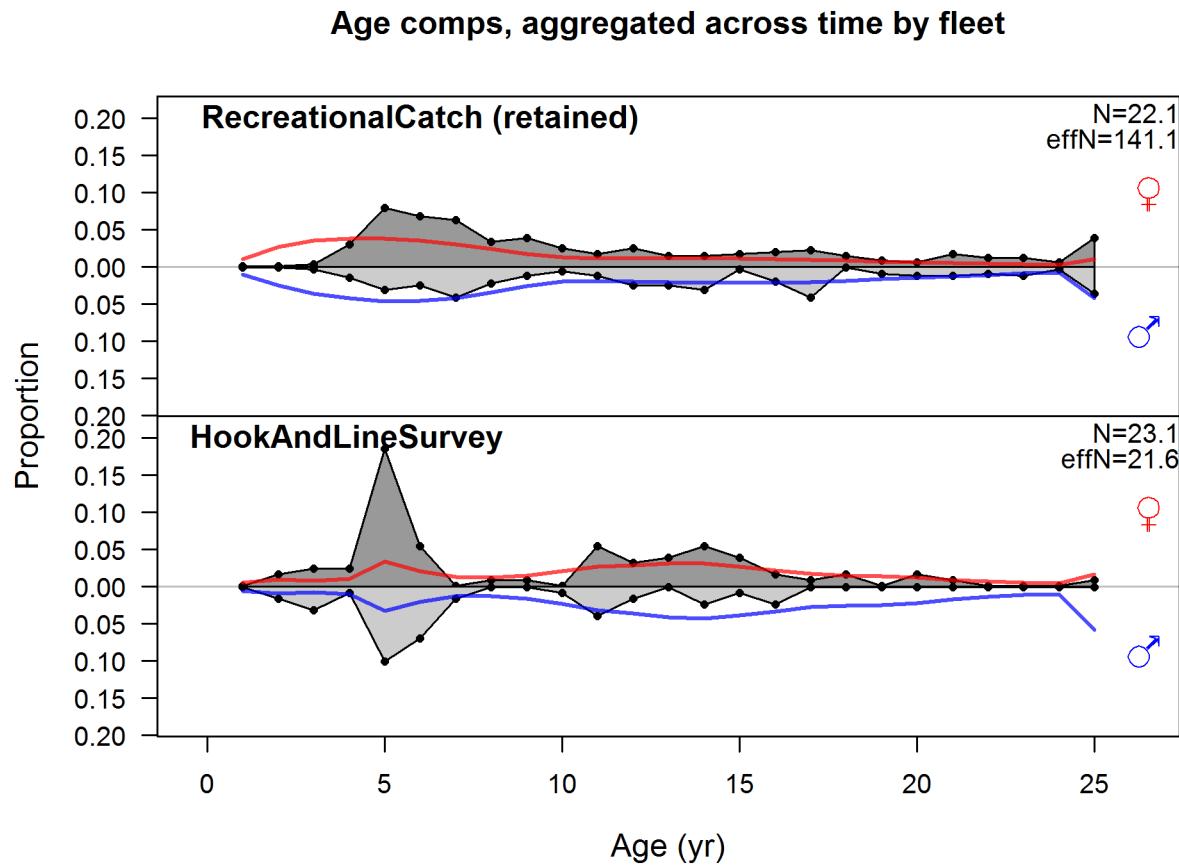


Figure 87: **Southern model** Age comps, aggregated across time by fleet. Labels ‘retained’ and ‘discard’ indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch. [fig:mod2_9_comp_agerfit__aggregated_across_time](#)

Pearson residuals, female, retained, comparing across fleets

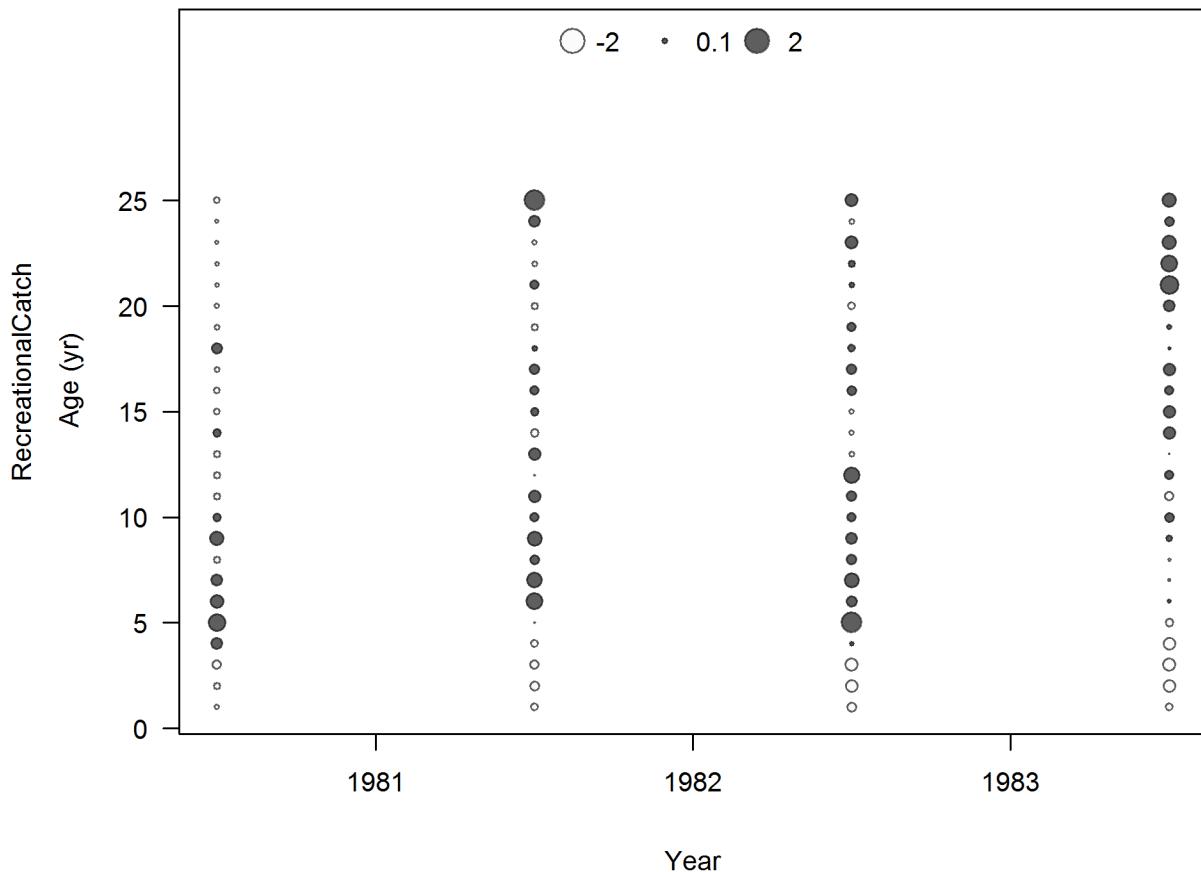


Figure 88: **Southern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, female, retained, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod2_10_comp_agefit_sex2mkt2_multi-fleet_comparison](#)

Pearson residuals, female, whole catch, comparing across fleets

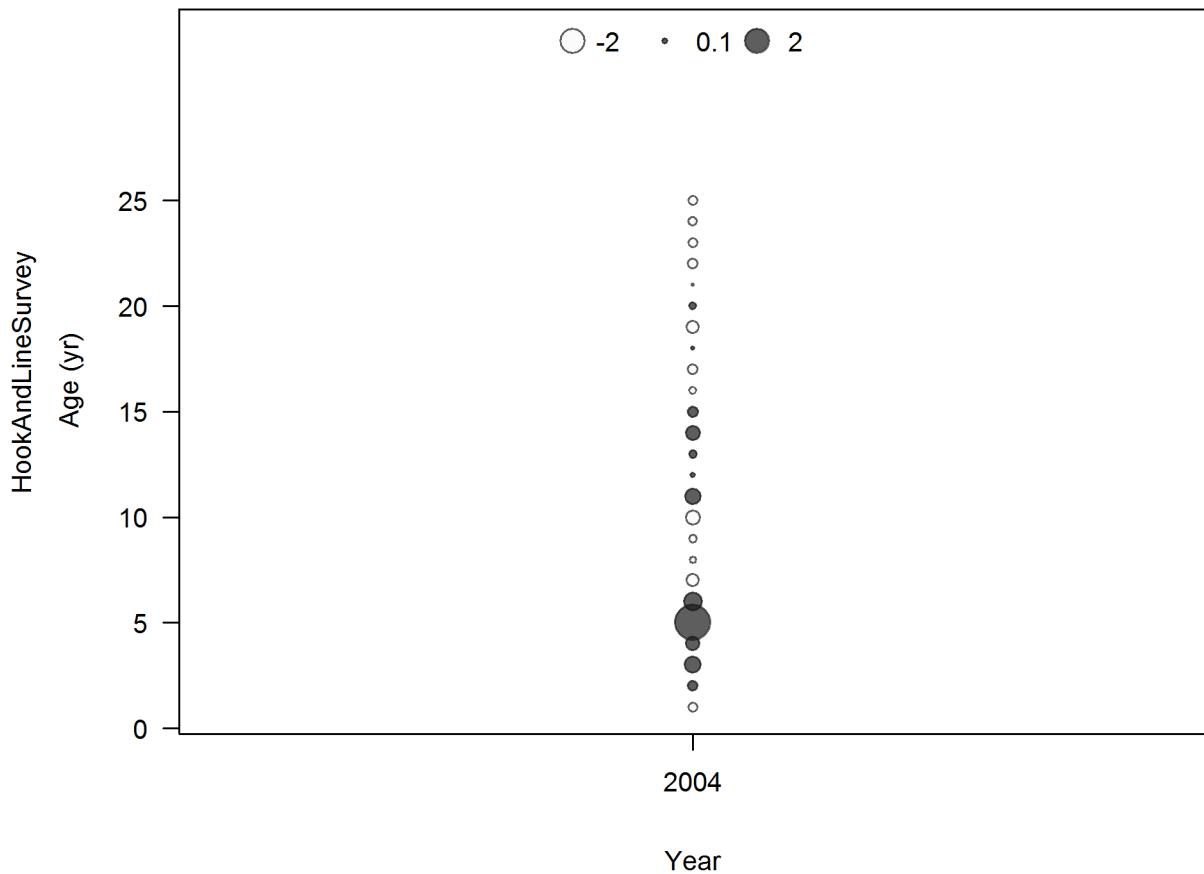


Figure 89: **Southern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, female, whole catch, comparing across fleets
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod2_11_comp_ägefit_sex2mkt0_multi-fleet_comparison](#)

Pearson residuals, male, retained, comparing across fleets

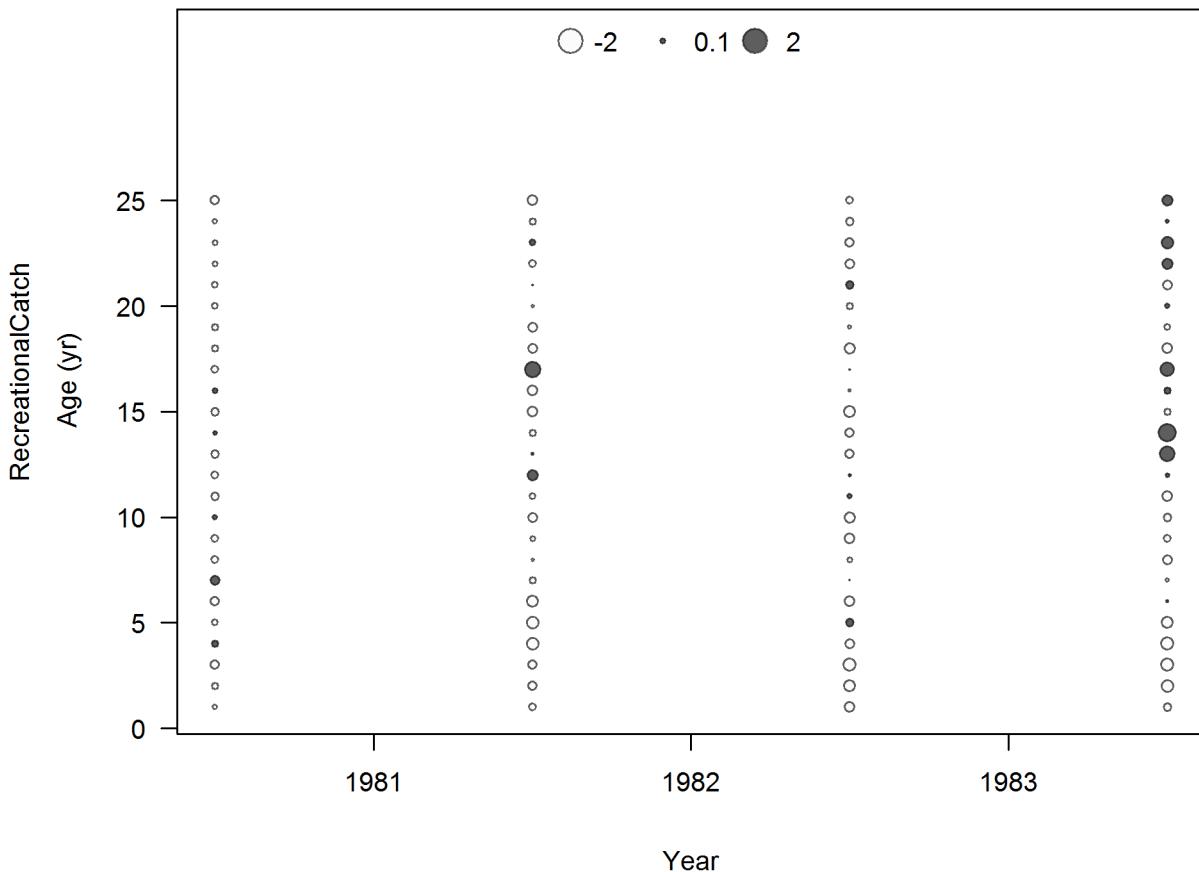


Figure 90: **Southern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, male, retained, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod2_12_comp_agefit_sex3mkt2_multi-fleet_comparison](#)

Pearson residuals, male, whole catch, comparing across fleets

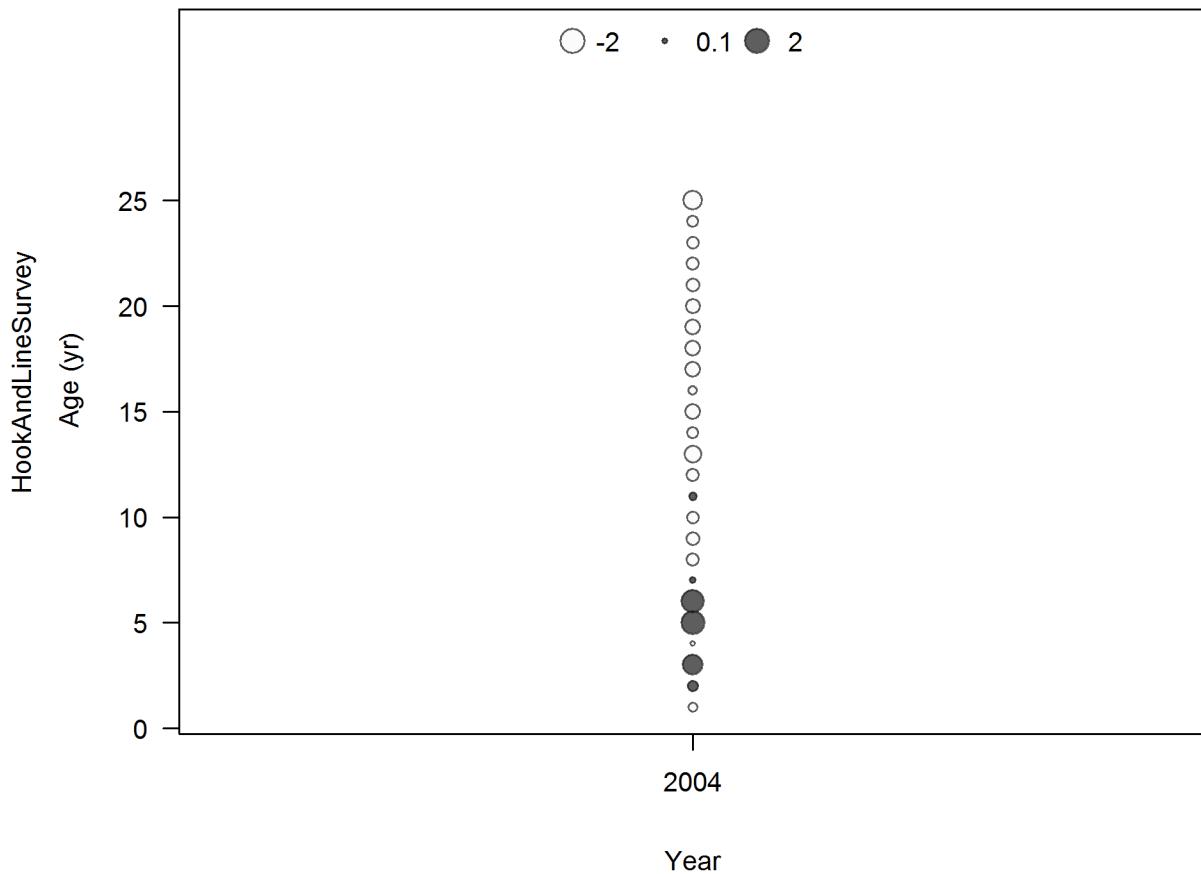


Figure 91: **Southern model** Note: this plot doesn't seem to be working right for some models. Pearson residuals, male, whole catch, comparing across fleets
 Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). [fig:mod2_13_comp_agefit_sex3mkt0_multi-fleet_comparison](#)

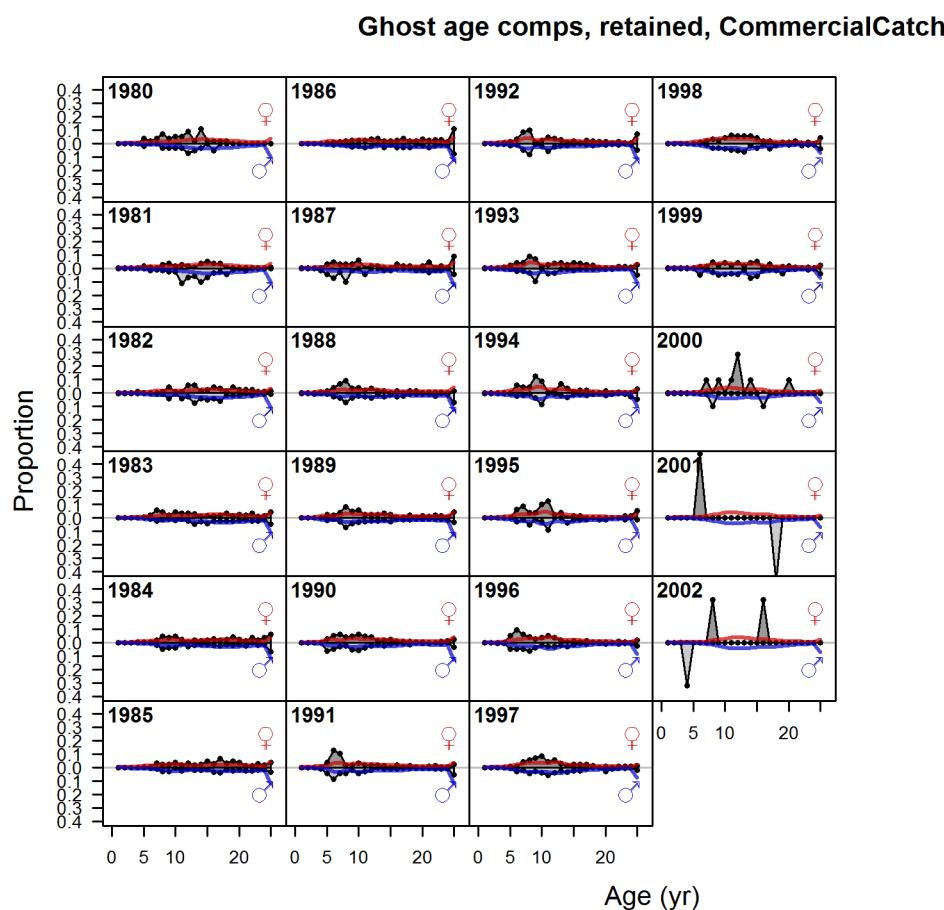


Figure 92: Southern model Ghost age comps, retained, CommercialCatch fig:mod2_14_comp_gs

Figure 93: **Southern model** Pearson residuals, retained, CommercialCatch (max=NA)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative
residuals (observed < expected). 

693 9.3.9 Fits to conditional-age-at-length compositions for Southern model
fits-to-conditional-age-at-length-compositions-for-southern-model

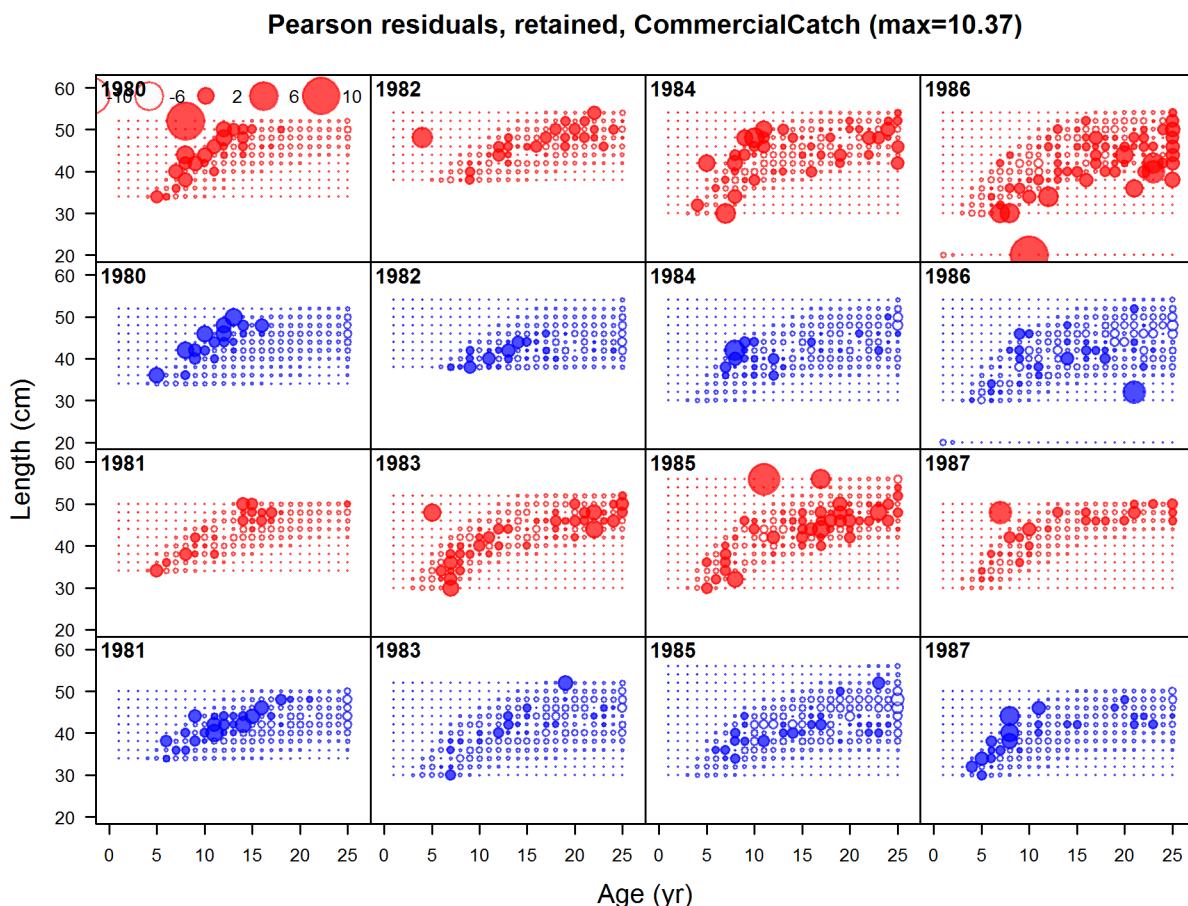
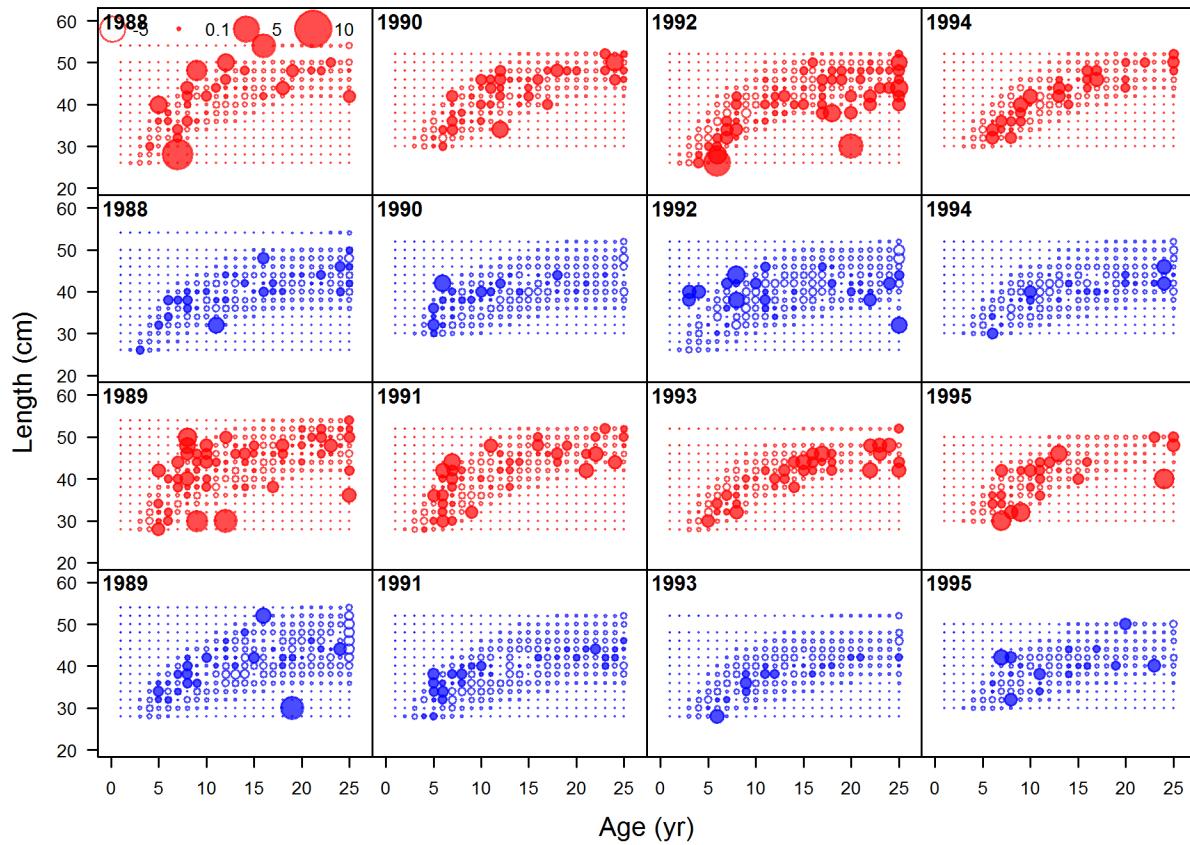


Figure 94: **Southern model** Pearson residuals, retained, CommercialCatch (max=10.37)
(plot 1 of 3) | fig:mod2_1_comp_condAALfit_residsfilt2mkt2_page1

Pearson residuals, retained, CommercialCatch (max=10.37)

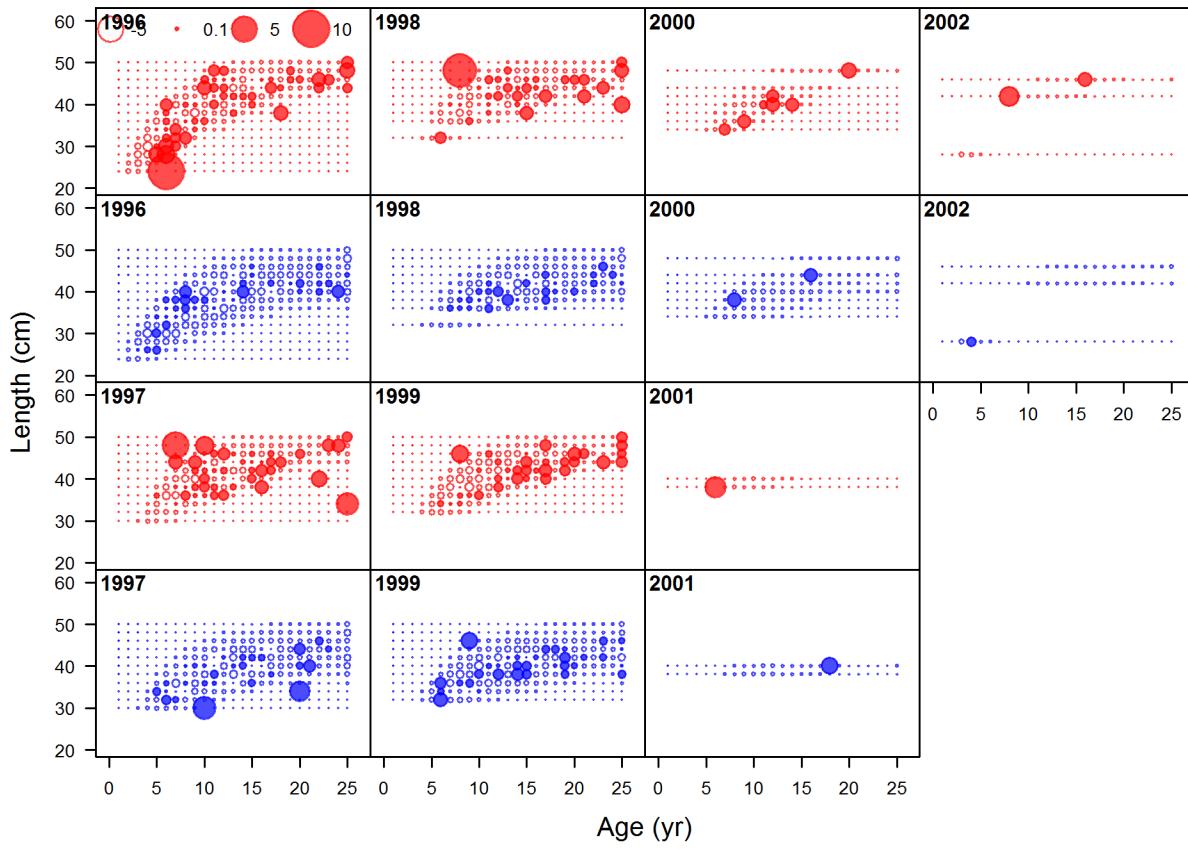


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Pearson residuals, retained, CommercialCatch (max=10.37)



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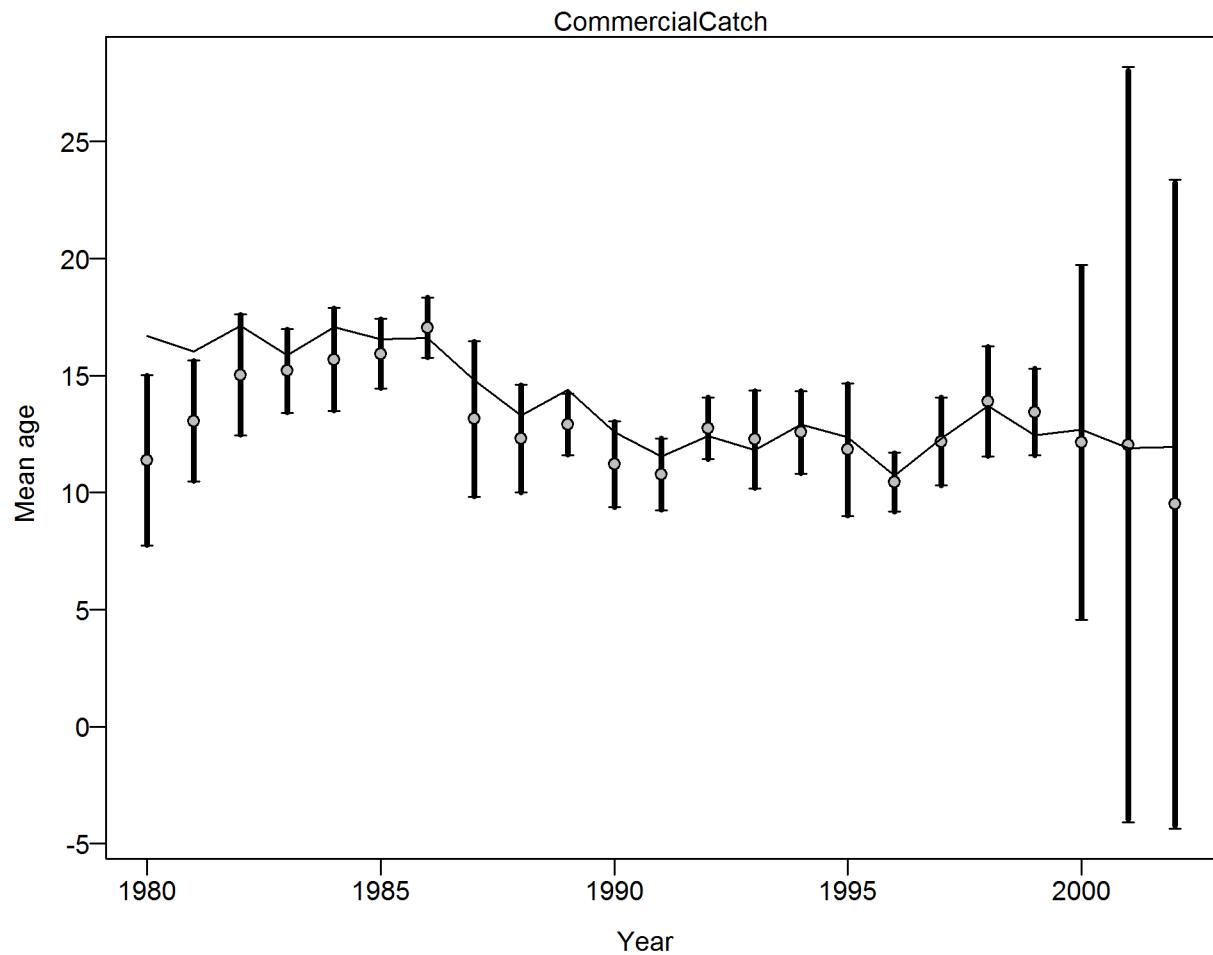


Figure 95: **Southern model** Francis data weighting method TA1.8 for conditional age data:[CommercialCatch](#) Suggested sample size adjustment (with 95% interval) for conditional age_at_length data from CommercialCatch: 0.9816 (0.6227_2.2389) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. [Can. J. Fish. Aquat. Sci.](#) 68: 1124_1138. | [fig:mod2_4_comp_condAALfit_data_weighting_TA1.8_condAgeCommercialCatch](#)

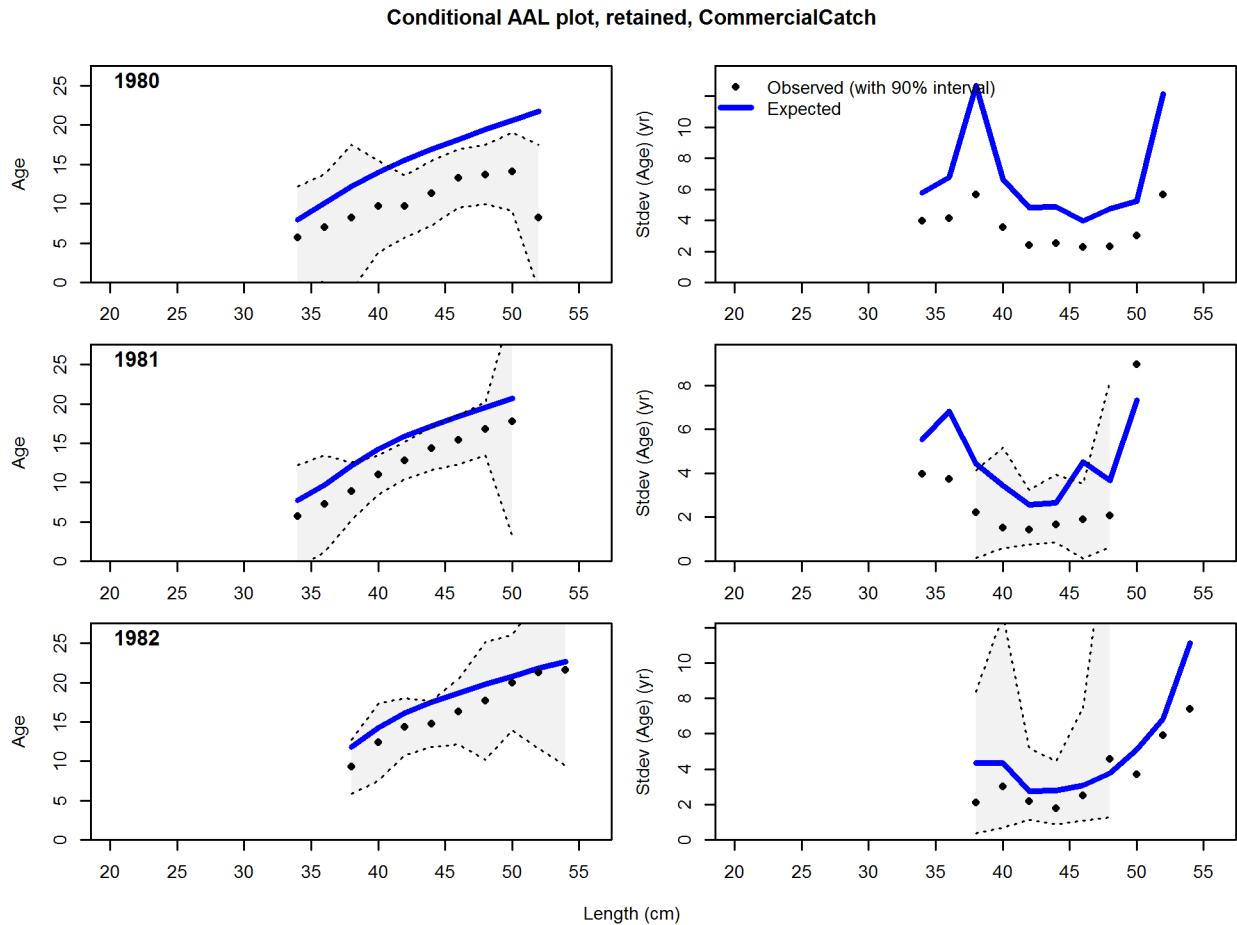
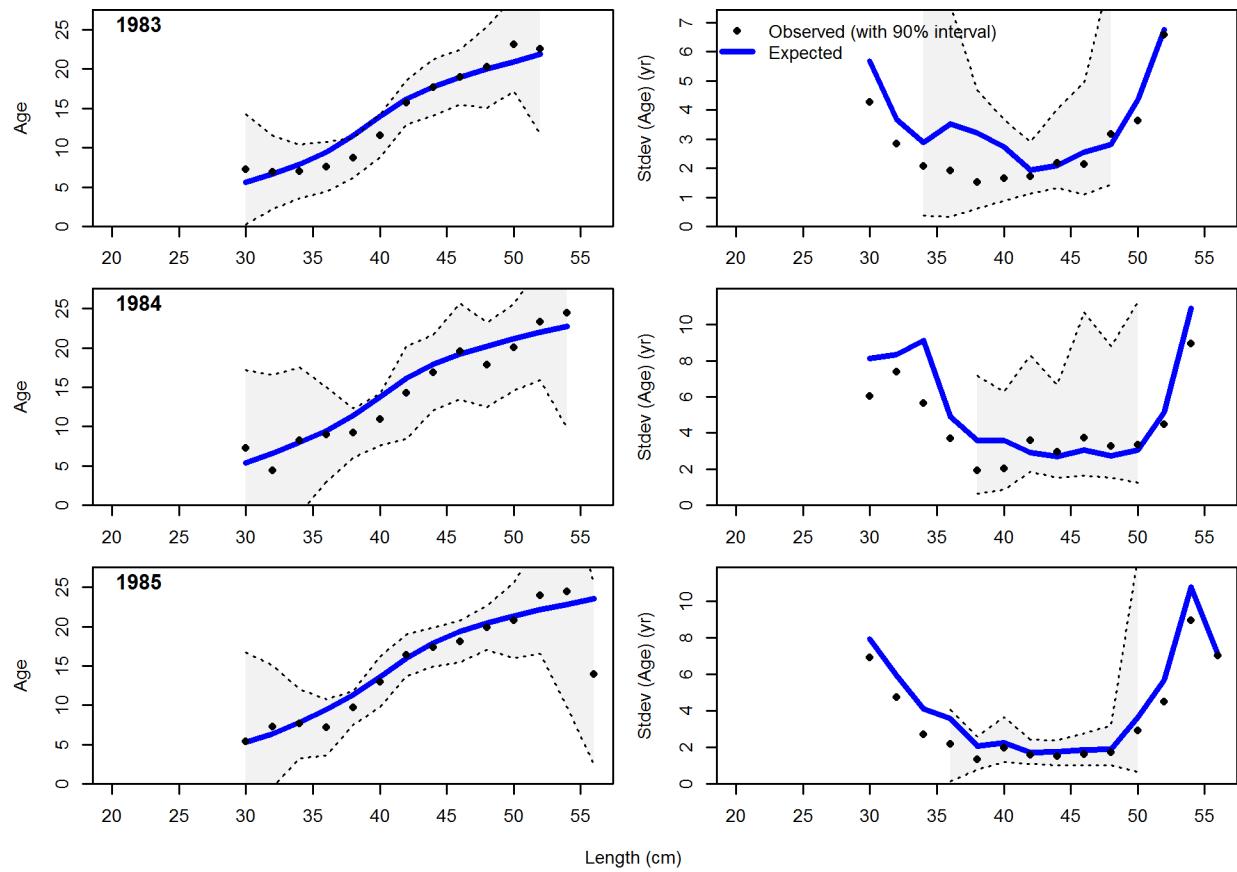


Figure 96: **Southern model** Conditional AAL plot, retained, CommercialCatch (plot 1 of 8) These plots show mean age and std. dev. in conditional AAL. Left plots are mean AAL by size_class (obs. and pred.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean AAL (obs. and pred.) with 90% CIs based on the chi_square distribution. | [fig:mod2_5_comp_condAALfitAndre_plotsf1t2mkt2_page1](#)

Conditional AAL plot, retained, CommercialCatch

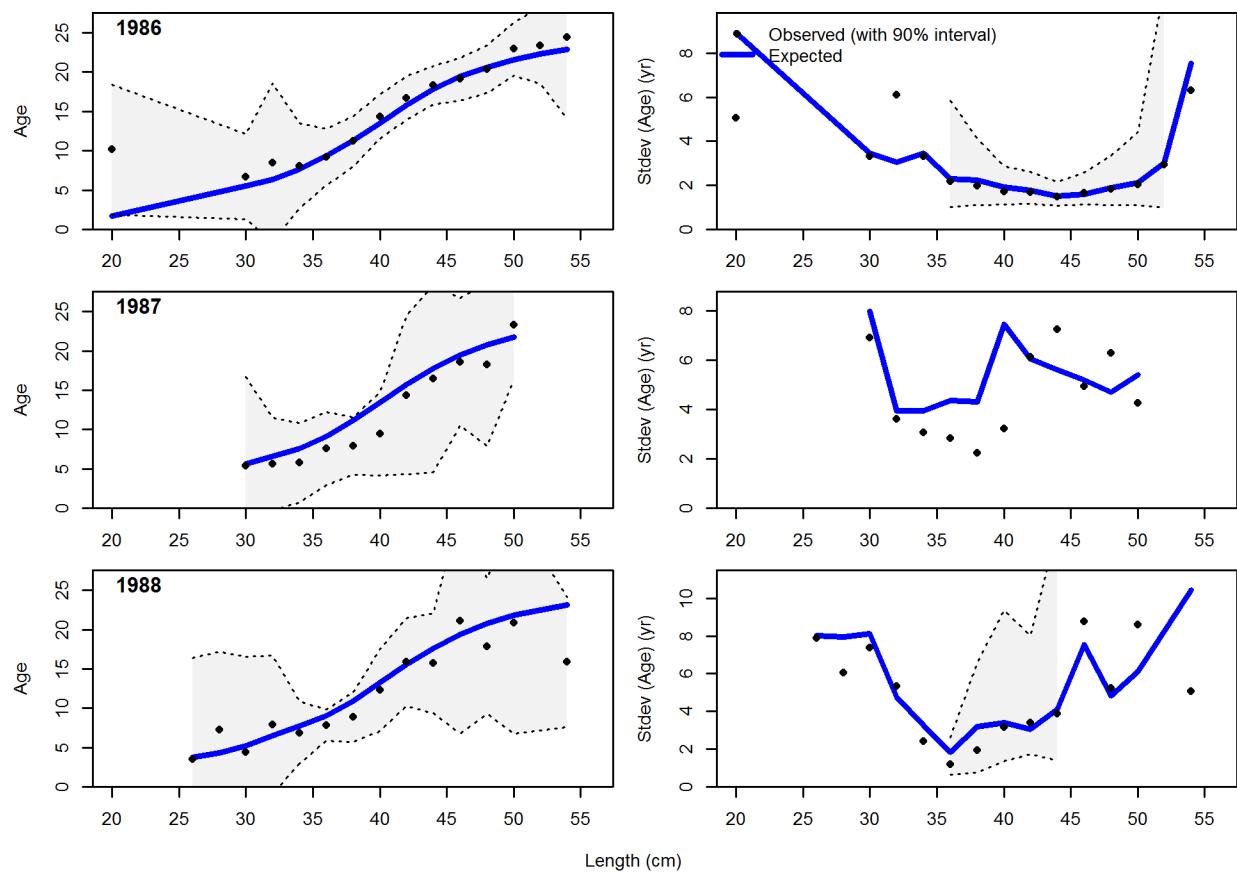


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Conditional AAL plot, retained, CommercialCatch

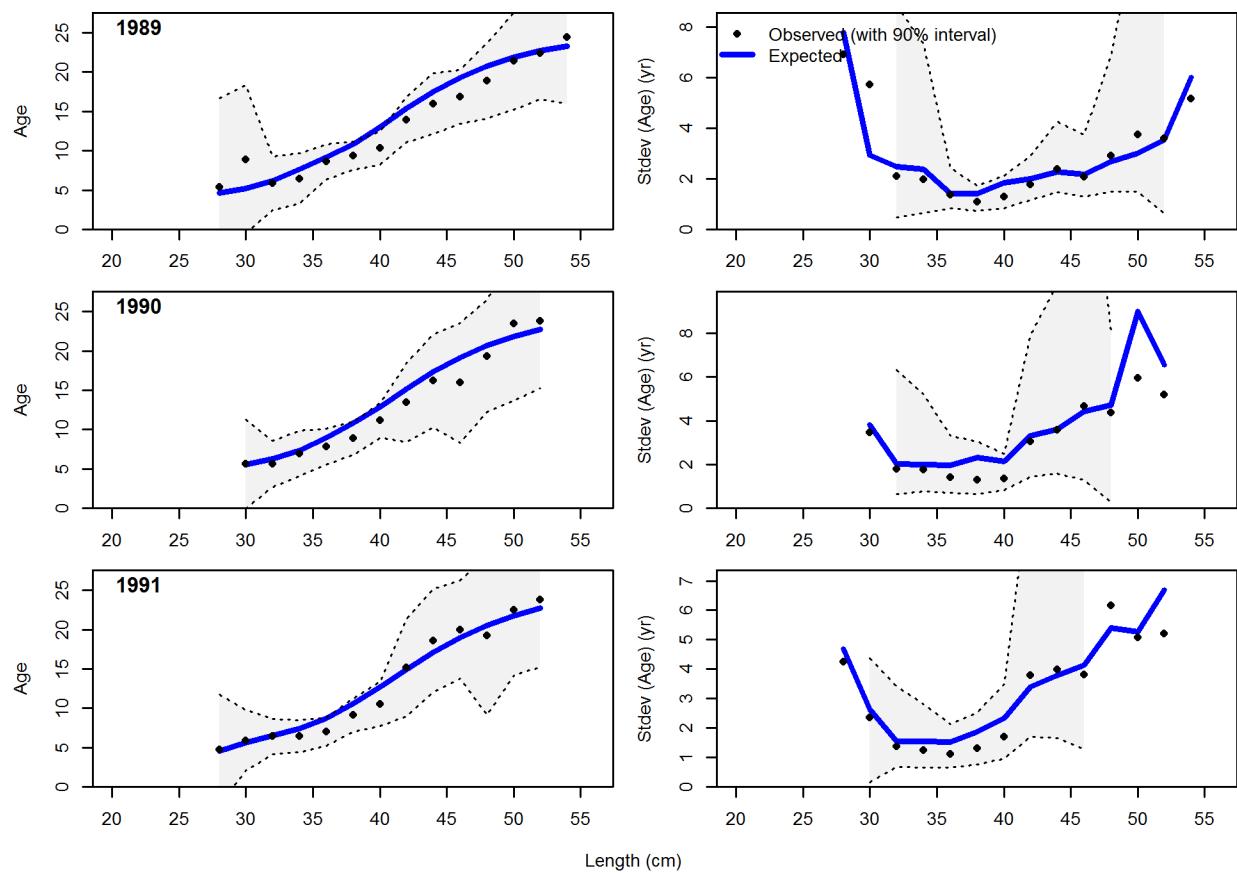


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Conditional AAL plot, retained, CommercialCatch

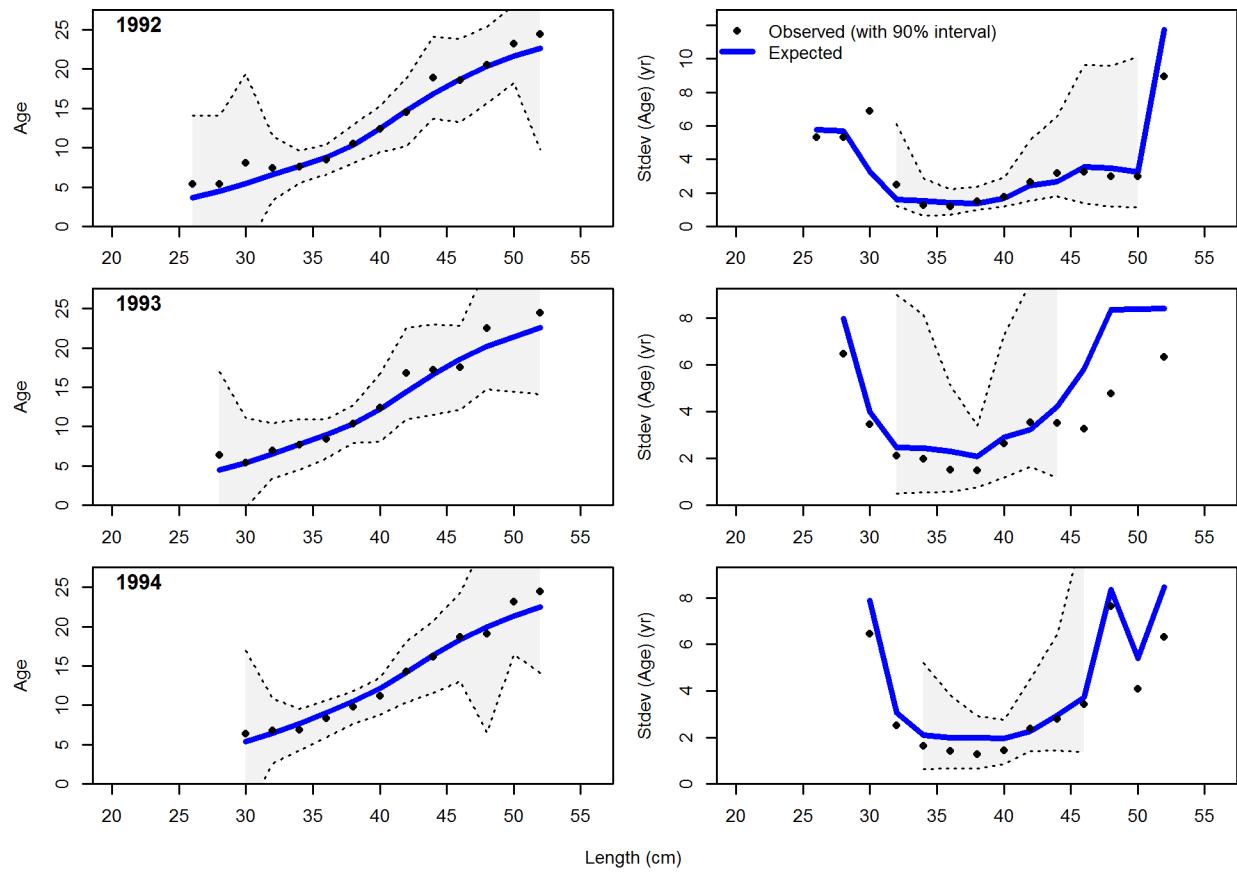


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Conditional AAL plot, retained, CommercialCatch

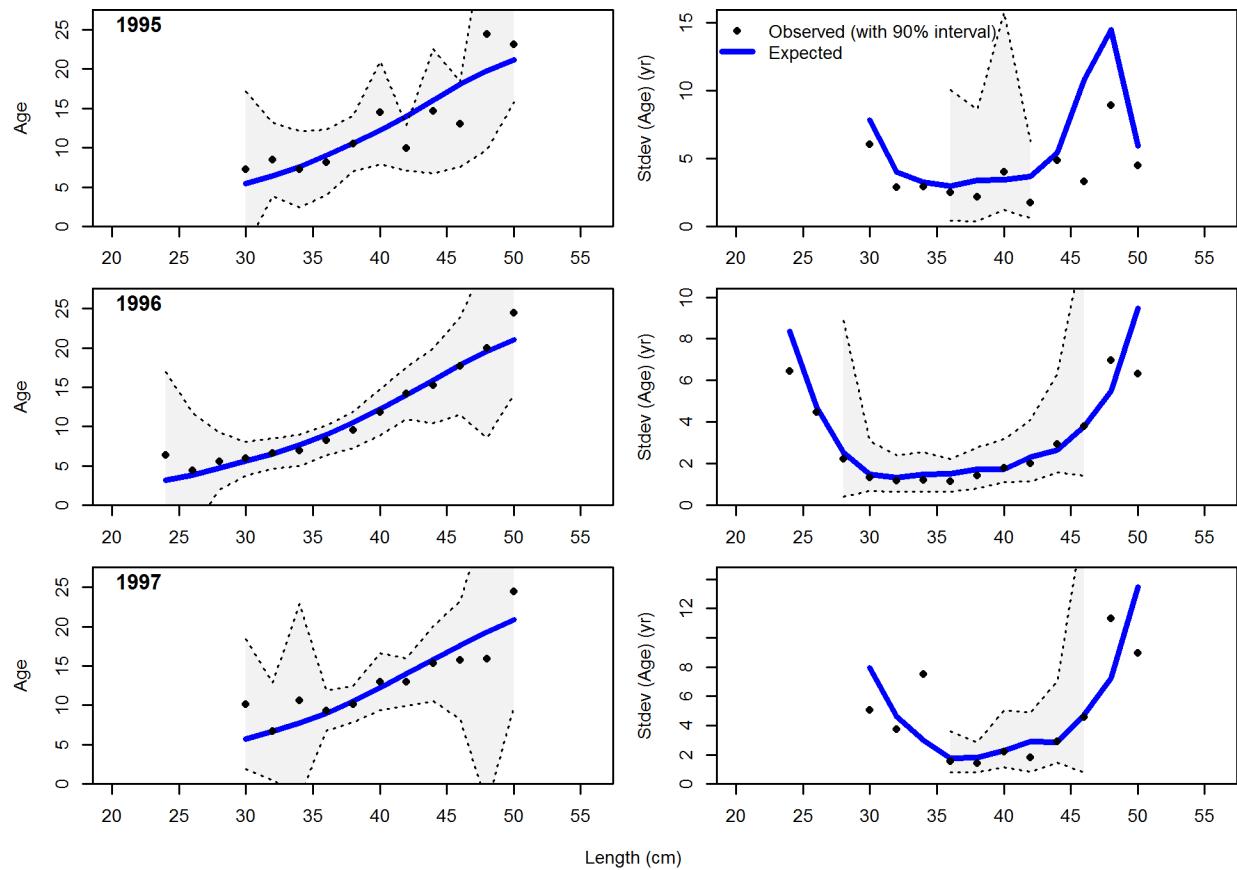


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Conditional AAL plot, retained, CommercialCatch

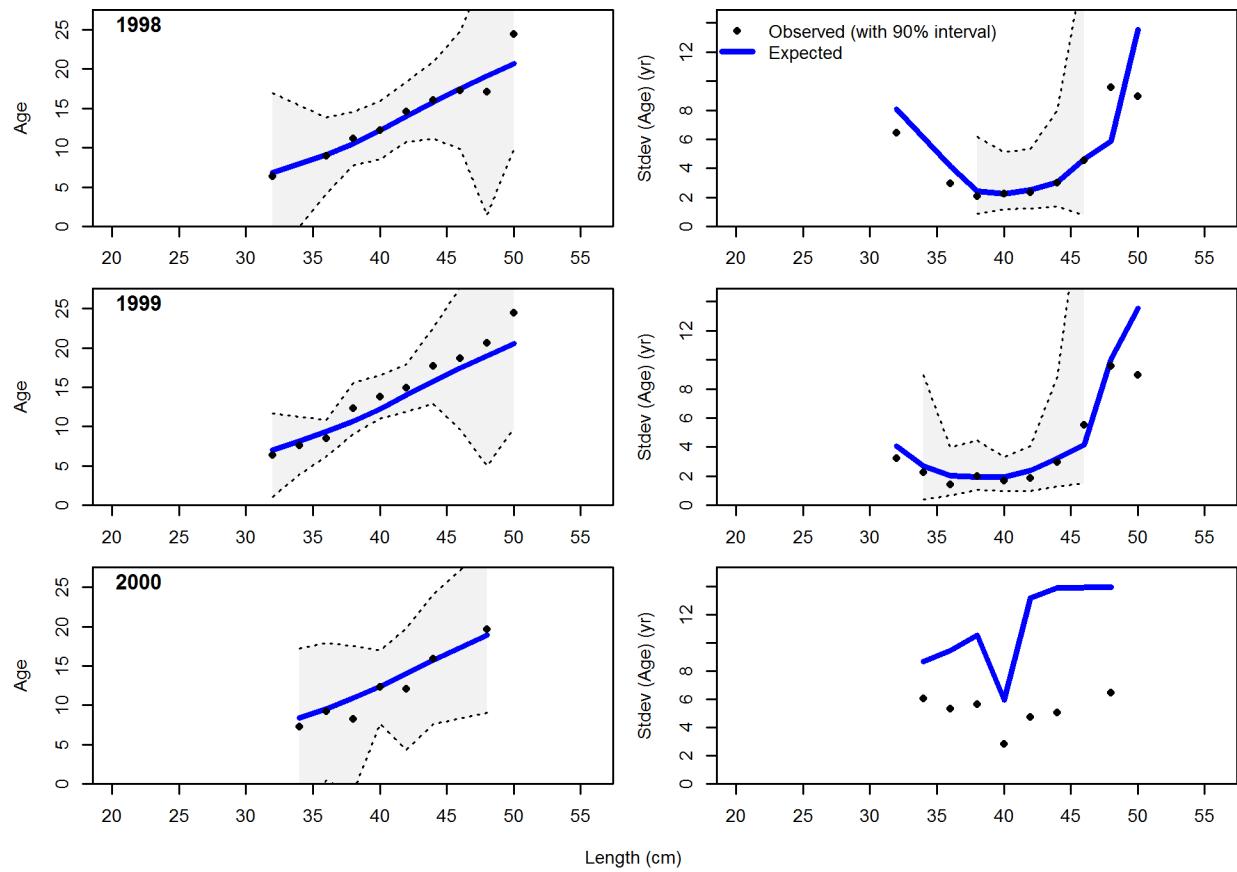


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Conditional AAL plot, retained, CommercialCatch

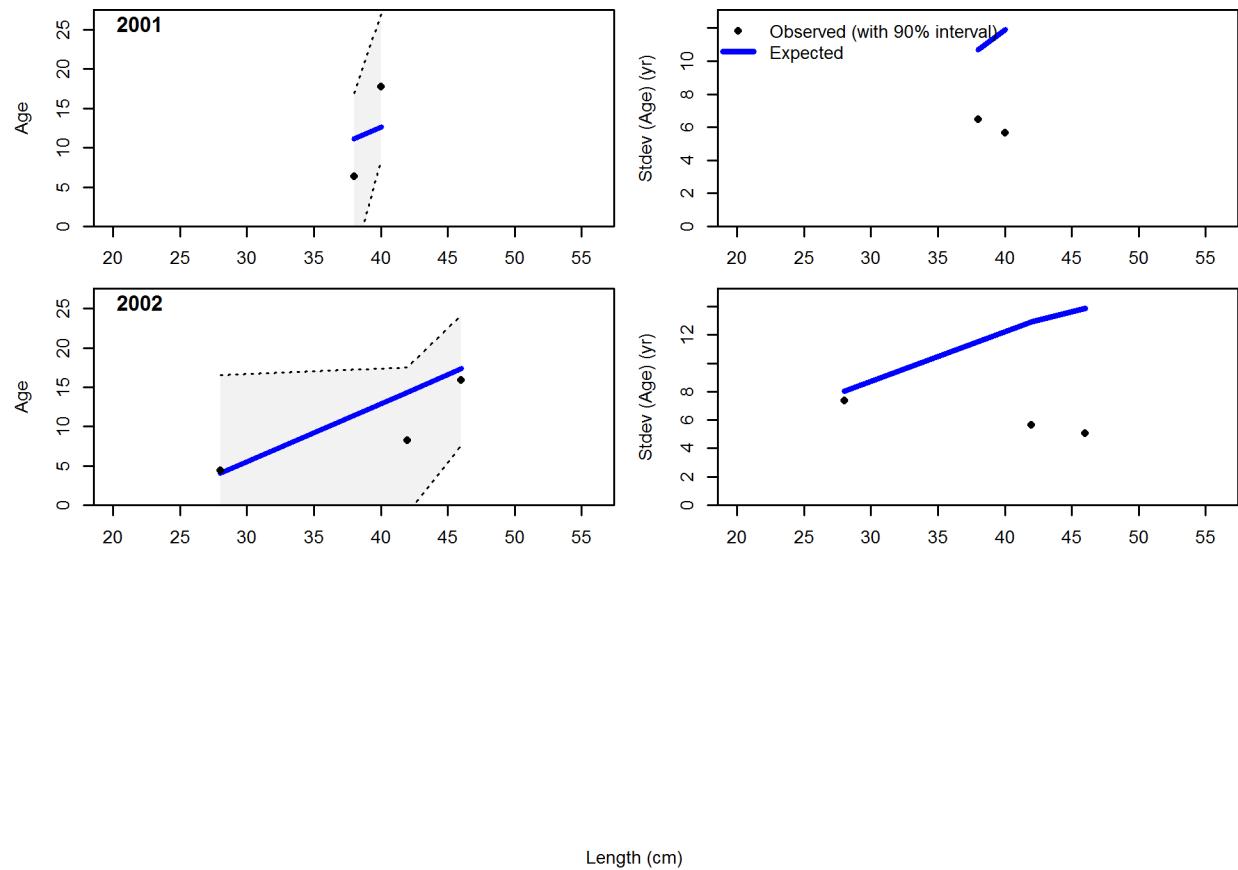


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Conditional AAL plot, retained, CommercialCatch



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₇₁₂ 9.4 Model results

model-results

₇₁₃ 9.4.1 Base model results

base-model-results

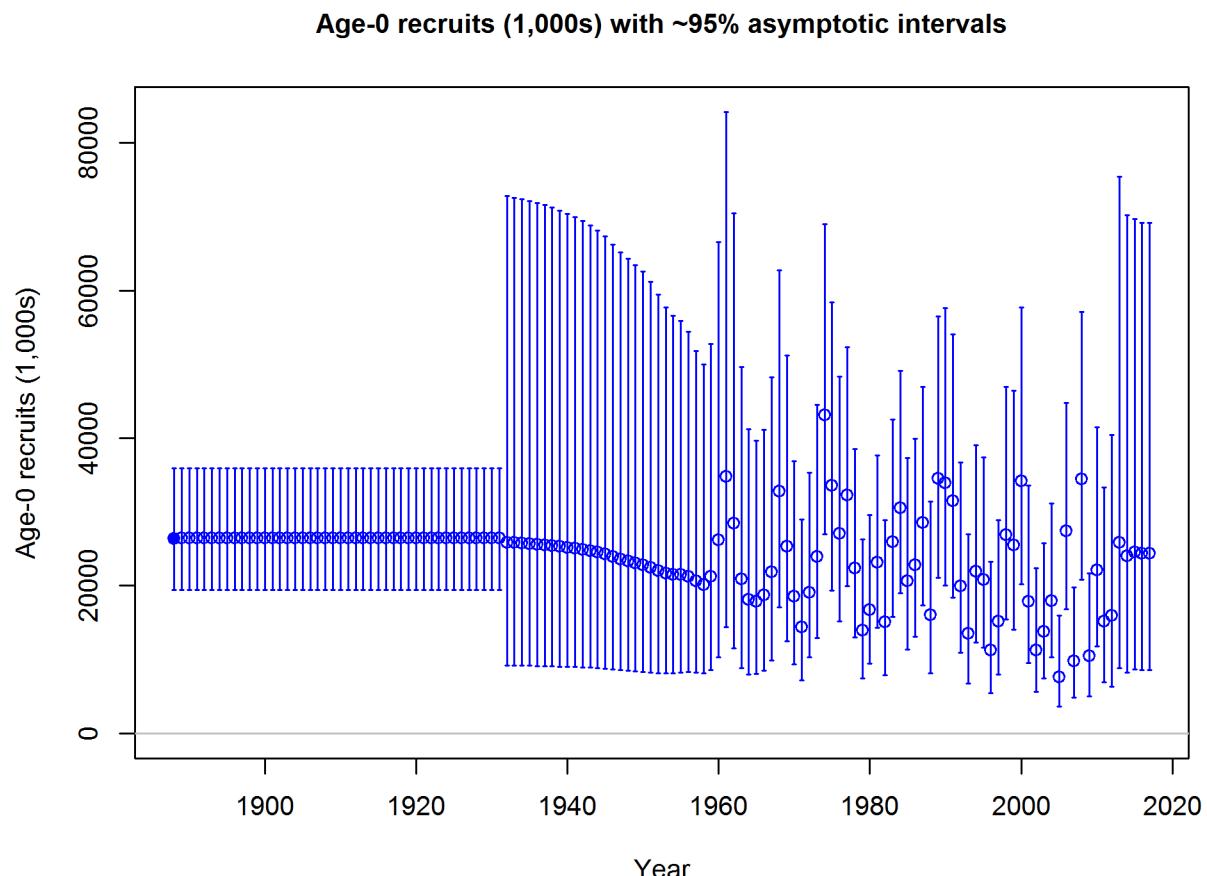


Figure 97: Estimated time-series of recruitment for the Northern model. fig:recruits1

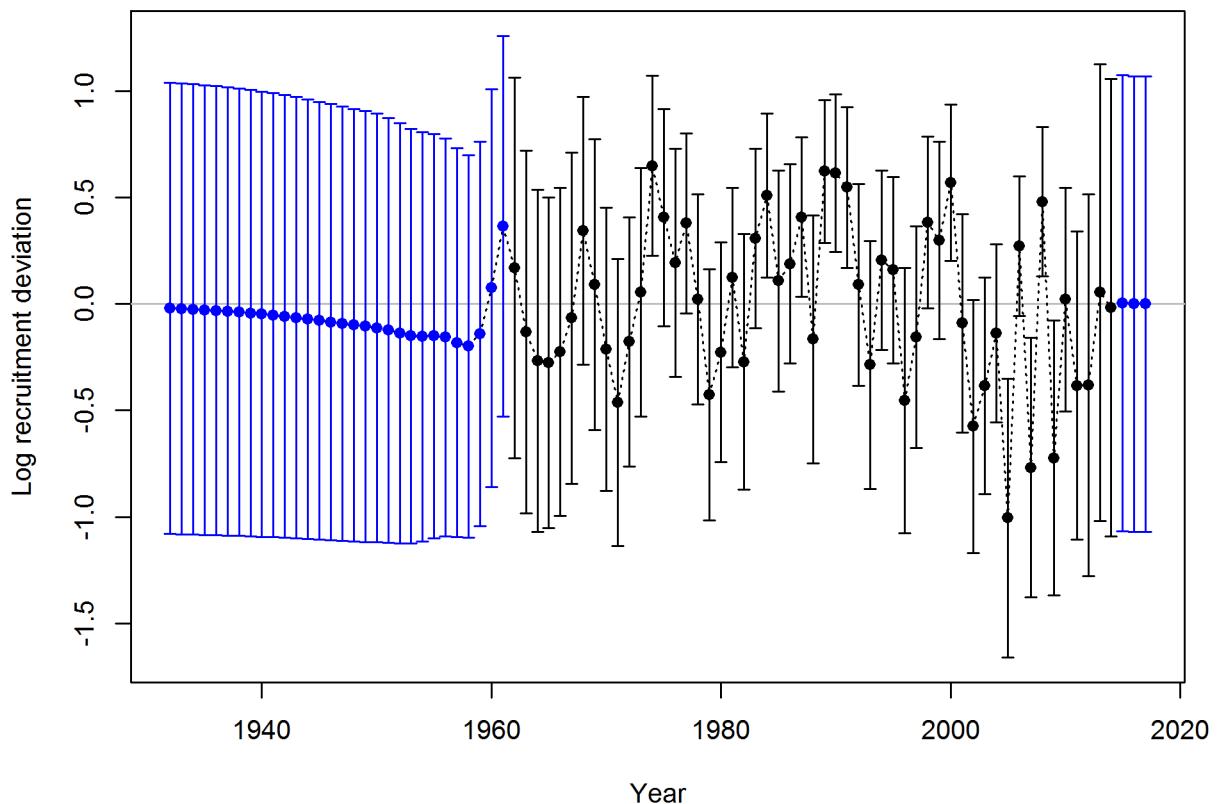


Figure 98: Estimated time-series of recruitment deviations for the Northern model. `fig:recdevs1`

714 9.4.2 Base model results for Northern model
base-model-results-for-northern-model

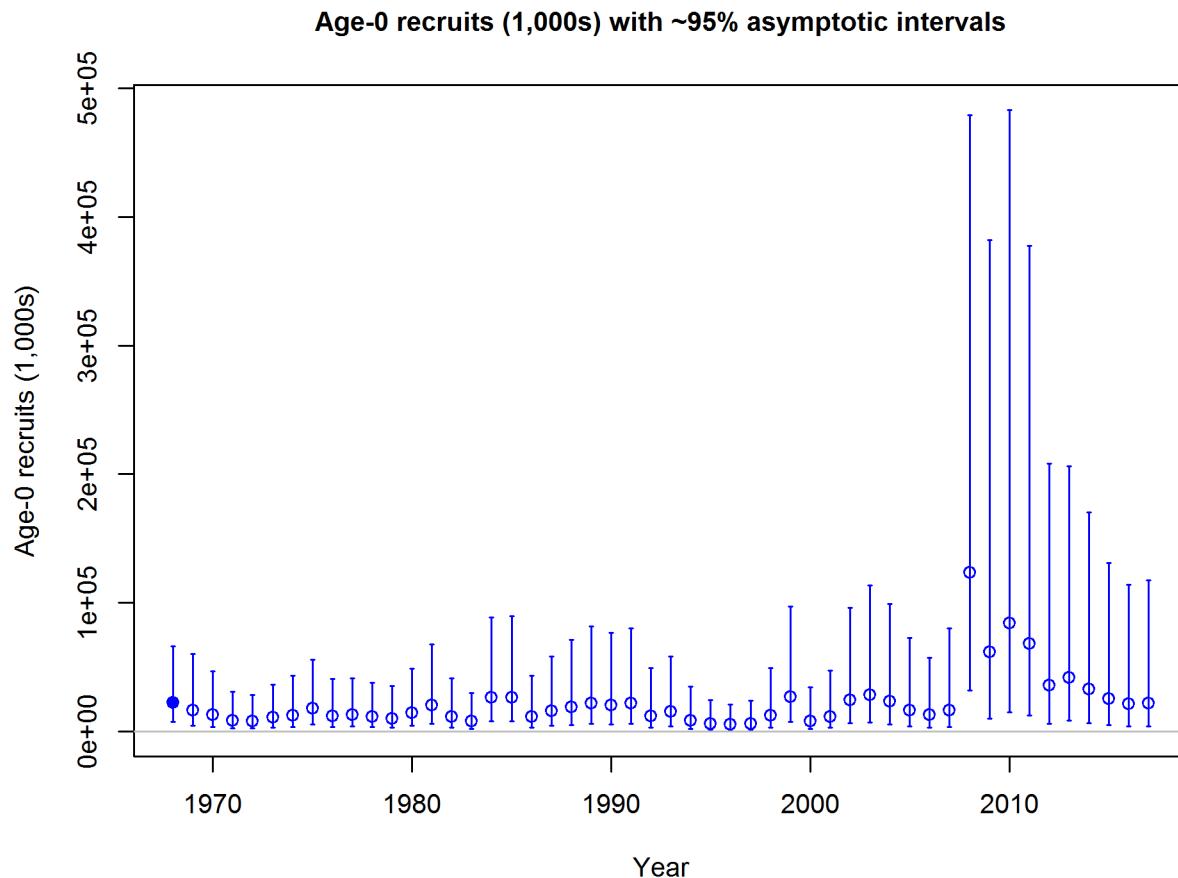


Figure 99: Estimated time-series of recruitment for the Southern model. fig:recruits2

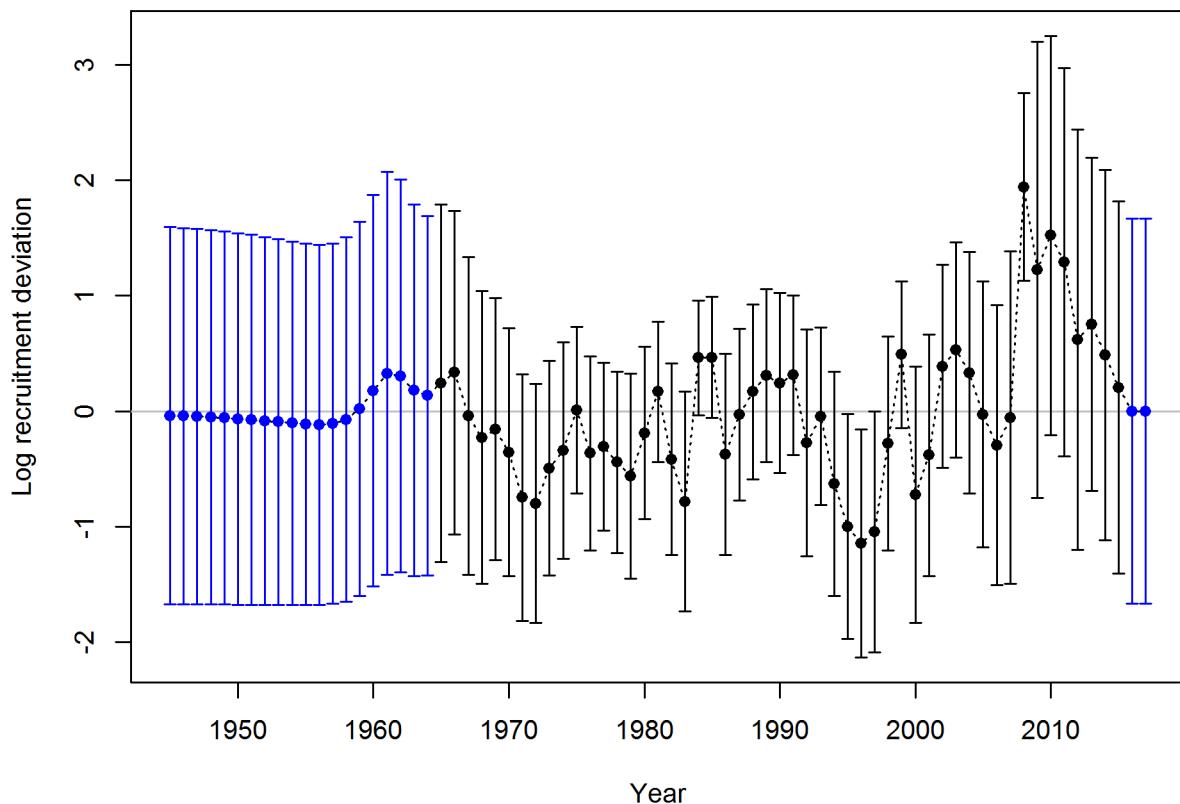


Figure 100: Estimated time-series of recruitment deviations for the Southern model. `fig:recdevs2`

715 References

references

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717 Fisheries of the Northeastern Pacific Ocean. Institute of Fisheries, University of British
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