GOA Deepwater Flatfish

November 2019

Carey McGilliard, Andrea Havron, Wayne Palsson, and Stephanie Zador

What is the deepwater flatfish complex?

Historically:

- Dover
- Greenland turbot
- Deepsea sole (AKRO does not track catches)
- Unidentified

Since 2011 AK Regional Office Includes:

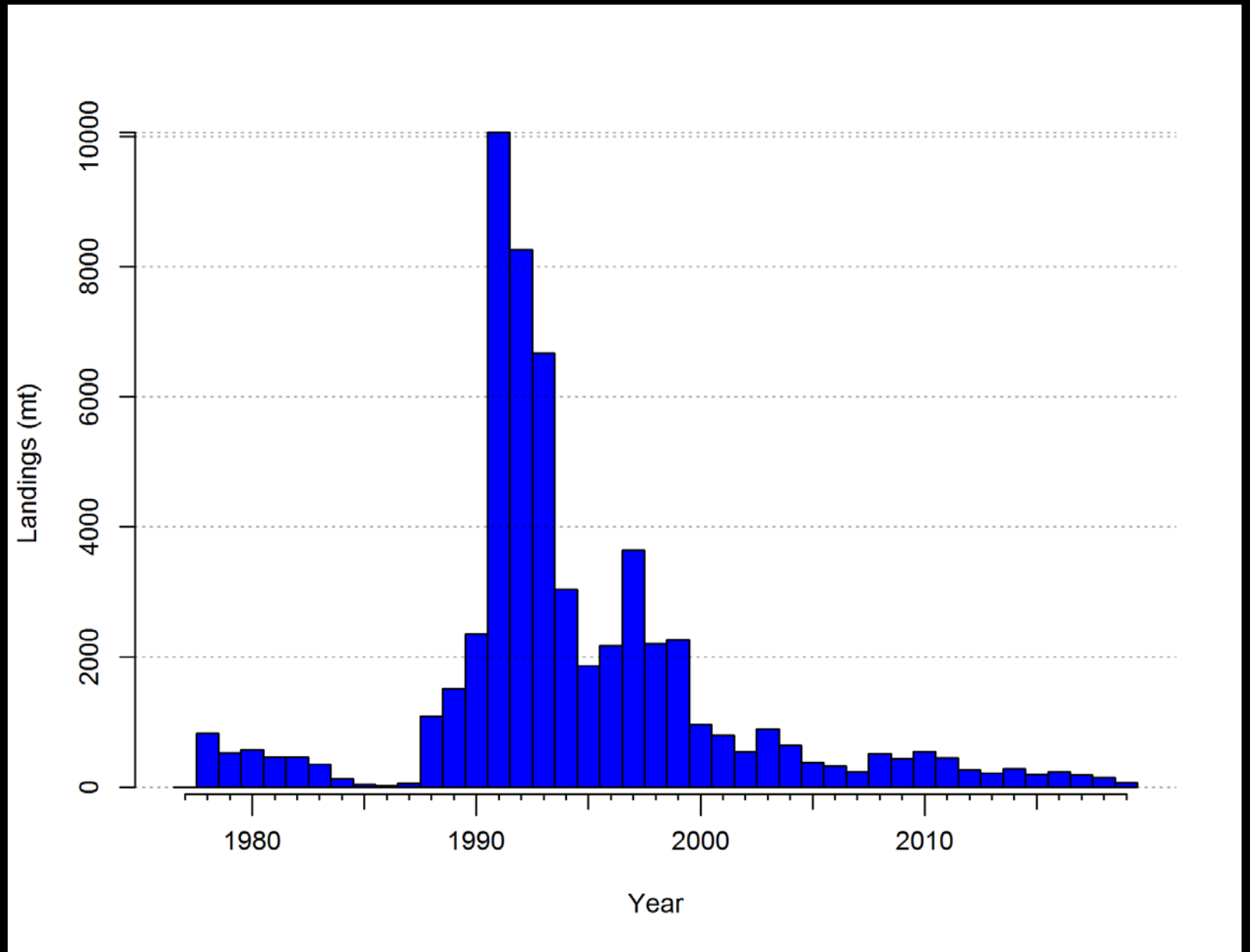
- Dover
- Greenland turbot
- **Kamchatka flounder**

Catch by species for the deepwater flatfish complex

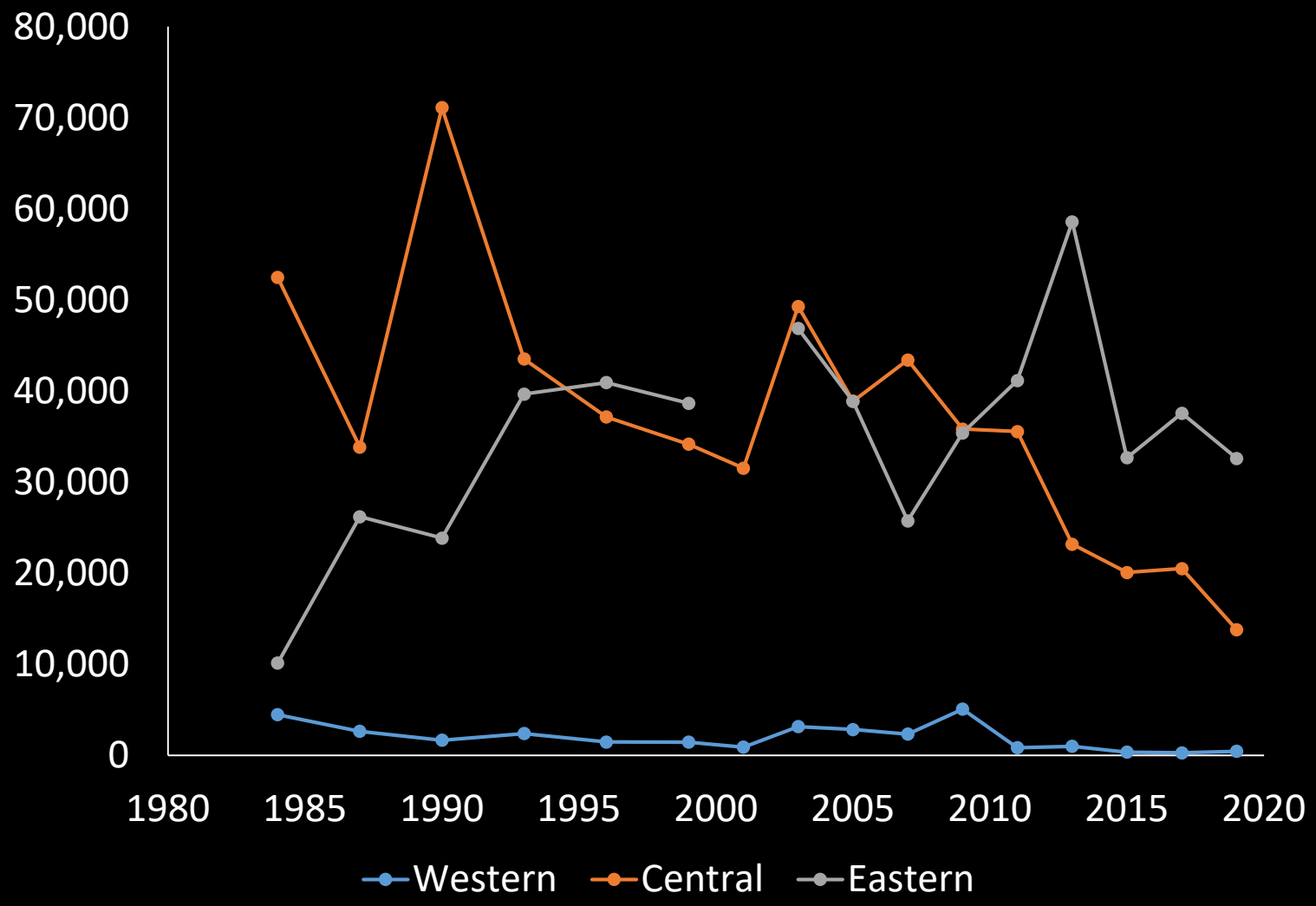
Year	Greenland turbot	Dover sole	Unidentified	Total
1978	51	827		878
1979	24	530		554
1980	57	570		627
1981	8	457		465
1982	23	457		480
1983	145	354		499
1984	18	132		150
1985	0	43		43
1986	0	23		23
1987	44	56		100
1988	256	1,087		1,343
1989	56	1,521		1,577
1990	0	2,348		2,348
1991			10,196	10,196
1992			8,497	8,497
1993	19	1,869	1,935	6,706
1994	3	2,538	537	3,078
1995	78	1,416	721	2,215
1996	6	1,485	704	2,195
1997	3	2,676	996	3,674
1998	10	2,111	168	2,289
1999	6	1,833	447	2,285
2000	5	813	167	985
2001	4	654	146	804
2002	4	411	146	560
2003	3	899	51	902
2004	1	646	41	647
2005	1	378	41	379
2006	10	327	74	337
2007	1	235	47	236
2008	4	517	53	521
2009	0	435	42	435
2010	0	546		546

Year	Greenland turbot	Dover sole	Kamchatka Flounder	Total
2011	3	453	12	467
2012	0	260	4	265
2013	15	216	15	245
2014	3	284	69	356
2015	26	198	35	259
2016	4	231	5	240
2017	8	188	67	263
2018	3	144	40	186
2019	9	72	4	86

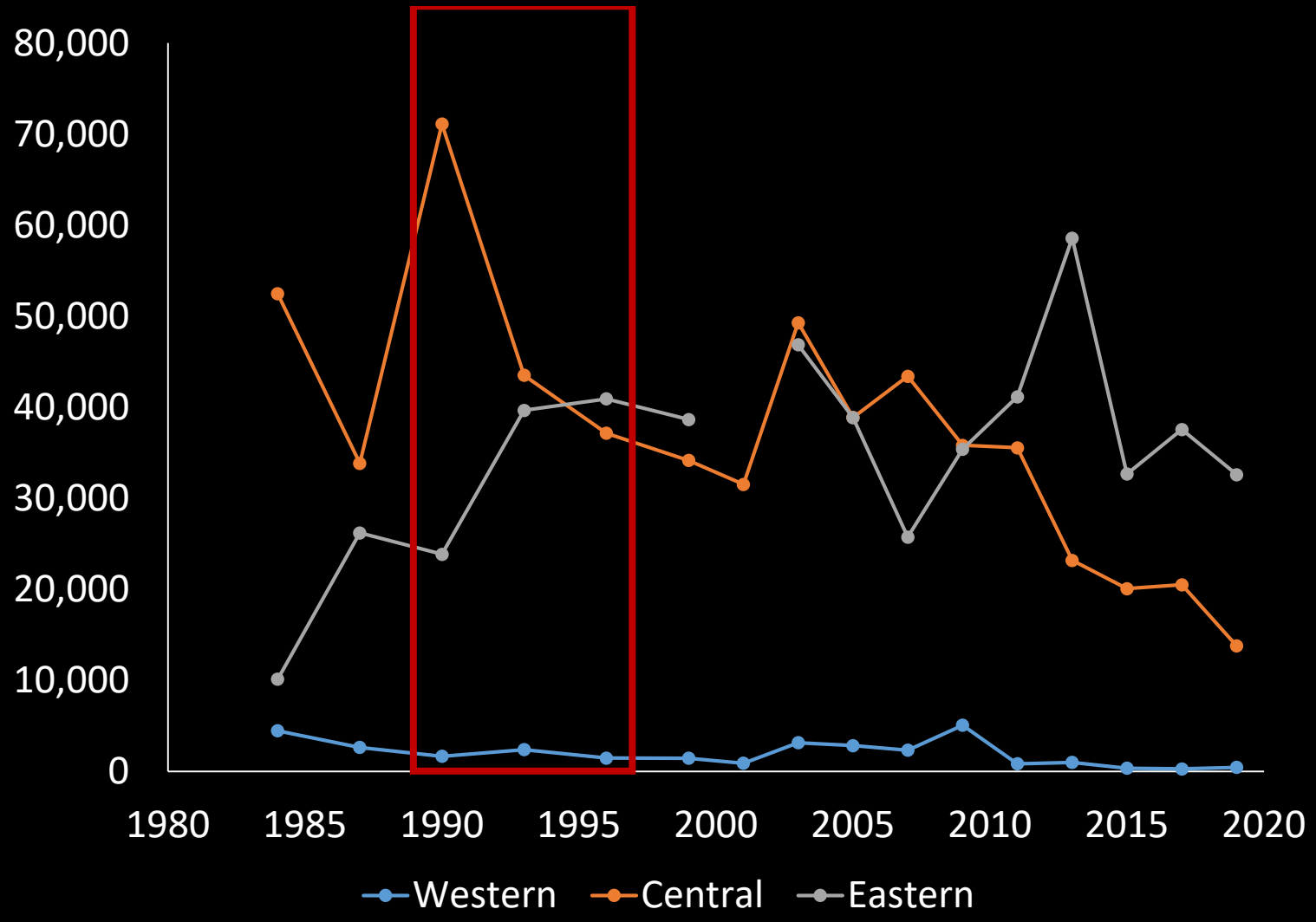
Time Series of Catches (Dover only, as input to models)



GOA survey bottom trawl biomass trends by Regulatory Area

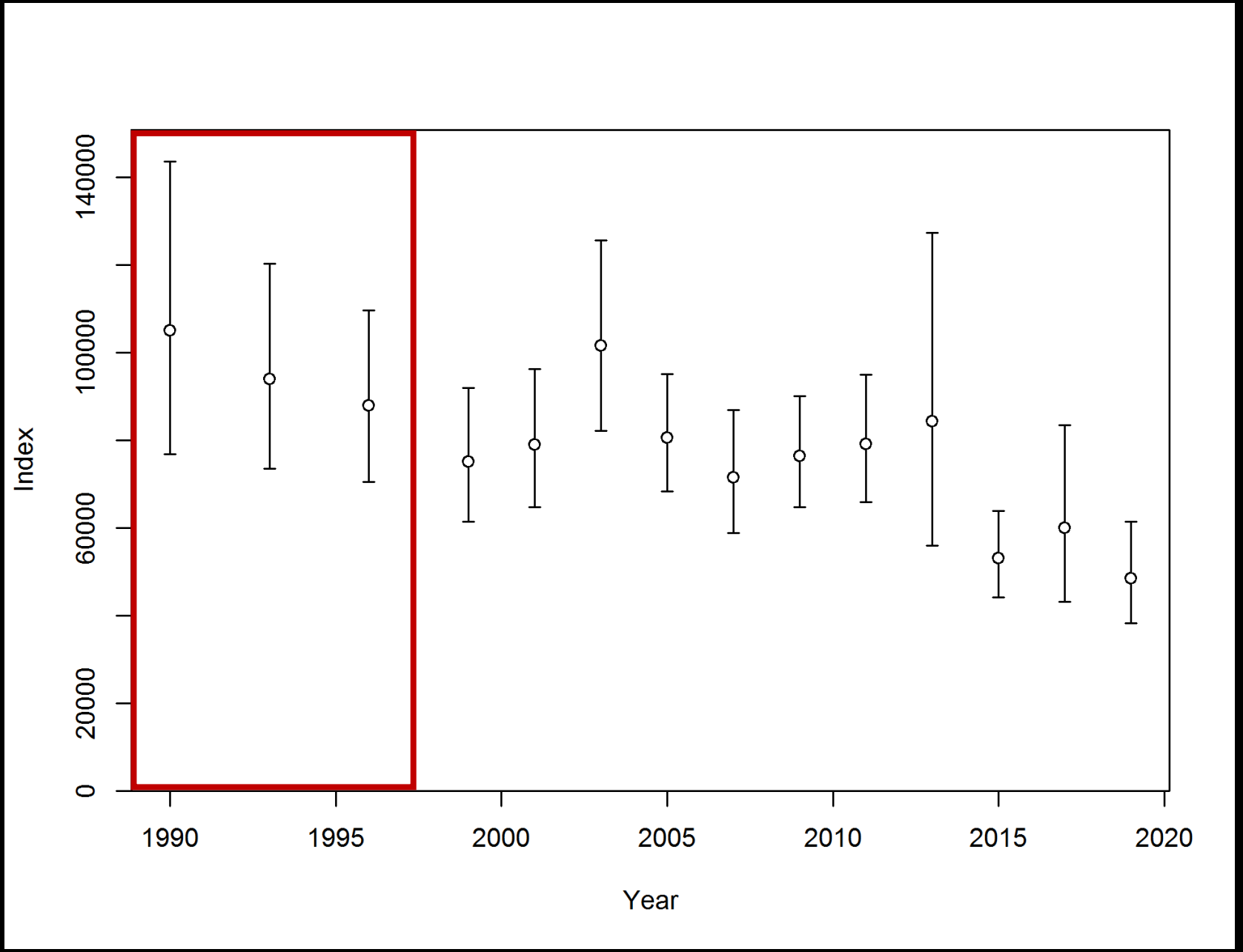


GOA survey bottom trawl biomass trends by Regulatory Area



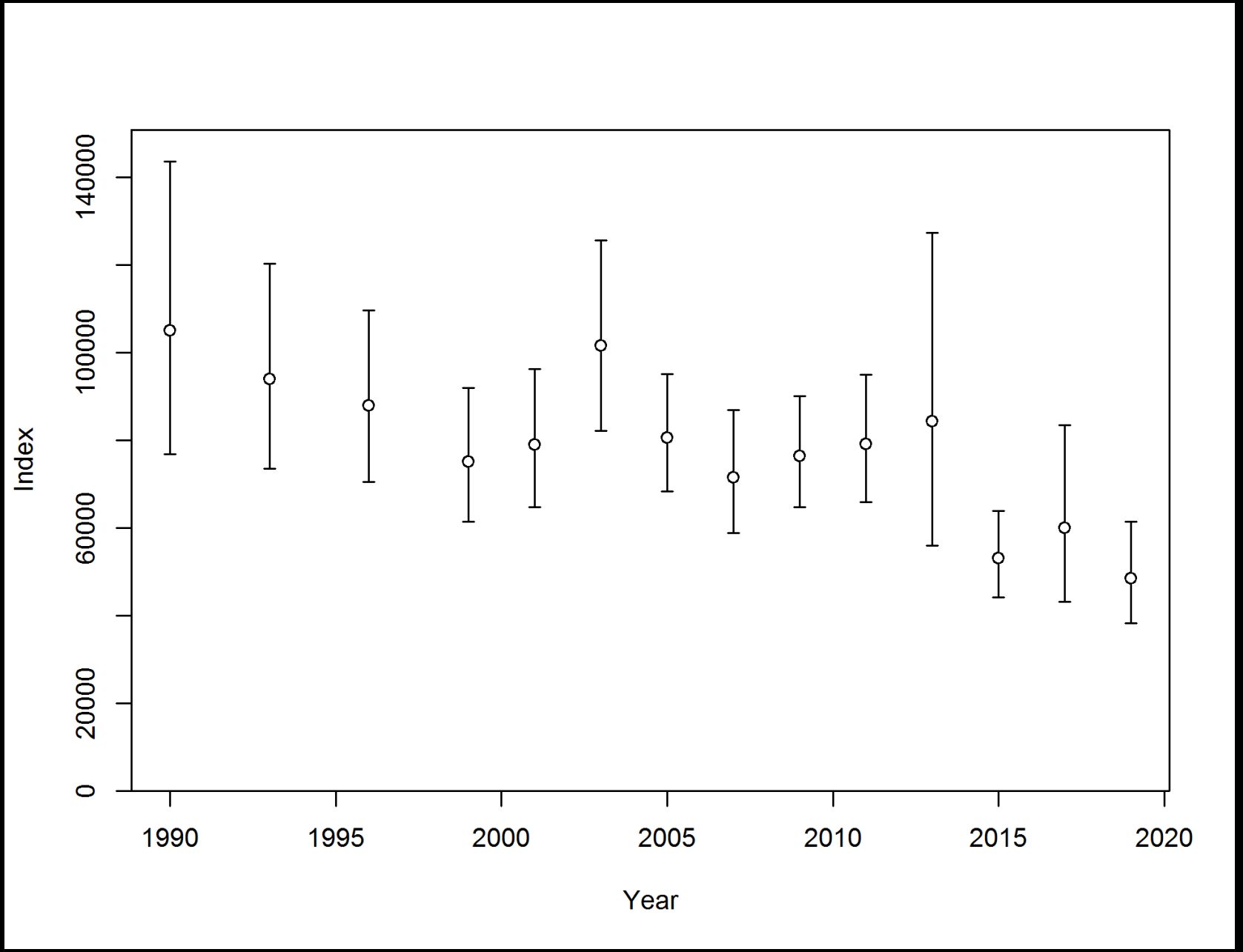
GOA survey bottom trawl biomass index

Using RE model to fillll depth-area gaps

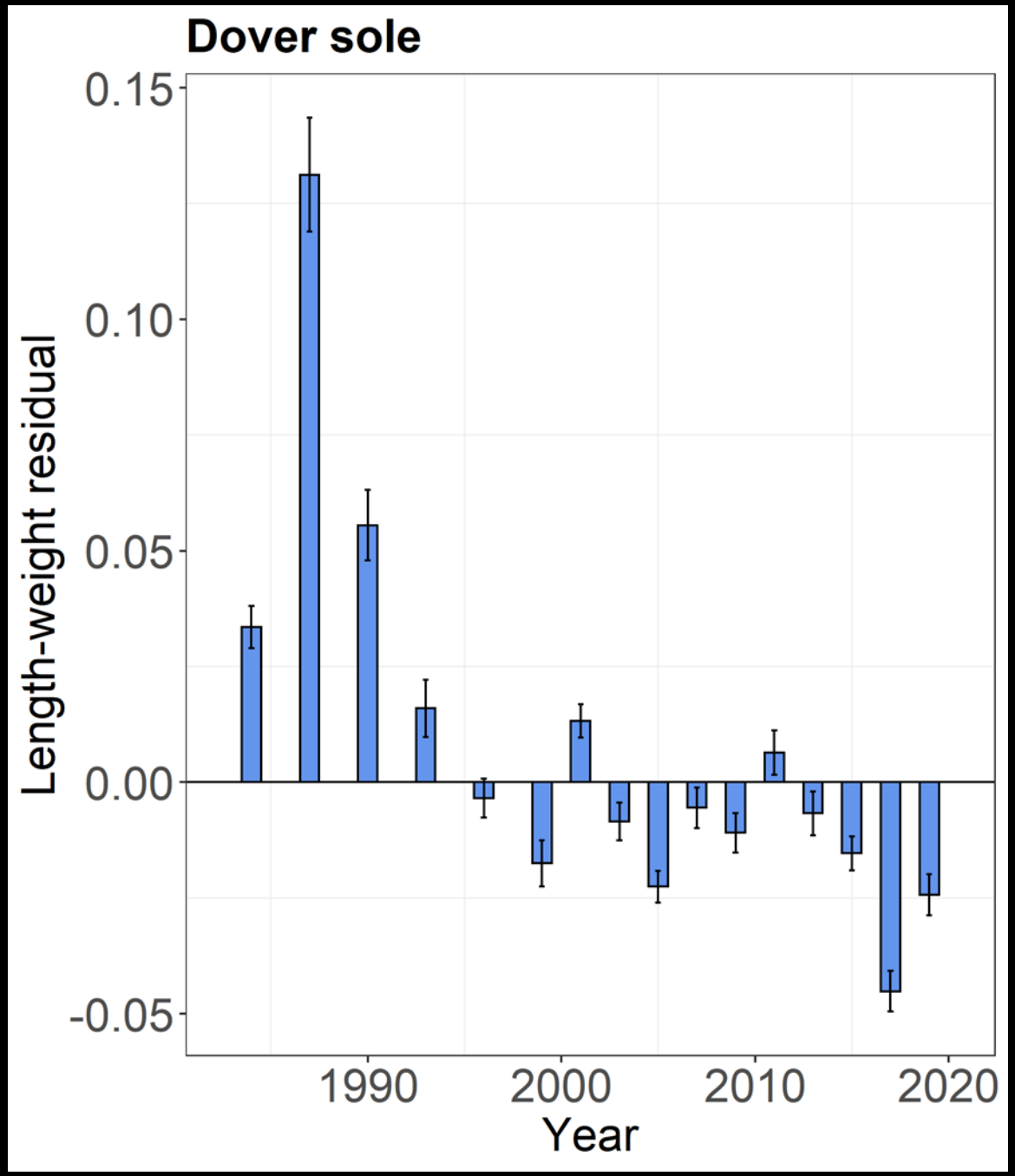


GOA survey bottom trawl biomass index

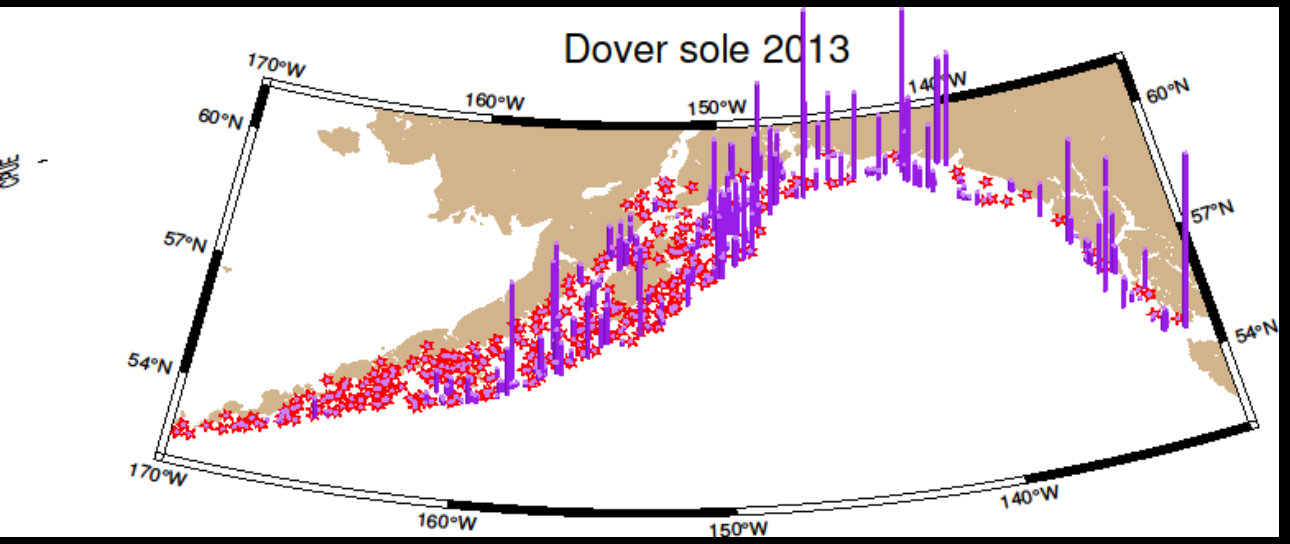
Using RE model to fillll depth-area gaps

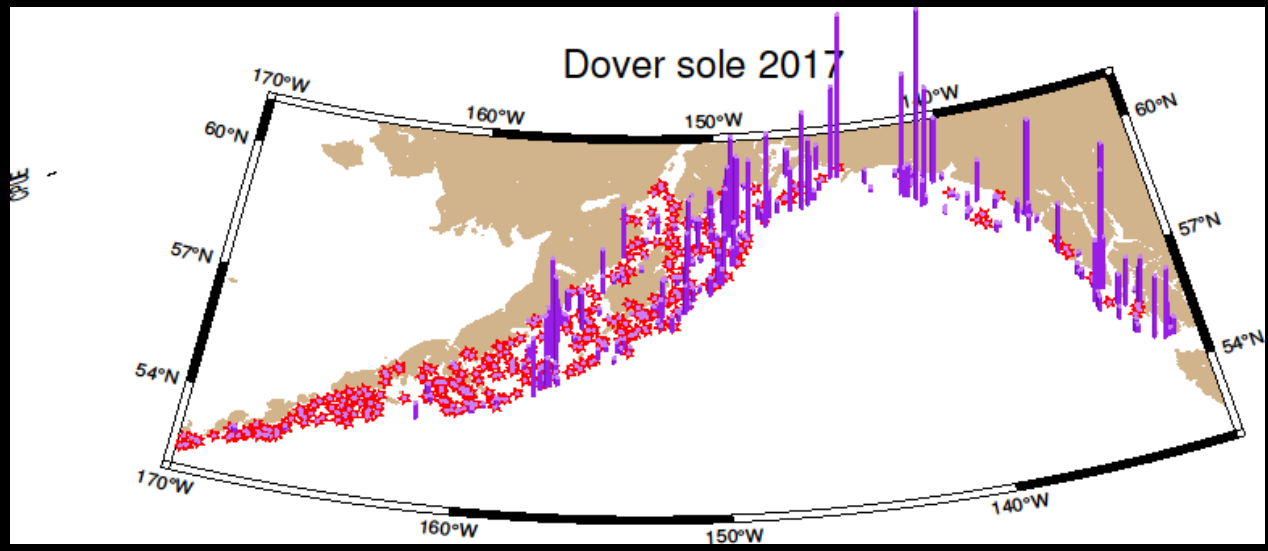


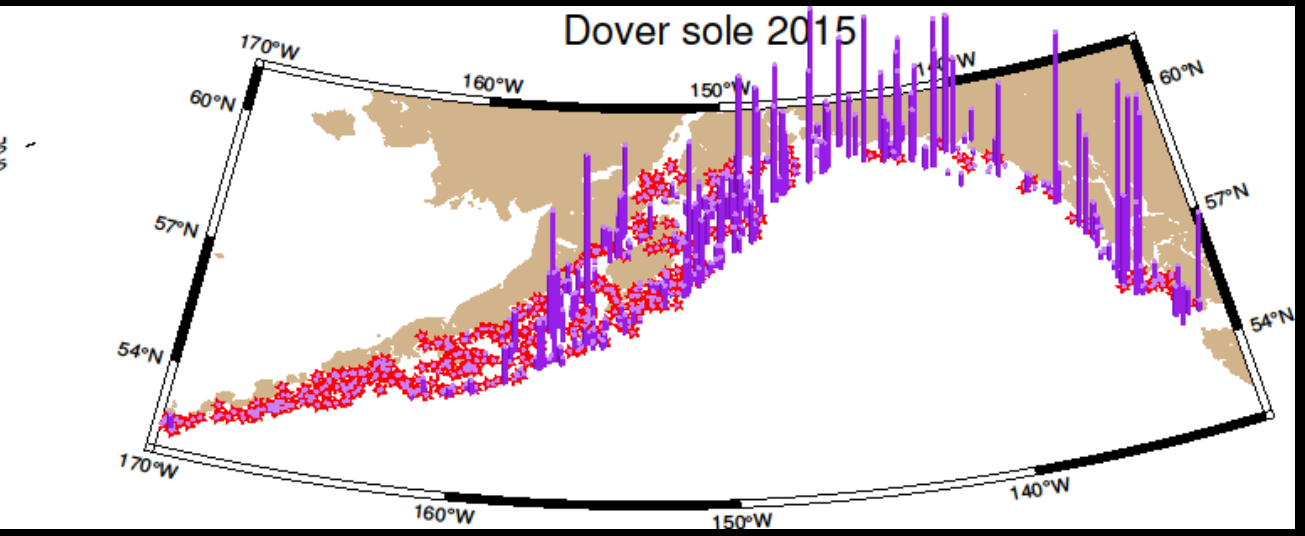
Length-weight residuals

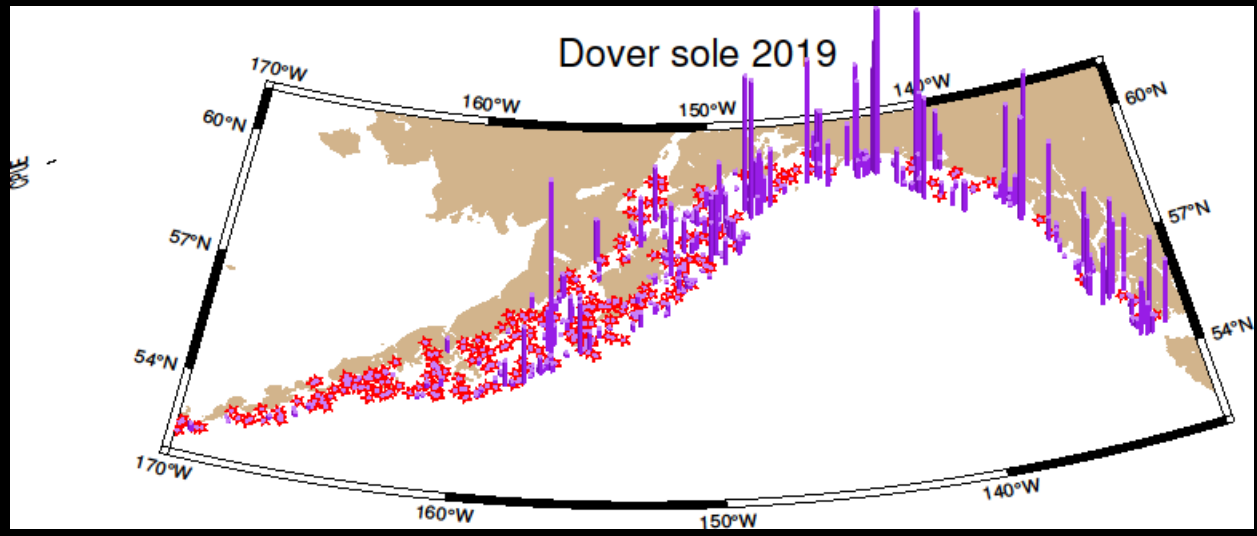


Survey cpue

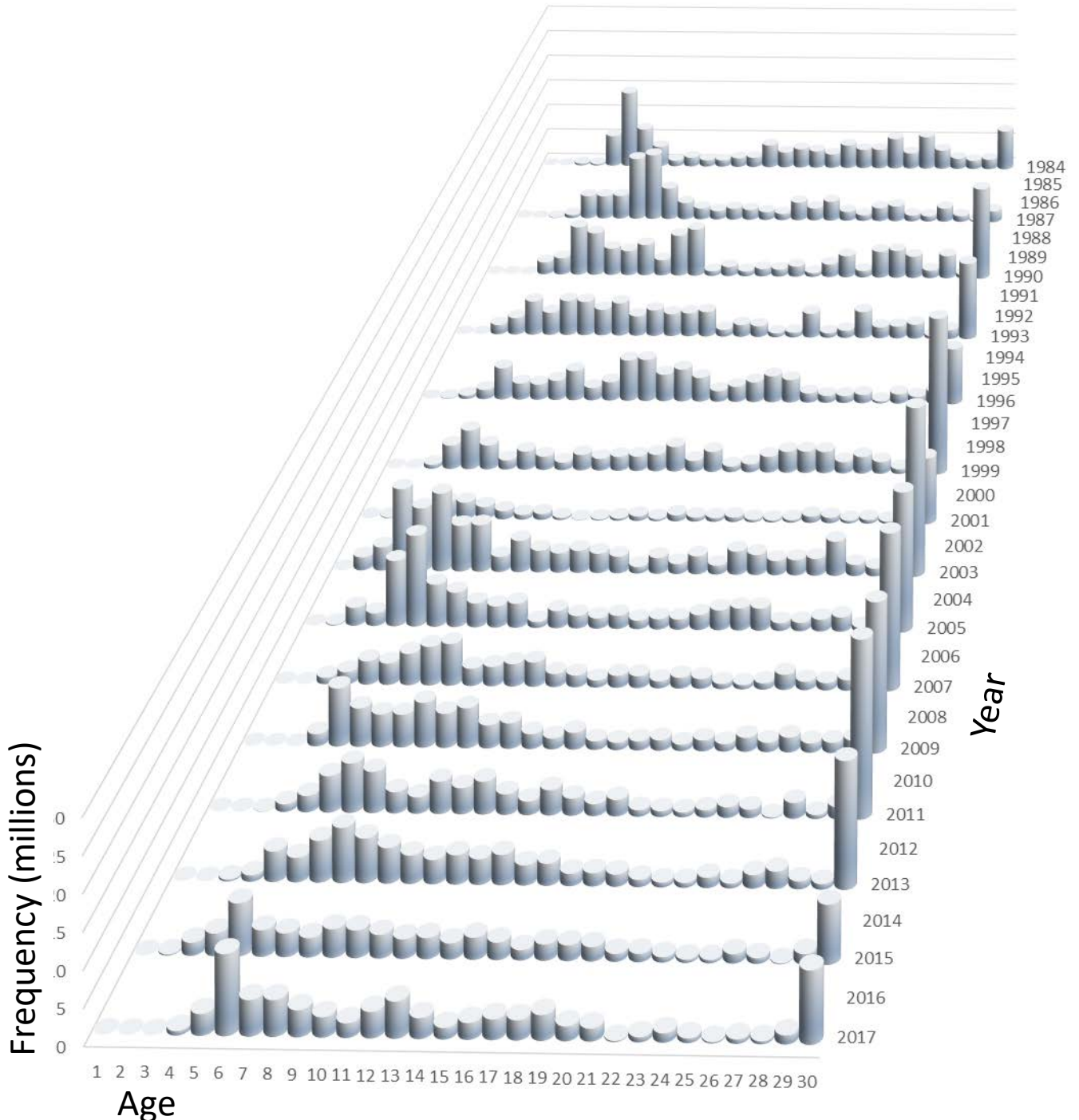

Dover sole 2013
170°W
160°W
150°W
60°N
57°N
54°N


Dover sole 2017
170°W
160°W
150°W
140°W
60°N
57°N
54°N

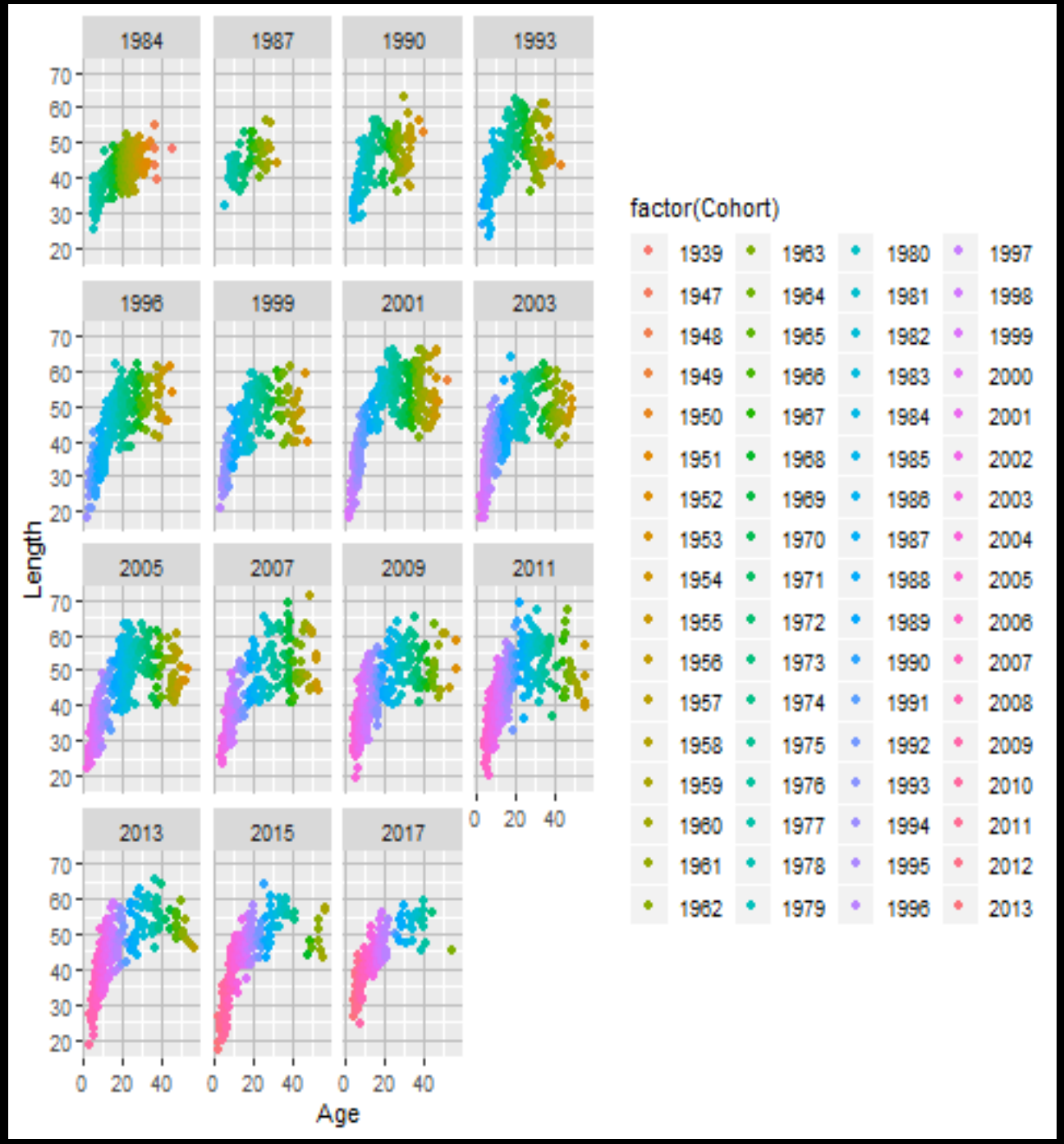

Dover sole 2015
170°W
160°W
150°W
140°W
60°N
57°N
54°N


Dover sole 2019
170°W
160°W
150°W
140°W
60°N
57°N
54°N

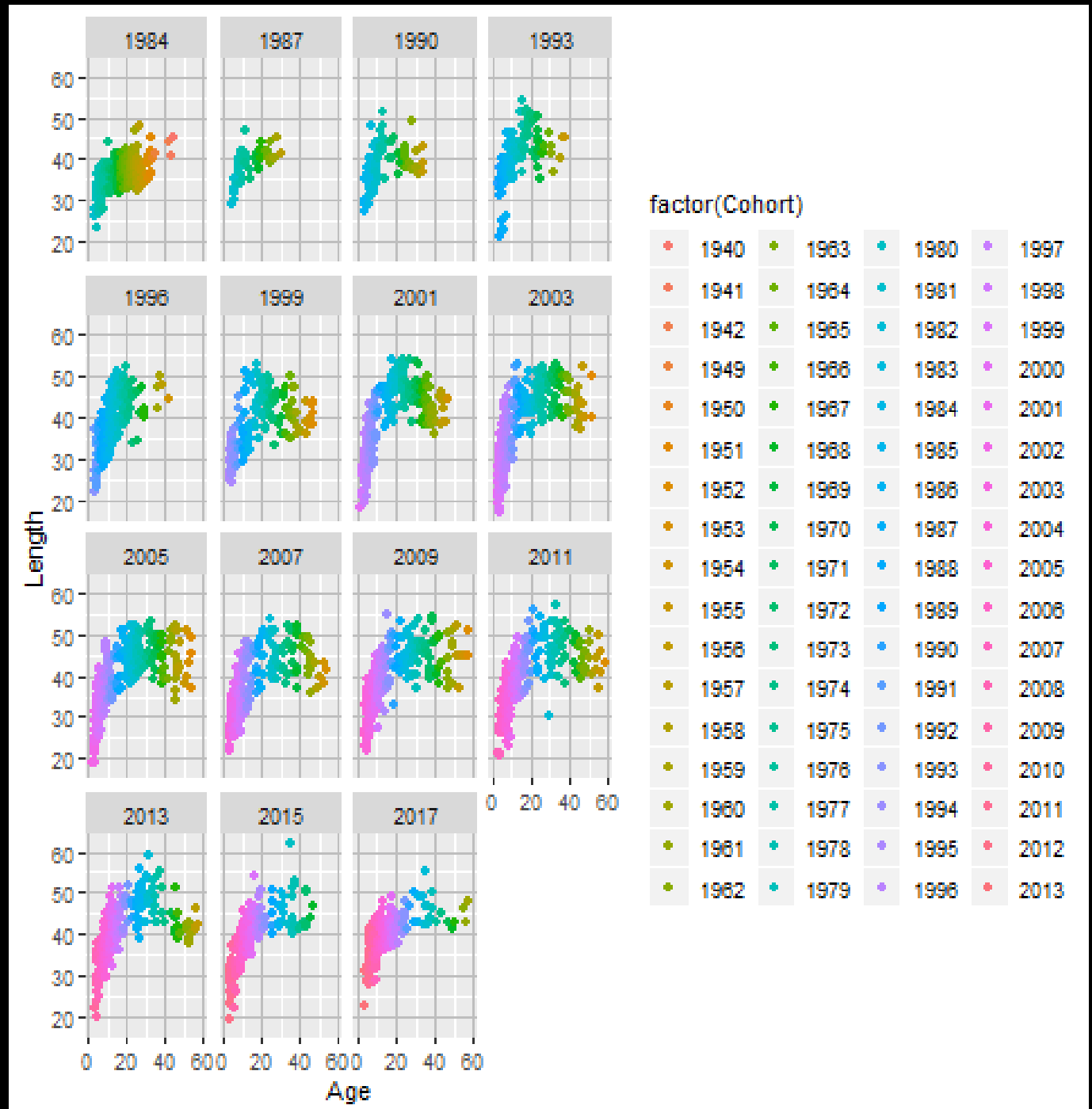
Distribution of age composition, males and females aggregated



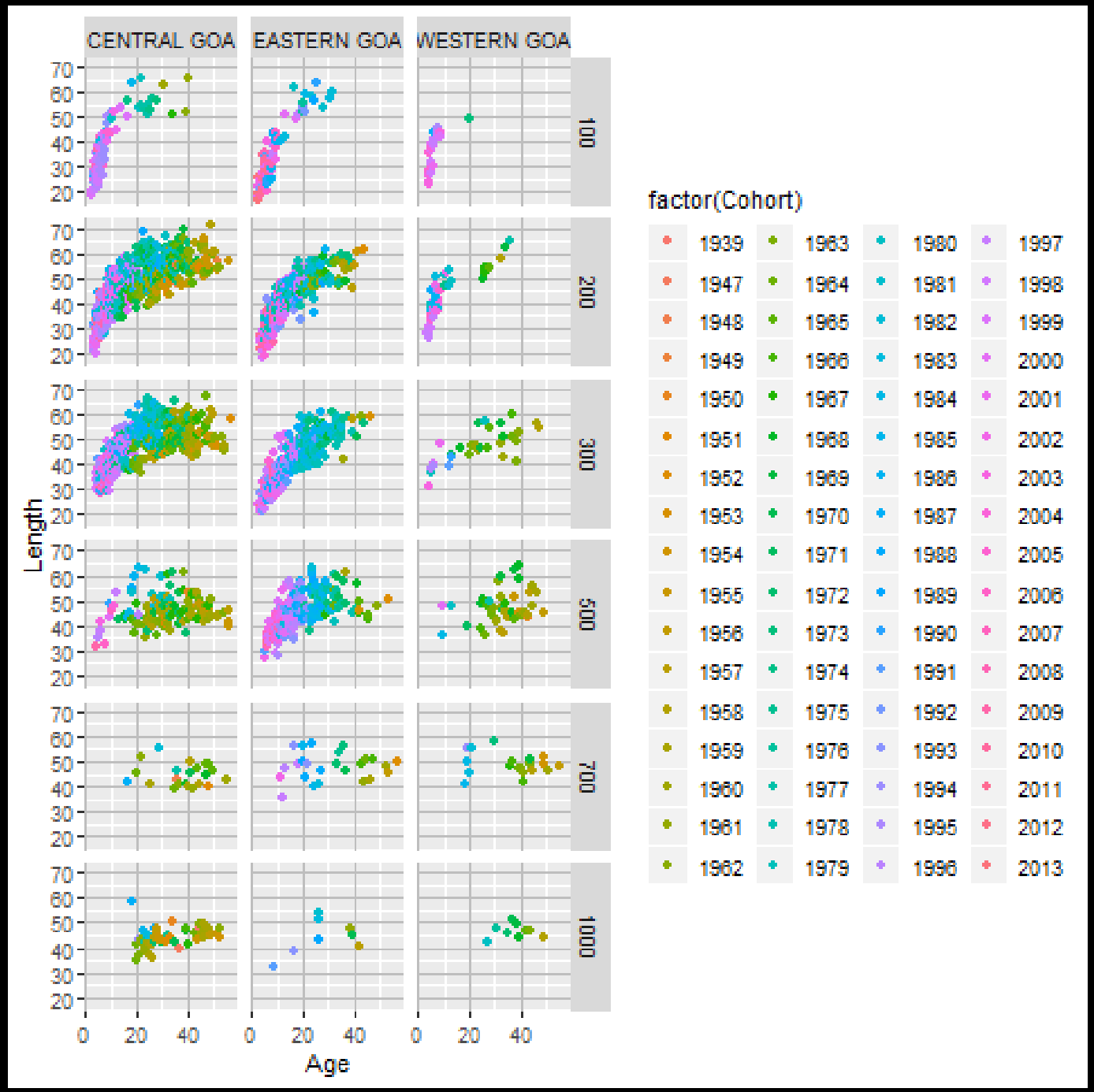
Female age-length plots by year and cohort



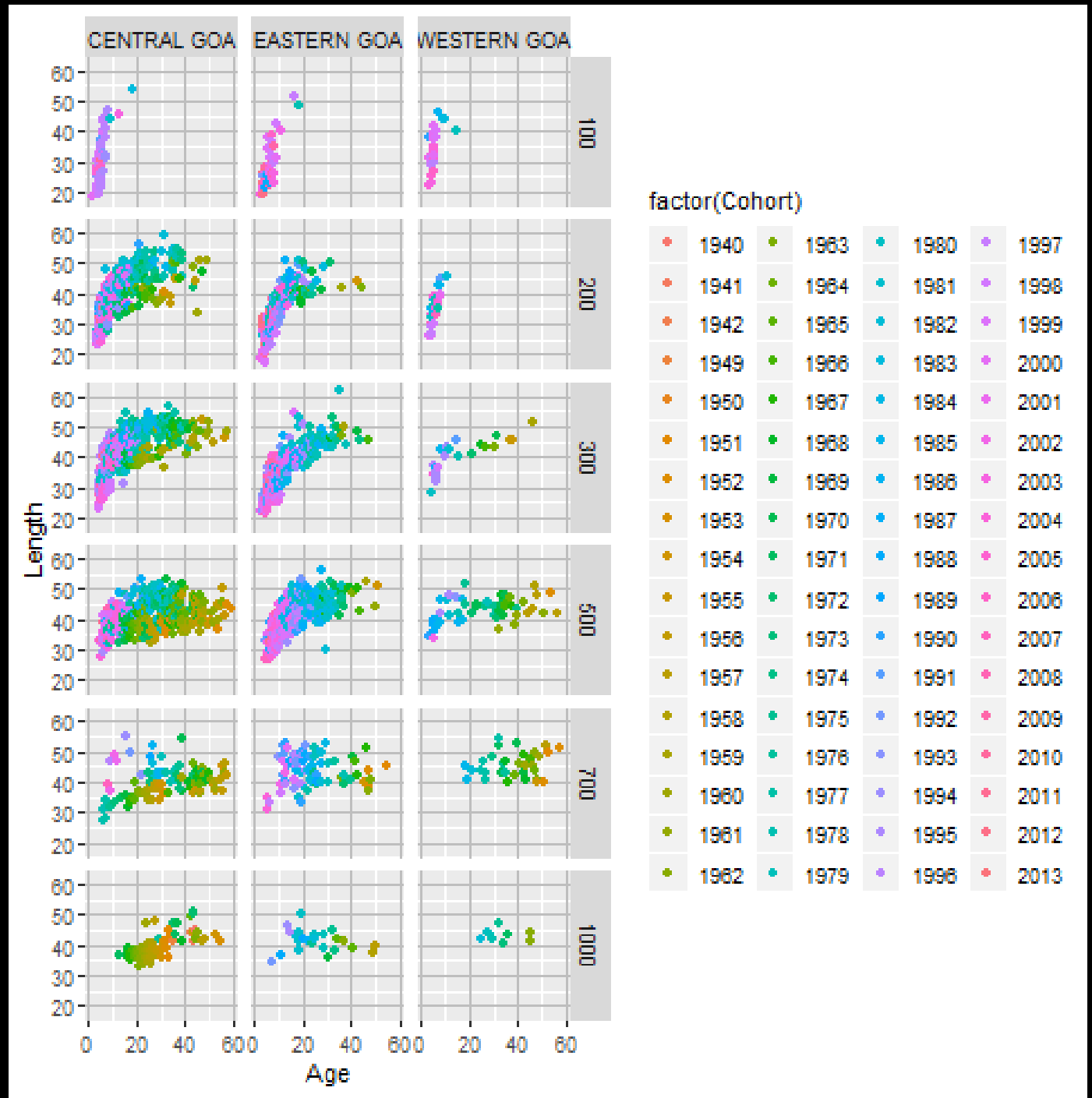
Male age-length plots by year and cohort



Female age-length plots by depth and cohort

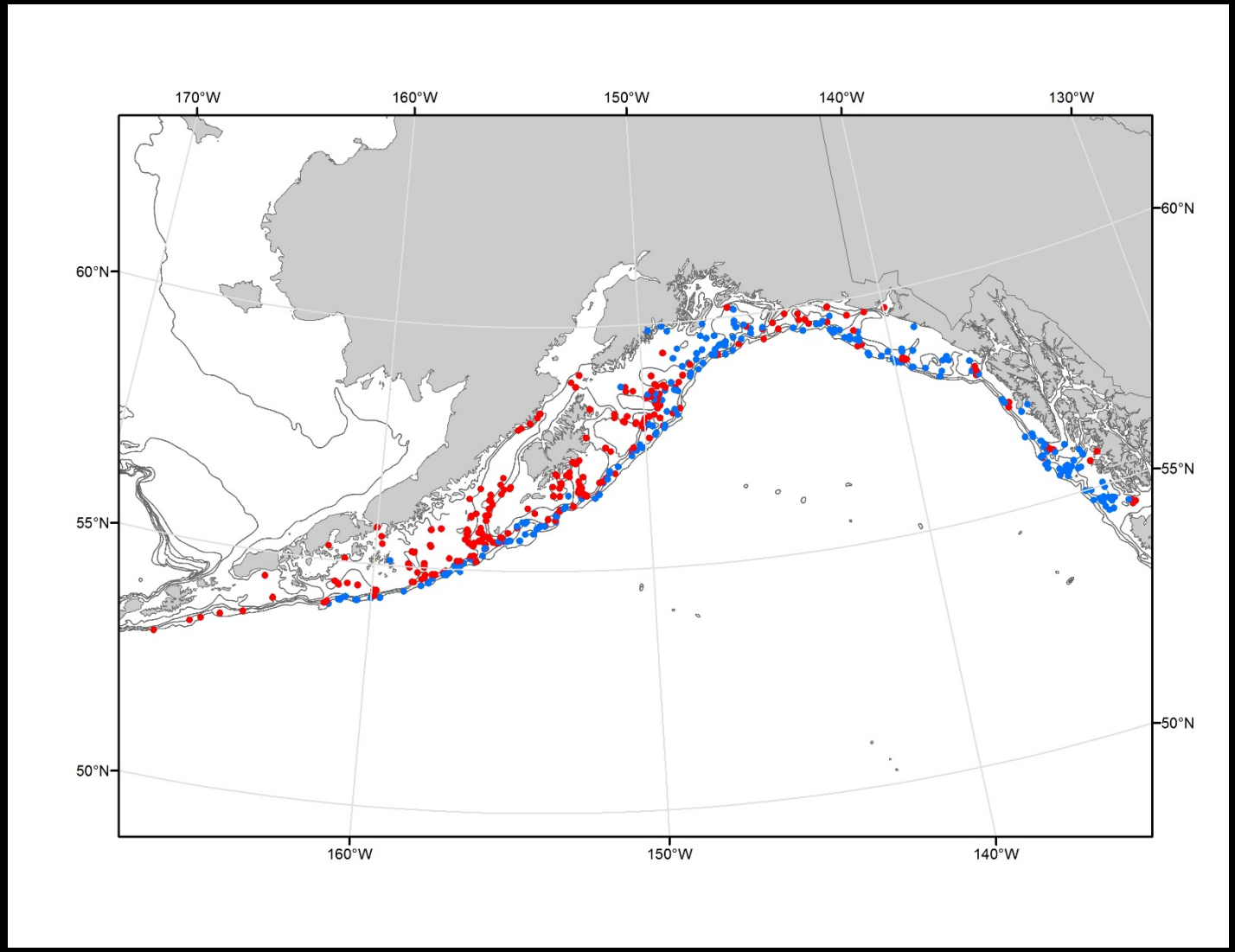


Male age-length plots by depth and cohort



GOA Dover sole residuals from sex-specific von-Bertalanffy models fit to survey data 2001-2015 outside the assessment model.

The blue points are more than 1 residual standard error below the curve and the red points are more than 1 RSE above the curve.



Models

Challenges for the Dover model

- Ageing error
- Time-varying growth, spatial growth
- Ontogenetic movement
- Inconsistent depth coverage by the GOA trawl survey over years
- Very small fishery (~3% of the catch limit is caught on average)
- No fishery age data

SSC Comments

PT, Sept, 2019: The Team recommends that, time permitting, the exploratory two-box model be included in the assessment as an appendix.

Included.

SSC Comments

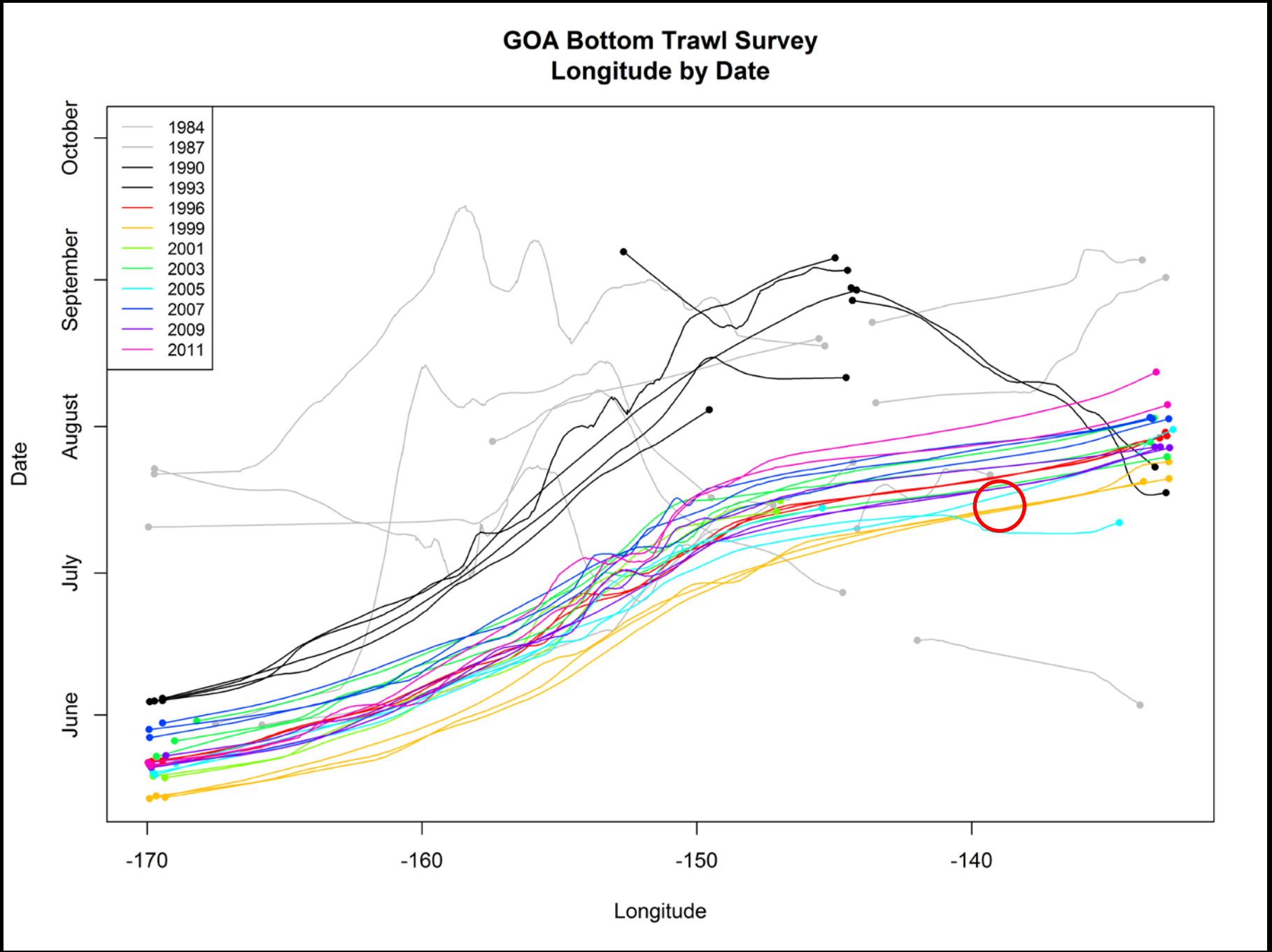
- *PT, Sept, 2019: The author's "clean up" model performed better than the [CIE] reviewer requested runs and it was proposed for moving forward. The Team agreed that the author's preferred model was appropriate to present on in November.*

The "cleaned-up" model will be presented, along with logical advances made after seeing the newest data.

SSC Comments

- *SSC, Dec. 2015: The SSC requests the authors to consider whether survey data from 1984 and 1987 are comparable or whether they should be removed from the analysis*

Considered and removed



30 minute tows in 1984 and 1987,

15 min tows in more recent years

SSC Comments

- *SSC, Dec. 2015: The SSC also asks the assessment authors to look into the decline in survey biomass in 2015. Given longevity and natural mortality rate of these flatfish species, the SSC questions whether such a decline is biologically reasonable, given relatively low fishery catches in recent years. As part of a broader analysis for all flatfish species, the SSC requests the assessment authors to consider whether a factor, such as temperature, could have negatively affected survey catchability for some flatfishes in 2015*

2017 and 2019 survey biomass was equally low.

Three hypotheses are considered for this:

1. Observation error
2. Change in catchability
3. Change in natural mortality

These were explored within the context of estimating catchability and natural mortality in general

SSC Comments

SSC, Dec. 2015: Finally, the SSC noted some odd selectivity curves for the full coverage survey (Fig. 10, p. 604). The authors are requested to consider the validity of a selectivity curve that appears asymptotic on the left-hand side of the curve, but drops precipitously to zero on the right-hand side of the curve. Is the right-hand side of the relationship informed by convincing data or should a straightforward asymptotic selectivity curve be assumed?

The “cleaned-up” model uses data inputs that better inform some selex parameters, and fixes selectivity parameters that are still poorly estimated

Top CIE Reviewer Requests

- Estimate catchability with a prior
- Remove all 1984 and 1987 data
- Stop estimating so many early-period recruitment deviations
- Even one year of fishery age data would help
- Francis data weighting

Data used in the models

Source	Type	Years
Fishery	Catch biomass	1978-Oct. 19, 2019
Fishery	Catch length composition	1991-Oct. 19, 2019
GOA survey bottom trawl	Survey biomass	Triennial: 1984-1999, Biennial: 2001-2019
GOA survey bottom trawl	Catch length composition	Triennial: 1990-1999, Biennial: 2003-2019 (1984, 1987, and 2001 data are excluded)
GOA survey bottom trawl	Catch age composition, conditioned on length	Triennial: 1990-1999, Biennial: 2003-2019 (1984, 1987, 1990, and 2001 data are excluded)

2015 Model Structure (last accepted assessment)

Growth:

- Conditional age-at-length approach
- Estimated parameters of the von-Bertalanffy growth within the model
- Estimated CV of length-at-age for youngest and oldest fish within the model

2015 Model Structure (last accepted assessment)

Selectivity:

- Fishery selectivity length-based, double-normal
- “Full coverage” survey selectivity: age-based, sex-specific double-normal, asymptotic.
- “Shallow coverage” survey selectivity: age-based, sex specific double-normal, dome-shape allowed

2015 Model Structure (last accepted assessment)

Other details:

- Estimated initial equilibrium F (but this is low, as are historical catches)
- Ageing error incorporated (borrowed from West Coast Dover sole assessment)
- Recruitment deviations prior to 1984 (“early-period recruits”) were estimated separately from main-period recruits (1984-2008)

2015 Model Fixed Parameters

- Natural mortality (0.085, as for previous assessments)
- Catchability (1, as for previous assessments)
- Weight-length relationship
- Maturity-at-age
- SigmaR = 0.49

Parameters Estimated within the 2015 model

- Ln(R0)
- Recruitment deviations (1965-2012) (no SR curve)

- Length-based, asymptotic fishery selectivity
- Age-based double-normal shallow and full coverage survey selectivity (separately), full coverage survey selectivity restricted to be asymptotic and to reach 1 at a reasonable age

- Yearly fishing mortality rates
- Parameters of the von-Bertalanffy growth curve
- CV of length-at-age for youngest and oldest fish

Bridging Analysis to 2019 Models

- 2015 Accepted Model

Selectivity Estimates:

Highlighted values correspond to a parameter on/near a bound

	Fishery		Full Coverage Survey		Shallow Coverage Survey	
Double-normal selectivity parameters	Est	Std. Dev.	Est	Std. Dev.	Est	Std. Dev.
Peak: beginning size for the plateau	48.81	1.27	**45.00**	0.09	23.16	1.80
Width: width of plateau	Fixed		Fixed		-0.28	0.25
Ascending width (log space)	4.26	0.24	**11.96**	1.21	5.06	0.22
Descending width (log space)	Fixed		Fixed		-0.73	14.80
Initial: selectivity at smallest length or age bin	Fixed		Fixed		-498	11236.20
Final: selectivity at largest length or age bin	Fixed		Fixed		**-4.99**	0.44
Male Peak Offset	-9.28	1.37	-13.35	1.41	**-15.00**	0.05
Male ascending width offset (log space)	-1.46	0.37	4.68	119.24	-2.74	0.65
Male descending width offset (log space)	Fixed		Fixed		3.75	14.12
Male "Final" offset (transformation required)	Fixed		Fixed		0.03	0.88
Male apical selectivity	Fixed		Fixed		0.58	0.06

Selectivity Estimates:

Highlighted values correspond to a parameter on/near a bound

	Fishery		Full Coverage Survey		Shallow Coverage Survey	
Double-normal selectivity parameters	Est	Std. Dev.	Est	Std. Dev.	Est	Std. Dev.
Peak: beginning size for the plateau	48.81	1.27	**45.00**			1.80
Width: width of plateau			Fixed			0.25
Ascending width (log space)		0.24	**11.96**			0.22
Descending width (log space)			Fixed		-0.73	14.80
Initial: selectivity at smallest length or age bin	Fixed		Fixed		-498	11236.20
Final: selectivity at largest length or age bin	Fixed		Fixed		**-4.99**	0.44
Male Peak Offset	-9.28	1.37	-13.35	1.41	**-15.00**	0.05
Male ascending width offset (log space)	-1.46	0.37	4.68	119.24	-2.74	0.65
Male descending width offset (log space)	Fixed		Fixed		3.75	14.12
Male "Final" offset (transformation required)	Fixed		Fixed		0.03	0.88
Male apical selectivity	Fixed		Fixed		0.58	0.06

Forces the curve to end up at 1 by age 45

Limits the shallowness of the curve between 0 and 1

Selectivity Estimates:

Highlighted values correspond to a parameter on/near a bound

	Fishery		Full Coverage Survey		Shallow Coverage Survey	
Double-normal selectivity parameters	Est	Std. Dev.	Est	Std. Dev.	Est	Std. Dev.
Peak: beginning size for the plateau	48.81	1.27	**45.00**	0.09	23.16	1.80
Width: width of plateau	Fixed		Fixed		-0.28	0.25
Ascending width (log space)	4.26	0.24	**11.96**	1.21	5.06	0.22
Descending width (log space)	Fixed		Fixed		-0.73	14.80
Initial: selectivity at smallest length or age bin	Fixed				-498	11236.20
Final: selectivity at largest length or age bin	Fixed				**-4.99**	0.44
Male Peak Offset	-9.28			1.41	**-15.00**	0.05
Male ascending width offset (log space)	-1.46	0.37	4.68	119.24	-2.74	0.65
Male descending width offset (log space)	Fixed				3.75	14.12
Male "Final" offset (transformation required)	Fixed				0.03	0.88
Male apical selectivity	Fixed				0.58	0.06

Shallow survey catches none of the very oldest fish

Males reach peak selectivity more than 15 years before females?

Bridging Analysis to 2019 Models

- 2015 Accepted Model
- “Cleaned-up” version of 2015 model
  - Disaggregated age 1-3 age data
  - Omitted 1984 and 1987 survey data (all)
  - Historical F = 0
  - Omit early recruitment deviations
  - Francis data weighting
  - Timing of survey refined to occur in June in model
  - Fixed poorly informed selectivity parameters (desc limb survey selex param, “final” male param)

- No parameters on bounds in cleaned-up model

Bridging Analysis to 2019 Models

- “Cleaned-up,” but estimate M and q
- “Cleaned-up,” estimate M and q with a block on 2014-2019 M and q (estimated separately in these years)

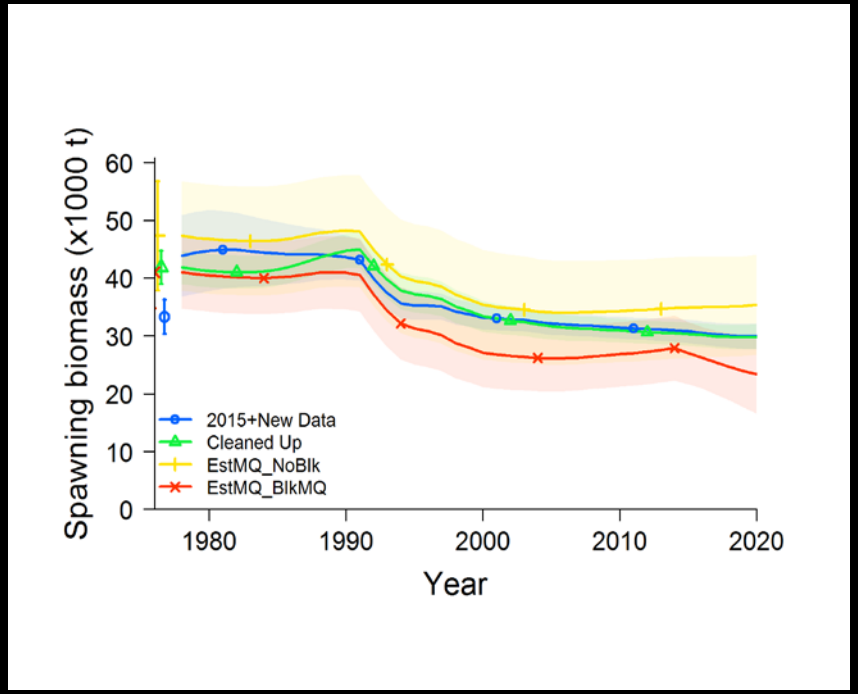
Distribution of natural mortality estimates

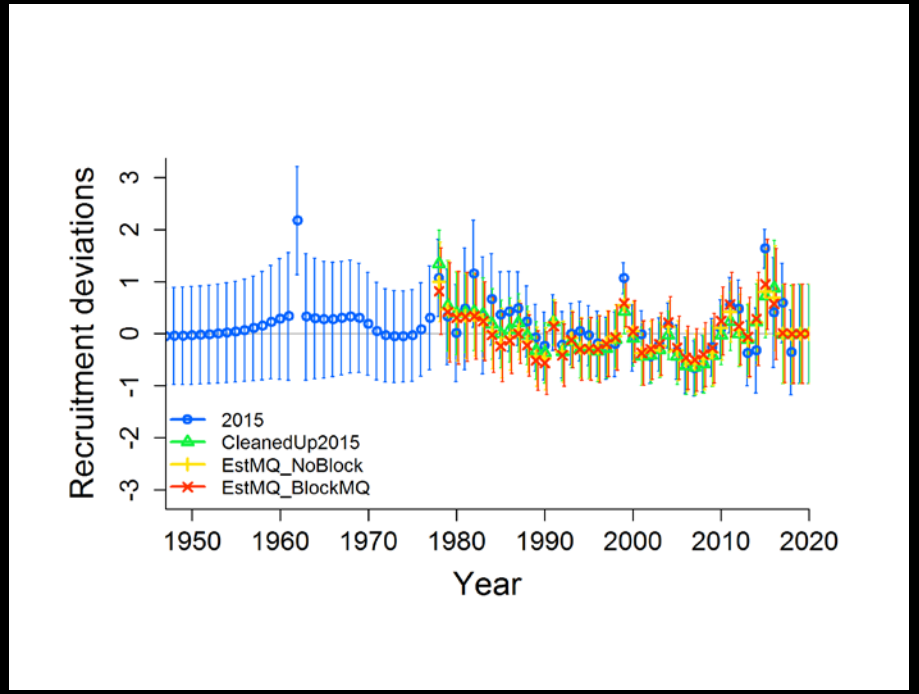
(weighted average of methods)

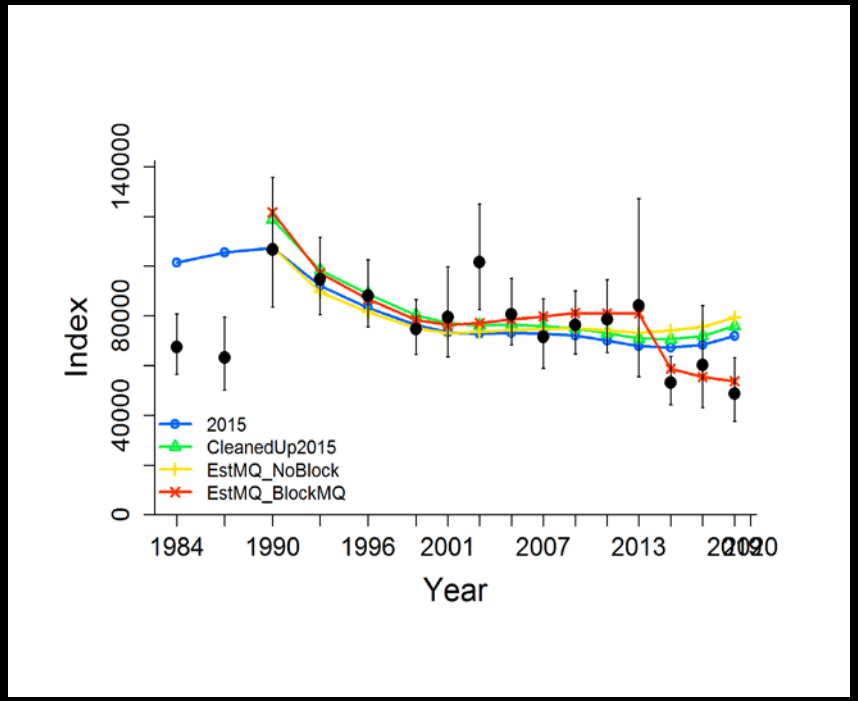
http://barefootecologist.com.au/shiny_m.html

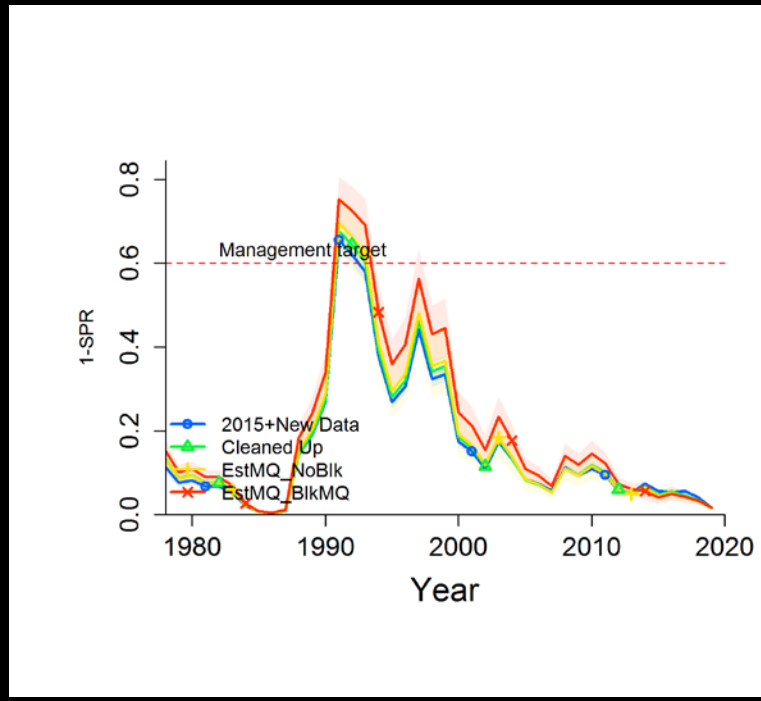
Author: Jason Cope

Bridging Analysis

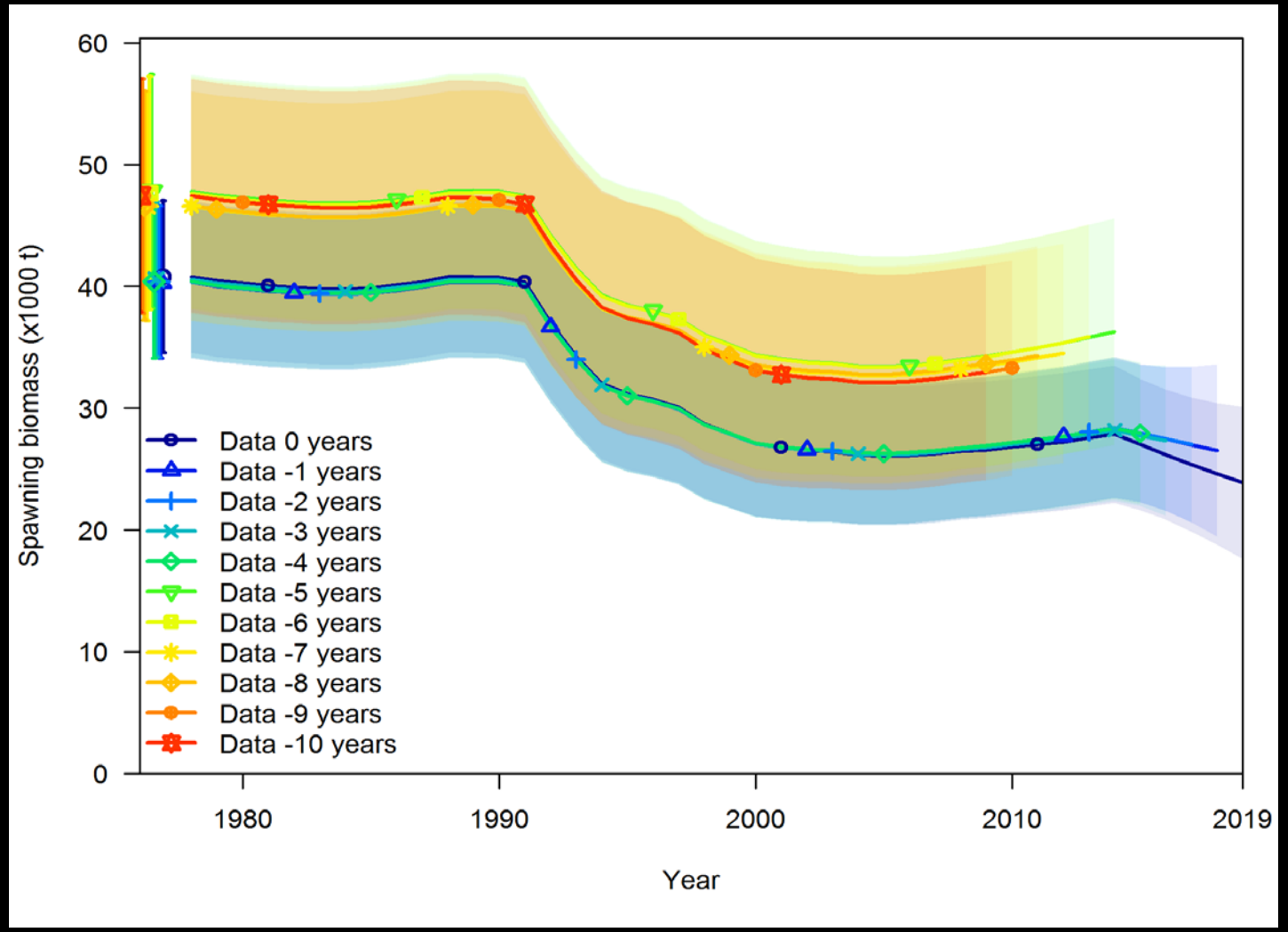








Bridging Analysis: Problem with retrospective pattern



Bridging Analysis: Key Parameter Values

	2015 Model + new data		Cleaned-up 2015 Model + new data		Est time-invariant M and Q (Model 19.0)		Est M & Q 1978-2014, est separate 2014-2019 M & Q	
Parameter	**Est**	**Std. Dev.**	**Est**	**Std. Dev.**	**Est**	**Std. Dev.**	**Est**	**Std. Dev.**
Natural mortality (f)	0.085		0.085		0.069	0.003	0.066	0.003
Natural mortality (m)	0.085		0.085		0.057	0.003	0.053	0.003
Natural mortality (f), 2014-2019							0.105	0.02
Natural mortality (m), 2014-2019							0.111	0.02
Length at age 3 (f)	26.30	0.50	24.26	0.75	24.55	0.76	24.47	0.77
Length at age 59 (f)	52.55	0.46	51.24	0.34	50.83	0.31	50.75	0.31
von Bertalanffy k (f)	0.11	0.01	0.15	0.01	0.16	0.01	0.16	0.01
CV in length at age 3 (f)	0.15	0.01	0.16	0.01	0.16	0.01	0.16	0.01
CV in length at age 59 (f)	0.10	0.00	0.10	0.00	0.10	0.00	0.10	0.00
Length at age 3 (m)	23.82	0.84	26.65	0.93	26.53	0.89	26.54	0.91
Length at age 59 (m)	43.50	0.21	43.80	0.30	43.48	0.28	43.44	0.27
von Bertalanffy k (m)	0.24	0.02	0.20	0.02	0.20	0.02	0.20	0.02
CV in length at age 3 (m)	0.17	0.01	0.15	0.01	0.15	0.01	0.15	0.01
CV in length at age 59 (m)	0.09	0.00	0.08	0.00	0.08	0.00	0.08	0.00
$\ln(R_0)$	9.44	0.04	9.65	0.04	9.36	0.14	9.13	0.11
Log catchability (ln(q))	0.00	NA	0.00		-0.17	0.12	0.12	0.10
Log catchability (ln(q)), 2014-2019							-0.16	0.10

2019 Candidate Models

Model 19.0: “Cleaned-up,” but M and q estimated (time-invariant)

=> Low recent survey bio. due to observation error

Model 19.1: As for 19.0, but M block 2014-2019

=> Low recent survey bio. due to change in natural mortality

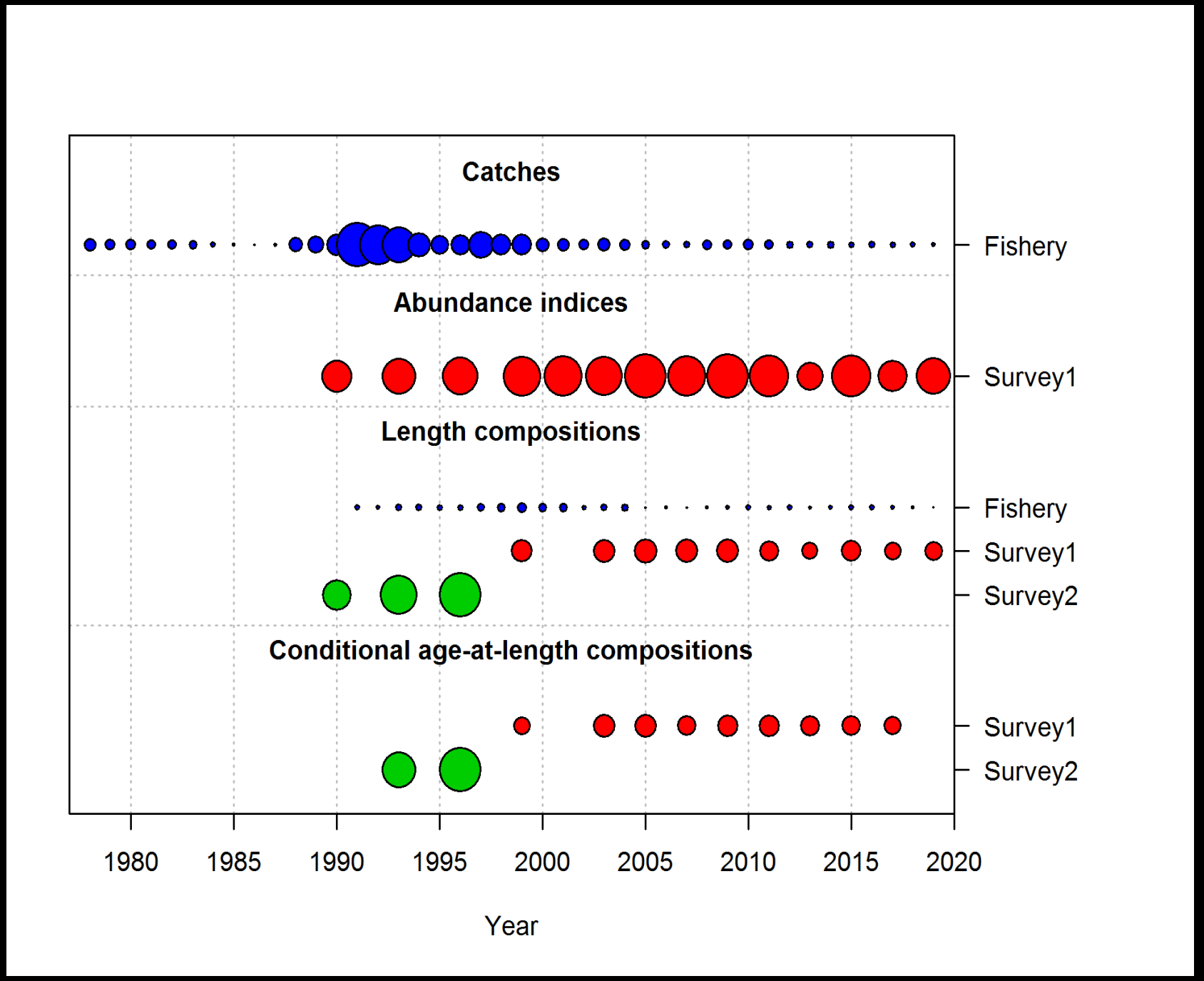
Model 19.2: As for 19.0, but q fixed at 19.1’s estimate for 1978-2013, q estimated 2014-2019

=> Low recent survey bio. due to change in catchability

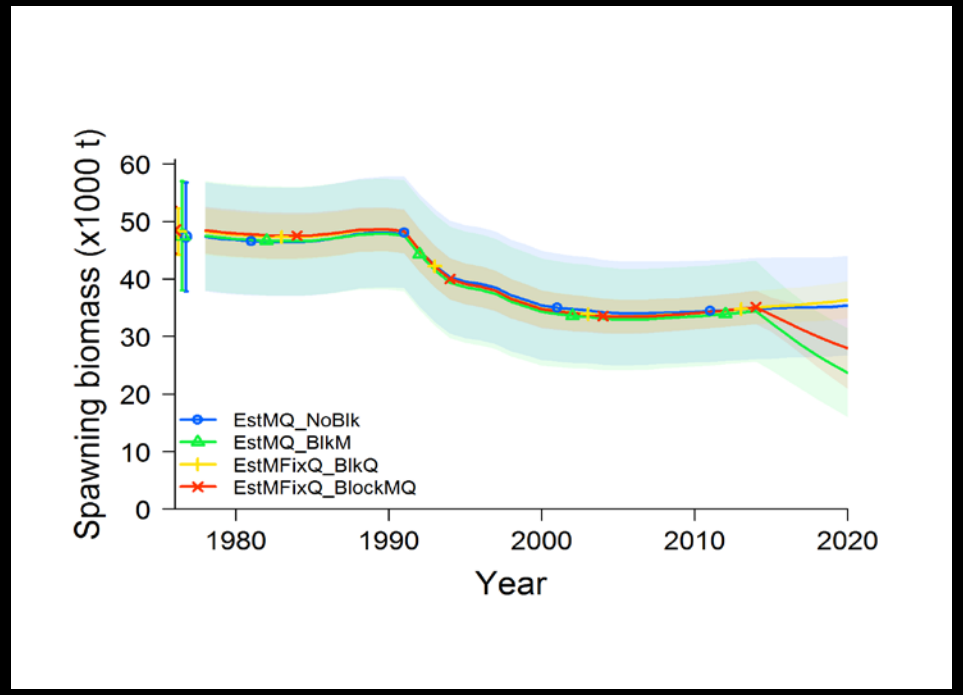
Model 19.3: As for 19.0, but Q fixed at 19.1’s estimate for 1978-2013; M and q block 2014-2019

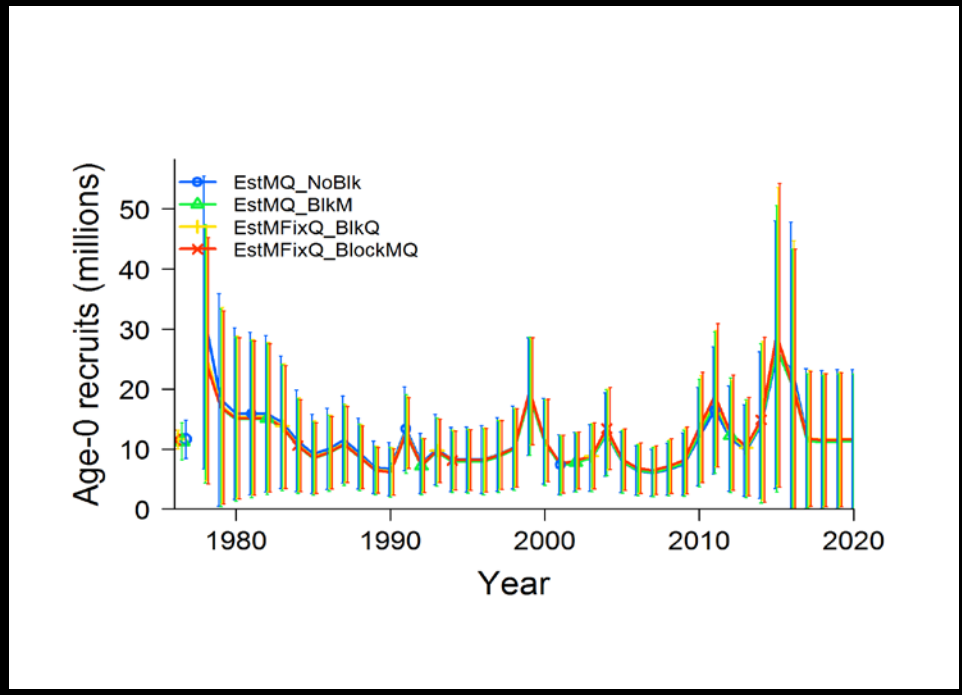
=> Low recent survey bio. due to both change in natural mortality and change in catchability

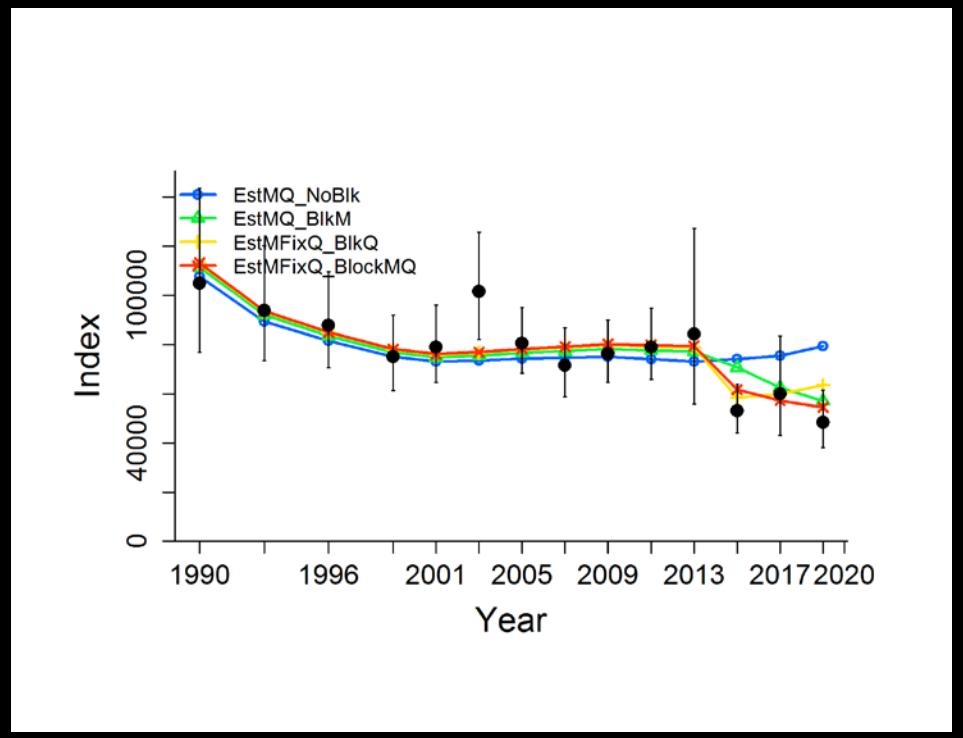
Data used in the 2019 candidate models

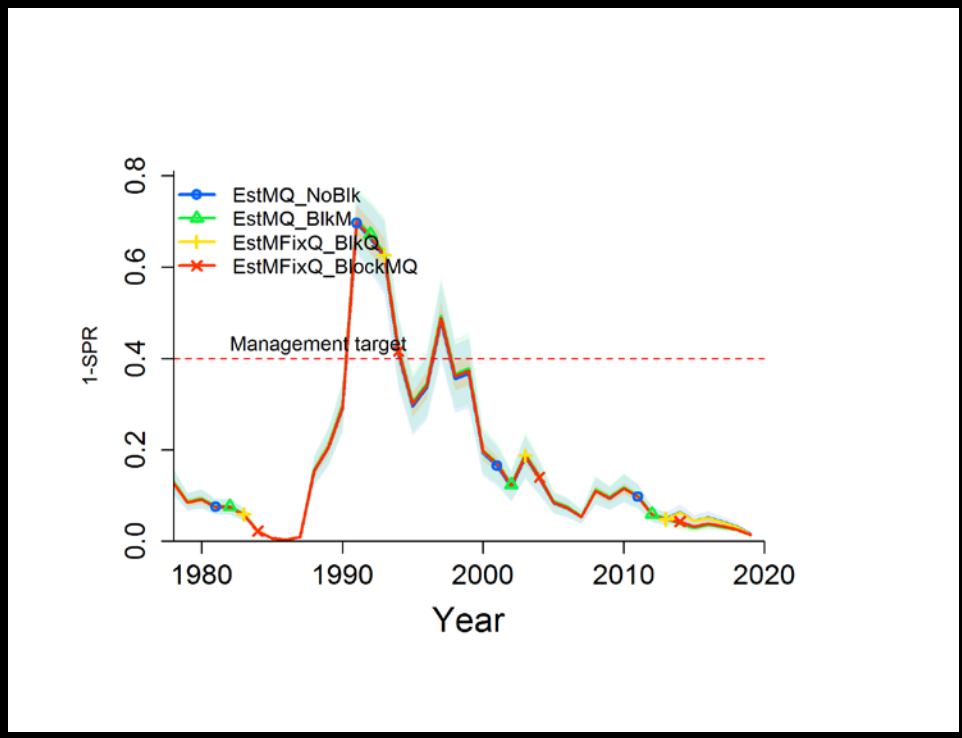


2019 Candidate Models

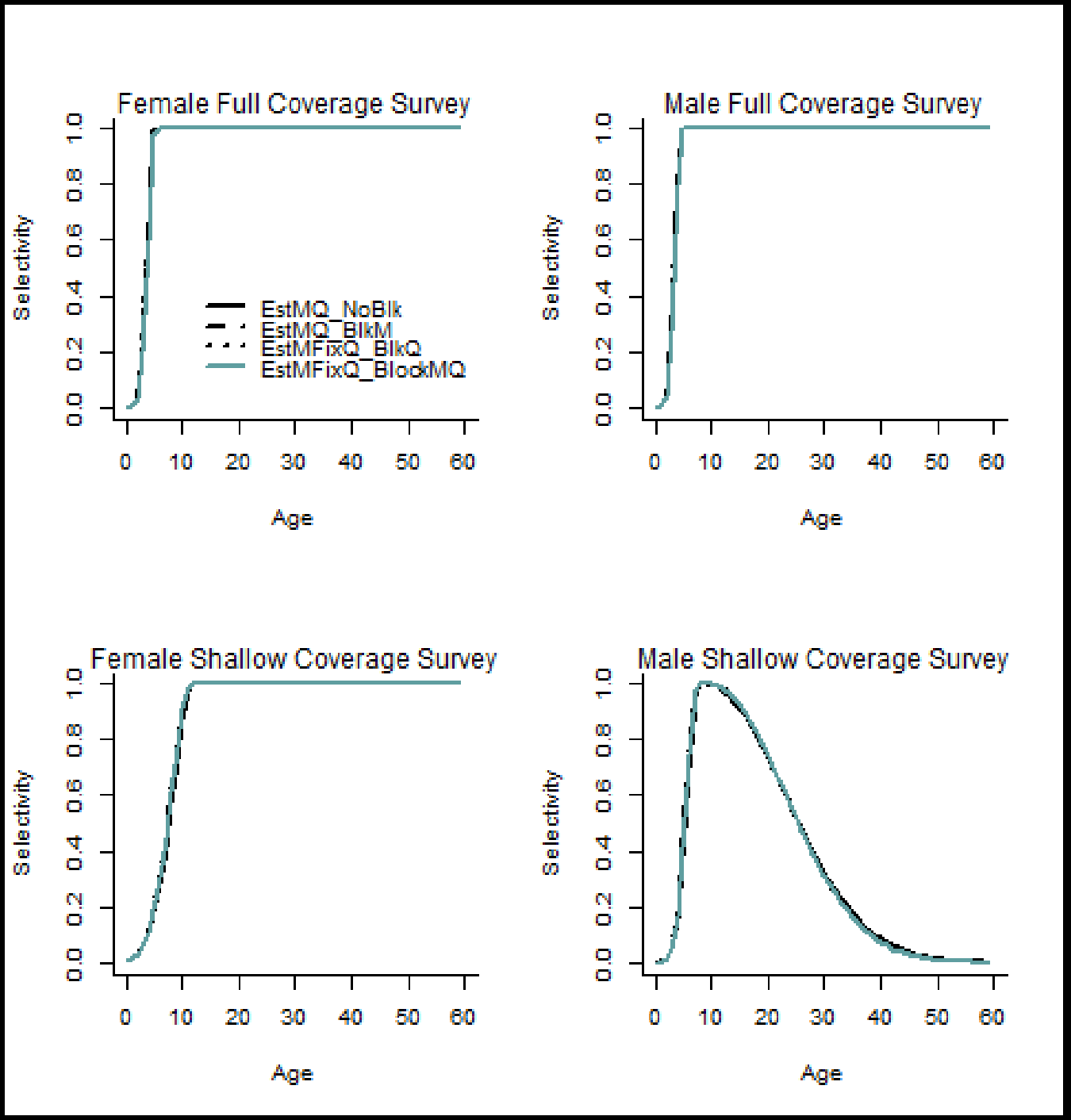








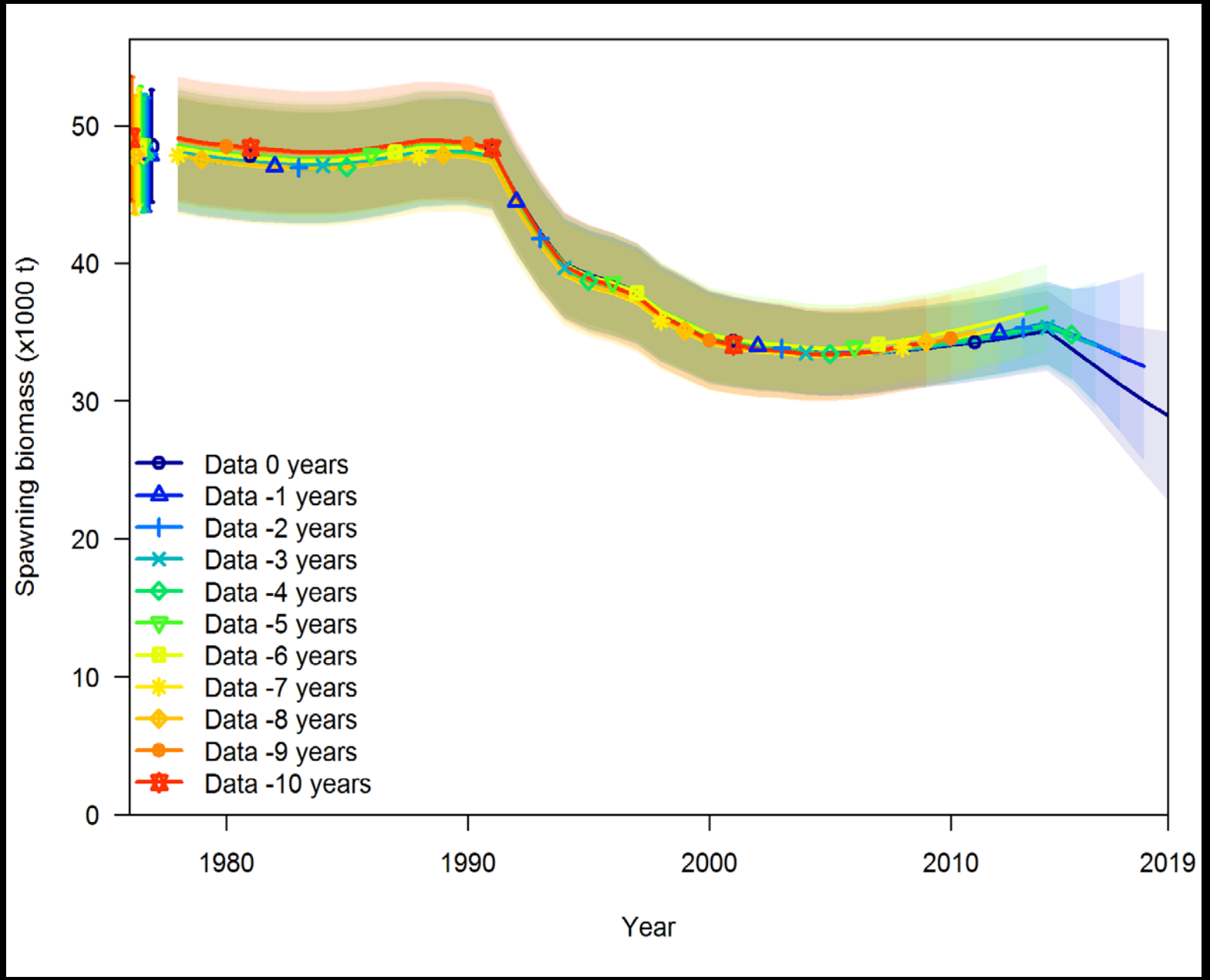
2019 Candidate Models



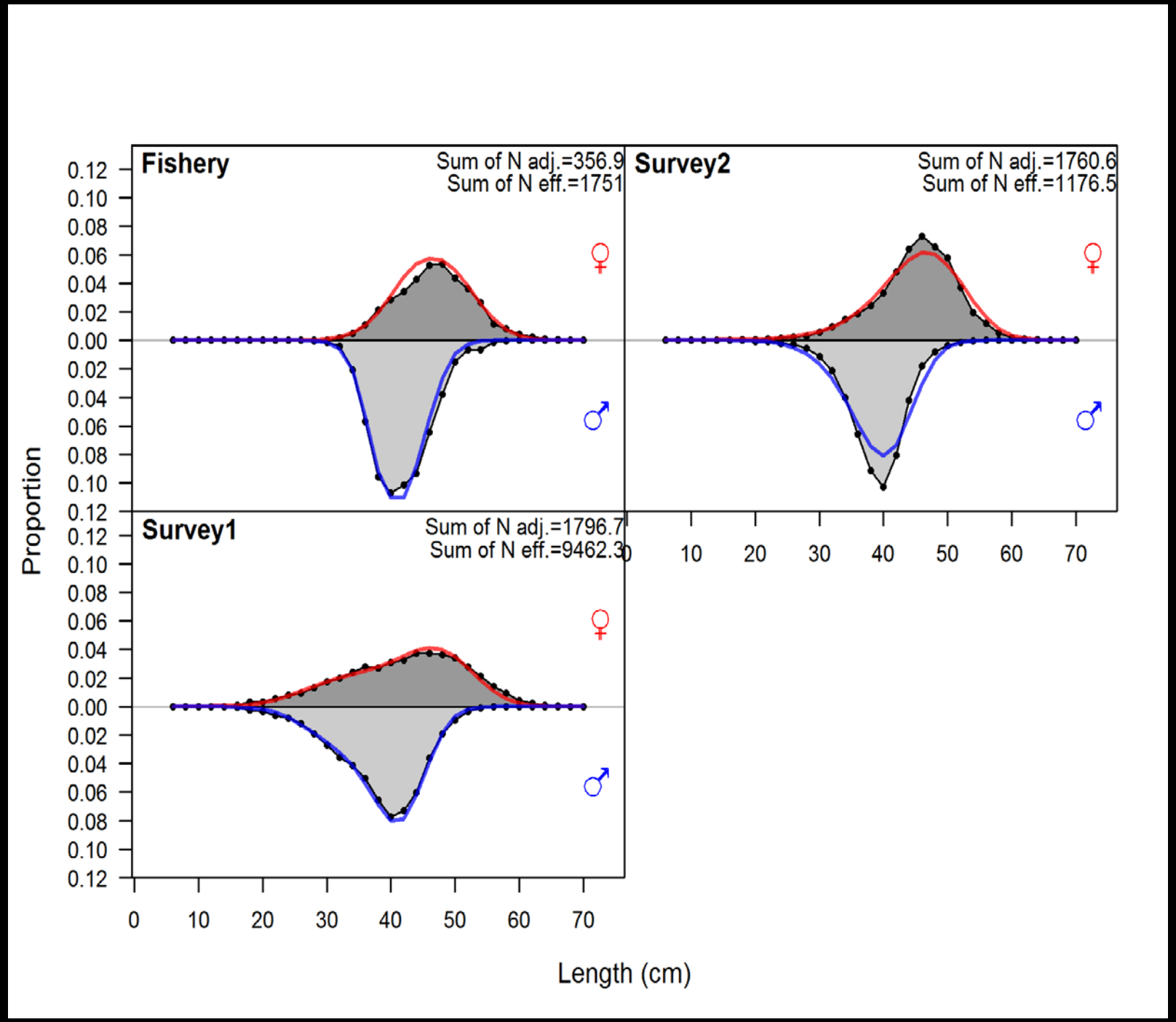
2019 Candidate Models: Key Parameter Values

	Model 19.0		Model 19.1		Model 19.2		Model 19.3	
	Est time-invariant M and Q		Est M & Q, est separate M 2014-2019		Est M, est separate Q 2014-2019		Est M, est separate M & Q 2014-2019	
Parameter	**Est**	**Std. Dev.**	**Est**	**Std. Dev.**	**Est**	**Std. Dev.**	**Est**	**Std. Dev.**
Natural mortality (f)	0.069	0.003	0.067	0.003	0.068	0.003	0.068	0.003
Natural mortality (m)	0.057	0.003	0.055	0.003	0.056	0.003	0.055	0.003
Natural mortality (f), 2014-2019			0.135	0.02			0.113	0.02
Natural mortality (m), 2014-2019			0.14	0.02			0.119	0.02
Length at age 3 (f)	24.55	0.76	24.54	0.77	24.51	0.77	24.51	0.77
Length at age 59 (f)	50.83	0.31	50.78	0.31	50.78	0.31	50.77	0.31
von Bertalanffy k (f)	0.16	0.01	0.16	0.01	0.16	0.01	0.16	0.01
CV in length at age 3 (f)	0.16	0.01	0.16	0.01	0.16	0.01	0.16	0.01
CV in length at age 59 (f)	0.10	0.00	0.10	0.00	0.10	0.00	0.10	0.00
Length at age 3 (m)	26.53	0.89	26.58	0.91	26.51	0.91	26.55	0.91
Length at age 59 (m)	43.48	0.28	43.45	0.27	43.45	0.27	43.44	0.27
von Bertalanffy k (m)	0.20	0.02	0.20	0.02	0.20	0.02	0.20	0.02
CV in length at age 3 (m)	0.15	0.01	0.15	0.01	0.15	0.01	0.15	0.01
CV in length at age 59 (m)	0.08	0.00	0.08	0.00	0.08	0.00	0.08	0.00
$\ln(R_0)$	9.36	0.14	9.33	0.14	9.36	0.07	9.36	0.07
Log catchability (ln(q))	-0.17	0.12	-0.12	0.13	-0.12	Fixed	-0.12	Fixed
Log catchability (ln(q)), 2014-2019					-0.44	0.07	-0.32	0.08

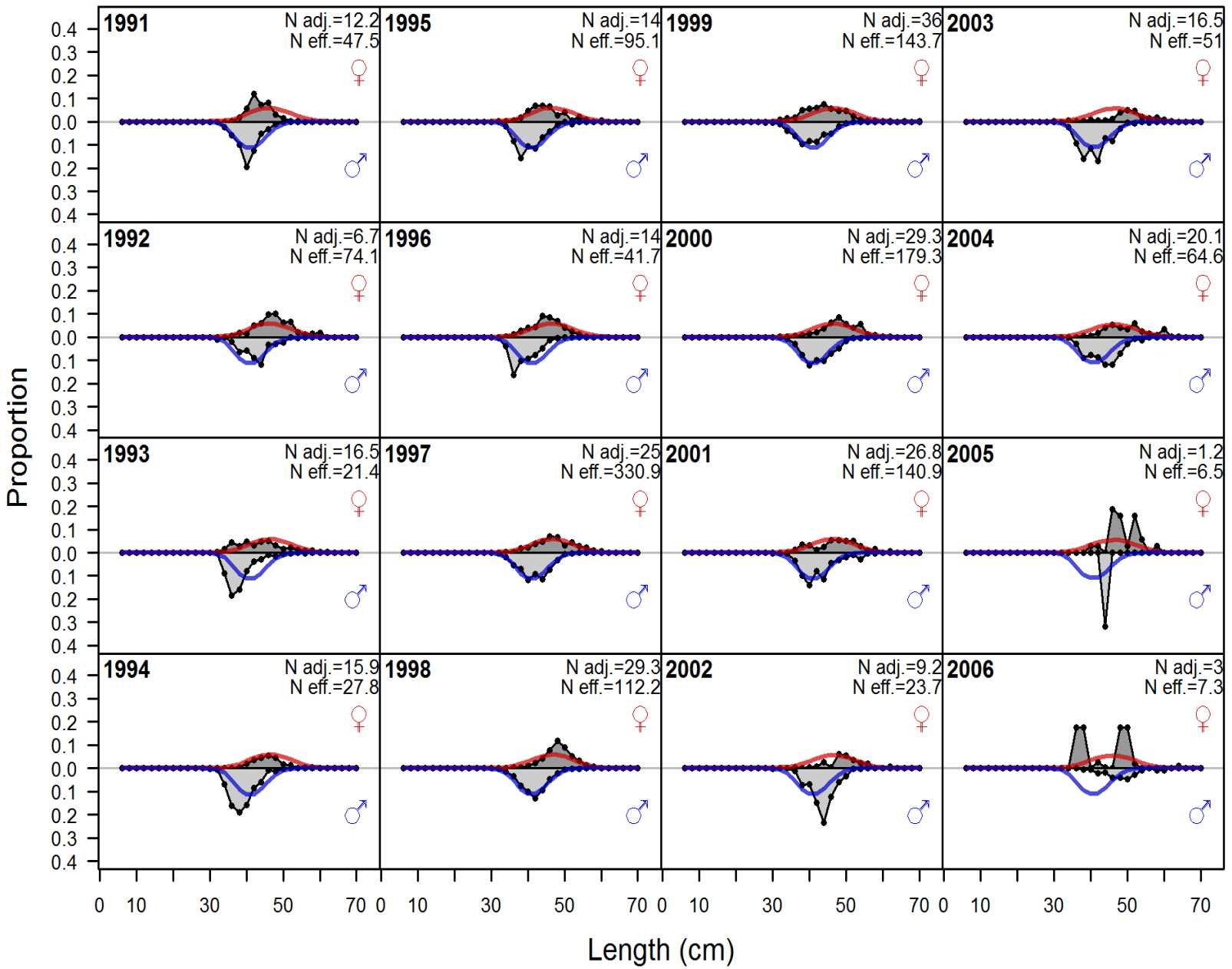
Model 19.3: Retrospective pattern



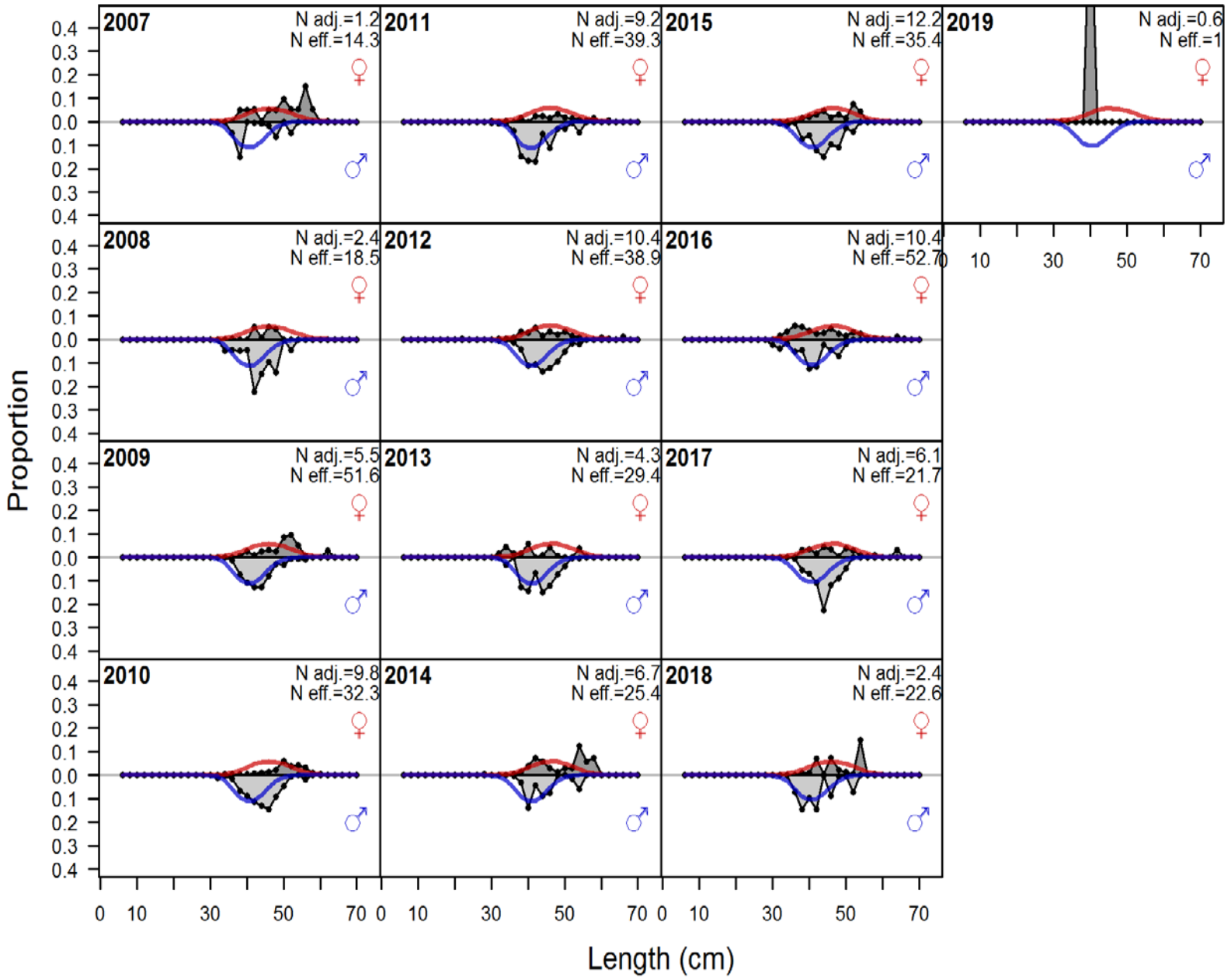
Model 19.3: Aggregated length comps



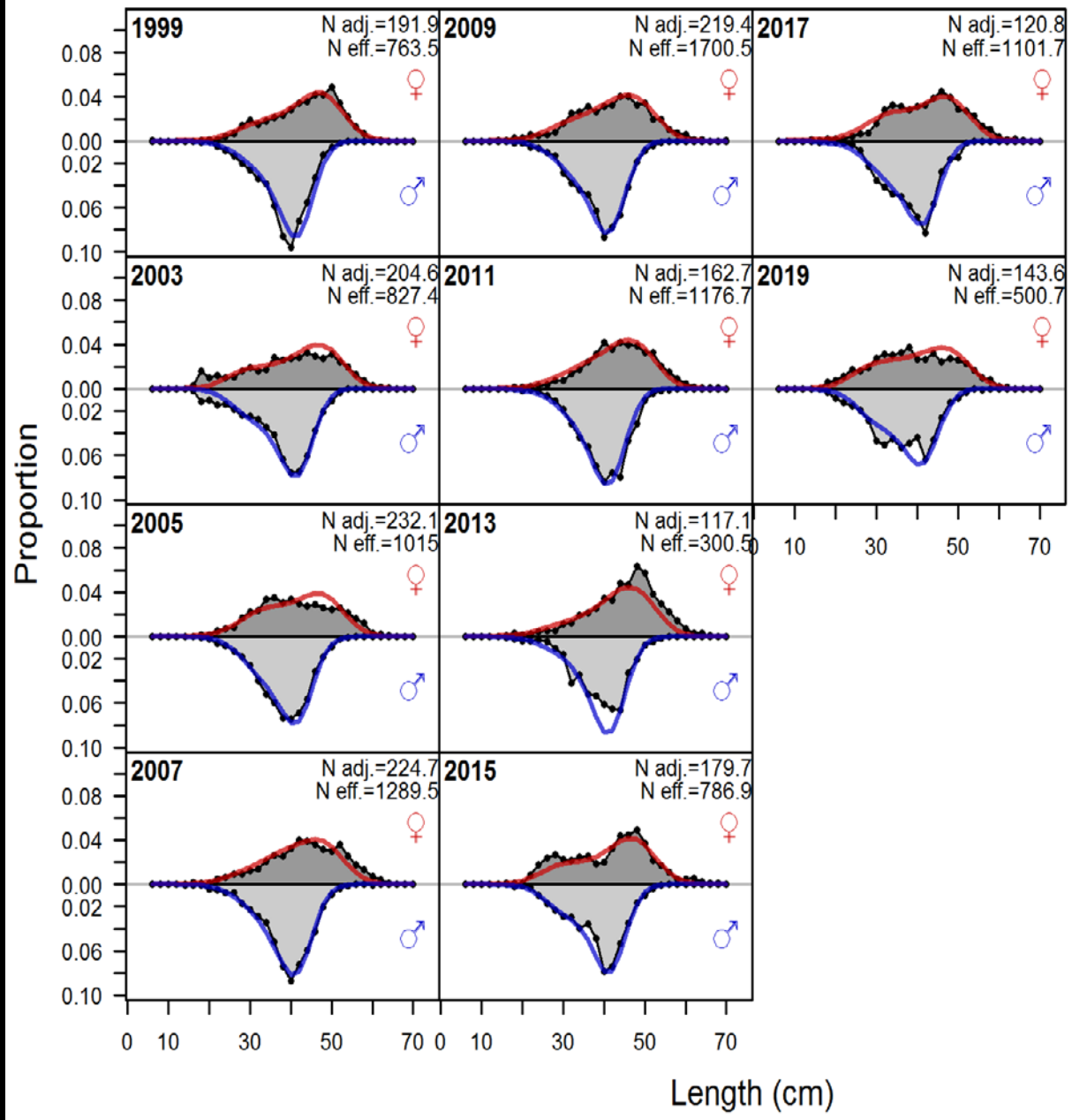
Model 19.3: Yearly fishery length comps



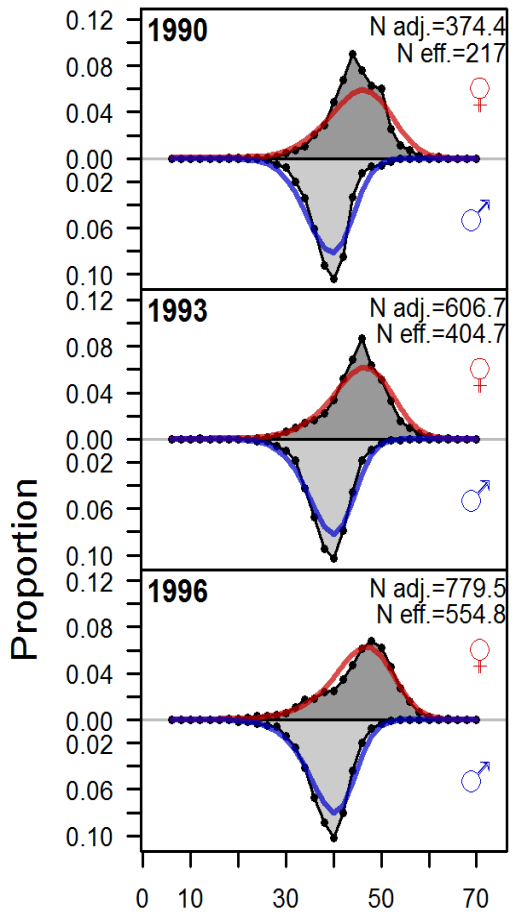
Model 19.3: More yearly fishery length comps



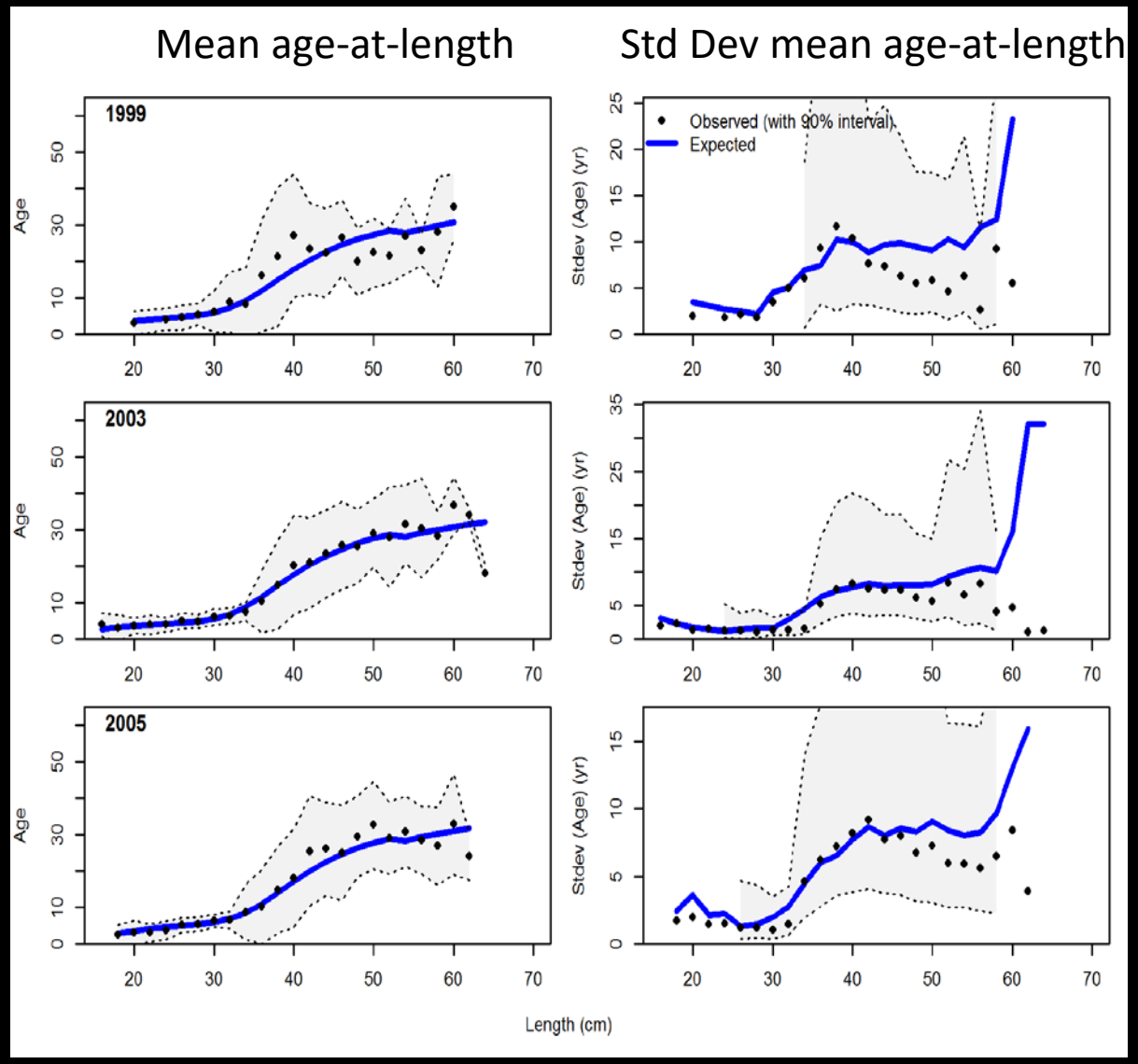
Model 19.3: Yearly “full-coverage” survey length comps

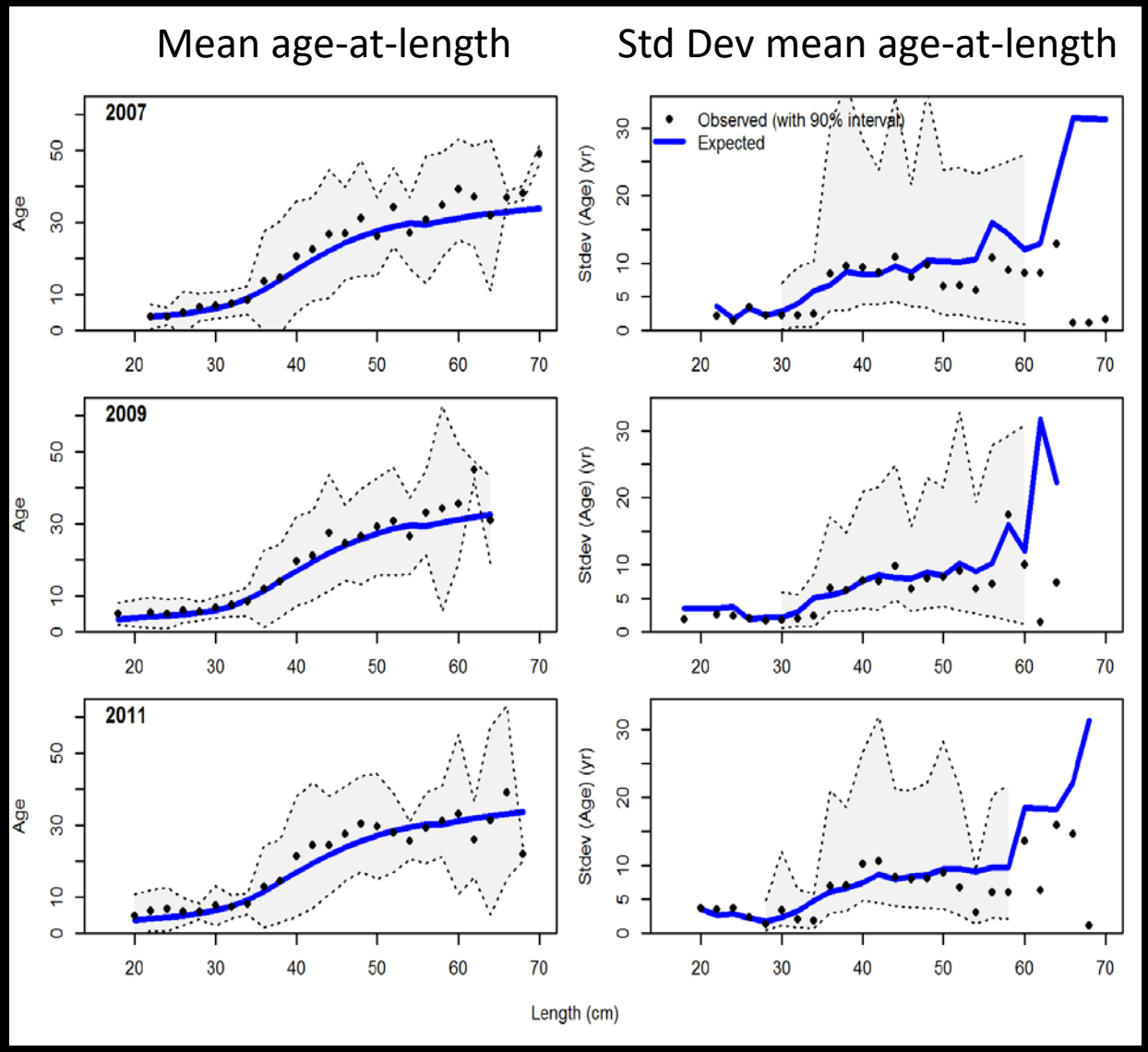


Model 19.3: Yearly “shallow-coverage” survey length comps

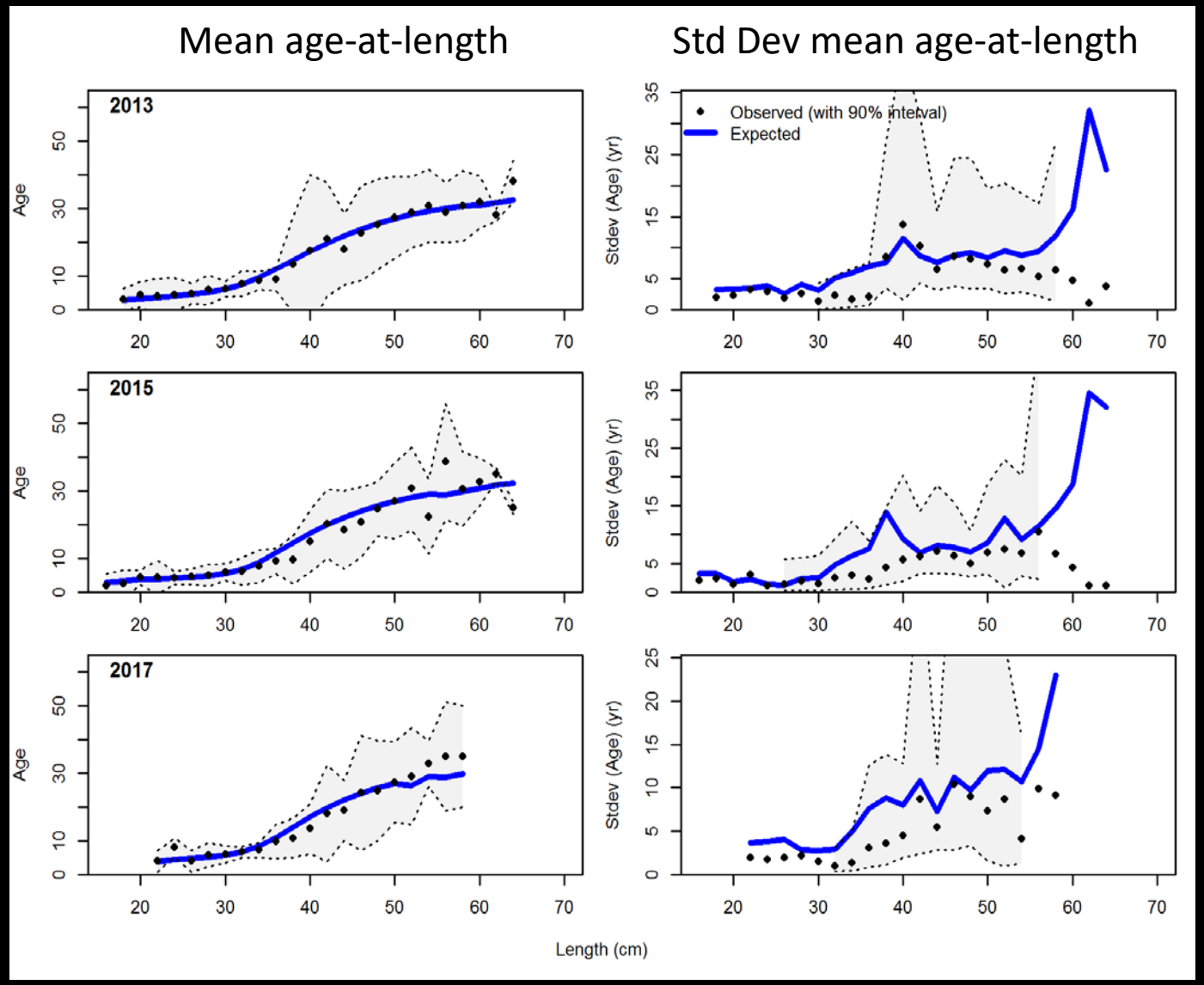


Model 19.3: Yearly fits to mean age-at-length (full-coverage survey)

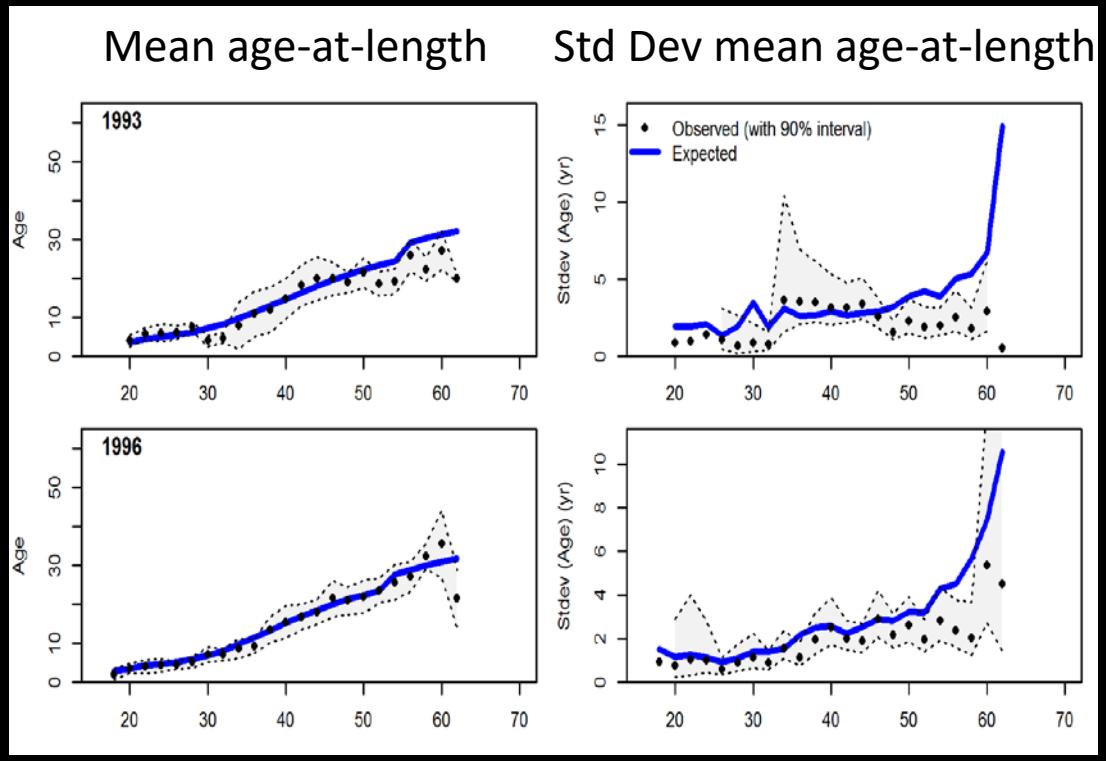




Model 19.3: Yearly fits to mean age-at-length (full-coverage survey)



Model 19.3: Yearly fits to mean age-at-length (shallow-coverage survey)



Risk Table:

- Assessment: 2
- Population dynamics: 1
- Environmental/ecosystem: 1
- Fishery performance: 1

	Assessment-related considerations	*Population dynamics considerations*	*Environmental/ecosystem considerations*	*Fishery Performance*
Level 1: Normal	Typical to moderately increased uncertainty/minor unresolved issues in assessment.	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental/ecosystem concerns	No apparent fishery/resource-use performance and/or behavior concerns
Level 2: Substantially increased concerns	Substantially increased assessment uncertainty/ unresolved issues.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.	Some indicators showing an adverse signals relevant to the stock but the pattern is not consistent across all indicators.	Some indicators showing adverse signals but the pattern is not consistent across all indicators
Level 3: Major Concern	Major problems with the stock assessment; very poor fits to data; high level of uncertainty; strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level as the stock, and/or b) up or down trophic levels (i.e., predators and prey of the stock)	Multiple indicators showing consistent adverse signals a across different sectors, and/or b different gear types
Level 4: Extreme concern	Severe problems with the stock assessment; severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented; More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns.	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock; Potential for cascading effects on other ecosystem components	Extreme anomalies in multiple performance indicators that ar highly likely to impact the stock

Executive Summary

- Projection model for Dover sole using output from age-structured model (Model 19.3)
- Used age 3 recruits
- 2019 catch estimated as 2019 current catch up to Oct 19 + 5-yr average Oct 19-Dec 31 catch
- 2020-2021 catch estimated as 2014-2018 average catch for Dover sole
- No management definitions for Kamchatka flounder

Species	Quantity	As estimated or *specified last* year for: 2019	2020	As estimated or *recommended this* year for: 2020*	2021*
Dover sole	*M* (natural mortality rate)	0.085	0.085	0.113(f), 0.119(m)	0.113(f), 0.119(m)
	Tier	3a	3a	3a	3a
	Projected total (3+) biomass (t)	145,926	147,001	86,827	84,771
	Projected Female spawning biomass (t)	49,385	49,418	27,935	27,011
	$B_{100\%}$	57,871	57,871	19,032	19,032
	$B_{40\%}$	23,148	23,148	7,613	7,613
	$B_{35\%}$	20,255	20,255	6,661	6,661
	F_{OFL}	0.12	0.12	0.11	0.11
	$maxF_{ABC}$	0.1	0.1	0.09	0.09
	F_{ABC}	0.1	0.1	0.09	0.09
	OFL (t)	11,190	11,337	6,919	6,796
	maxABC (t)	9,318	9,441	5,847	5,743
	ABC (t)	9,318	9,441	5,847	5,743
Greenland turbot	Tier	6	6	6	6
	OFL (t)	238	238	238	238
	maxABC (t)	179	179	179	179
	ABC (t)	179	179	179	179
Deepsea sole	Tier	6	6	6	6
	OFL (t)	6	6	6	6
	maxABC (t)	4	4	4	4
	ABC (t)	4	4	4	4
Deepwater Flatfish Complex	OFL (t)	11,434	11,581	7,163	7,040
	maxABC (t)	9,501	9,624	6,030	5,926
	ABC (t)	9,501	9,624	6,030	5,926
	Status	As determined *last* year for: 2017	2018	As determined *this* year for: 2018	2019
	Overfishing	no	n/a	no	n/a
	Overfished	n/a	no	n/a	no
	Approaching overfished	n/a	no	n/a	no

Area Apportionment (PT chose method in 2016)

- Dover sole proportions from area- and depth-specific random effects models to smooth survey biomass and fill in depth/area gaps
- Greenland turbot and deepsea sole proportions based on average survey biomass for each species since 2001
- ABCs are applied at the complex level

Species	Year	Western	Central	West Yakutat	Southeast	Total
Dover Sole		0.8%	33.3%	36.0%	29.9%	100.0%
	2020	47	1,945	2,104	1,751	5,847
	2021	46	1,911	2,067	1,719	5,743
Greenland Turbot		100.0%	0.0%	0.0%	0.0%	100.0%
	2020	179	0	0	0	179
	2021	179	0	0	0	179
Deepsea Sole		0.7%	72.8%	14.5%	12.0%	100.0%
	2020	0	3	1	0	4
	2021	0	3	1	0	4
Deepwater Flatfish	**2020**	**226**	**1,948**	**2,105**	**1,751**	**6,030**
	2021	**225**	**1,914**	**2,068**	**1,719**	**5,926**

Extra slides, if needed:

2015 Model Alternative

- Projection model for Dover sole using output from age-structured model
- Used age 3 recruits
- 2019 catch estimated as 2019 current catch up to Oct 19 + 5-yr average Oct 19-Dec 31 catch
- 2020-2021 catch estimated as 2014-2018 average catch for Dover sole
- No management definitions for Kamchatka flounder

Species	Quantity	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
		2019	2020	2020*	2021*
Dover sole	*M* (natural mortality rate)	0.085	0.085	0.085	0.085
	Tier	3a	3a	3a	3a
	Projected total (3+) biomass (t)	145,926	147,001	99,530	101,696
	Projected Female spawning biomass (t)	49,385	49,418	29,908	29,972
	$B_{100\%}$	57,871	57,871	42,132	42,132
	$B_{40\%}$	23,148	23,148	16,853	16,853
	$B_{35\%}$	20,255	20,255	14,746	14,746
	F_{OFL}	0.12	0.12	0.11	0.11
	$maxF_{ABC}$	0.1	0.1	0.09	0.09
	F_{ABC}	0.1	0.1	0.09	0.09
	OFL (t)	11,190	11,337	6,718	7,021
	maxABC (t)	9,318	9,441	5,615	5,868
	ABC (t)	9,318	9,441	5,615	5,868
Greenland turbot	Tier	6	6	6	6
	OFL (t)	238	238	238	238
	maxABC (t)	179	179	179	179
	ABC (t)	179	179	179	179
Deepsea sole	Tier	6	6	6	6
	OFL (t)	6	6	6	6
	maxABC (t)	4	4	4	4
	ABC (t)	4	4	4	4
Deepwater Flatfish Complex	OFL (t)	11,434	11,581	6,962	7,265
	maxABC (t)	9,501	9,624	5,798	6,051
	ABC (t)	9,501	9,624	5,798	6,051
	Status	As determined *last* year for:		As determined *this* year for:	
		2017	2018	2018	2019
	Overfishing	no	n/a	no	n/a
	Overfished	n/a	no	n/a	no
	Approaching overfished	n/a	no	n/a	no

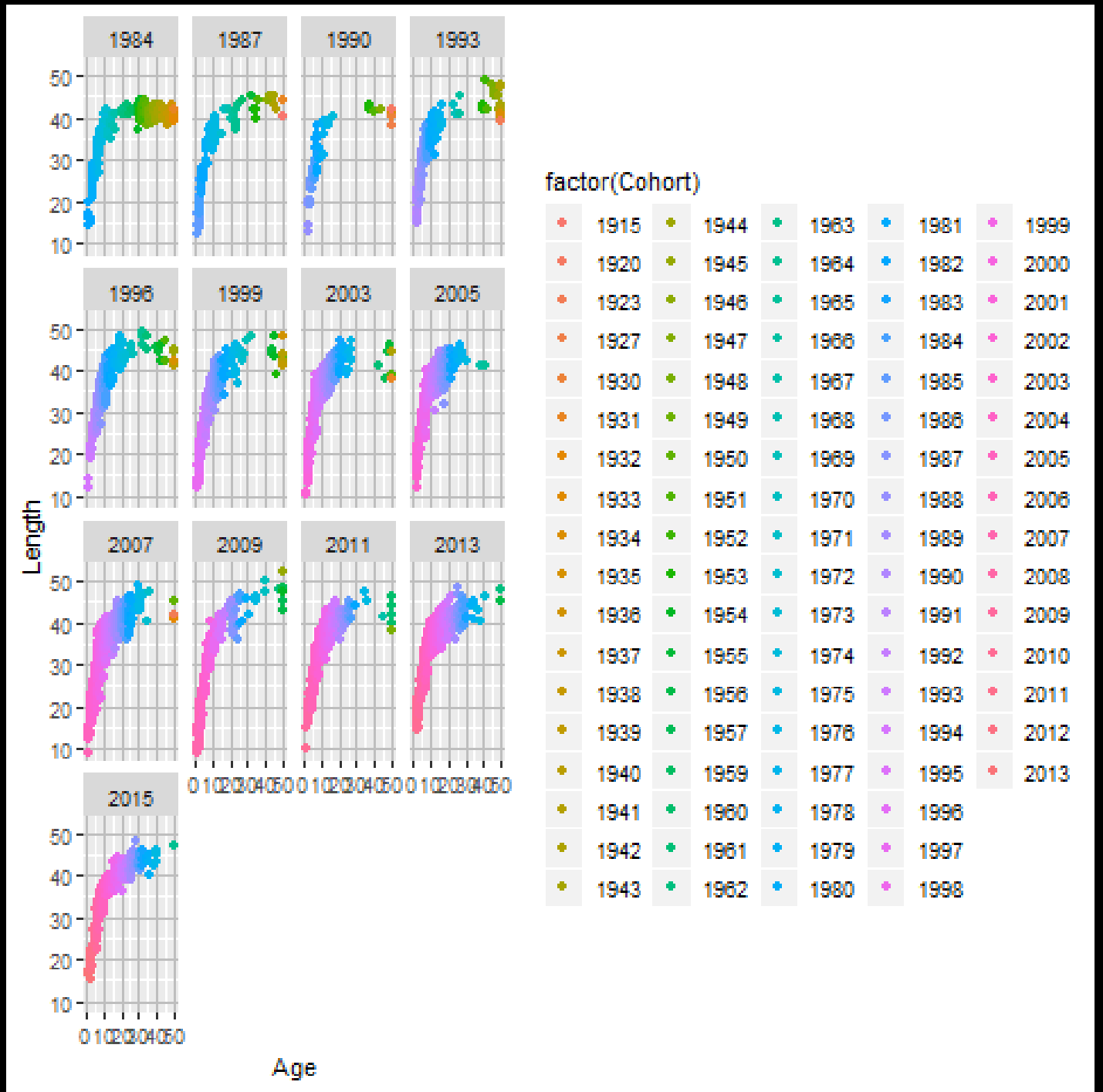
Model 19.0 Alternative

- Projection model for Dover sole using output from age-structured model
- Used age 3 recruits
- 2019 catch estimated as 2019 current catch up to Oct 19 + 5-yr average Oct 19-Dec 31 catch
- 2020-2021 catch estimated as 2014-2018 average catch for Dover sole
- No management definitions for Kamchatka flounder

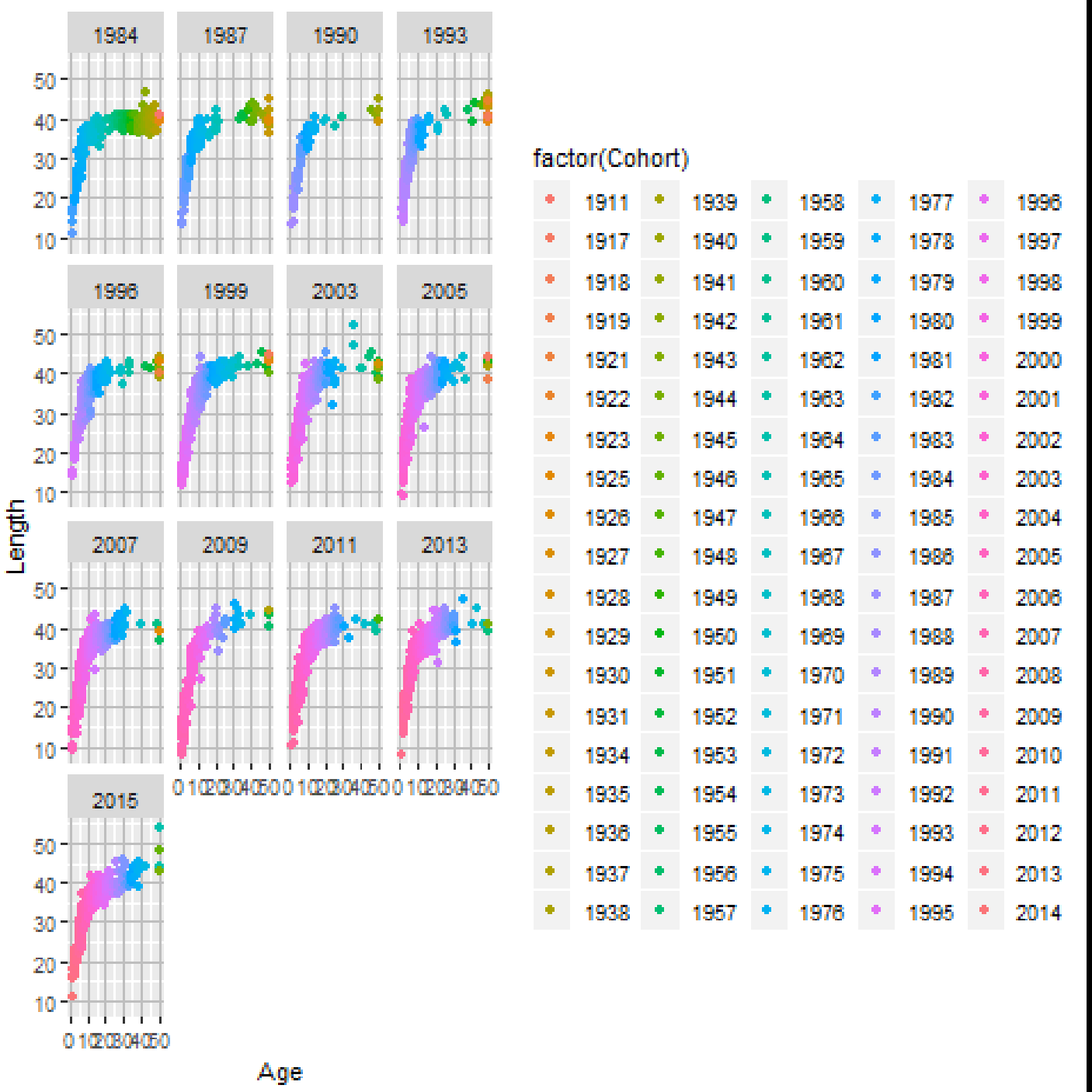
Species	Quantity	As estimated or *specified last* year for: 2019	2020	As estimated or *recommended this* year for: 2020*	2021*
Dover sole	*M* (natural mortality rate)	0.085	0.085	0.069(f), 0.057(m)	0.069(f), 0.057(m)
	Tier	3a	3a	3a	3a
	Projected total (3+) biomass (t)	145,926	147,001	111,338	113,380
	Projected Female spawning biomass (t)	49,385	49,418	35,371	35,600
	$B_{100\%}$	57,871	57,871	49,199	49,199
	$B_{40\%}$	23,148	23,148	19,680	19,680
	$B_{35\%}$	20,255	20,255	17,220	17,220
	F_{OFL}	0.12	0.12	0.07	0.07
	$maxF_{ABC}$	0.1	0.1	0.06	0.06
	F_{ABC}	0.1	0.1	0.06	0.06
	OFL (t)	11,190	11,337	6,294	6,480
	maxABC (t)	9,318	9,441	5,306	5,463
	ABC (t)	9,318	9,441	5,306	5,463
Greenland turbot	Tier	6	6	6	6
	OFL (t)	238	238	238	238
	maxABC (t)	179	179	179	179
	ABC (t)	179	179	179	179
Deepsea sole	Tier	6	6	6	6
	OFL (t)	6	6	6	6
	maxABC (t)	4	4	4	4
	ABC (t)	4	4	4	4
Deepwater Flatfish Complex	OFL (t)	11,434	11,581	6,538	6,724
	maxABC (t)	9,501	9,624	5,489	5,646
	ABC (t)	9,501	9,624	5,489	5,646
	Status	As determined *last* year for: 2017	2018	As determined *this* year for: 2018	2019
	Overfishing	no	n/a	no	n/a
	Overfished	n/a	no	n/a	no
	Approaching overfished	n/a	no	n/a	no

How do these length-at-age plots compare to another long-lived GOA fish: Pacific Ocean Perch?

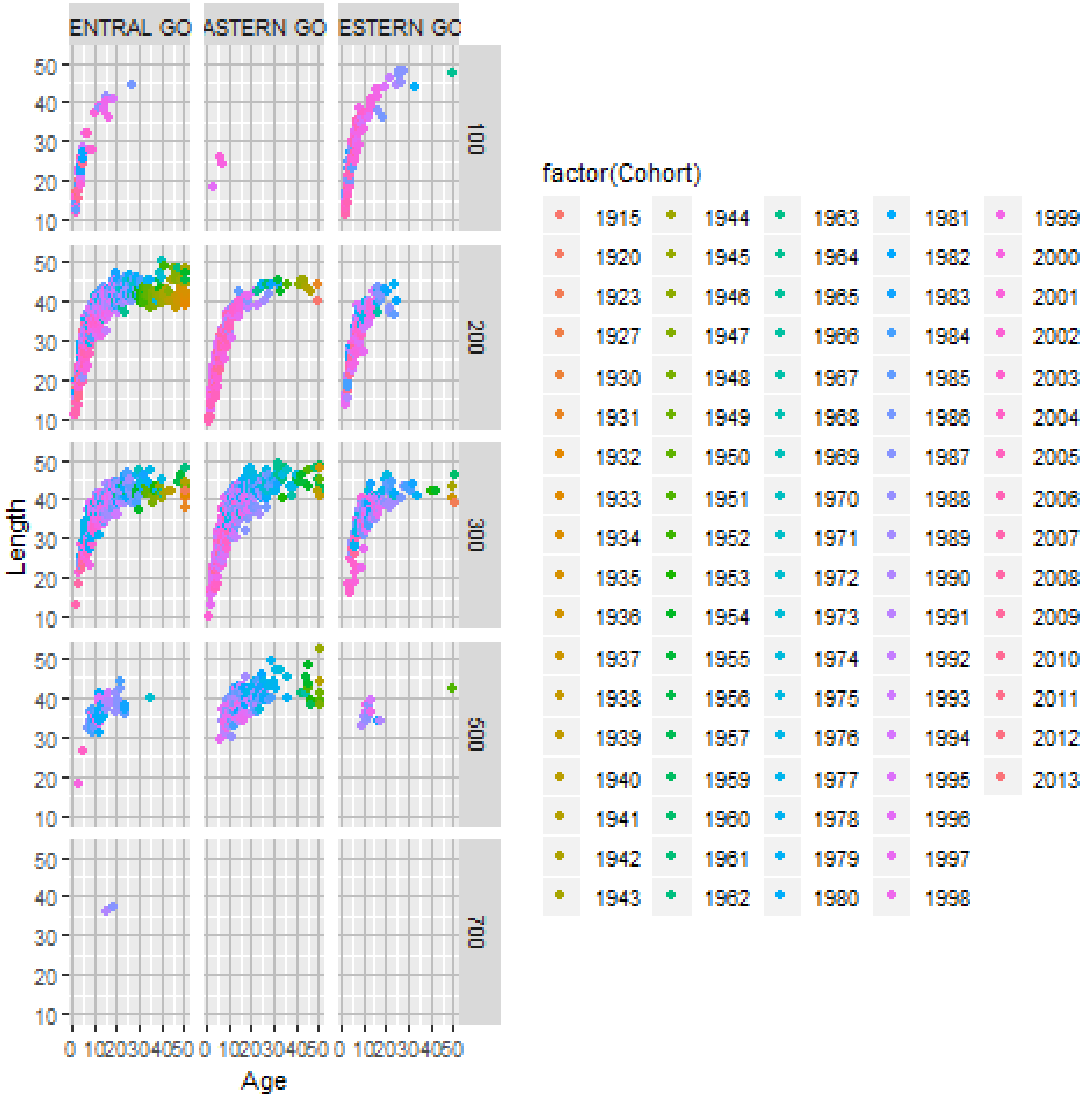
POP: Female length-at-age by cohort and year



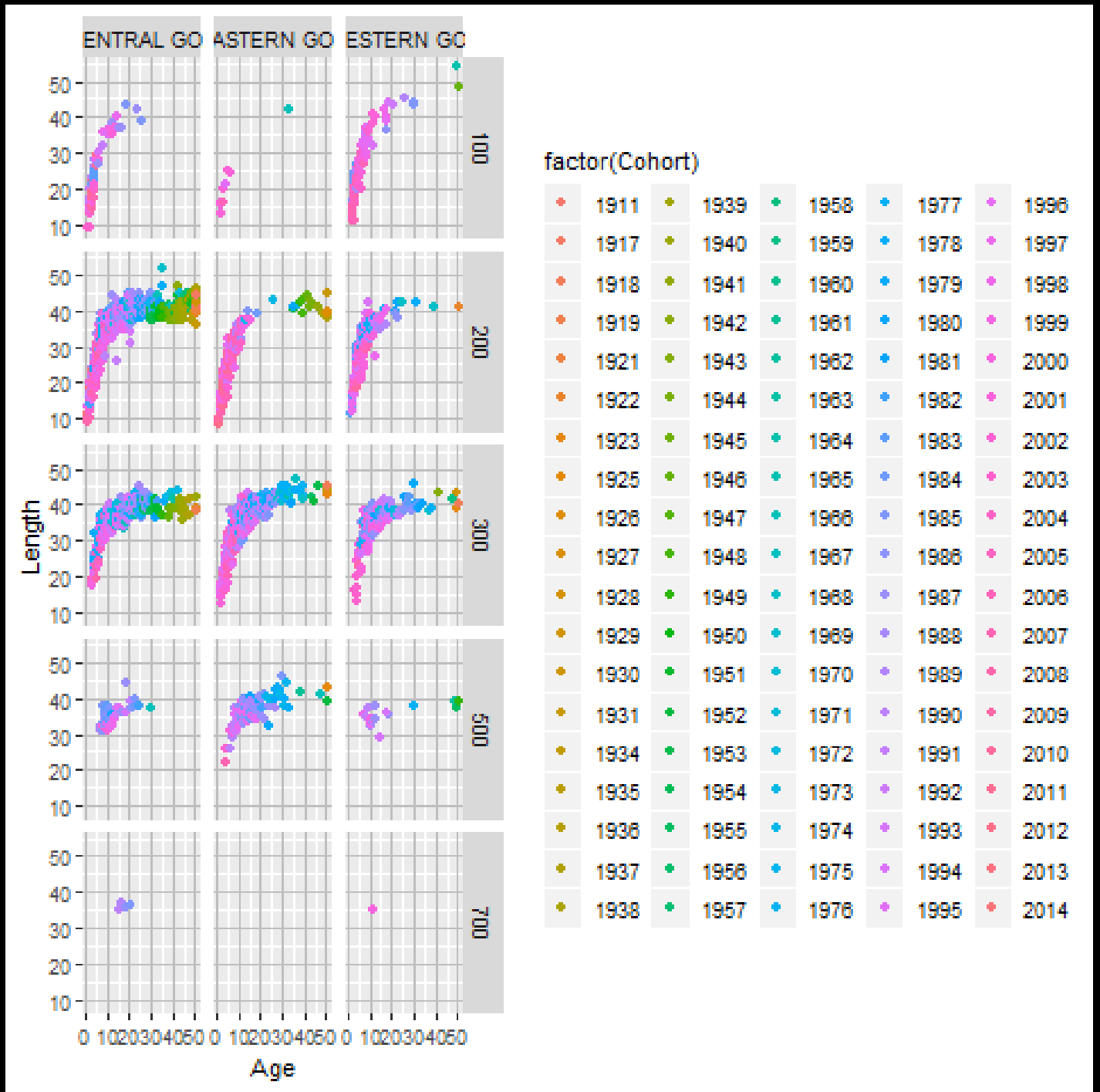
POP: Male length-at-age by cohort and year



POP: Female length-at-age by cohort, depth, and area



POP: Male length-at-age by cohort, depth, and area



Francis (2011) Data Weighting Method

- Purpose:
  - Initial: to investigate whether effective sample sizes of fishery length comps were reasonable relative to effective sample sizes of survey composition data
  - To assign weights to composition data sources that account for the influence of intra-year correlations in length or age comps that are not explicitly modeled, to avoid preventing the model from fitting the biomass index well
- Examples of correlations not in the model: time-varying selectivity, time- and age-varying natural mortality
- Background:
  - Length and age comp data are often overdispersed relative to the variance assumed by the multinomial likelihood in the model
  - McAllister and Ianelli (1997), Appendix 2: calculates weights to account for overdispersed data relative to variance of the multinomial, ignores correlations
  - Pennington and Volstad (2004): Intra-haul correlation lowers effective sample size
    - E.g. fish of similar ages or lengths are often caught together in a haul
    - The precision of the mean lengths or ages based on a sample of fish from marine surveys is much lower relative to the precision of the mean length or age based on a random sample of the population
    - Precision for some marine surveys is close to the number of hauls, not number of fish
  - Francis (2011):
    - Same concept as for Pennington and Volstad, (measuring precision of means), except applied to intra-year correlations, rather than intra-haul correlations
    - Same idea as McAllister and Ianelli, but accounts for correlations by comparing variation in mean lengths or ages relative to expected means by year (where means are assumed to be normally distributed)
- Potential alternative: explicitly model time-varying effects that influence proportions at length and age so that residuals are not as correlated

Conditional age-at-length standard deviation plots

$$\text{Std Dev} = \sqrt{\text{age}^2\,(\text{proportion-at-age})\text{-}(\text{age} \times \text{proportion-at-age})^2}$$

- Observed standard deviations are often low (or 0) for larger length bins because there are few samples (or 1 sample) in those bins
- Expected standard deviations at larger length bins are a direct function of the modeled numbers at age and length.
  - standard deviations reflect the model's interpretation of the population variability in ages within a length bin and not a standard deviation calculated from a sample.
- Variability in expected standard deviation can occur from year to year due to fluctuations in recruitment and fishing mortality