BSAI Tanner Crab

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Roadmap for the 2017 SAFE Chapter

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- Appendix B: NMFS Survey Time Series
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CPT/SSC Comments

June 2017 SSC Meeting

The SSC requested an evaluation of all parameters estimated to be at or very near bounds, or substantially limited by priors (unless those priors can be logically defended).

Response: An initial approach to evaluating parameters at or near bounds using ADMB's likelihood profiling capability revealed that errors had apparently been introduced to the profiling algorithm in a recent version (11.2) of the ADMB libraries. These errors have subsequently been resolved, and will be incorporated in the next scheduled version release (11.7). However, likelihood profiling results from the author's version (11.5/11.6) would provide erroneous results.

May2017 Crab Plan Team Meeting

The CPT noted that the EBS growth data should be used in the assessment if at all possible, that the growth increment function should be adopted, and that the scale parameter should be estimated rather than being set to 0.75.

Response: All three requests have been addressed in the assessment (Model B1 and subsequent models).

The CPT noted that there was a tendency for the model to overpredict the abundance of large crab and recommended that the issue be evaluated by modeling retention with a logistic curve that asymptotes to a value less than one.

Response: The option of fitting a retention curve that asymptotes less than one has been implemented in the model framework. Models B2a, B2b and B3 incorporate this option and address this issue. Results from these models suggest that retention is indeed asymptotically less than one.

CPT/SSC Comments

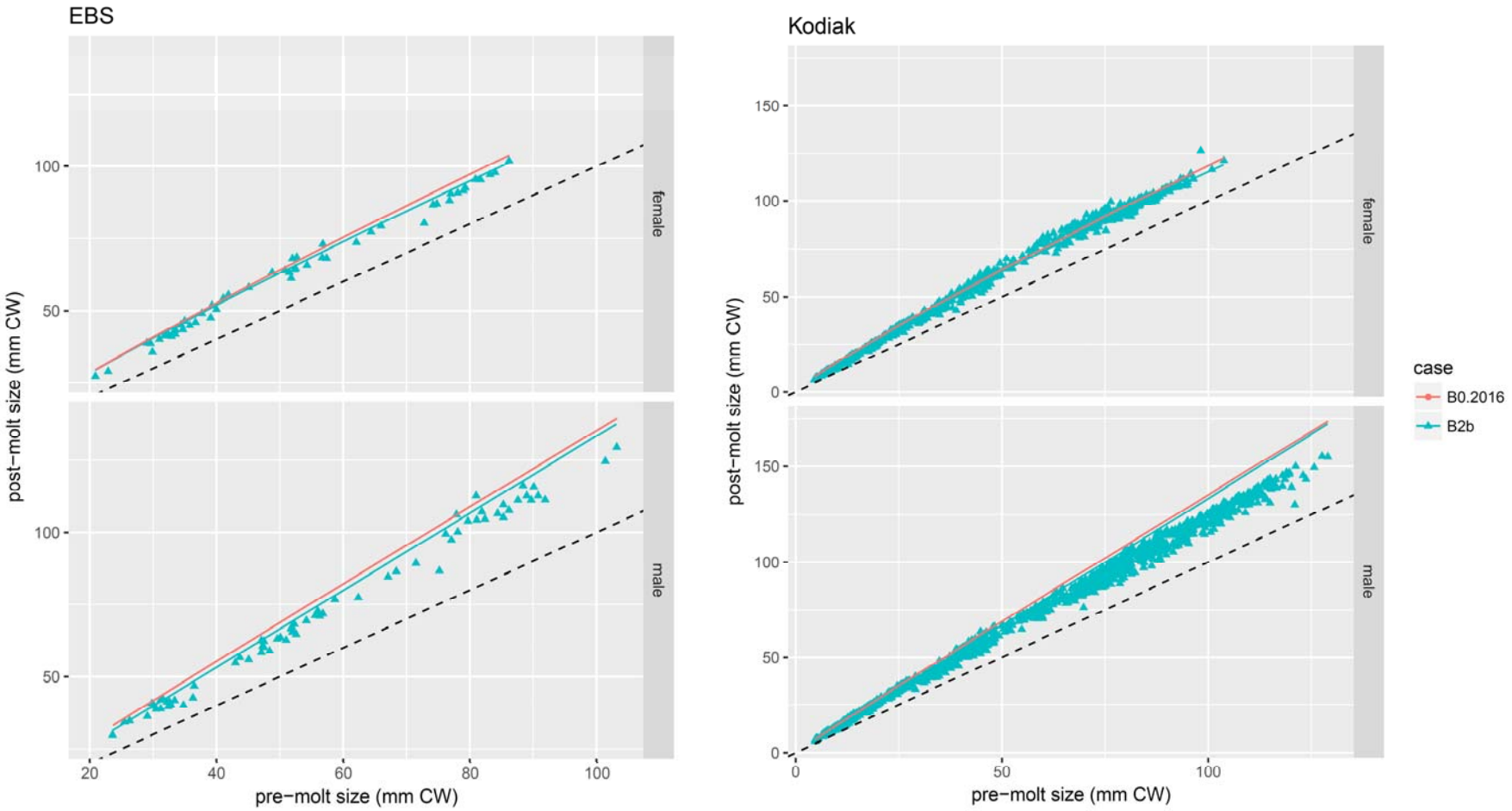
The CPT outlined the base model to be used for this assessment, based on results presented by the author for a suite of models.
Response: The base model recommended by the CPT is the base model used here (Model B0).

The CPT outlined a number of alternative models built on its recommended base model to be evaluated.
Response: Models B1, B2, and B3 were evaluated for this assessment. Requests to address time-varying retention and potential less-than-complete retention of legal-size crab were also addressed (models B2, B2a, and B2b). It was not possible to address the potential use of Francis-style iterative re-weighting for size composition data.

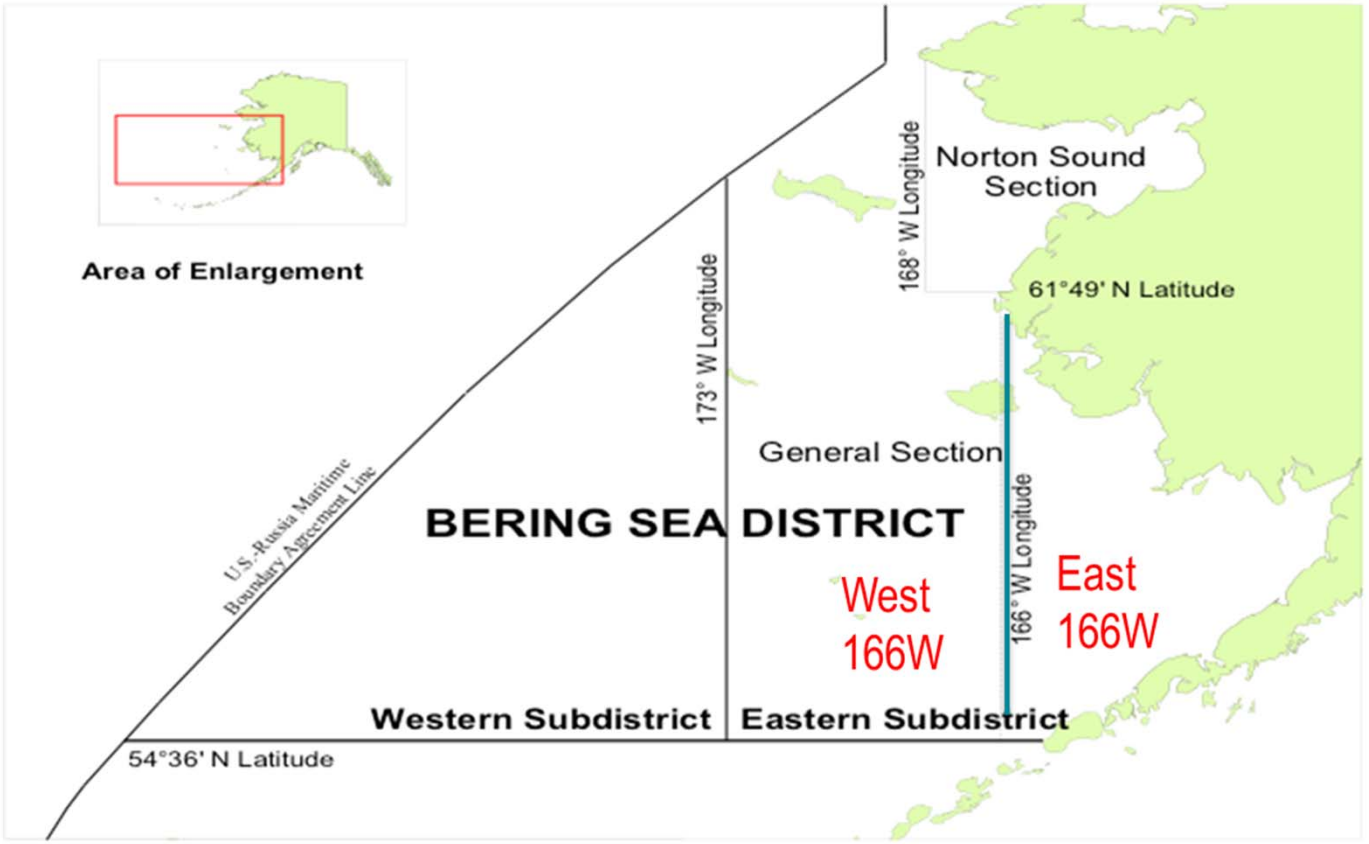
Changes From 2016 Assessment

- Changes to model
  - New model code
  - EBS molt increment data fit in model
- New trawl survey data for 2017
  - mature survey biomass
    - new cv calculation
  - size compositions by sex, shell condition, maturity
- New Fishery Data for 2016/17
  - Tanner crab pot fishery
    - NO catch or size compositions
  - snow crab pot fishery
    - 2016/17 bycatch, size compositions
  - BBRKC pot fishery
    - 2016/17 bycatch, size compositions
  - groundfish fisheries
    - 2016/17 bycatch, size compositions
    - 1991+ gear-specific bycatch, size compositions

Model Fits: 2016 vs. 2017

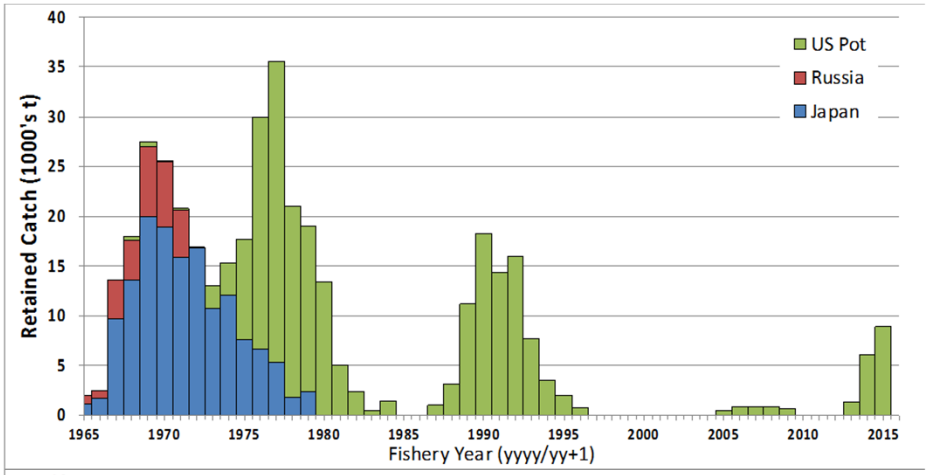


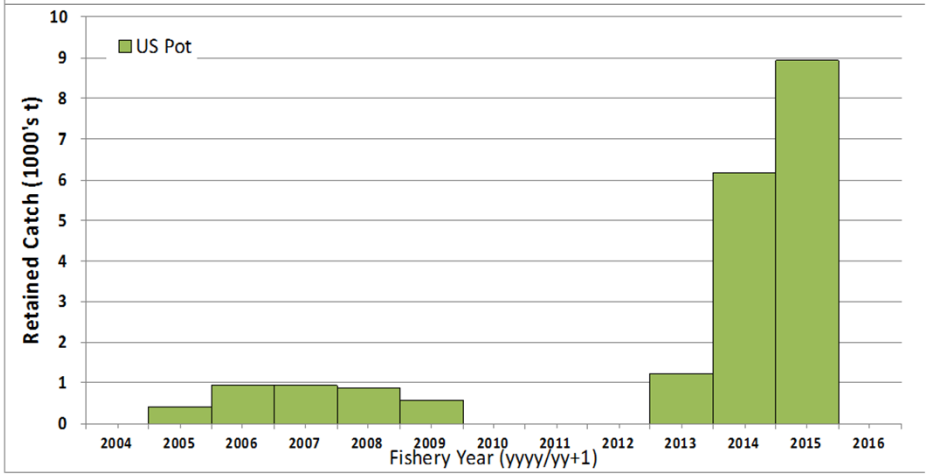
Management Regions



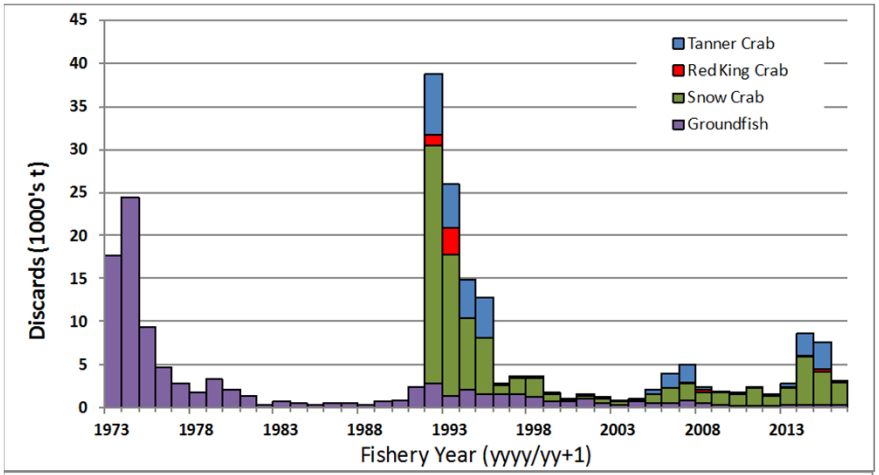
Fishery Trends

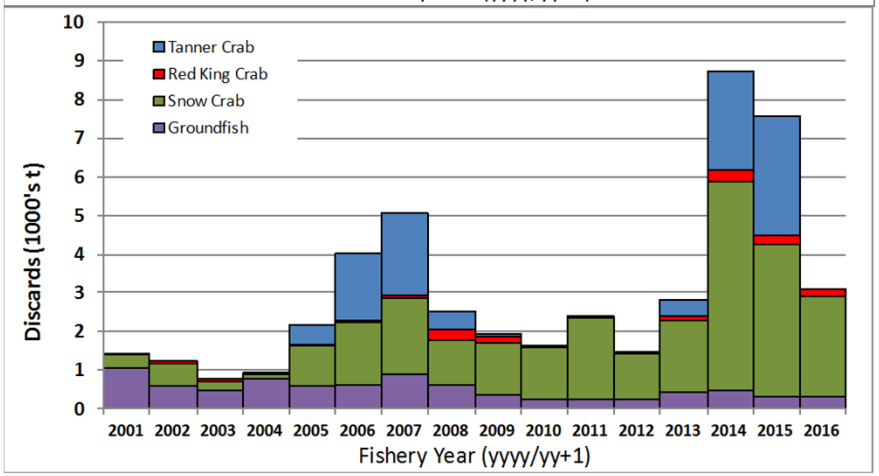
Retained catch



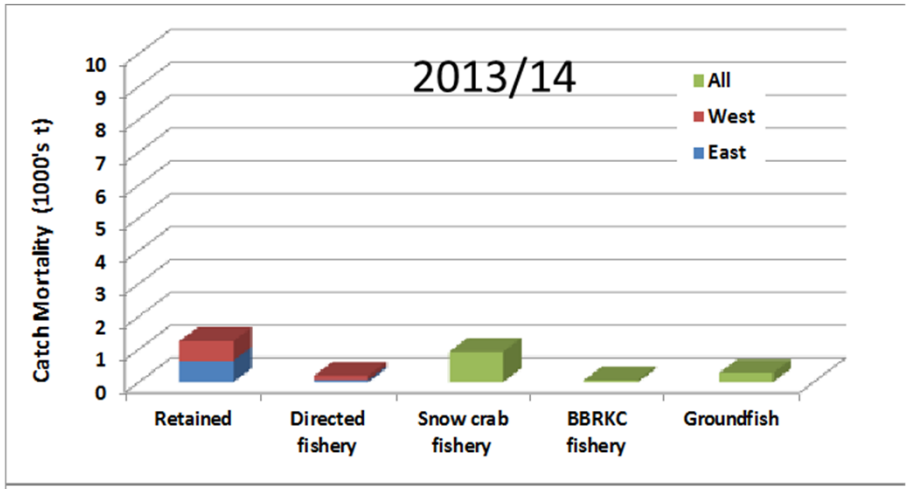


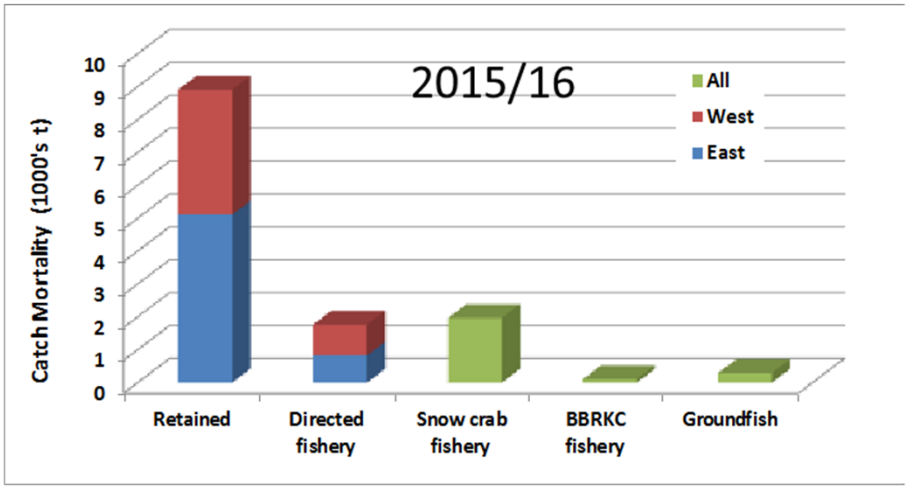
Bycatch

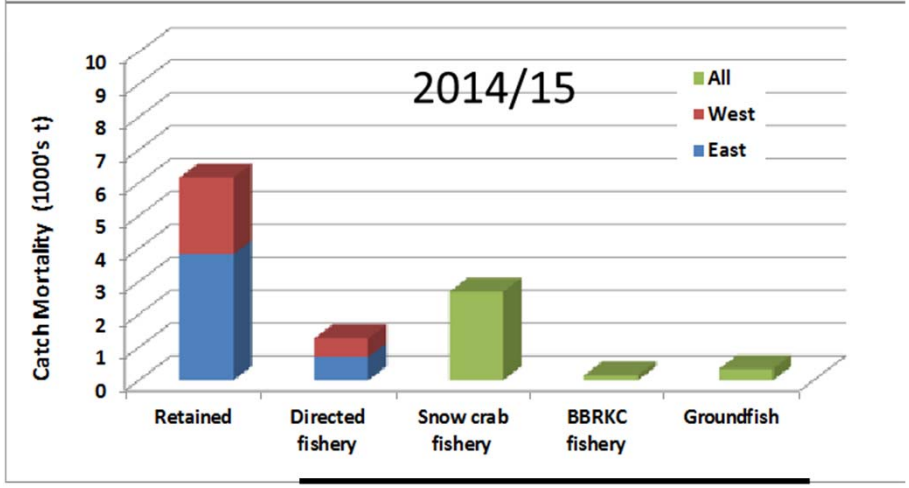


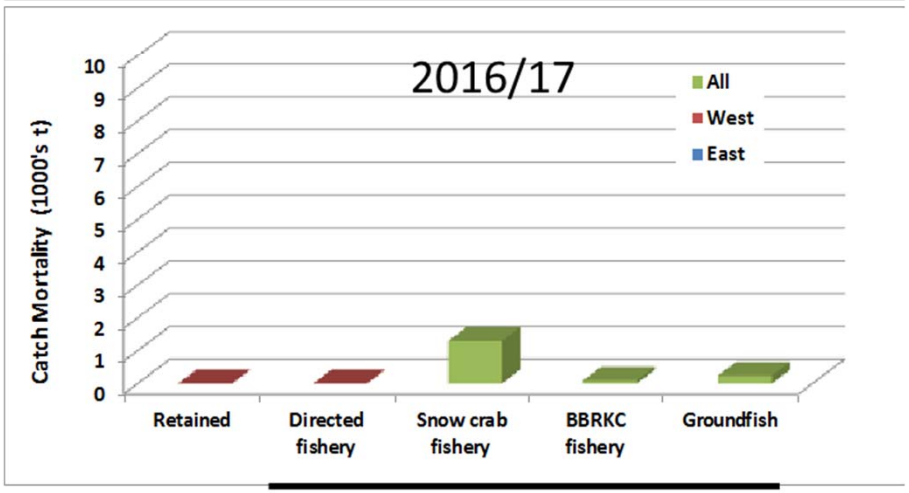


Recent Fishery Trends





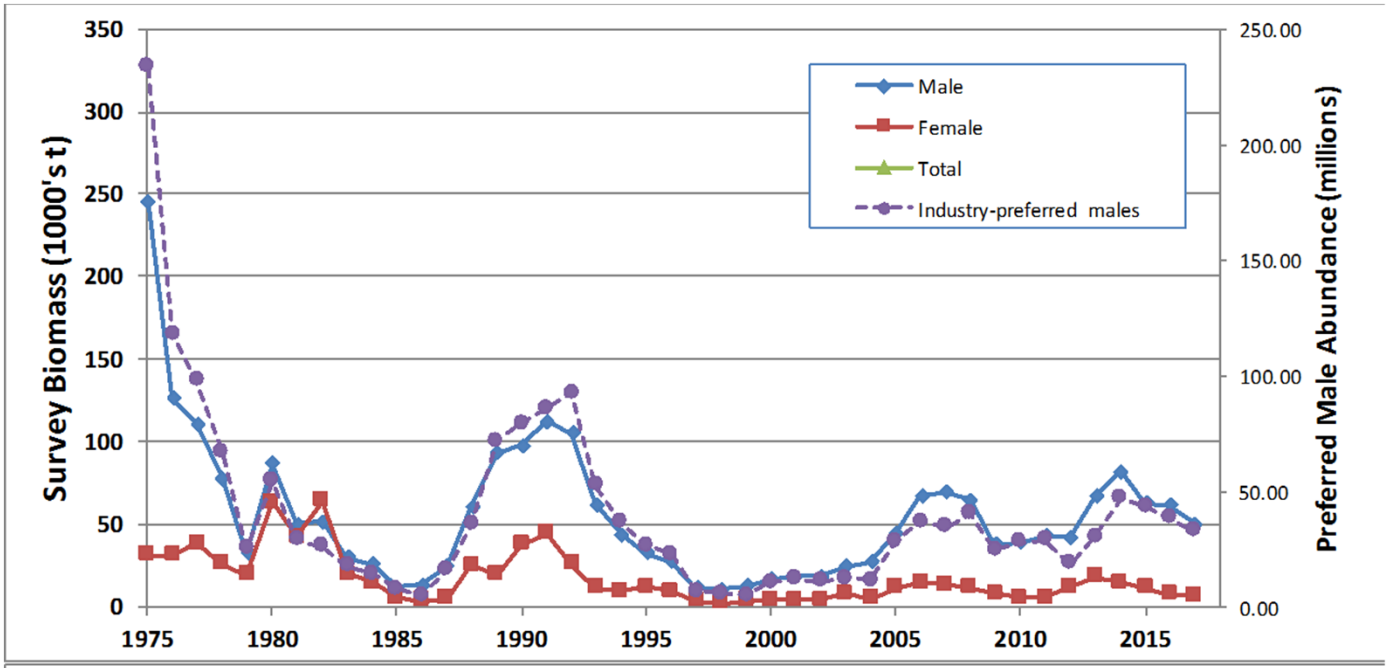


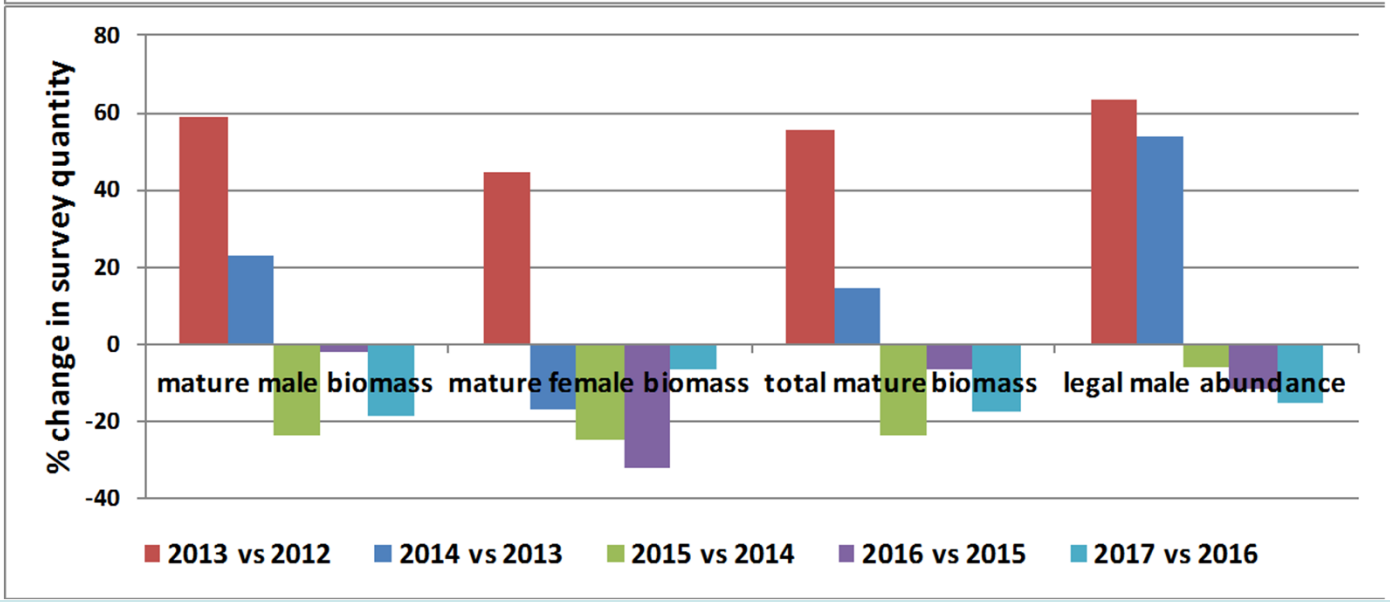


Discard Mortality

Discard Mortality

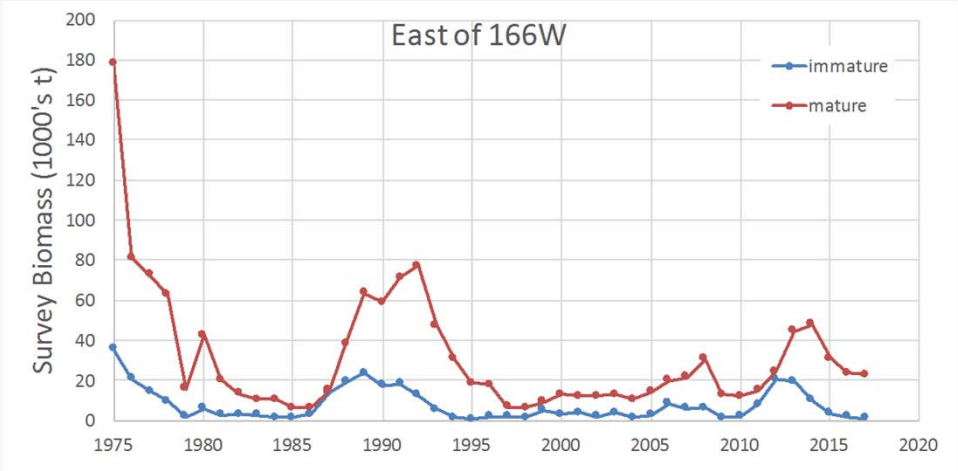
NMFS EBS Trawl Survey Trends

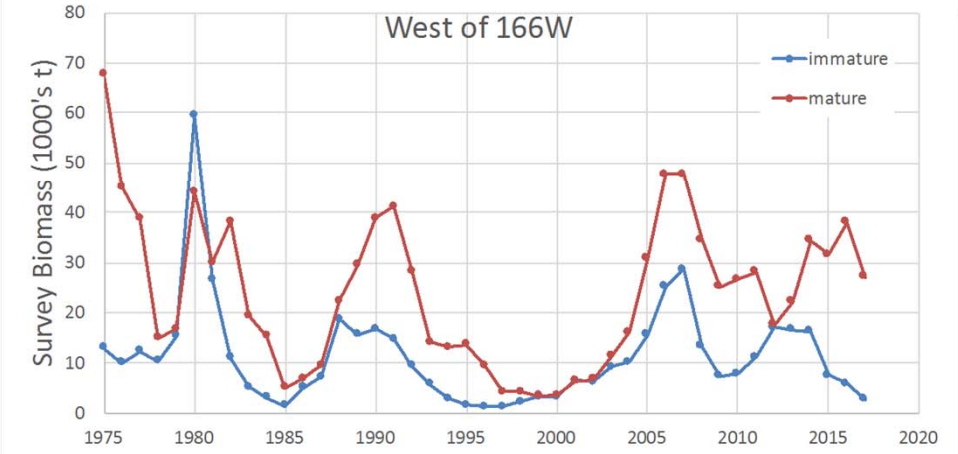




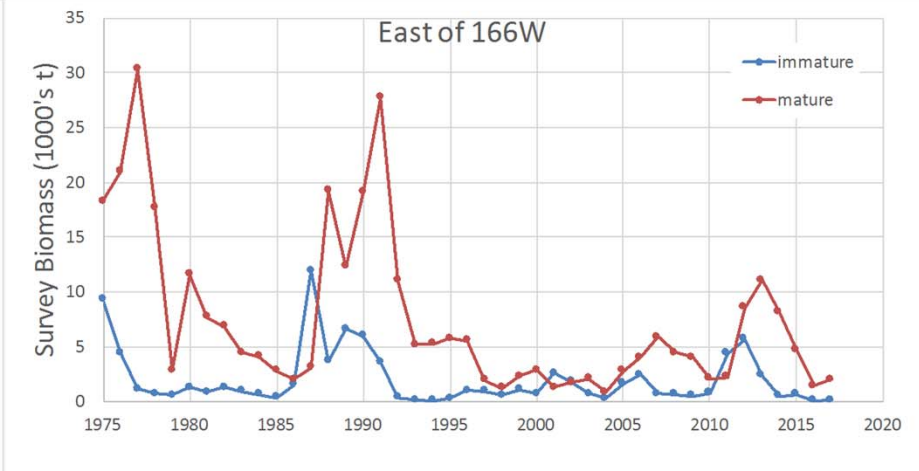
NMFS EBS Trawl Survey Trends

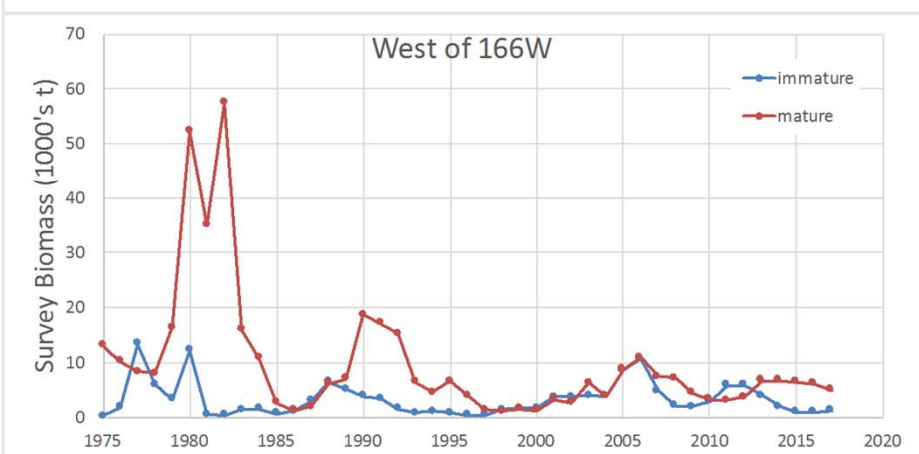
Males

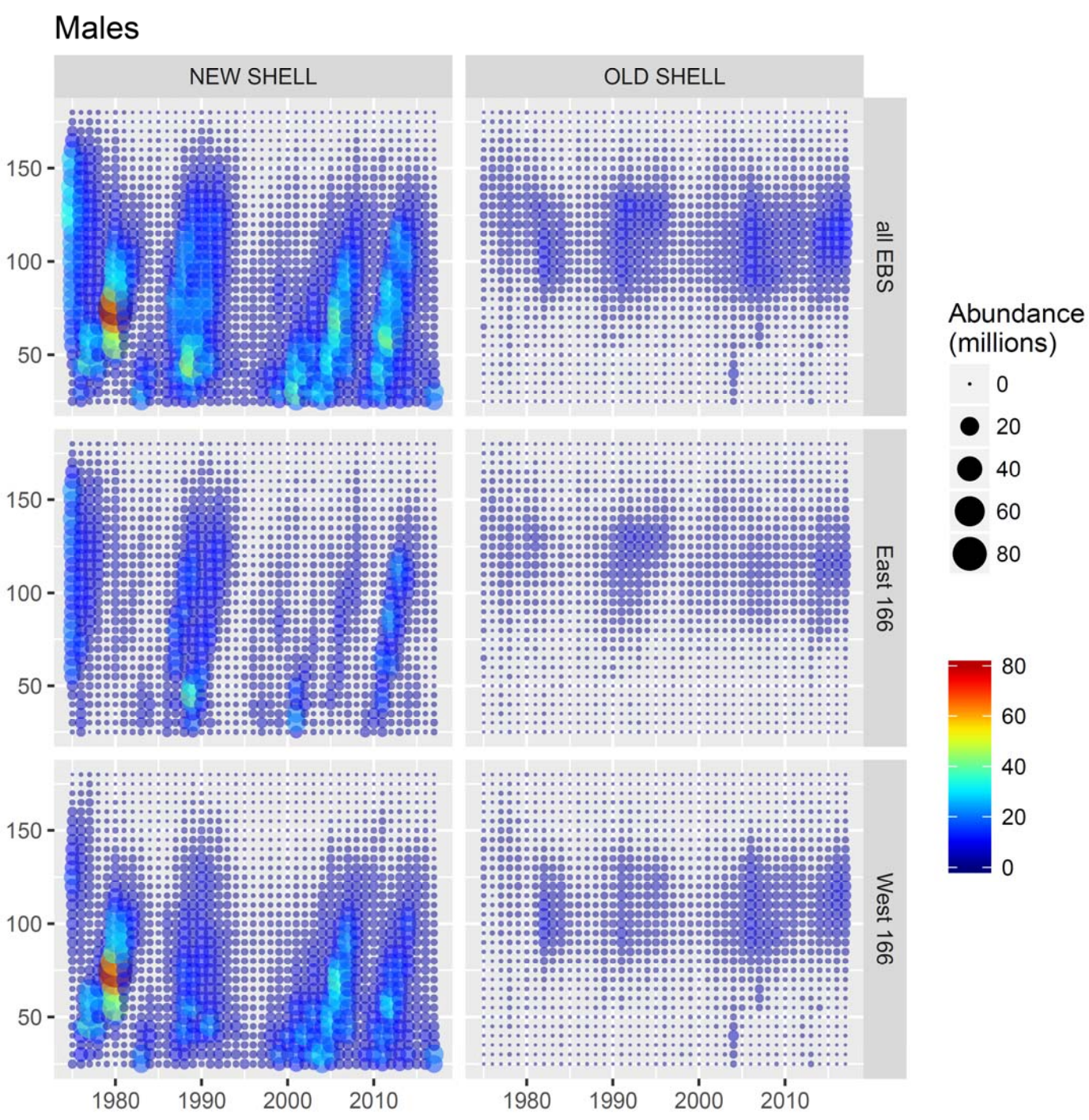


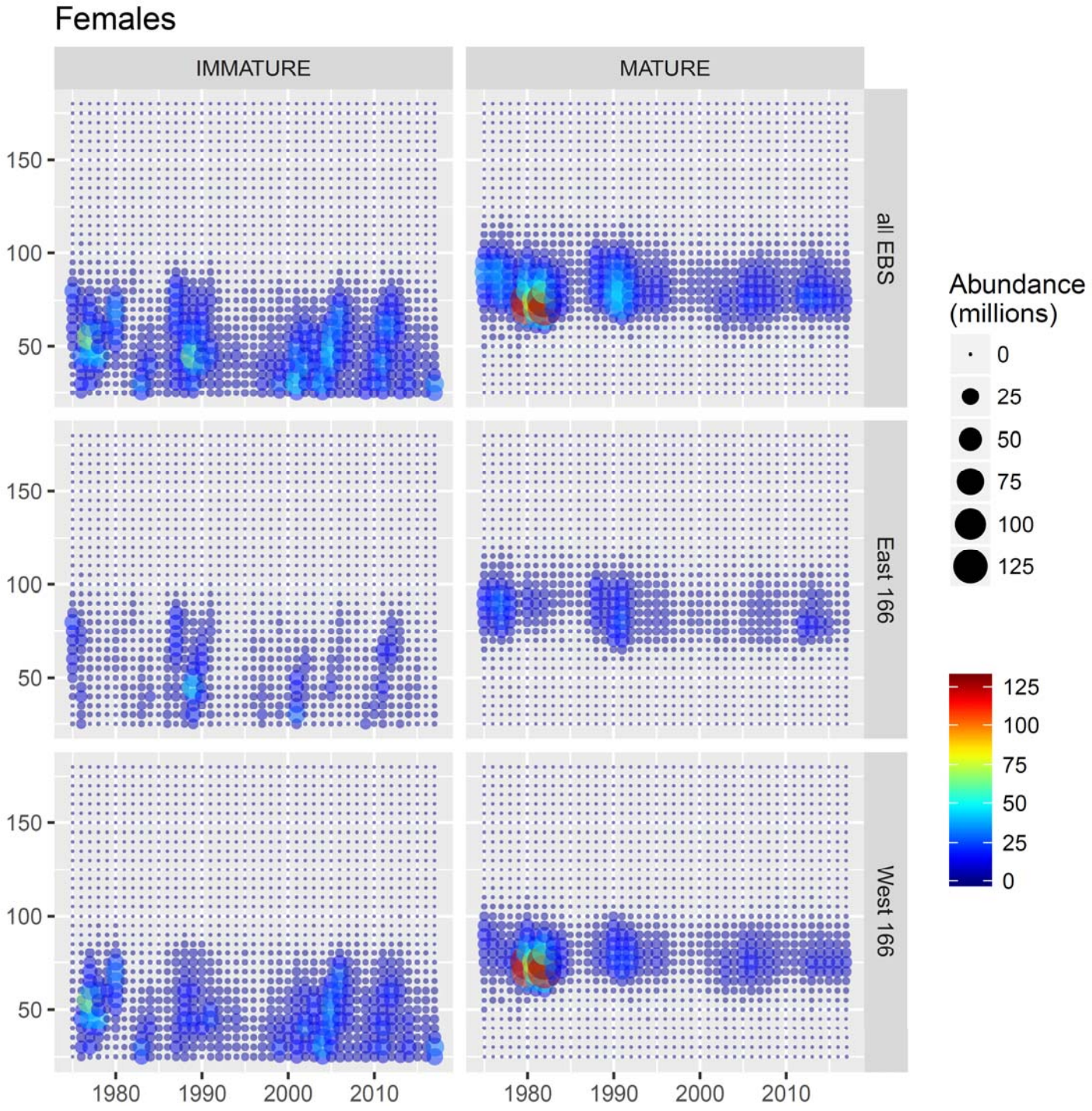


Females

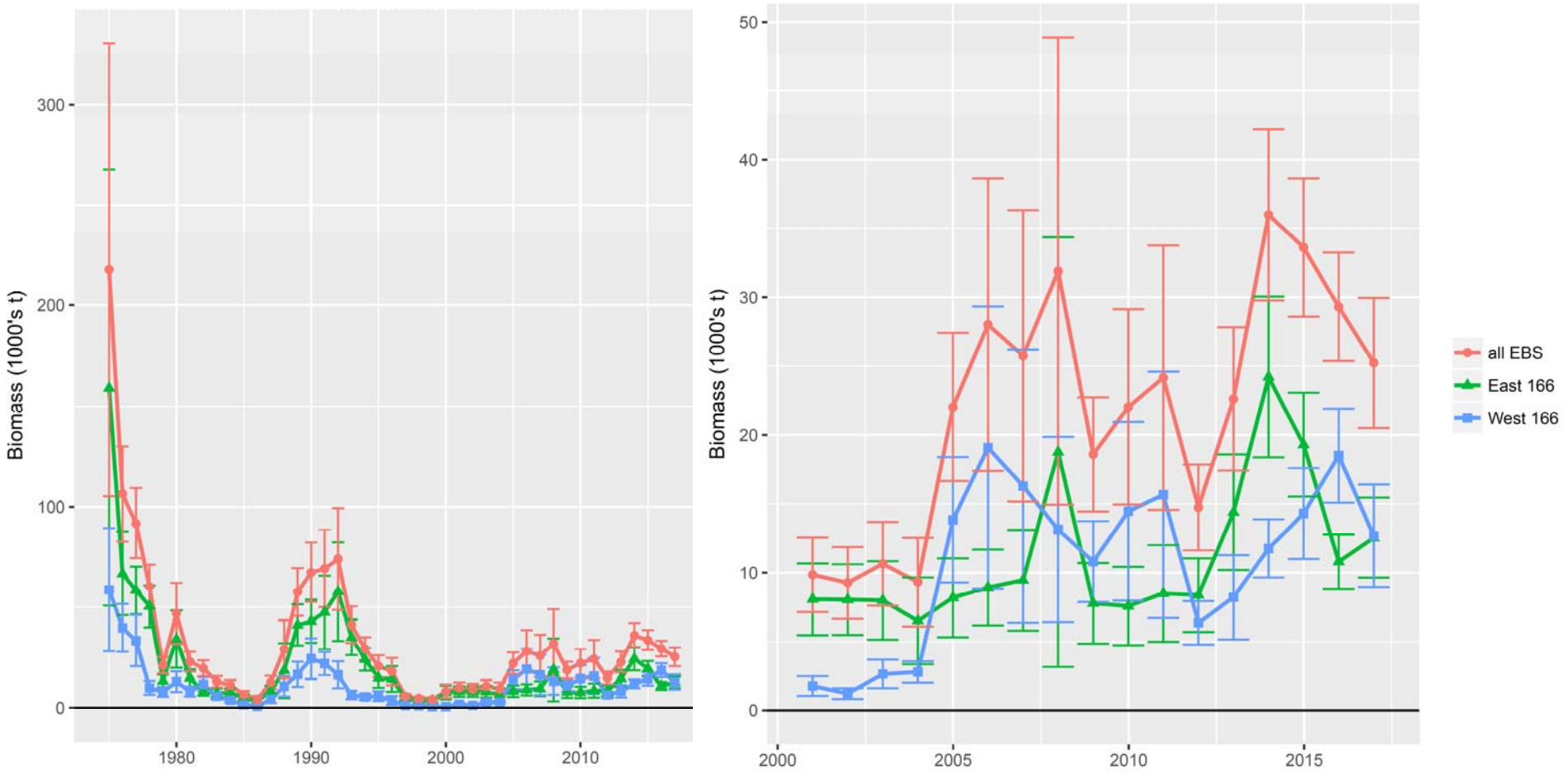




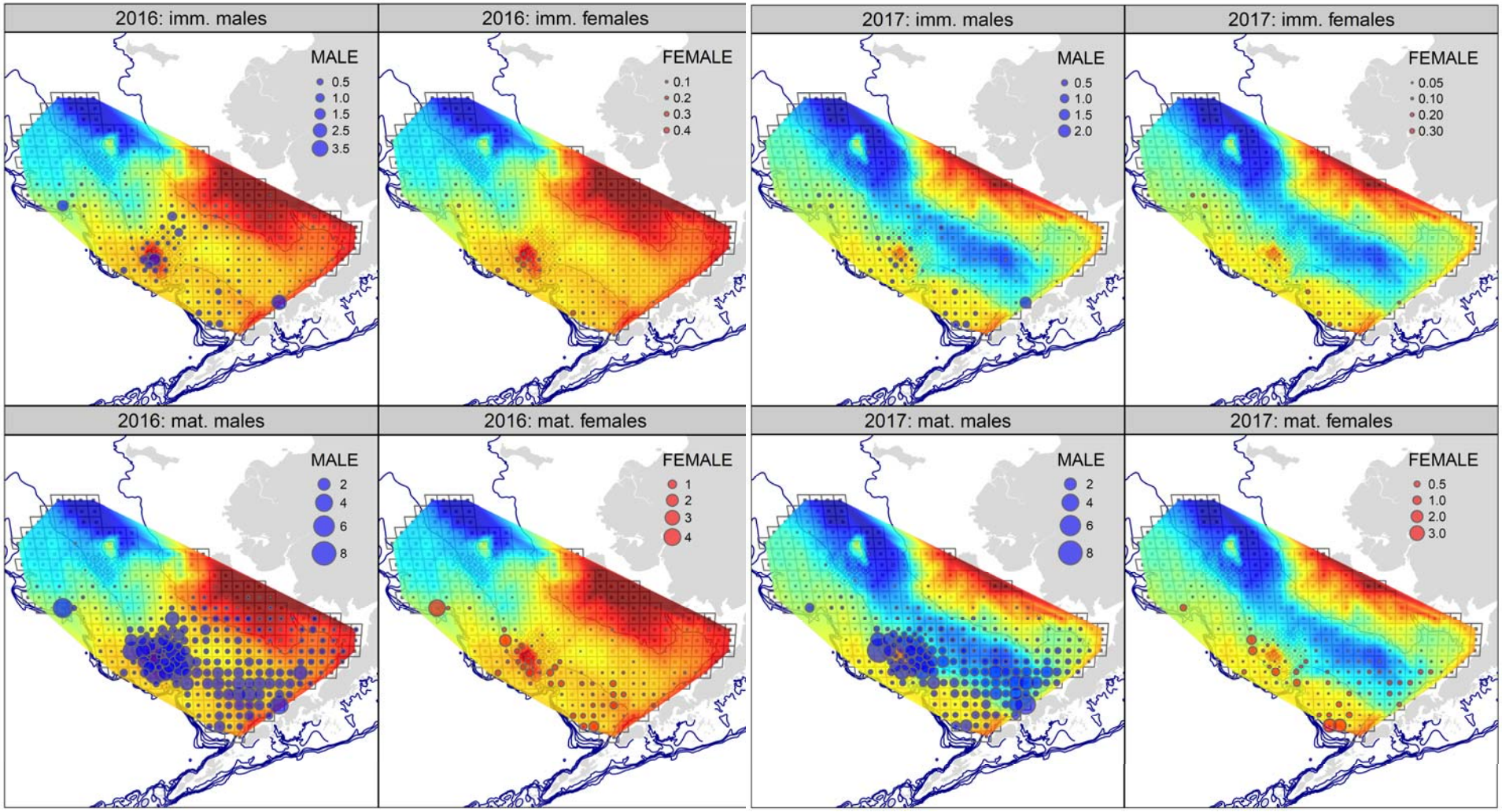

Males
NEW SHELL
OLD SHELL
all EBS
East 166
West 166
150
100
50
1980
1990
2000
2010
Abundance
(millions)
0
20
40
60
80


Females
IMMATURE
MATURE
all EBS
East 166
West 166
150
100
50
1980
1990
2000
2010
Abundance
(millions)
0
25
50
75
100
125

Industry-preferred size males



Spatial patterns



Base Model Inputs

Annual NMFS EBS Survey Data
- 1975-2017
- mature survey biomass
  - sex-specific
  - cv's
- size compositions
  - sex *x* maturity *x* shell condition

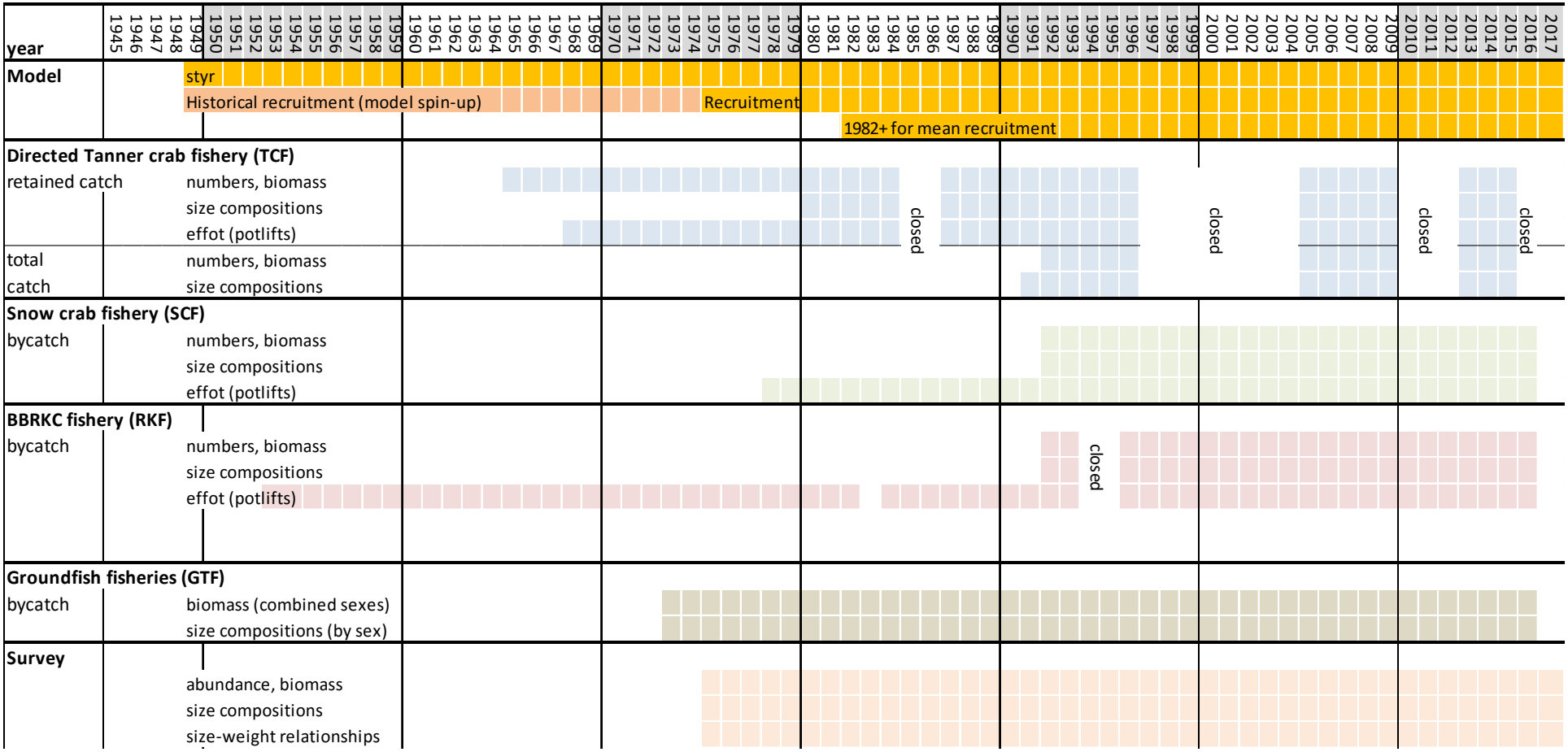
Retained catch in directed fishery
- from fish ticket data and "dockside" observer sampling
- Aggregated across 166^{o}W
- catch biomass (1965/66+)
- size compositions (1980/81+)

Total catch data in crab fisheries
- from "at-sea" observer sampling
  - total (by)catch biomass (by sex)
  - size compositions (by sex, shell condition)
- directed Tanner crab fishery (1992/93+)
- snow crab fishery (1992/93+)
- BBRKC fishery (1992/93+)

Total catch groundfish fisheries
- from "at-sea" observer sampling
  - bycatch biomass (aggregated over sexes)
  - size compositions (by sex)
- 1973/74+

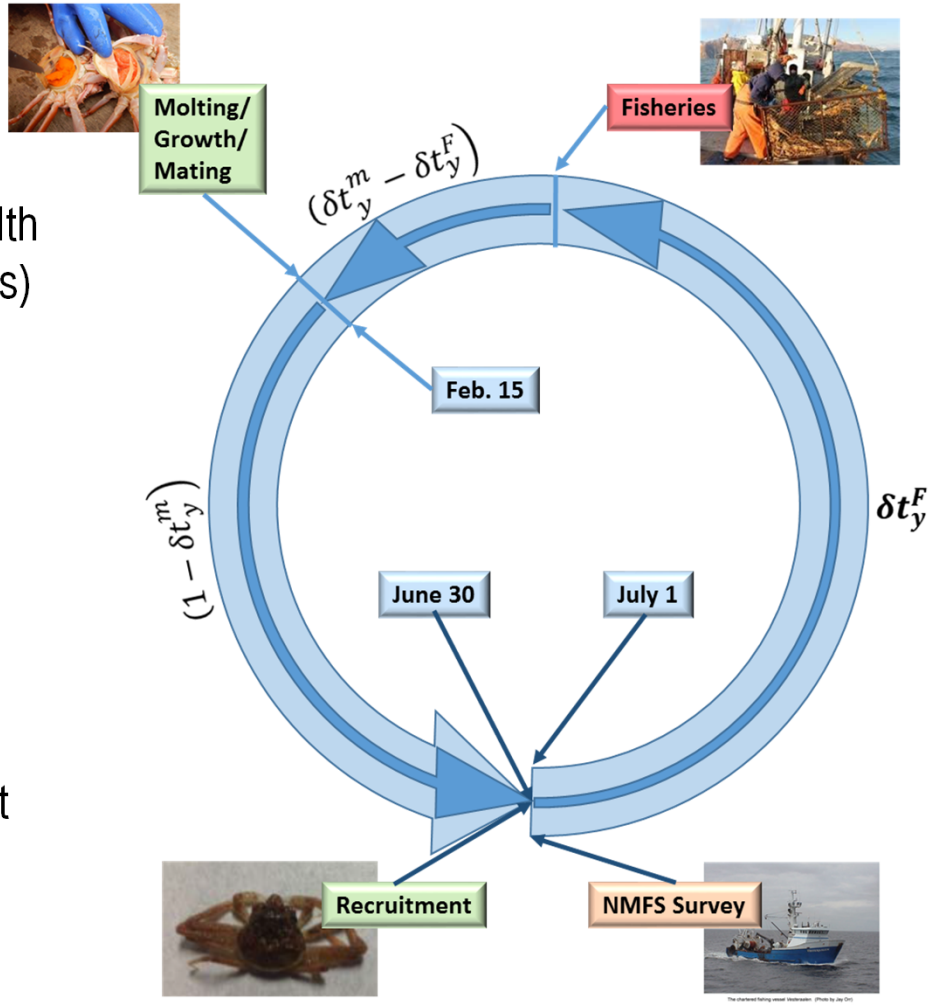
Assumed discard mortality rates
- 0.321 for crab fisheries
- 0.800 for groundfish fisheries

Model Data Coverage



Tier 3 stage/size-based population dynamics model

- model year runs July 1 to June 30
- sex, shell condition, maturity state, carapace width
- sex/stage-based natural mortality (2 time stanzas)
- trawl survey occurs July 1
- fisheries occur Feb. 15
  - directed fishery (retained and bycatch)
  - bycatch in snow crab fishery
  - bycatch in BBRKC fishery
  - bycatch in groundfish fisheries
- sex-specific growth & maturity (after fisheries)
  - pre-molt/post-molt size transition matrix
  - size-specific probability of maturing on molt
  - terminal molt to maturity
- spawning stock (MMB) assessed at mating, BEFORE GROWTH



Model scenarios evaluated in May

TCSAM2013 Model	Incremental change
AM	2016 assessment model
AMa	AM + removed size-specific "old shell" re-classification for input data
AMb	AMa + fit to total capture (not mortality) size compositions
AMc	AMb + fit to total capture (not mortality) biomass
AMd	AMc + apply seasonal M after molt-to-maturity
B0	same as AMd
B1	B0 + fit to input survey biomass based on 1-mm size bins
B2	B1 + using 2.20462262 to convert from kg to lbs
B3	B2 + capture rates in RKF not explicitly set to 0 for 1984,1985 and 1994, 1995
B4	B3 + corrected retained size comps for 2015/16
B5	B4 + using median size-at-50% selected for TCF males pre1991 (not average)
B6	B5 + using post-1972 median F for GTF before 1973 (not average)

- Demonstrates progression from 2016 assessment model to B6, which is “exactly equivalent” to Model B0 here

B0: The "Exactly Equivalent" TCSAM02 model

process	time blocks	description
Population rates and quantities		
Population built from annual recruitment		
Recruitment	1949-1974	ln-scale mean + annual devs constrained as AR1 process
	1975-2017	ln-scale mean + annual devs
Growth	1949-2016	sex-specific
		mean post-molt size: power function of pre-molt size
		priors on mean post-molt parameters from Kodiak growth data
		post-molt size: gamma distribution conditioned on pre-molt size
Maturity	1949-2016	sex-specific
		size-specific probability of terminal molt
		logit-scale parameterization
Natural mortalty	1949-1979, 1985-2	estimated sex/maturity state-specific multipliers on base rate
		priors on multipliers based on uncertainty in max age
	1980-1984	estimated "enhanced mortality" period multipliers
Surveys		
NMFS EBS trawl survey		
male survey q	1975-1981	ln-scale
	1982+	ln-scale w/ prior based on Somerton's underbag experiment
female survey q	1975-1981	ln-scale
	1982+	ln-scale w/ prior based on Somerton's underbag experiment
male selectivity	1975-1981	ascending logistic
	1982+	ascending logistic
female selectivity	1975-1981	ascending logistic
	1982+	ascending logistic

B0:
The "Exactly Equivalent" TCSAM02 model (cont.)

Fishery/process	time blocks	description
TCF	directed Tanner crab fishery	
capture rates	pre-1965	male nominal rate
	1965-2016	male ln-scale mean + annual devs
	1949-2016	ln-scale female offset
male selectivity	1949-1990	ascending logistic
	1991-1996	annually-varying ascending logistic
	2005-2016	annually-varying ascending logistic
female selectivity	1949-2016	ascending logistic
male retention	1949-1990	ascending logistic
	1991-2016	ascending logistic
SCF	bycatch in snow crab fishery	
capture rates	pre-1978	nominal rate on males
	1979-1991	extrapolated from effort
	1992-2016	male ln-scale mean + annual devs
	1949-2016	ln-scale female offset
male selectivity	1949-1996	dome-shaped
	1997-2004	dome-shaped
	2005-2016	dome-shaped
female selectivity	1949-1996	ascending logistic
	1997-2004	ascending logistic
	2005-2016	ascending logistic
RKF	bycatch in BBRKC fishery	
capture rates	pre-1952	nominal rate on males
	1953-1991	extrapolated from effort
	1992-2016	male ln-scale mean + annual devs
	1949-2016	ln-scale female offset
male selectivity	1949-1996	ascending logistic
	1997-2004	ascending logistic
	2005-2016	ascending logistic
female selectivity	1949-1996	ascending logistic
	1997-2004	ascending logistic
	2005-2016	ascending logistic
GTF	bycatch in groundfish fisheries	
capture rates	pre-1973	male ln-scale mean from 1973+
	1973+	male ln-scale mean + annual devs
	1973+	ln-scale female offset
male selectivity	1949-1986	ascending logistic
	1987-1996	ascending logistic
	1997+	ascending logistic
female selectivity	1949-1986	ascending logistic
	1987-1996	ascending logistic
	1997+	ascending logistic

Model Scenarios

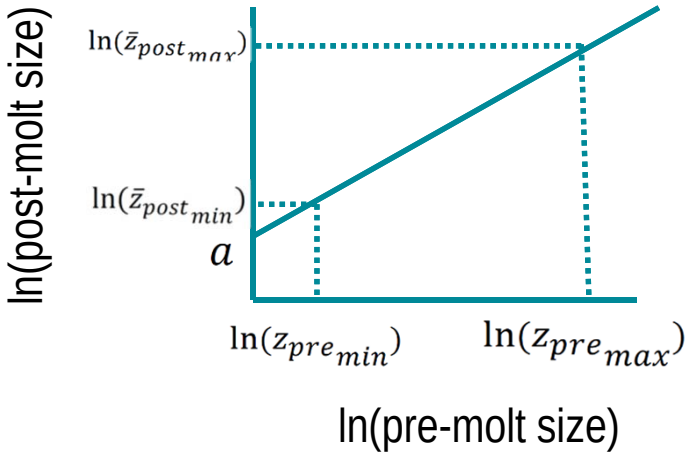
model scenario	number of parameters	objective function value	description
B0.2016	332	2,665.27	"fully-equivalent" model from May 2017 CPT meeting
B0	336	2,765.43	Base model for 2017 assessment (B0.2016 + 2017 data)
B0a	336	2,763.31	B0 + new growth parameterization (growth data not fit)
B1	337	3,109.39	B0 + fit to EBS growth data, drop riors on growth, estimate growth scale parameter
B1a	337	3,108.64	B1 + new growth parameterization
B1b	337	3,110.35	B1a + new parameterization for RKF selectivity
B1c	337	8,367.14	B1b + 20 *x* higher likelihood weight on EBS growth data
B2	350	2,872.42	B1b + annual devs on retention function z50's
B2a	353	2,870.33	B2 + 3 time blocks for asymptotic retention level
B2b	344	2,894.80	B2a - annual retention devs + 3 retention time blocks
B3	391	2,381.20	B2b + bycatch in groundfish fisheries by gear type (1991+)

New mean growth parameterization

old: $$\ln(\bar{z}_{post}) = a + b \cdot \ln(z_{pre})$$

new:

$$\ln(\bar{z}_{post}) = \ln(\bar{z}_{post_{min}}) + \frac{\left[\ln(\bar{z}_{post_{max}}) - \ln(\bar{z}_{post_{min}})\right]}{\left[\ln(z_{pre_{max}}) - \ln(z_{pre_{min}})\right]} \cdot \left[\ln(z_{pre}) - \ln(z_{pre_{min}})\right]$$



New selectivity parameterization

- old: z_{50}, slope at z_{50}
- new: z_{95}, (z_{95} -z_{50})
  - "fully-selected" refers to

Jittering

- Done inside the ADMB code
- Only estimated parameters are jittered
- All parameters are bounded
- Values sampled from uniform distributions across 60% of parameter range
- Some parameter combinations cause model to fail immediately
- Jitter runs generally converge to “discrete” set of objective function values

Jitter Results

idx	objFun	maxGrad	seed	MMB	B0	Bmsy	Fmsy	OFL	curB	run
60	2894.798	0.000181	1503998562	77.9588	83.33511	29.16729	1.267922	31.80396	80.57028	c
127	2894.798	0.000468	1504027821	77.9588	83.33511	29.16729	1.267922	31.80396	80.57028	a
163	2894.798	0.000141	1504065880	77.9588	83.33511	29.16729	1.267922	31.80396	80.57028	c
189	2894.798	0.000558	1504074003	77.9588	83.33511	29.16729	1.267922	31.80396	80.57028	a
182	2894.798	0.000936	1504070414	77.9588	83.33511	29.16729	1.267922	31.80396	80.57028	a
91	2894.798	0.000243	1504014449	77.9588	83.33511	29.16729	1.267922	31.80396	80.57028	a
87	2894.798	0.000565	1504014390	77.9588	83.33511	29.16729	1.267922	31.80396	80.57028	c
90	2894.798	0.003447	1504015787	77.9588	83.33511	29.16729	1.267922	31.80396	80.57028	b
163	2894.798	0.000631	1504063030	77.9588	83.33511	29.16729	1.267922	31.80396	80.57028	a
139	2895.786	6.21E-05	1504043027	77.09225	82.68284	28.93899	1.261475	31.36204	79.60673	b
161	2903.674	0.001554	1504060572	88.51583	89.12145	31.19251	1.673545	39.69805	91.50934	a
150	2903.674	0.000717	1504056615	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	c
107	2903.674	0.001757	1504024685	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	c
102	2903.674	0.000202	1504020863	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	b
7	2903.674	0.001493	1503958467	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	c
23	2903.674	0.000786	1503982155	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	a
58	2903.674	0.000624	1503997197	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	b
66	2903.674	0.000419	1504003299	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	c
146	2903.674	0.000477	1504053024	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	b
186	2903.674	0.000462	1504075708	88.51583	89.12145	31.19251	1.673545	39.69805	91.50934	c
103	2903.674	0.001628	1504023007	88.51583	89.12145	31.19251	1.673545	39.69805	91.50934	c
106	2903.674	0.00024	1504023882	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	b
140	2903.674	0.000819	1504044272	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	b
9	2903.674	5.05E-05	1503974783	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	c
190	2903.674	0.001376	1504078593	88.51583	89.12145	31.19251	1.673545	39.69804	91.50934	c
32	2903.674	0.000898	1503987784	88.51583	89.12145	31.19251	1.673545	39.69805	91.50934	a
177	2903.674	0.000464	1504065858	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	b
179	2903.674	0.000369	1504067175	88.51584	89.12145	31.19251	1.673545	39.69805	91.50934	a
46	2903.674	0.002	1503992584	88.51583	89.12145	31.19251	1.673545	39.69805	91.50934	c
61	2903.674	0.001612	1504003207	88.51583	89.12145	31.19251	1.673545	39.69805	91.50934	a
43	2903.718	0.001263	1503994794	72.11345	80.26137	28.09148	1.246046	29.04645	74.65713	a
170	2903.718	0.000375	1504068364	72.11345	80.26137	28.09148	1.246046	29.04645	74.65713	c
67	2903.718	0.000772	1504004438	72.11345	80.26137	28.09148	1.246046	29.04645	74.65713	c

Summary Results

model scenario	number of parameters	objective function
2016AM	341	2,406.75
B02016	332	2,665.27
B0	336	2,765.43
B0a	336	2,763.31
B1	337	3,109.39
B1a	337	3,108.64
B1b	337	3,110.35
B1c	337	8,367.14
B2	350	2,872.42
B2a	353	2,870.33
B2b	344	2,894.80
B3	391	2,381.20

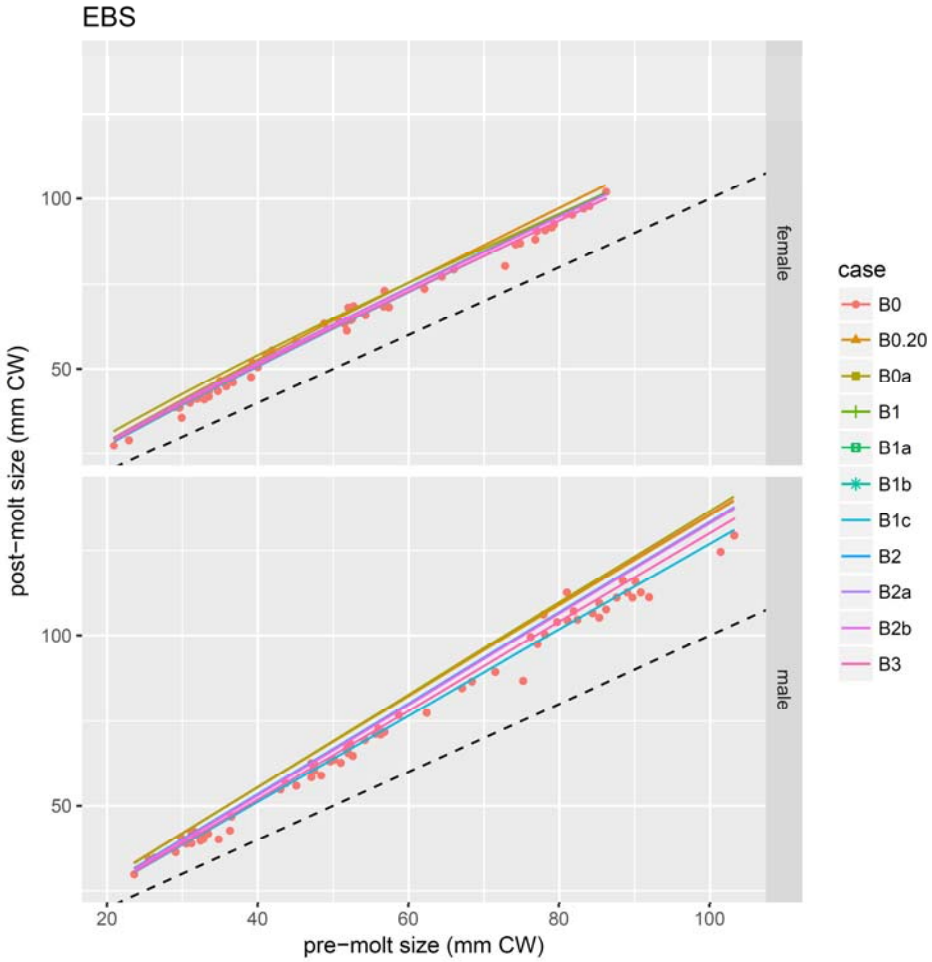
category	name	case	test	bound	description
fisheries	pLgtRet[1]	B2a	at upper bound	15	
		B2b	at upper bound	15	TCF: logit-scale max retention (pre-1997)
		B3	at upper bound	15	
population processes	pGrA[1]	B1	at lower bound	0.3	a coefficient, males
	pGrA[2]	B0	at upper bound	0.7	a coefficient, females
		B0.2016	at upper bound	0.7	
		B1	at upper bound	0.7	
	pGrBeta[1]	B1c	at lower bound	0.5	growth scale parameter
		B3	at lower bound	0.5	
	pLgtPrM2M[1]	B0	at upper bound	15	pr(terminal molt, males)
		B0.2016	at upper bound	15	
		B0a	at upper bound	15	
		B1	at upper bound	15	
		B1a	at upper bound	15	
		B1b	at upper bound	15	
		B1c	at upper bound	15	
		B2	at upper bound	15	
		B2a	at upper bound	15	
		B2b	at upper bound	15	
		B3	at upper bound	15	
	pLgtPrM2M[2]	B0	at lower bound	-15	pr(terminal molt, females)
		B0.2016	at lower bound	-15	
		B0a	at lower bound	-15	
		B1	at lower bound	-15	
		B1a	at lower bound	-15	
		B1b	at lower bound	-15	
		B1c	at lower bound	-15	
		B2	at lower bound	-15	
		B2a	at lower bound	-15	
		B2b	at lower bound	-15	
		B3	at lower bound	-15	
surveys	pLnQ[1]	B0	at lower bound	-0.693	NMFS survey Q: males, pre-1982
		B0.2016	at lower bound	-0.693	
		B0a	at lower bound	-0.693	
		B1	at lower bound	-0.693	
		B1a	at lower bound	-0.693	
		B1b	at lower bound	-0.693	
		B1c	at lower bound	-0.693	
		B2	at lower bound	-0.693	
		B2a	at lower bound	-0.693	
		B2b	at lower bound	-0.693	
		B3	at lower bound	-0.693	
	pLnQ[3]	B0	at lower bound	-0.693	NMFS survey Q: females, pre-1982
		B0.2016	at lower bound	-0.693	
		B0a	at lower bound	-0.693	
		B1	at lower bound	-0.693	
		B1a	at lower bound	-0.693	
		B1b	at lower bound	-0.693	
		B1c	at lower bound	-0.693	
		B2	at lower bound	-0.693	
		B2a	at lower bound	-0.693	
		B2b	at lower bound	-0.693	
		B3	at lower bound	-0.693	

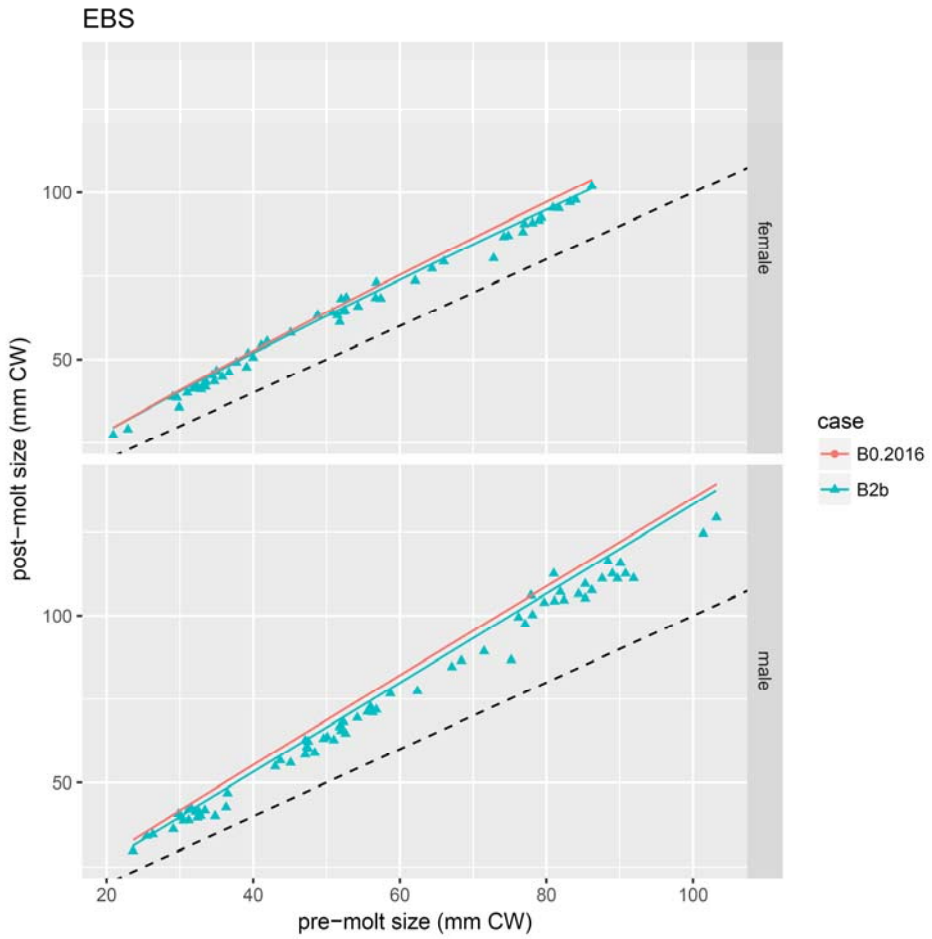
name	case	test	bound	label
pS1[1]	B1c	at upper bound	90	z50 for NMFS survey selectivity (males, pre-1982)
pS1[19]	B0a	at lower bound	40	z50 for GTF.AllGear selectivity (males, pre-1987)
pS1[20]	B0	at lower bound	40	z50 for GTF.AllGear selectivity (males, 1987-1996)
	B0.2016	at lower bound	40	
	B0a	at lower bound	40	
	B1	at lower bound	40	
	B1a	at lower bound	40	
	B1b	at lower bound	40	
	B1c	at lower bound	40	
	B2	at lower bound	40	
	B2a	at lower bound	40	
	B2b	at lower bound	40	
	B3	at lower bound	40	
pS1[22]	B3	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
pS1[23]	B0	at upper bound	150	z50 for RKF selectivity (males, 1997-2004)
	B0.2016	at upper bound	150	
	B0a	at upper bound	150	
	B1	at upper bound	150	
	B1a	at upper bound	150	
	B1b	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
	B1c	at upper bound	180	
	B2	at upper bound	180	
	B2a	at upper bound	180	
	B2b	at upper bound	180	
	B3	at upper bound	180	z95 for RKF selectivity (males, 2005+)
pS1[24]	B0	at upper bound	150	z50 for RKF selectivity (males, 2005+)
	B0.2016	at upper bound	150	
	B0a	at upper bound	150	
	B1	at upper bound	150	
	B1a	at upper bound	150	
	B1b	at upper bound	180	
	B1c	at upper bound	180	
	B2	at upper bound	180	
	B2a	at upper bound	180	
	B2b	at upper bound	180	
pS1[25]	B0a	at upper bound	150	z50 for RKF selectivity (females, pre-1997)
pS1[26]	B3	at upper bound	140	z95 for RKF selectivity (females, 2005+)
pS1[27]	B0	at upper bound	170	z50 for RKF selectivity (females, 2005+)
	B1	at upper bound	170	
	B1a	at upper bound	170	
	B1b	at upper bound	140	
	B1c	at upper bound	140	
	B2	at upper bound	140	
	B2a	at upper bound	140	
	B2b	at upper bound	140	
pS1[29]	B3	at lower bound	40	z50 for GTF.AllGear selectivity (females, pre-1987)
pS1[30]	B3	at lower bound	40	z50 for GTF.AllGear selectivity (females, 1987-1990)
pS1[33]	B3	at upper bound	120	z50 for GTF.FixedGear selectivity (females, 1991-1996)
pS1[4]	B3	at lower bound	-50	z50 for NMFS survey selectivity (females, 1982+)
pS2[1]	B3	at upper bound	100	z95-z50 for NMFS survey selectivity (males, pre-1982)
pS2[2]	B1c	at upper bound	100	z95-z50 for NMFS survey selectivity (males, 1982+)
pS2[4]	B0	at upper bound	100	z95-z50 for NMFS survey selectivity (females, 1982+)
	B0.2016	at upper bound	100	
	B1	at upper bound	100	
	B1a	at upper bound	100	
	B1b	at upper bound	100	
	B1c	at upper bound	100	
	B2	at upper bound	100	
	B2a	at upper bound	100	
	B2b	at upper bound	100	
	B3	at upper bound	100	
pS3[4]	B3	at upper bound	4.5	ln(dz50-az50) for GTF.FixedGear selectivity (males, 1991-1996)
pS4[1]	B0	at upper bound	0.5	descending slope for SCF selectivity (males, pre-1997)
	B0.2016	at upper bound	0.5	
	B0a	at upper bound	0.5	
	B1	at upper bound	0.5	
	B1a	at upper bound	0.5	
	B1b	at upper bound	0.5	
	B1c	at upper bound	0.5	
	B2b	at upper bound	0.5	
	B3	at upper bound	0.5	
pS4[4]	B3	at upper bound	0.5	descending slope for GTF.FixedGear selectivity (males, 1991-1996)
pS4[5]	B3	at lower bound	0.1	descending slope for GTF.FixedGear selectivity (males, 1997+)

Data components of the likelihood

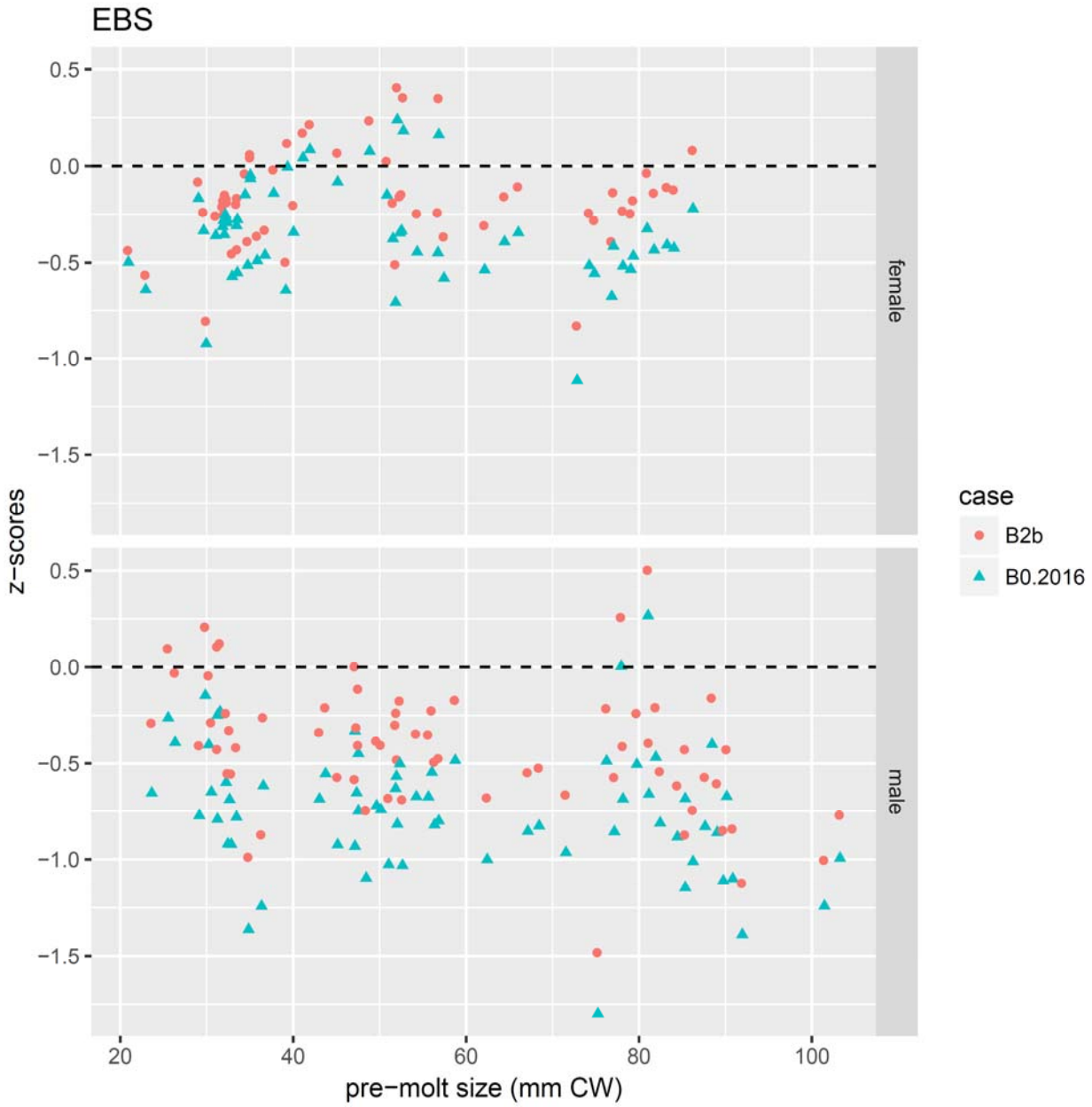
category	fleet	catch.type	data.type	x	maturity	B0-B0.2016	B0a-B0	B1-B0a	B1a-B1	B1b-B1a	B1c-B1b	B2-B1b	B2a-B2	B2b-B2a	B3-B2b
effort data	RKF	fishery		all sexes	all maturity states	93.81	1.27	13.32	0.69	12.16	6.42	38.16	-23.40	-4.93	-26.42
effort data	SCF	fishery		all sexes	all maturity states	55.83	-13.48	34.21	-5.96	-0.37	82.09	32.60	-20.05	-28.22	36.87
fisheries data	GTF.FixedGear	total catch	abundance	all sexes	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
fisheries data	GTF.FixedGear	total catch	biomass	all sexes	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
fisheries data	GTF.FixedGear	total catch	n.at.z	female	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.10
fisheries data	GTF.FixedGear	total catch	n.at.z	male	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.31
fisheries data	GTF.TrawlGear	total catch	abundance	all sexes	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.60
fisheries data	GTF.TrawlGear	total catch	biomass	all sexes	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.87
fisheries data	GTF.TrawlGear	total catch	n.at.z	female	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.65
fisheries data	GTF.TrawlGear	total catch	n.at.z	male	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.62
fisheries data	GTF.AllGear	total catch	abundance	all sexes	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
fisheries data	GTF.AllGear	total catch	biomass	all sexes	all maturity states	-0.37	0.02	-0.08	0.01	0.00	-0.10	0.01	-0.01	0.00	-1.14
fisheries data	GTF.AllGear	total catch	n.at.z	female	all maturity states	41.65	2.87	0.17	0.91	0.01	6.05	1.03	0.16	0.85	-233.63
fisheries data	GTF.AllGear	total catch	n.at.z	male	all maturity states	8.33	-2.82	8.40	-0.57	0.10	13.98	1.62	-0.03	2.00	-261.01
fisheries data	RKF	total catch	abundance	female	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
fisheries data	RKF	total catch	abundance	male	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
fisheries data	RKF	total catch	biomass	female	all maturity states	-0.02	0.11	-0.14	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01
fisheries data	RKF	total catch	biomass	male	all maturity states	0.33	-0.02	0.15	0.02	0.26	0.06	0.54	-0.21	-0.12	-0.43
fisheries data	RKF	total catch	n.at.z	female	all maturity states	0.72	0.09	-0.11	0.00	0.04	0.01	-0.01	0.01	0.00	-0.01
fisheries data	RKF	total catch	n.at.z	male	all maturity states	6.63	-0.61	2.55	-0.21	1.06	1.18	4.33	-3.82	0.23	-1.38
fisheries data	SCF	total catch	abundance	female	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
fisheries data	SCF	total catch	abundance	male	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
fisheries data	SCF	total catch	biomass	female	all maturity states	-0.13	0.13	0.65	0.05	-0.01	1.68	0.42	0.23	0.23	-0.29
fisheries data	SCF	total catch	biomass	male	all maturity states	0.17	0.00	-0.06	0.00	0.00	-0.09	-0.06	0.04	0.02	-0.09
fisheries data	SCF	total catch	n.at.z	female	all maturity states	0.08	-0.04	-0.15	-0.01	0.00	-0.06	-0.09	0.09	0.08	-0.74
fisheries data	SCF	total catch	n.at.z	male	all maturity states	3.20	-0.33	-1.91	-0.44	-0.01	-1.56	0.17	-0.02	1.22	-3.93
fisheries data	TCF	retained catch	abundance	female	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
fisheries data	TCF	retained catch	abundance	male	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
fisheries data	TCF	retained catch	biomass	female	all maturity states	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
fisheries data	TCF	retained catch	biomass	male	all maturity states	-0.78	-0.13	1.65	-0.08	0.01	3.20	-29.62	-5.69	7.89	-2.08
fisheries data	TCF	retained catch	n.at.z	male	all maturity states	4.48	-0.39	2.56	-0.48	0.01	-5.95	-187.16	-6.74	-8.85	-6.34
fisheries data	TCF	total catch	biomass	female	all maturity states	-1.25	0.42	0.65	0.10	0.03	1.90	-23.66	26.71	5.24	-0.90
fisheries data	TCF	total catch	biomass	male	all maturity states	-0.41	-0.11	0.69	-0.06	0.00	1.15	-12.14	0.20	1.91	-0.31
fisheries data	TCF	total catch	n.at.z	female	all maturity states	-0.14	0.48	-0.19	0.07	-0.01	0.12	-0.21	0.24	0.02	-0.03
fisheries data	TCF	total catch	n.at.z	male	all maturity states	-2.85	1.77	-3.65	0.72	0.00	-5.02	-12.63	0.08	12.23	0.07
growth data			EBS	female	immature	0.00	0.00	127.32	0.19	-0.05	2,201.11	1.21	-1.35	-0.40	-9.85
growth data			EBS	male	immature	0.00	0.00	191.47	0.19	-0.13	2,957.73	2.04	-3.01	0.04	-20.02
surveys data	NMFS trawl survey	index catch	biomass	female	mature	-1.76	-1.58	9.44	-0.19	0.06	9.56	-0.97	1.91	0.16	12.60
surveys data	NMFS trawl survey	index catch	biomass	male	mature	3.36	-1.74	14.00	-0.36	0.01	26.23	-0.35	1.53	-0.80	-25.75
surveys data	NMFS trawl survey	index catch	n.at.z	female	immature	2.13	-19.03	-18.12	-5.83	0.10	-25.57	3.66	-1.48	0.13	2.42
surveys data	NMFS trawl survey	index catch	n.at.z	female	mature	10.30	-1.50	38.16	0.78	0.24	53.38	-0.56	1.13	-0.50	-40.96
surveys data	NMFS trawl survey	index catch	n.at.z	male	immature	19.33	9.24	-59.01	3.78	-0.34	-27.74	7.20	-7.95	2.73	34.18
surveys data	NMFS trawl survey	index catch	n.at.z	male	mature	-4.92	2.73	34.84	0.29	-0.29	25.90	-5.36	1.39	-3.24	-23.68

Model Comparisons

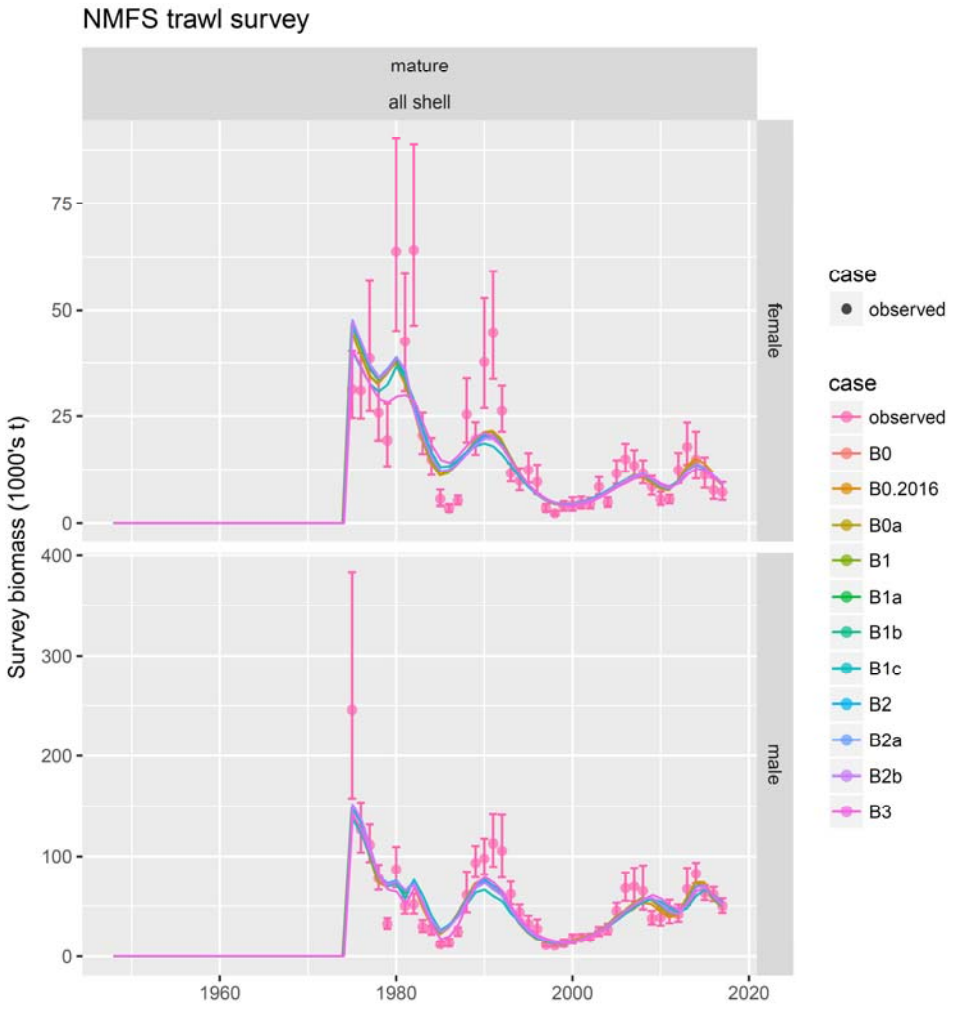


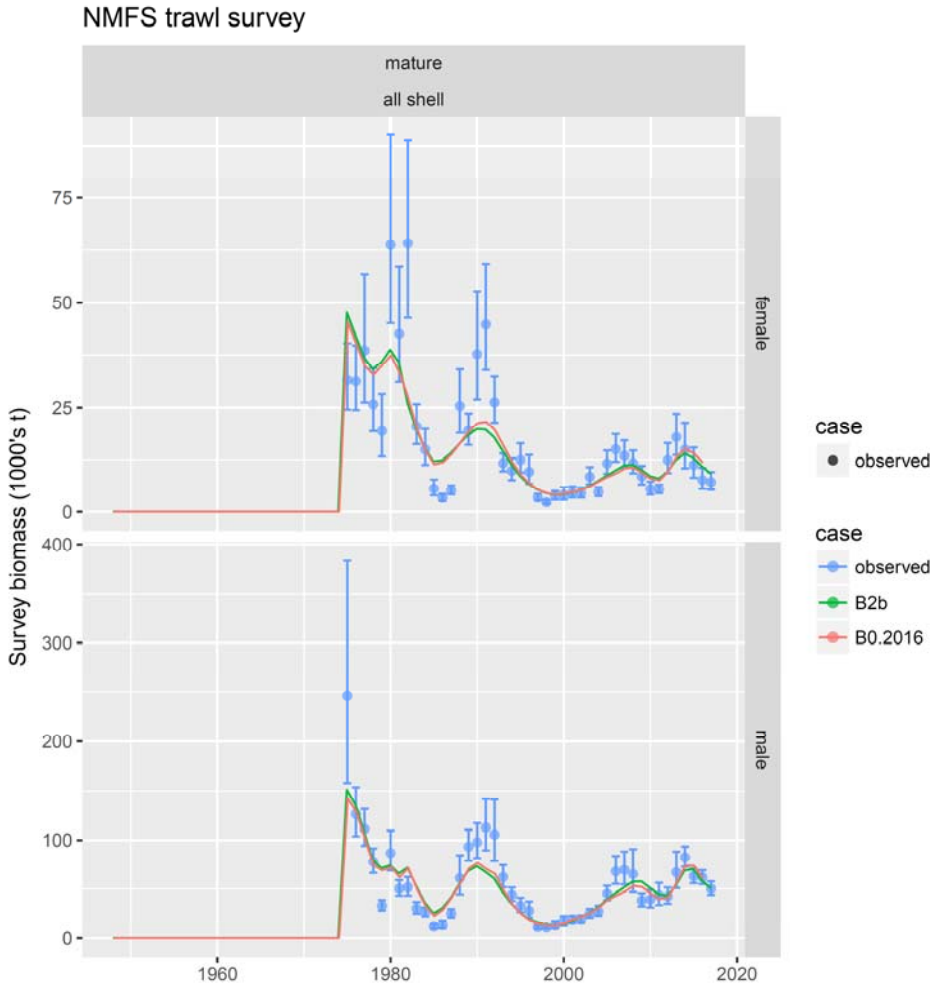


Model comparisons

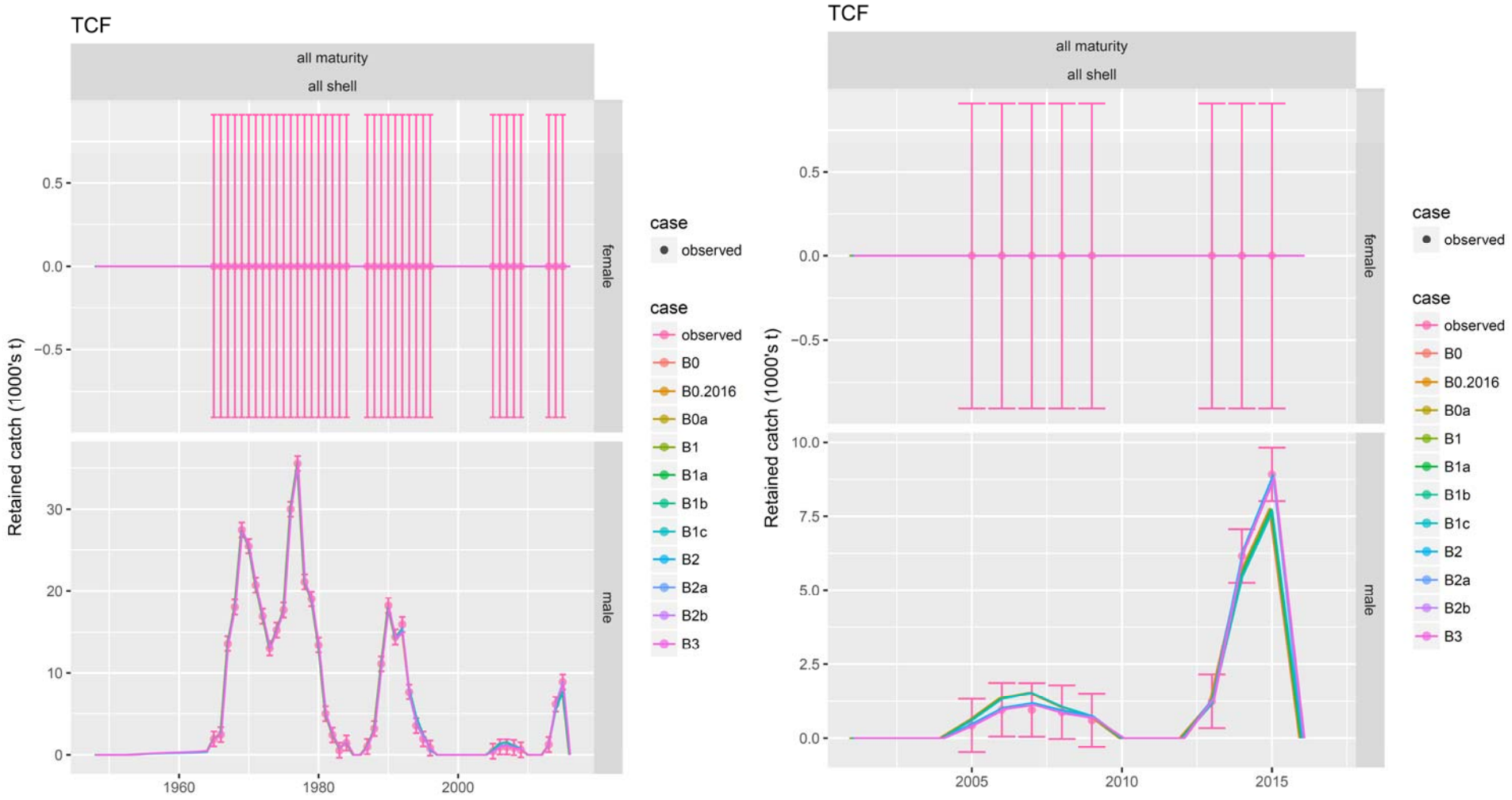


Model fits

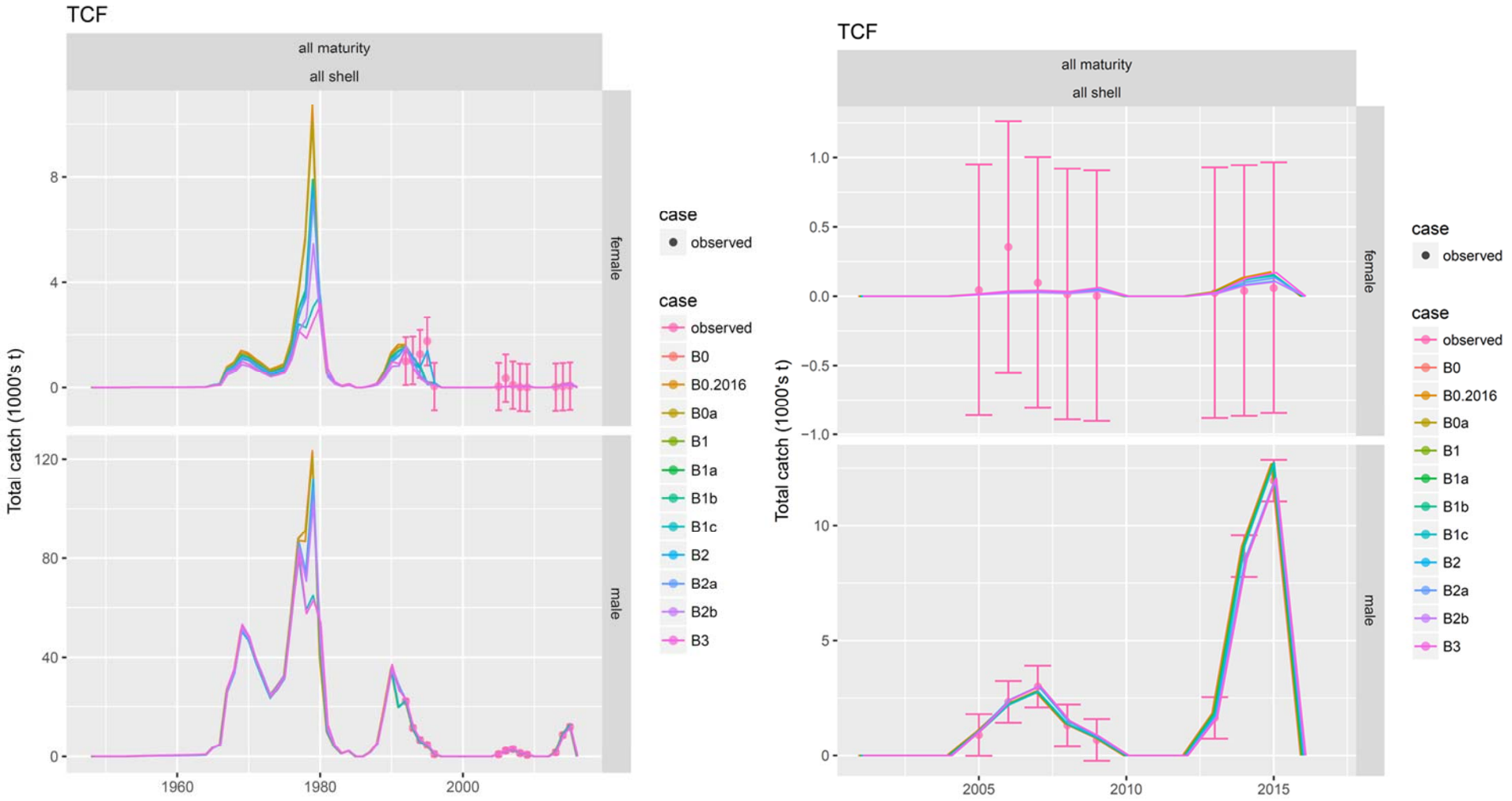

NMFS trawl survey
mature
all shell
female
male
Survey biomass (1000's t)
0
25
50
75
100
200
300
400
1960
1980
2000
2020
case
observed
case
observed
B0
B0.2016
B0a
B1
B1a
B1b
B1c
B2
B2a
B2b
B3


NMFS trawl survey
mature
all shell
female
male
Survey biomass (1000's t)
0
25
50
75
100
200
300
400
1960
1980
2000
2020
case
observed
case
observed
B2b
B0.2016

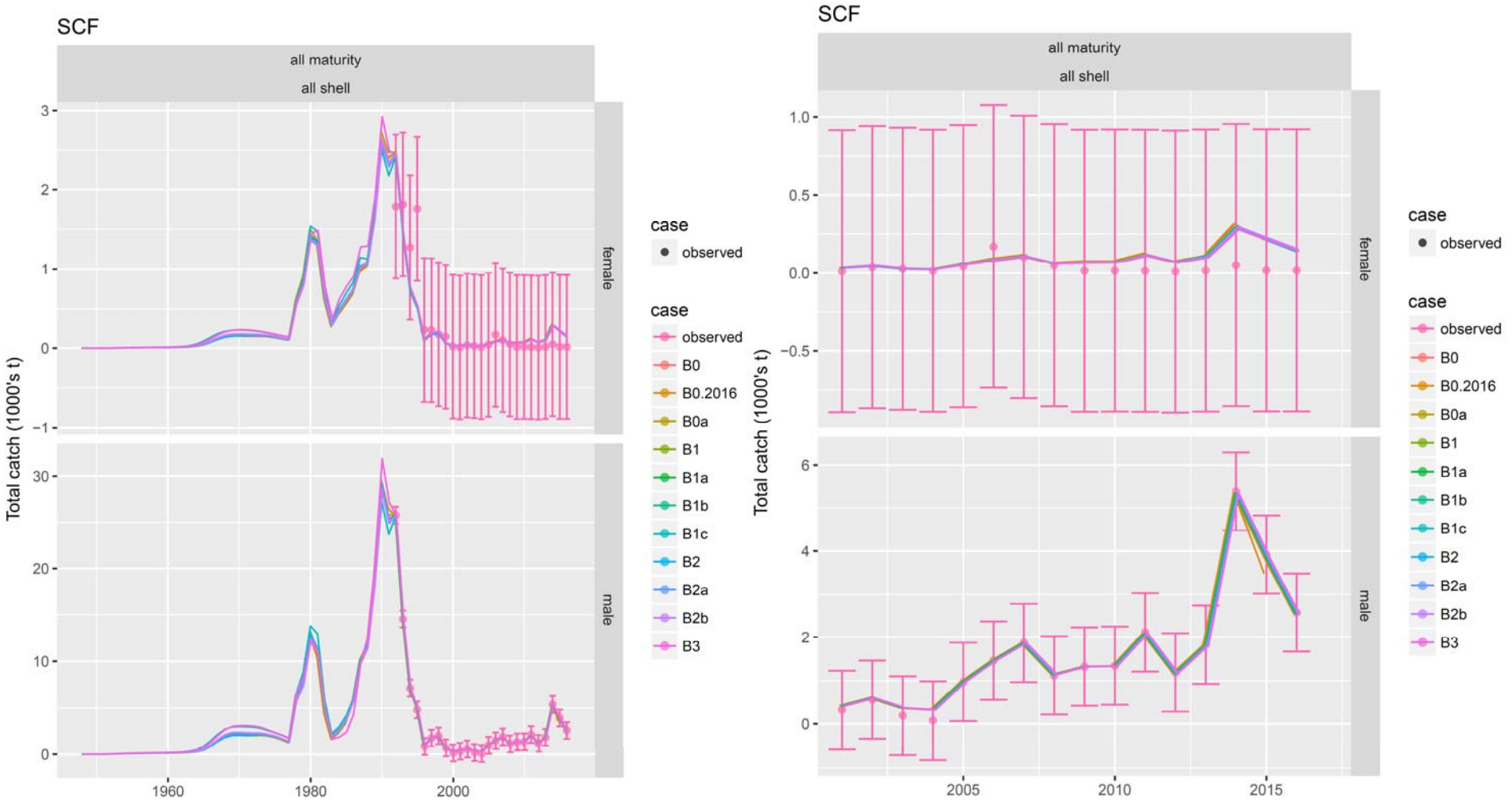
Model fits


TCF
all maturity
all shell
female
male
Retained catch (1000's t)
0.5
0.0
−0.5
30
20
10
0
1960
1980
2000
case
observed
B0
B0.2016
B0a
B1
B1a
B1b
B1c
B2
B2a
B2b
B3
TCF
all maturity
all shell
female
male
Retained catch (1000's t)
0.5
0.0
−0.5
10.0
7.5
5.0
2.5
0.0
2005
2010
2015
case
observed
B0
B0.2016
B0a
B1
B1a
B1b
B1c
B2
B2a
B2b
B3

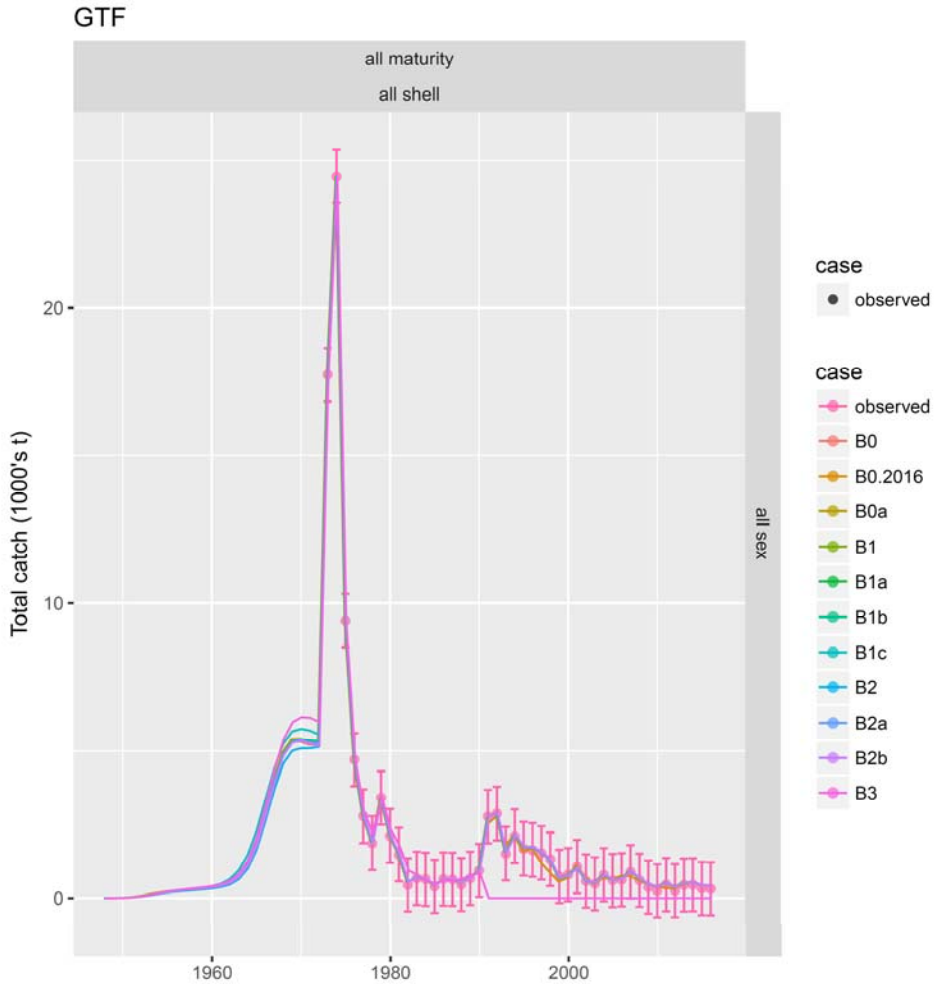
Model fits

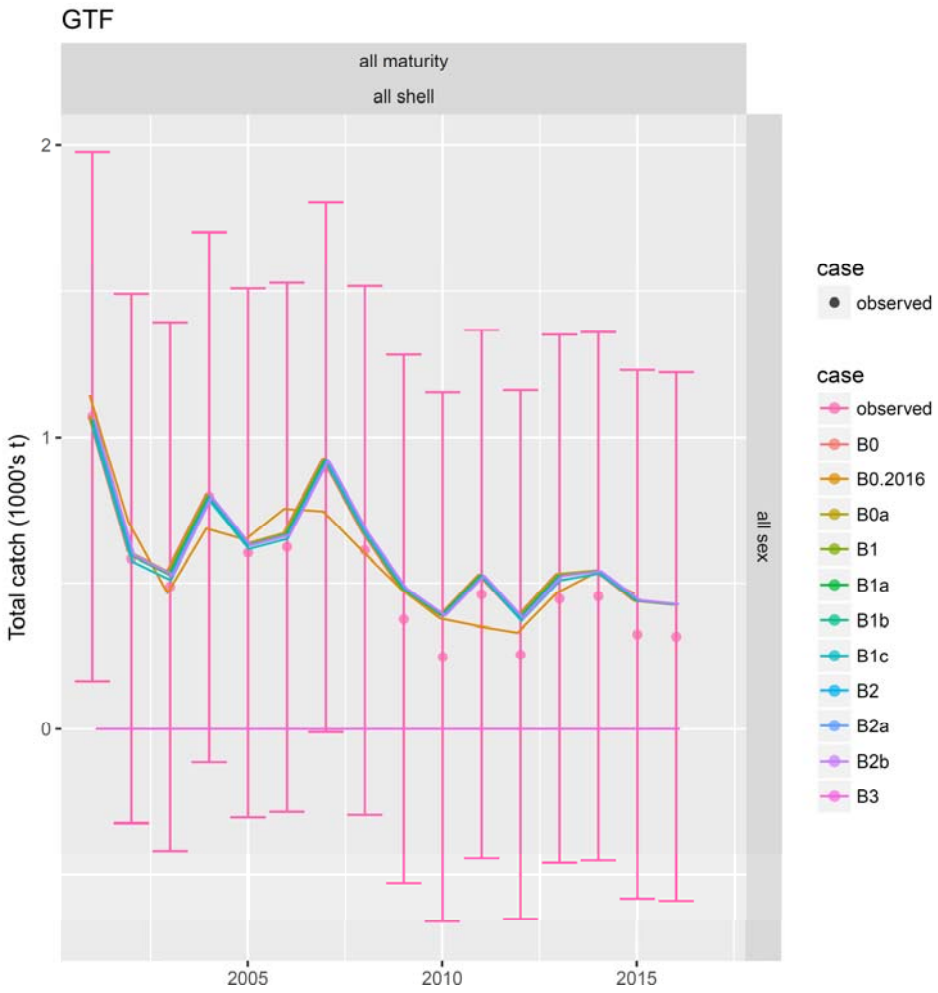

TCF
all maturity
all shell
female
male
Total catch (1000's t)
8
4
0
120
80
40
0
1960
1980
2000
case
observed
case
observed
B0
B0.2016
B0a
B1
B1a
B1b
B1c
B2
B2a
B2b
B3
TCF
all maturity
all shell
female
male
Total catch (1000's t)
1.0
0.5
0.0
−0.5
−1.0
10
5
0
2005
2010
2015
case
observed
case
observed
B0
B0.2016
B0a
B1
B1a
B1b
B1c
B2
B2a
B2b
B3

Model fits

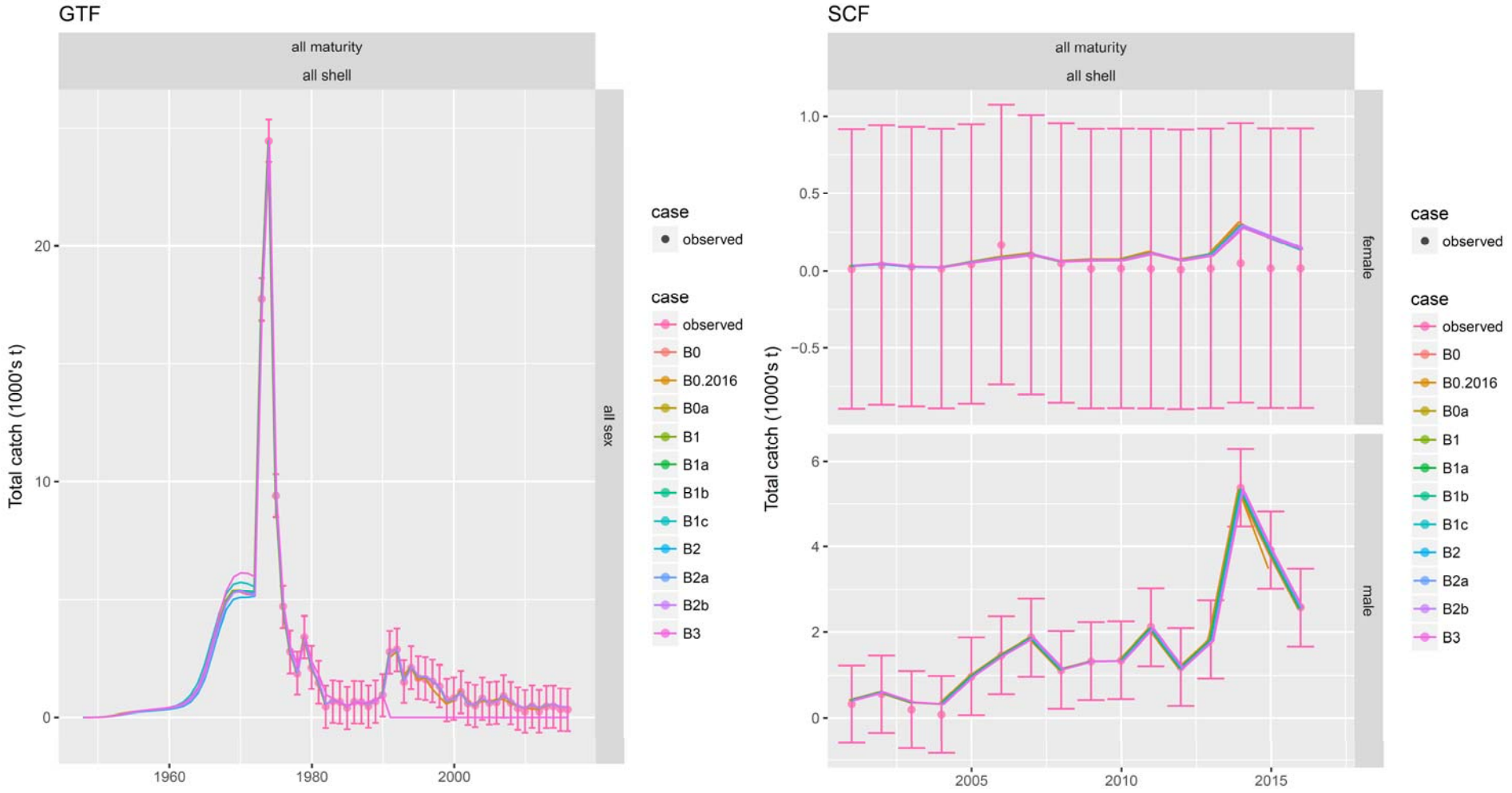

SCF
all maturity
all shell
female
male
Total catch (1000's t)
3
2
1
0
−1
30
20
10
0
1960
1980
2000
case
observed
case
observed
B0
B0.2016
B0a
B1
B1a
B1b
B1c
B2
B2a
B2b
B3
SCF
all maturity
all shell
female
male
Total catch (1000's t)
1.0
0.5
0.0
−0.5
6
4
2
0
2005
2010
2015
case
observed
case
observed
B0
B0.2016
B0a
B1
B1a
B1b
B1c
B2
B2a
B2b
B3

Model comparisons

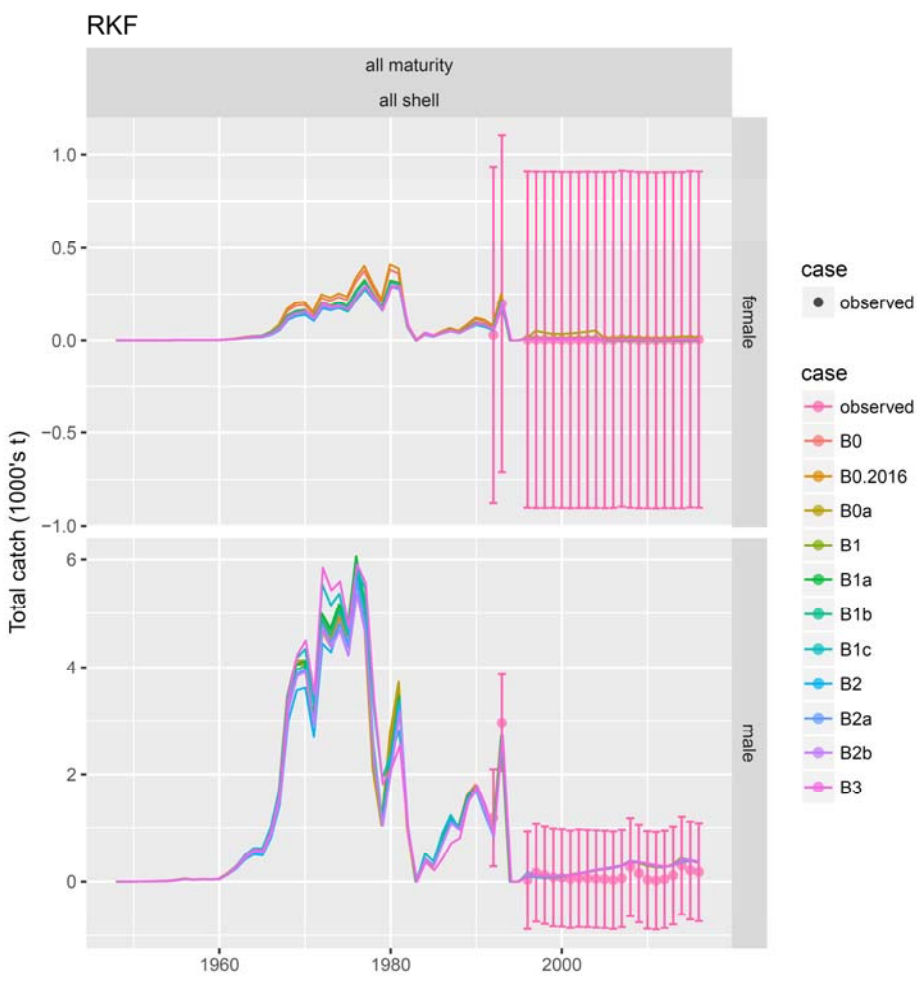


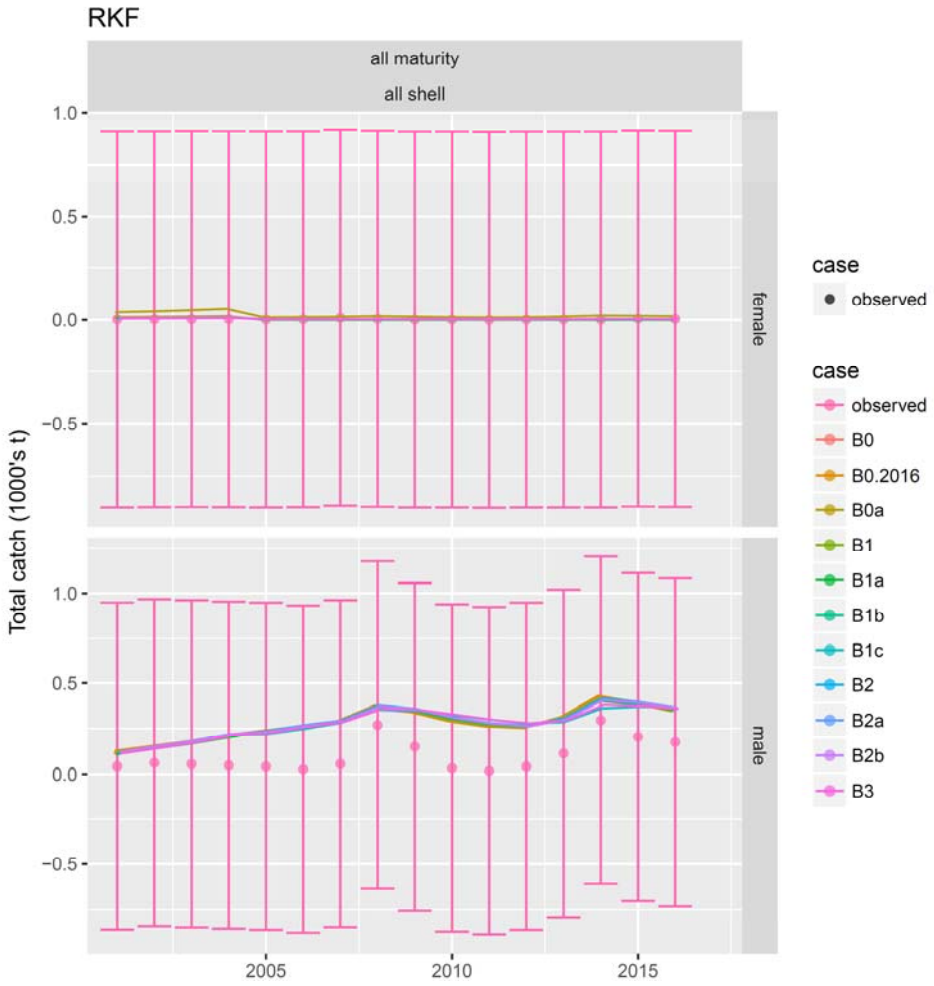


Model fits

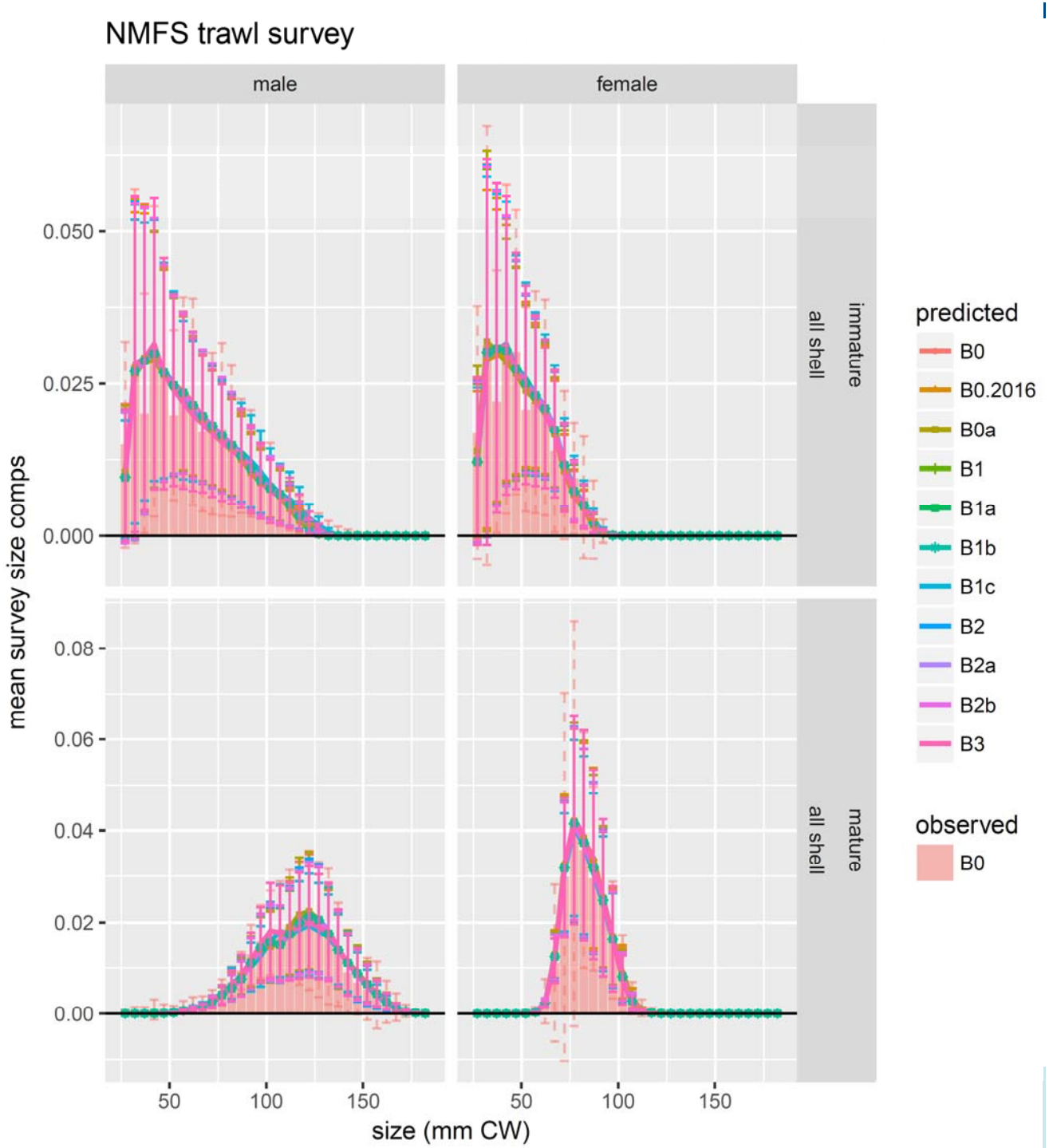

GTF
all maturity
all shell
all sex
Total catch (1000's t)
20
10
0
1960
1980
2000
case
observed
B0
B0.2016
B0a
B1
B1a
B1b
B1c
B2
B2a
B2b
B3
SCF
all maturity
all shell
female
male
1.0
0.5
0.0
−0.5
6
4
2
0
2005
2010
2015

Model fits


RKF
all maturity
all shell
female
male
Total catch (1000's t)
1.0
0.5
0.0
−0.5
−1.0
6
4
2
0
1960
1980
2000
case
observed
case
observed
B0
B0.2016
B0a
B1
B1a
B1b
B1c
B2
B2a
B2b
B3

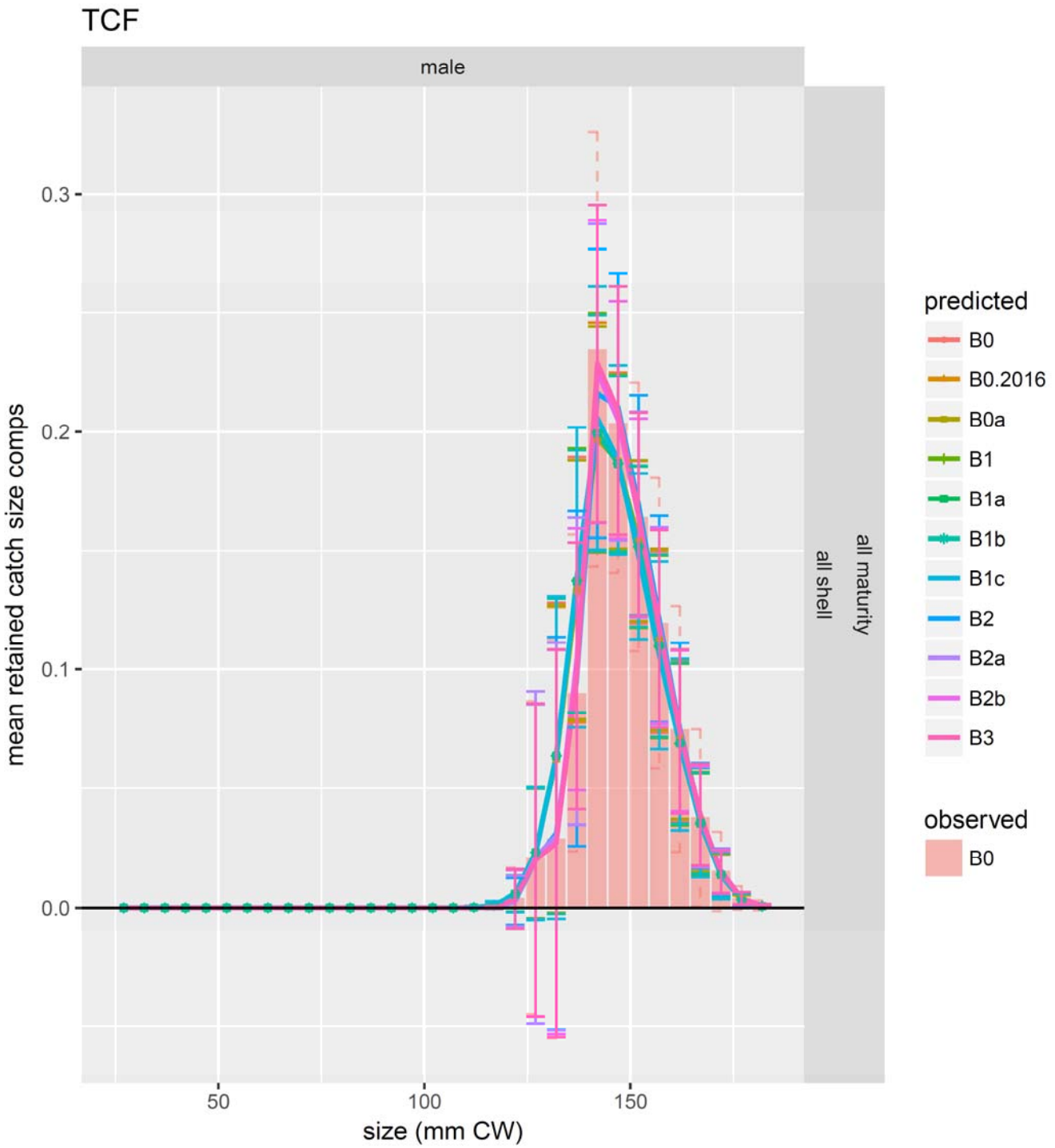

RKF
all maturity
all shell
female
male
Total catch (1000's t)
1.0
0.5
0.0
−0.5
2005
2010
2015
case
observed
case
observed
B0
B0.2016
B0a
B1
B1a
B1b
B1c
B2
B2a
B2b
B3

Model fits



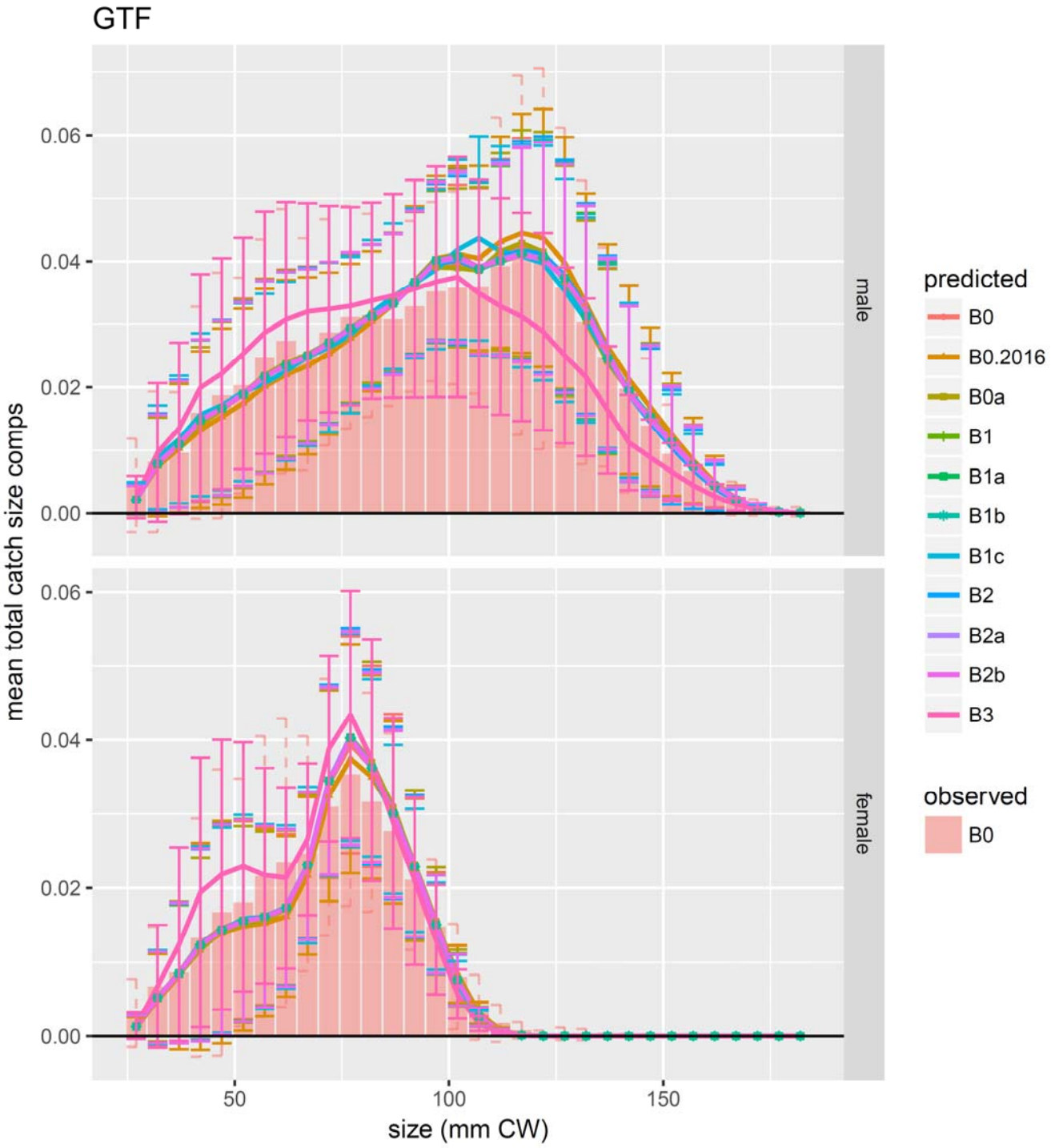
NOAA FISHERIES

Model fits



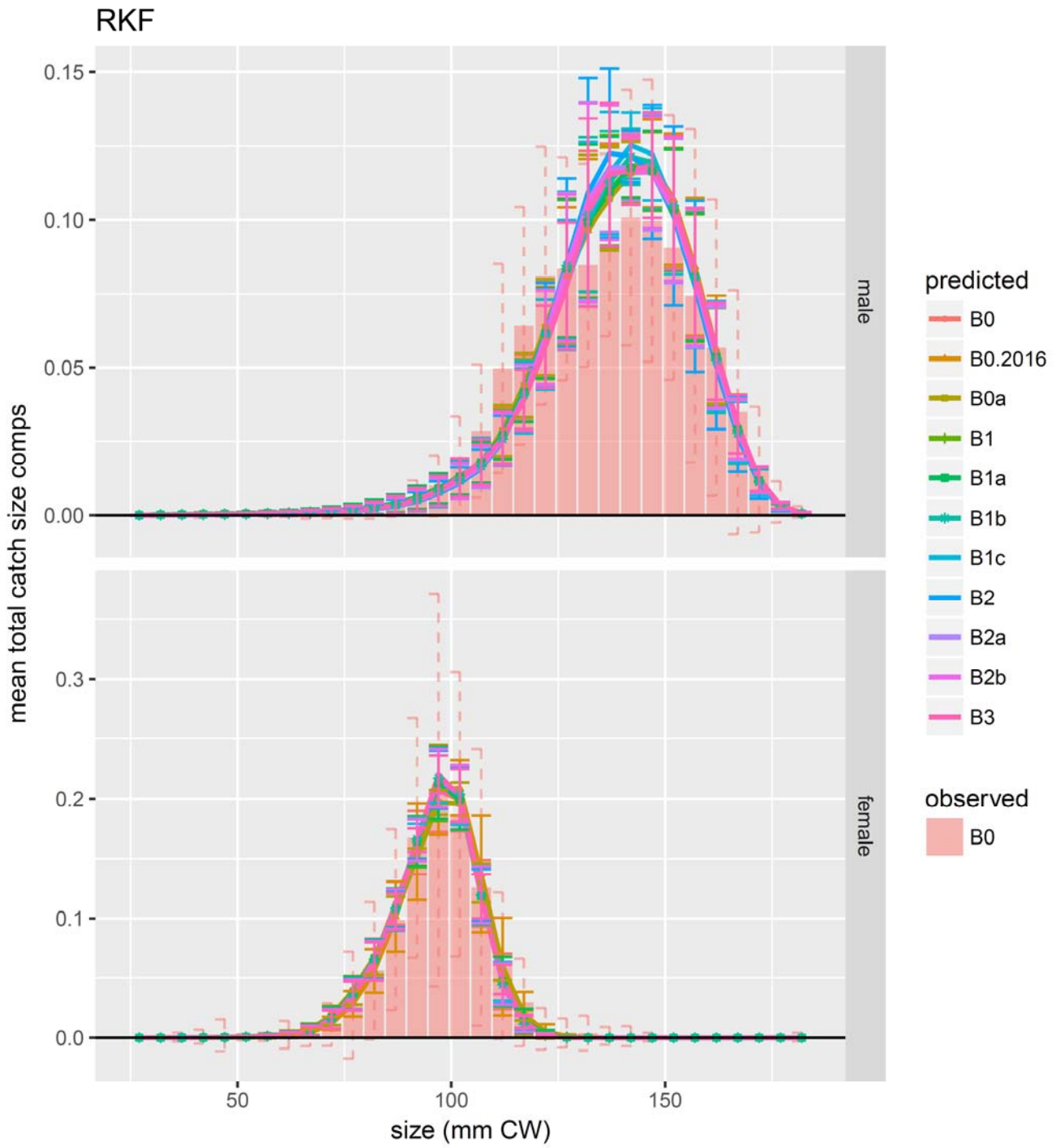
NOAA FISHERIES

Model fits



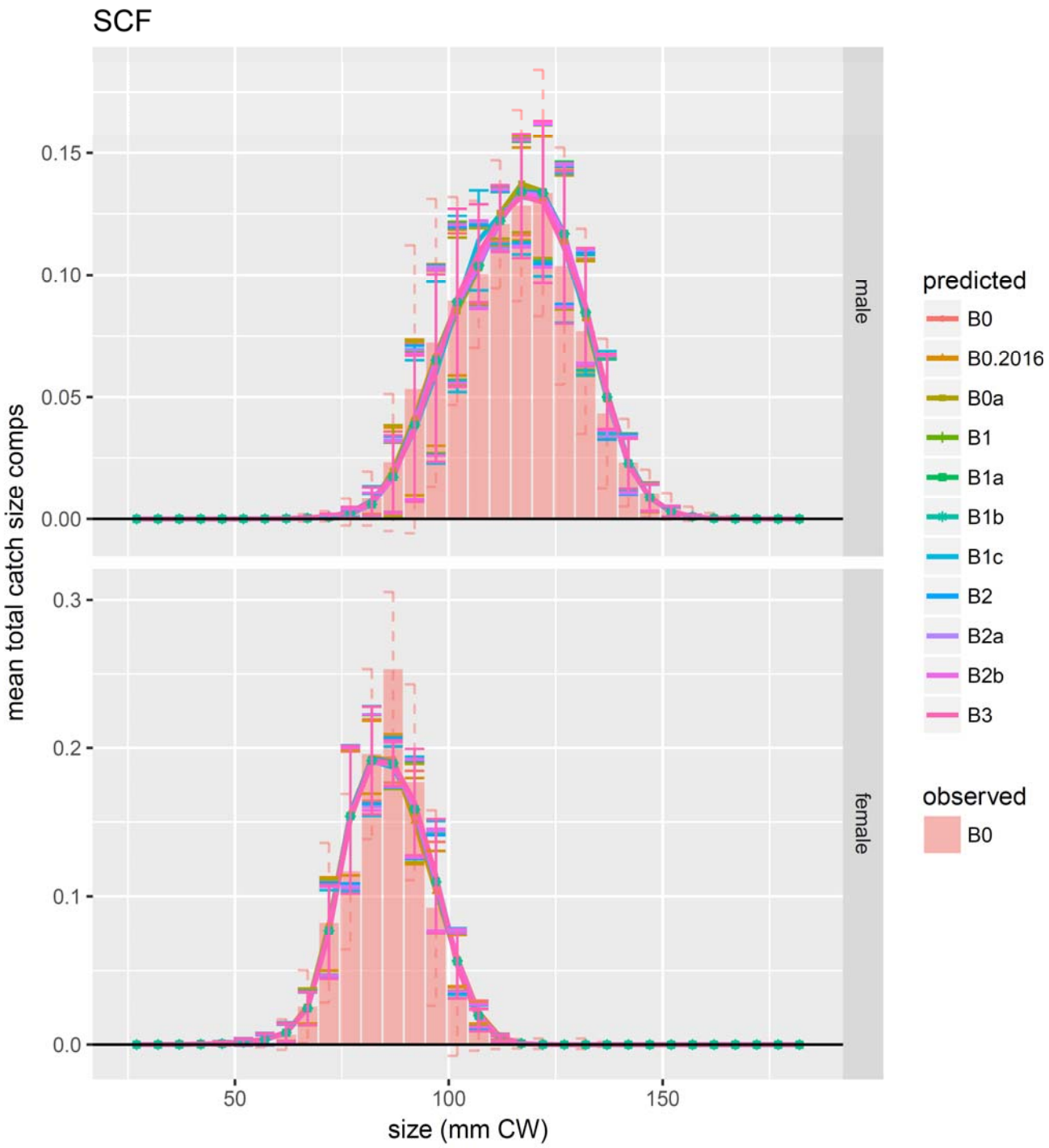
NOAA FISHERIES

Model fits



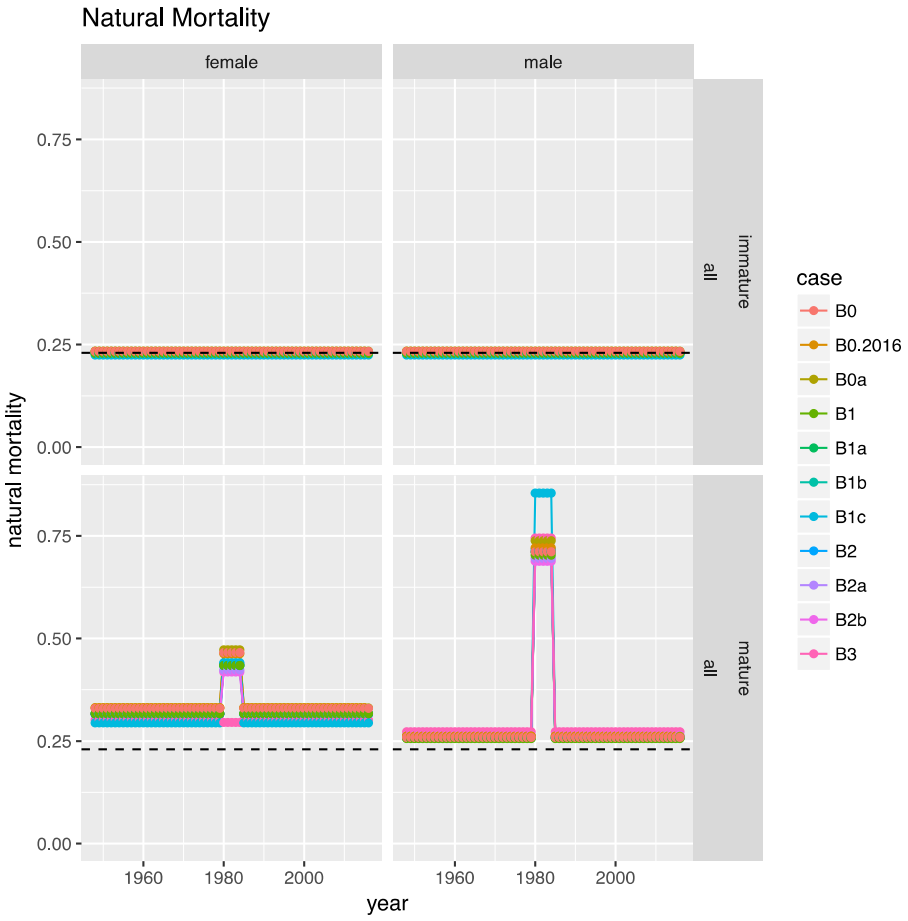
NOAA FISHERIES

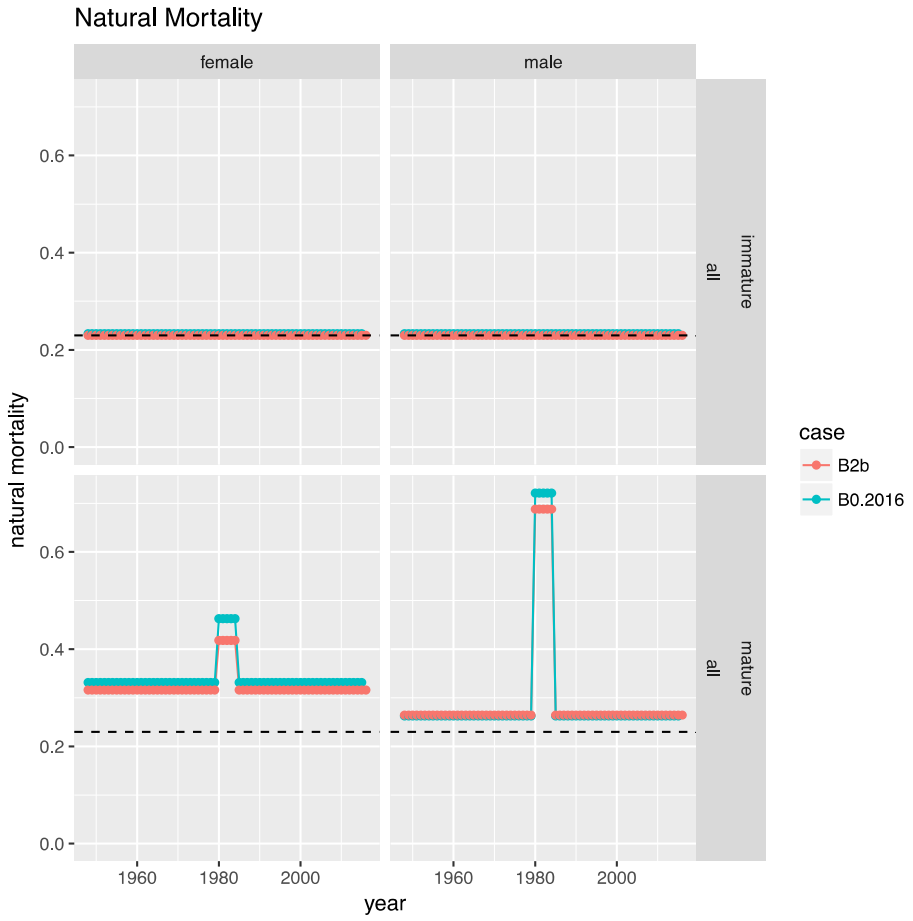
Model fits



NOAA FISHERIES

Model Comparisons





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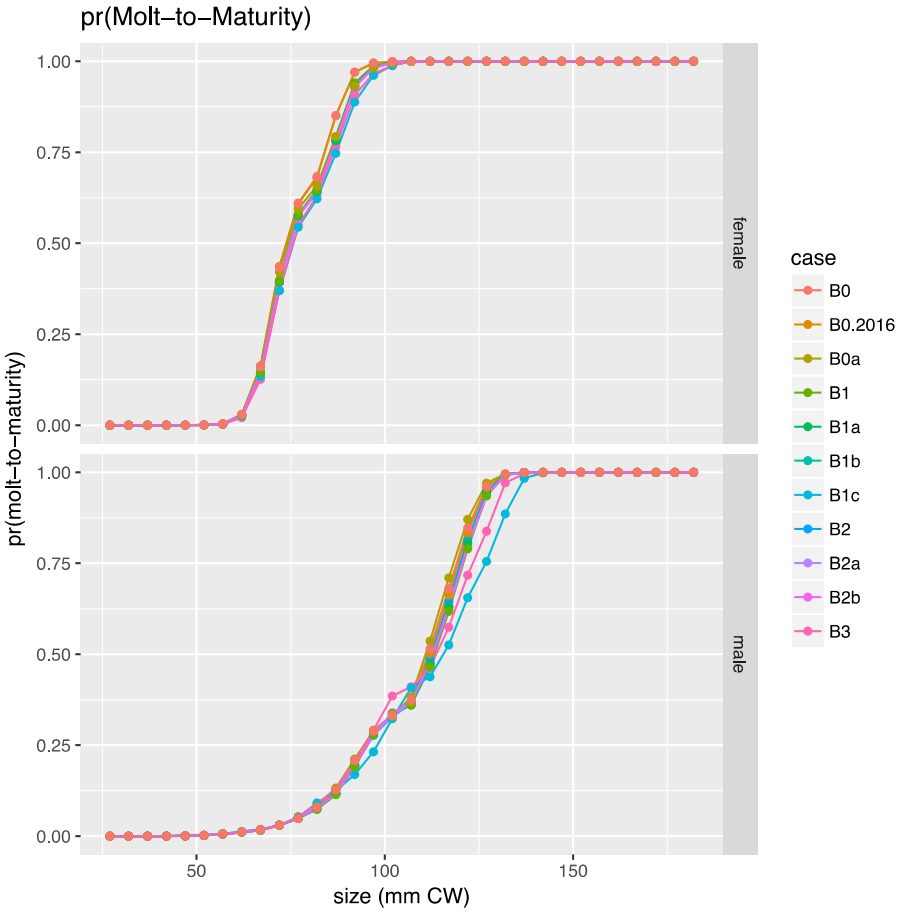

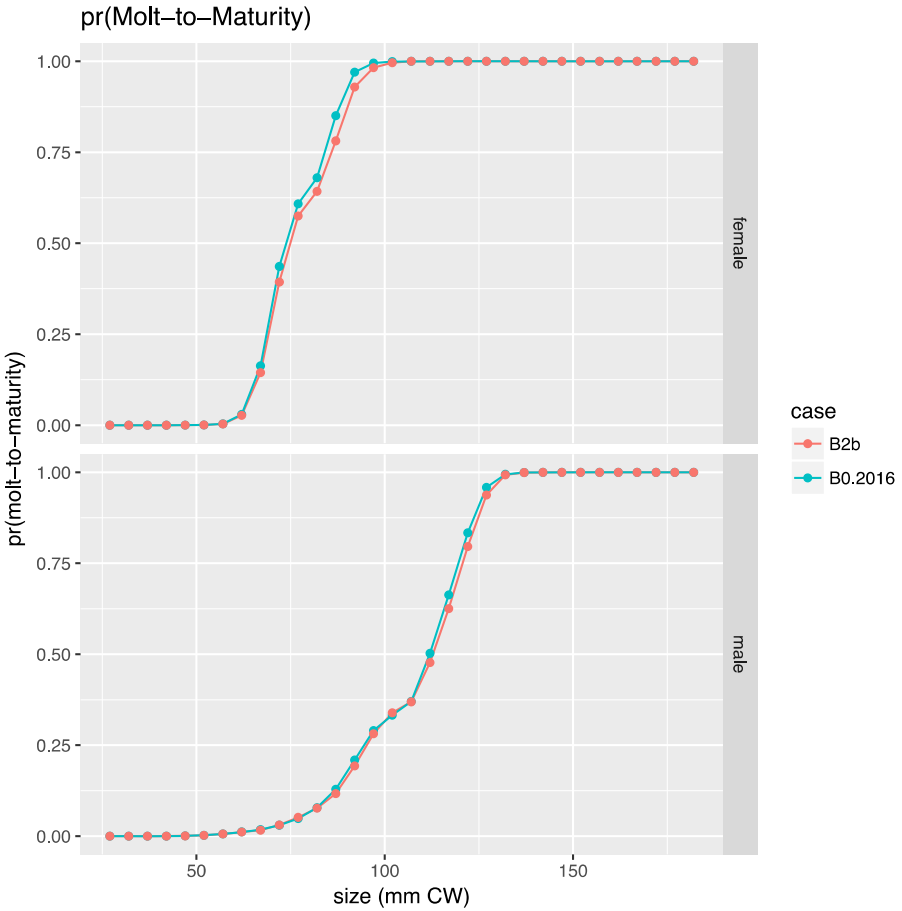

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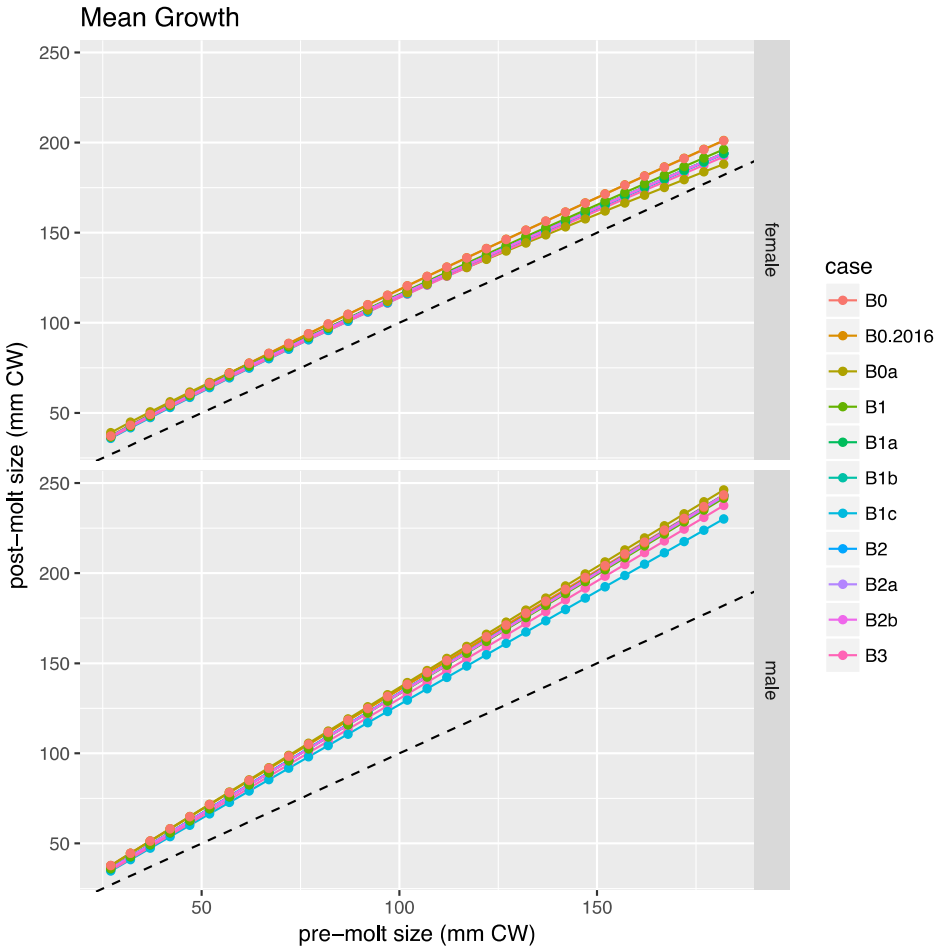
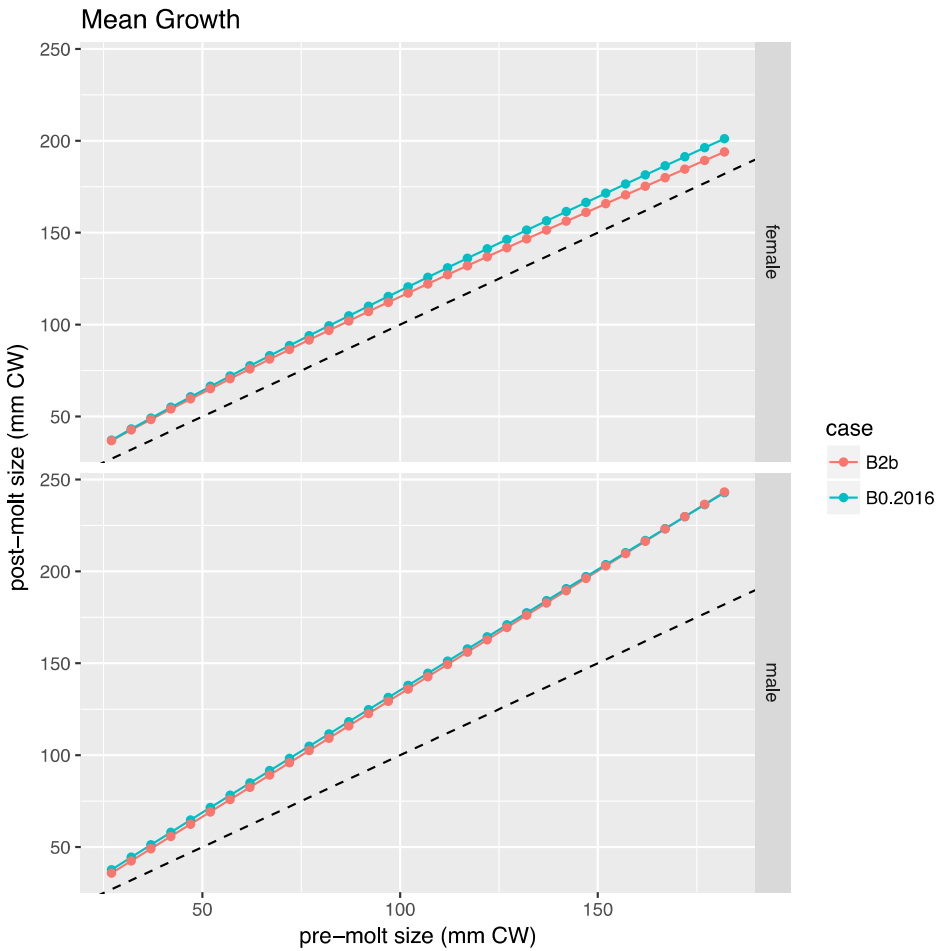
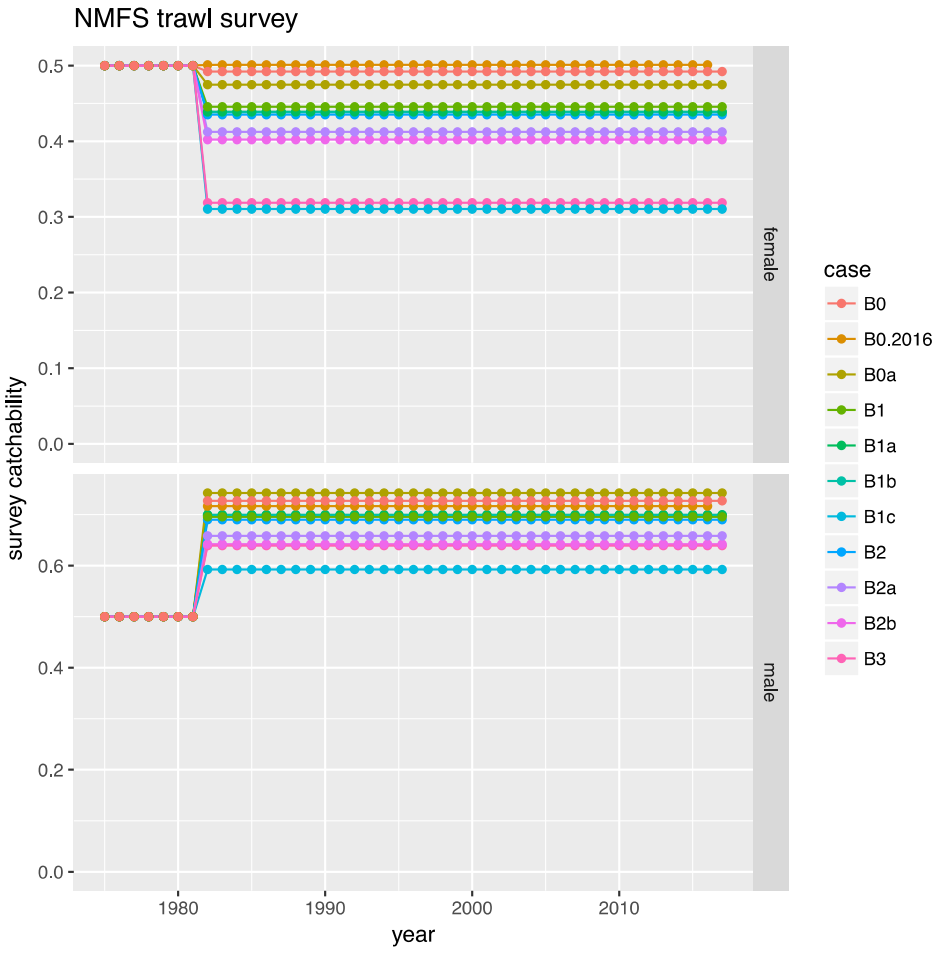
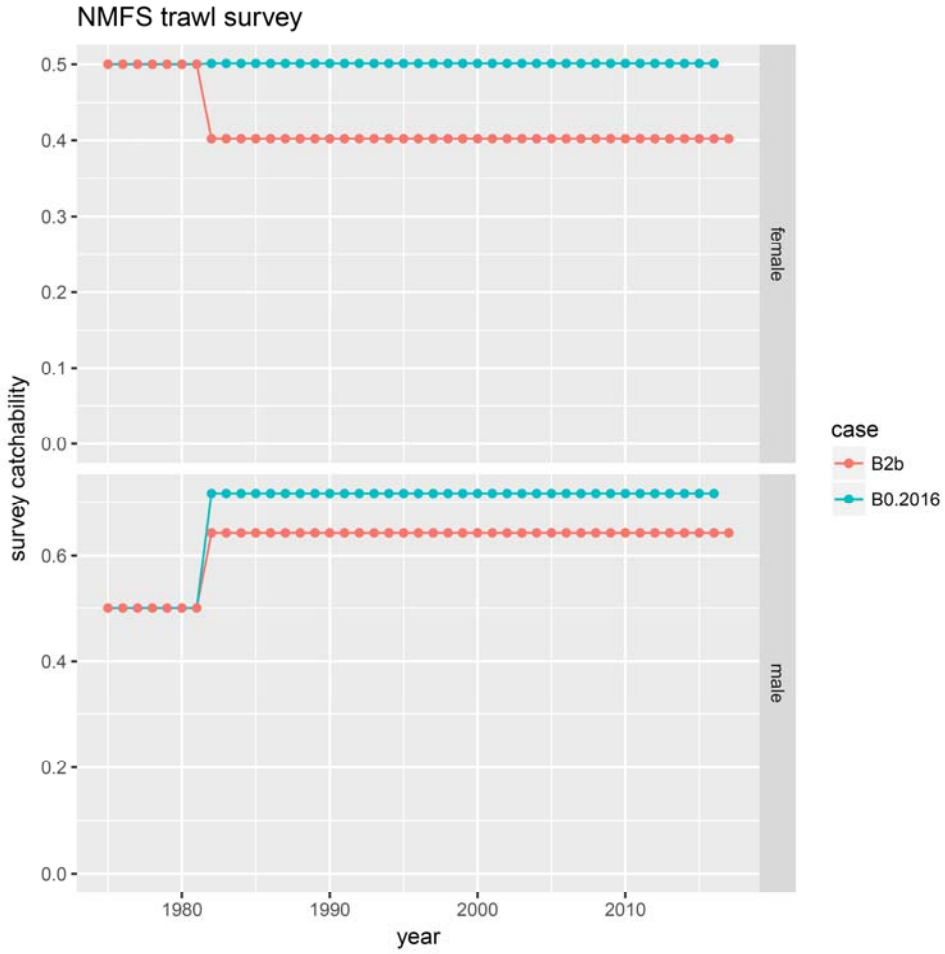




Model Comparisons: Survey q's





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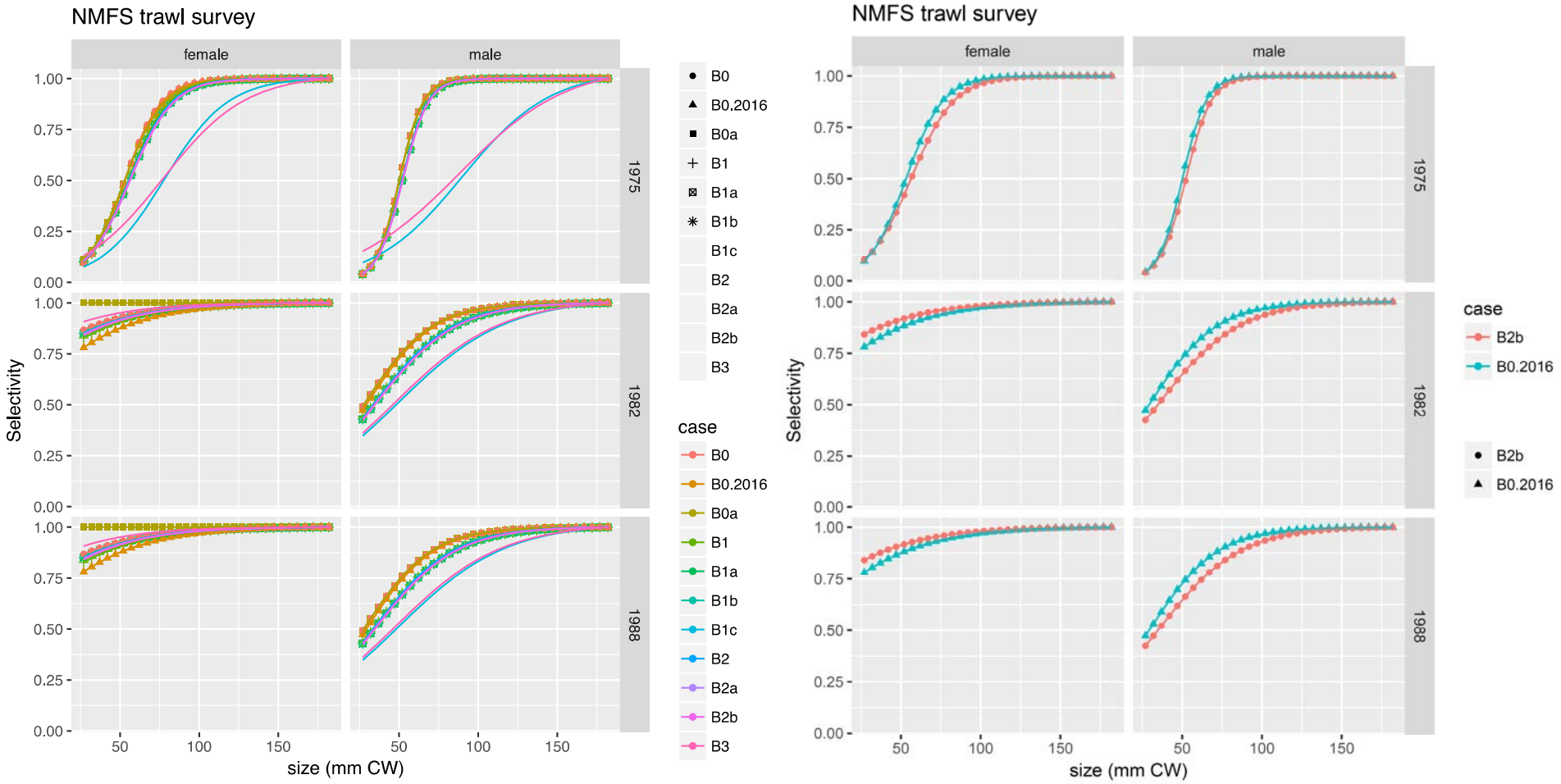
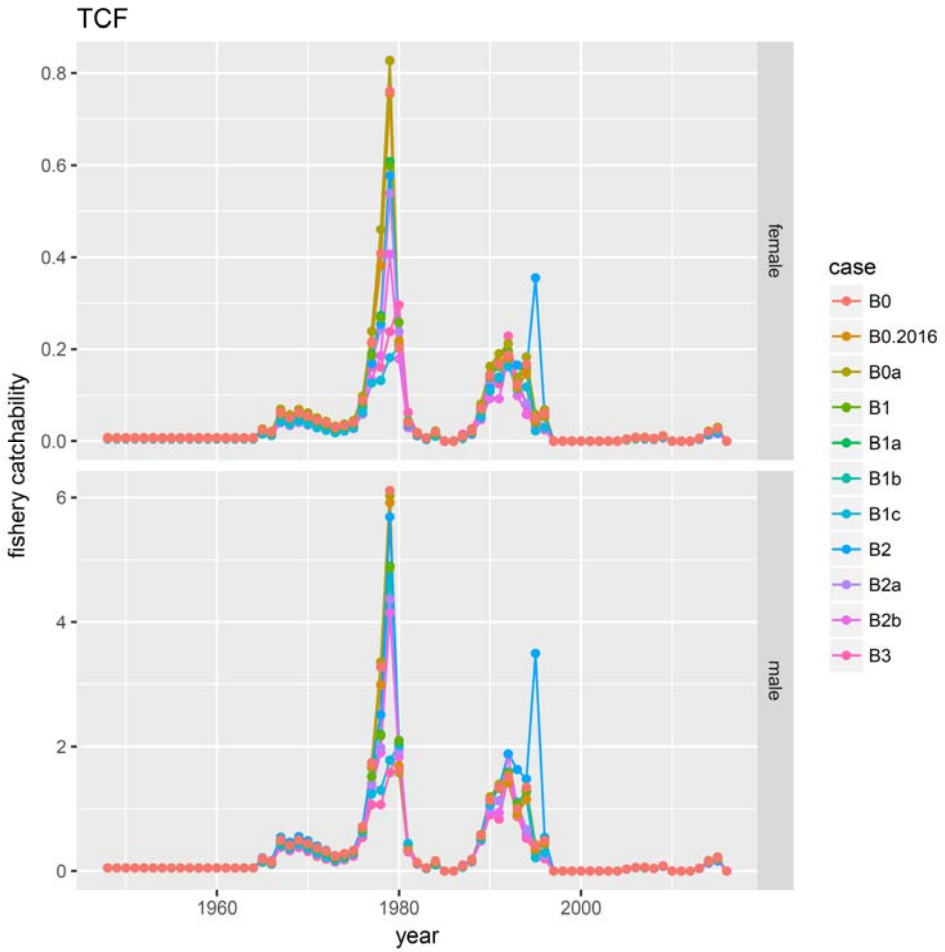
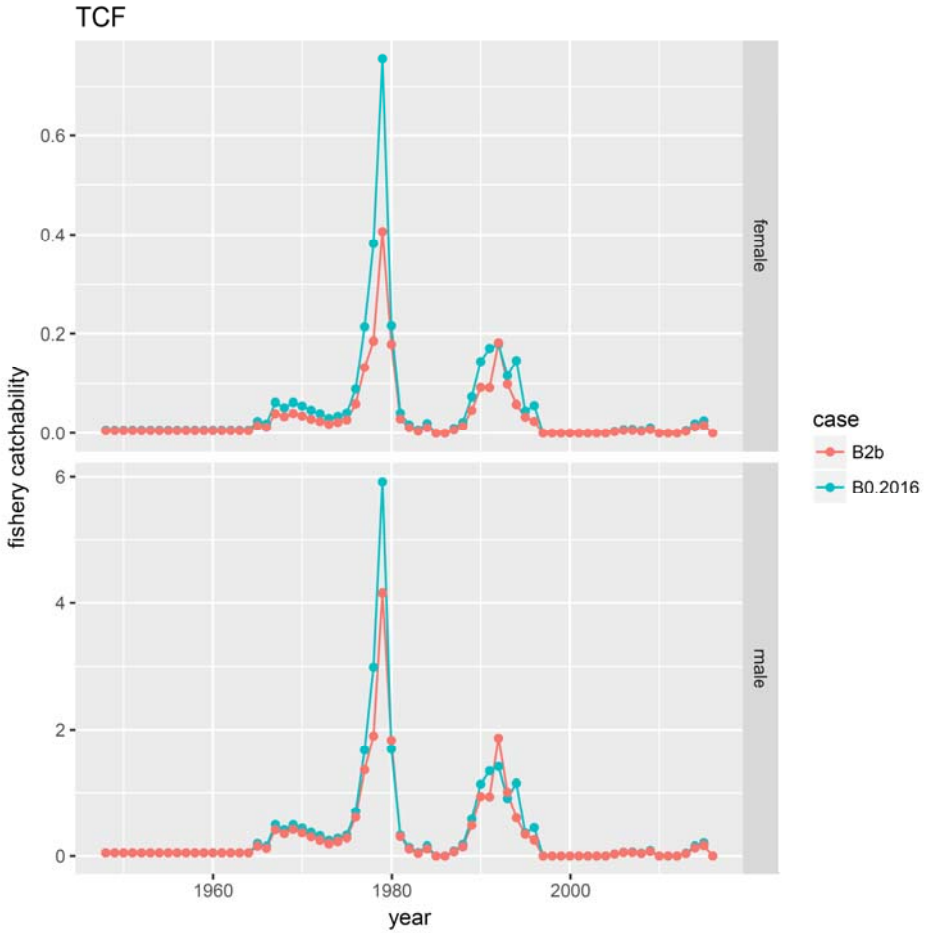


Model comparisons





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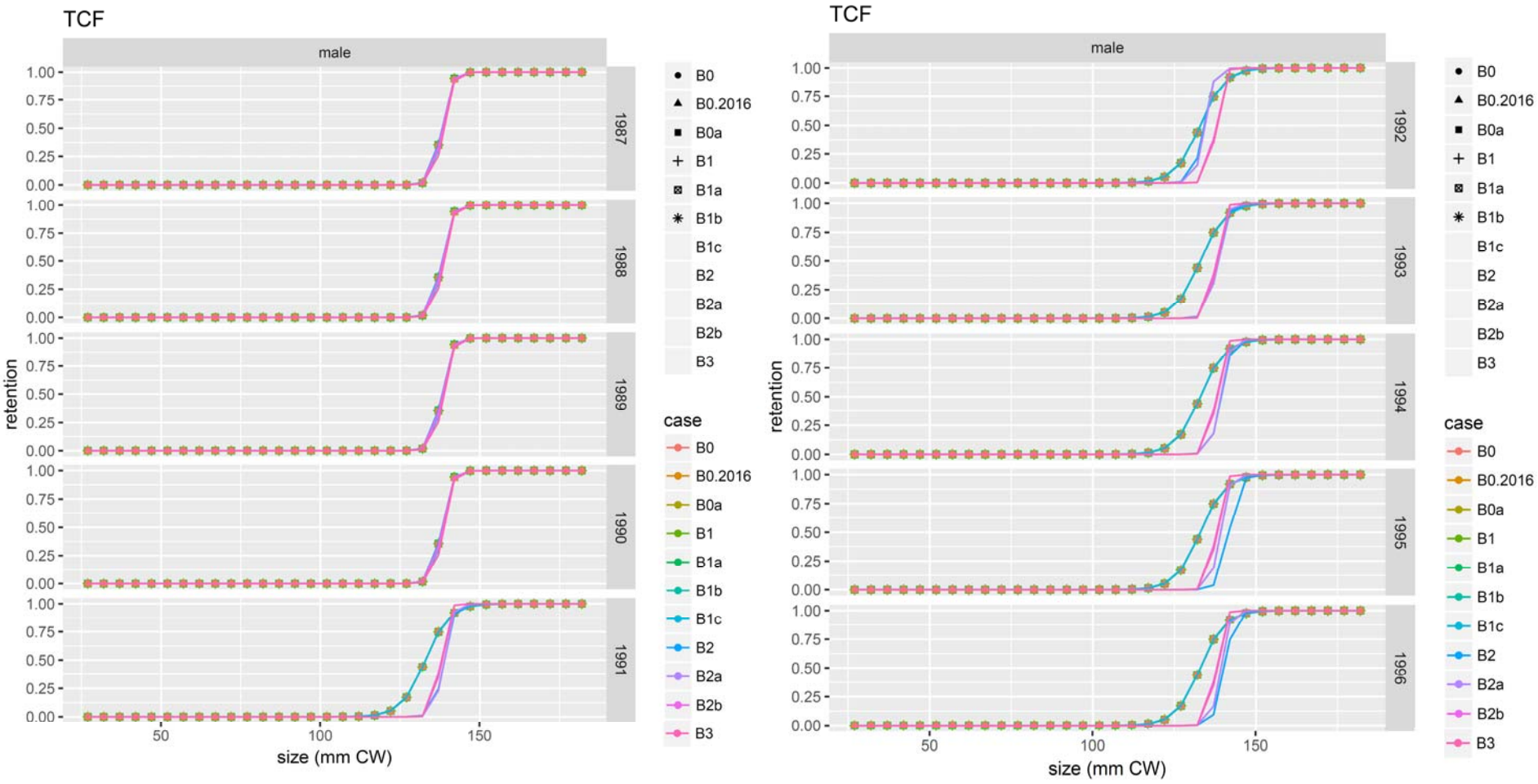
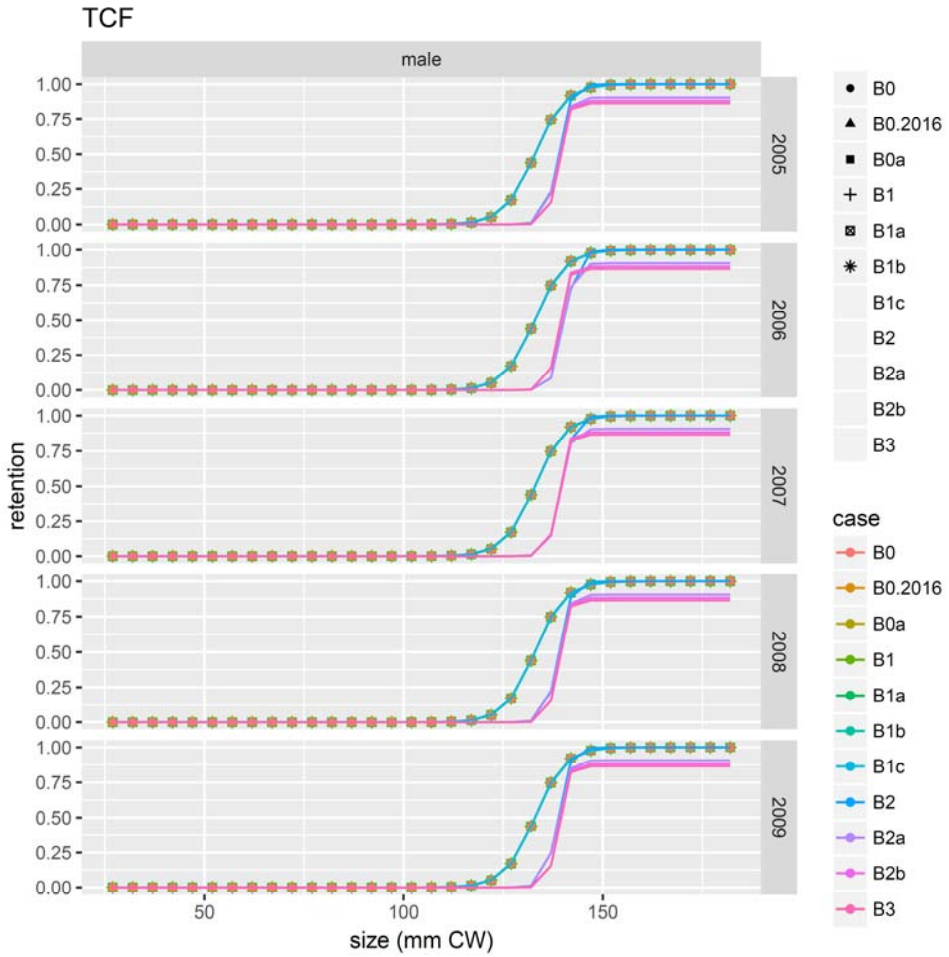
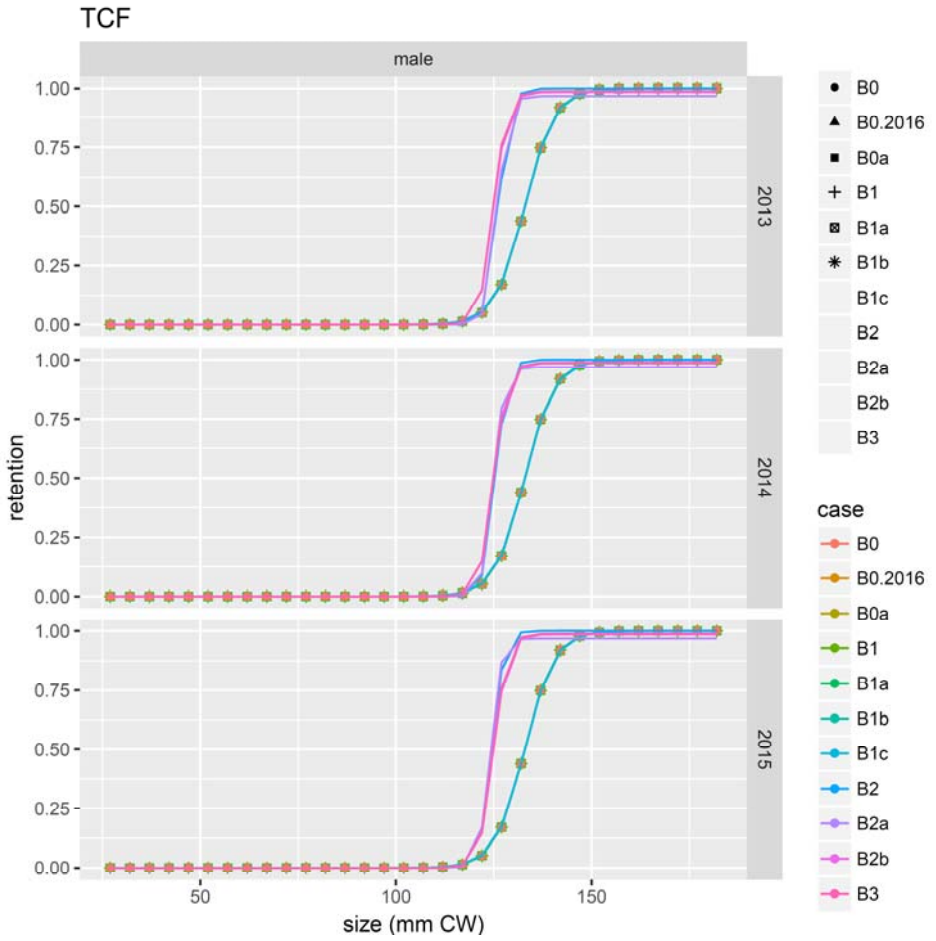


Model Comparisons





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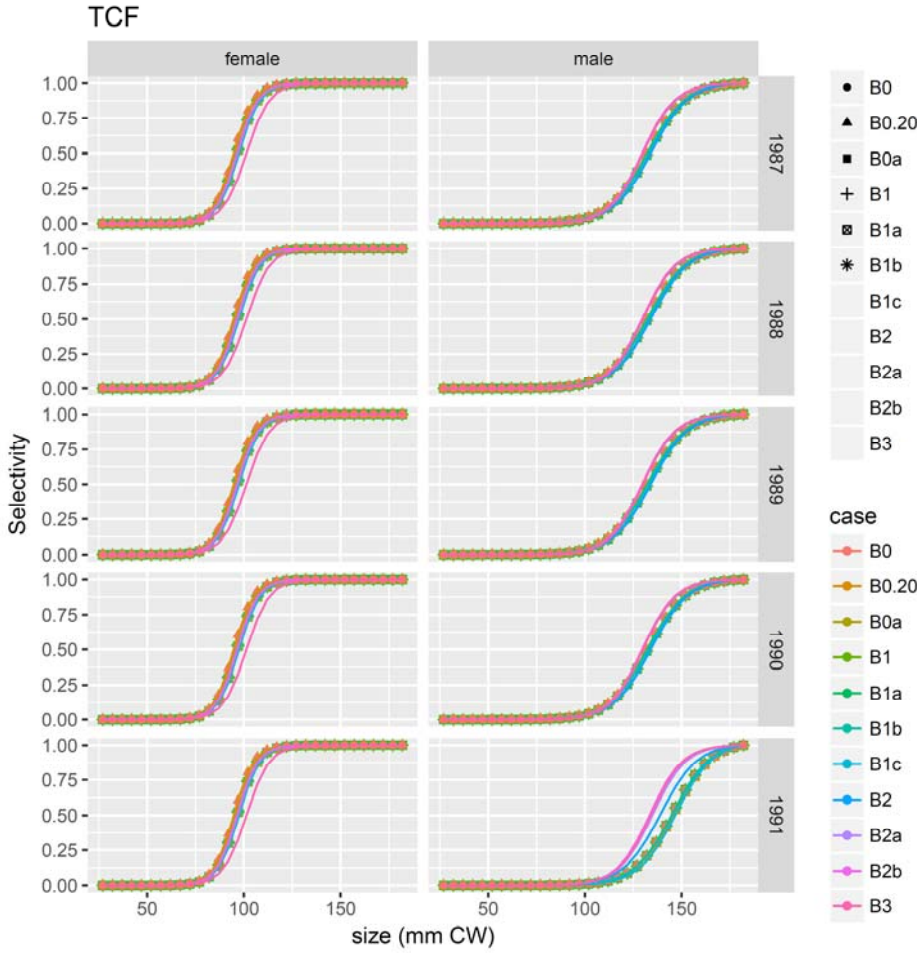

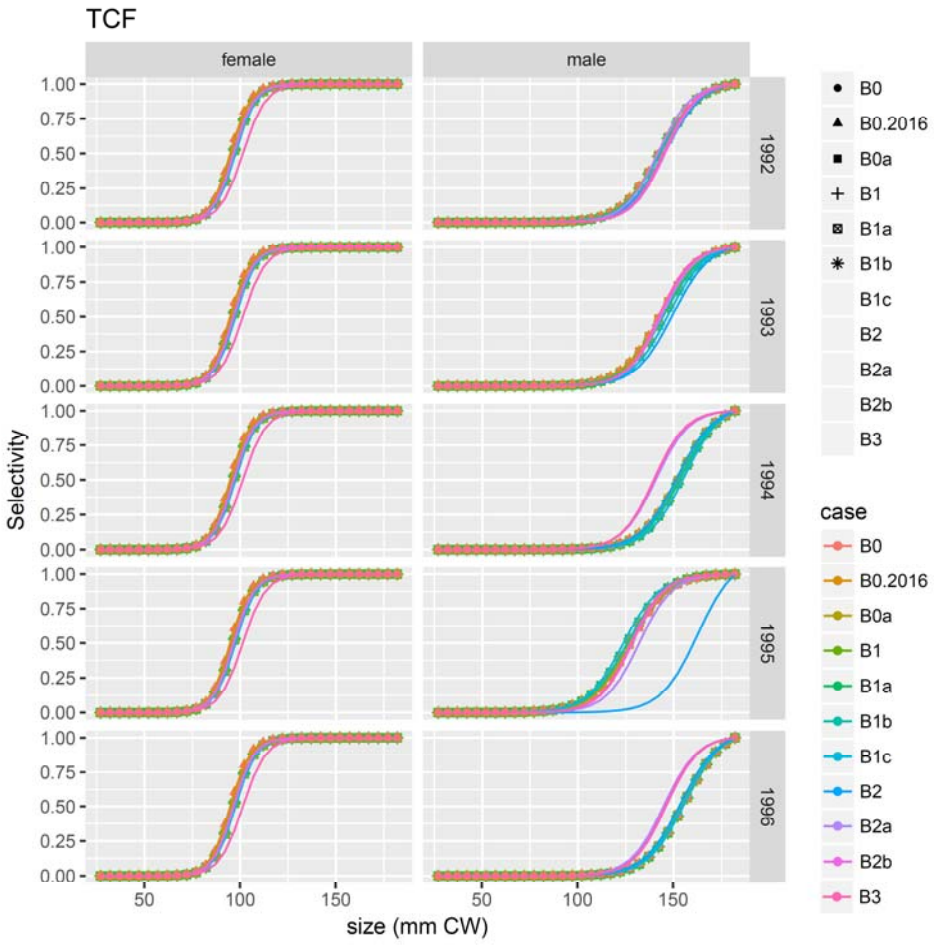

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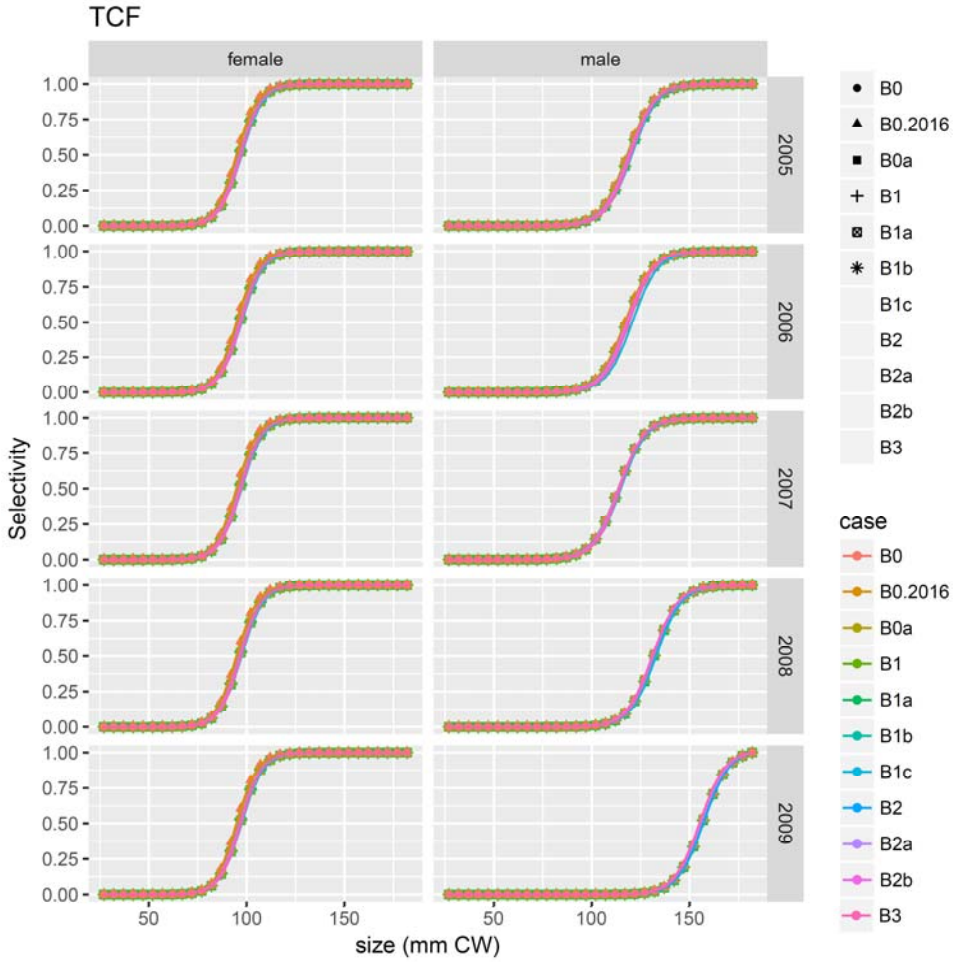
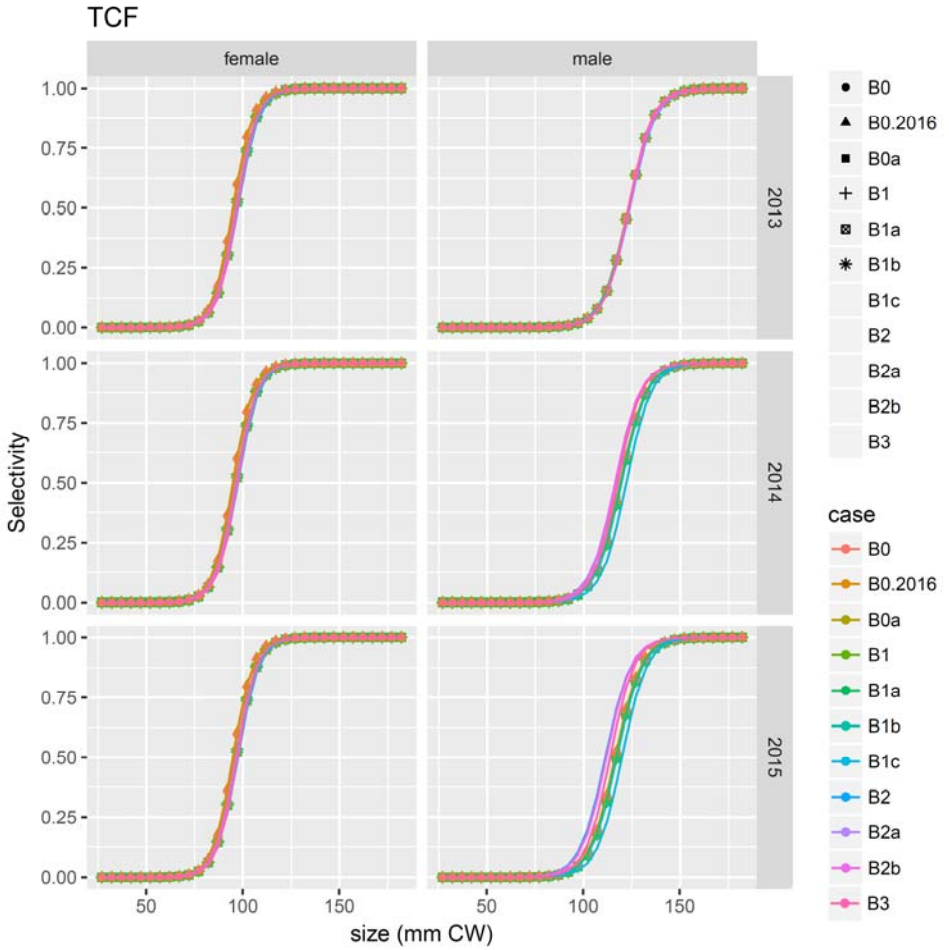
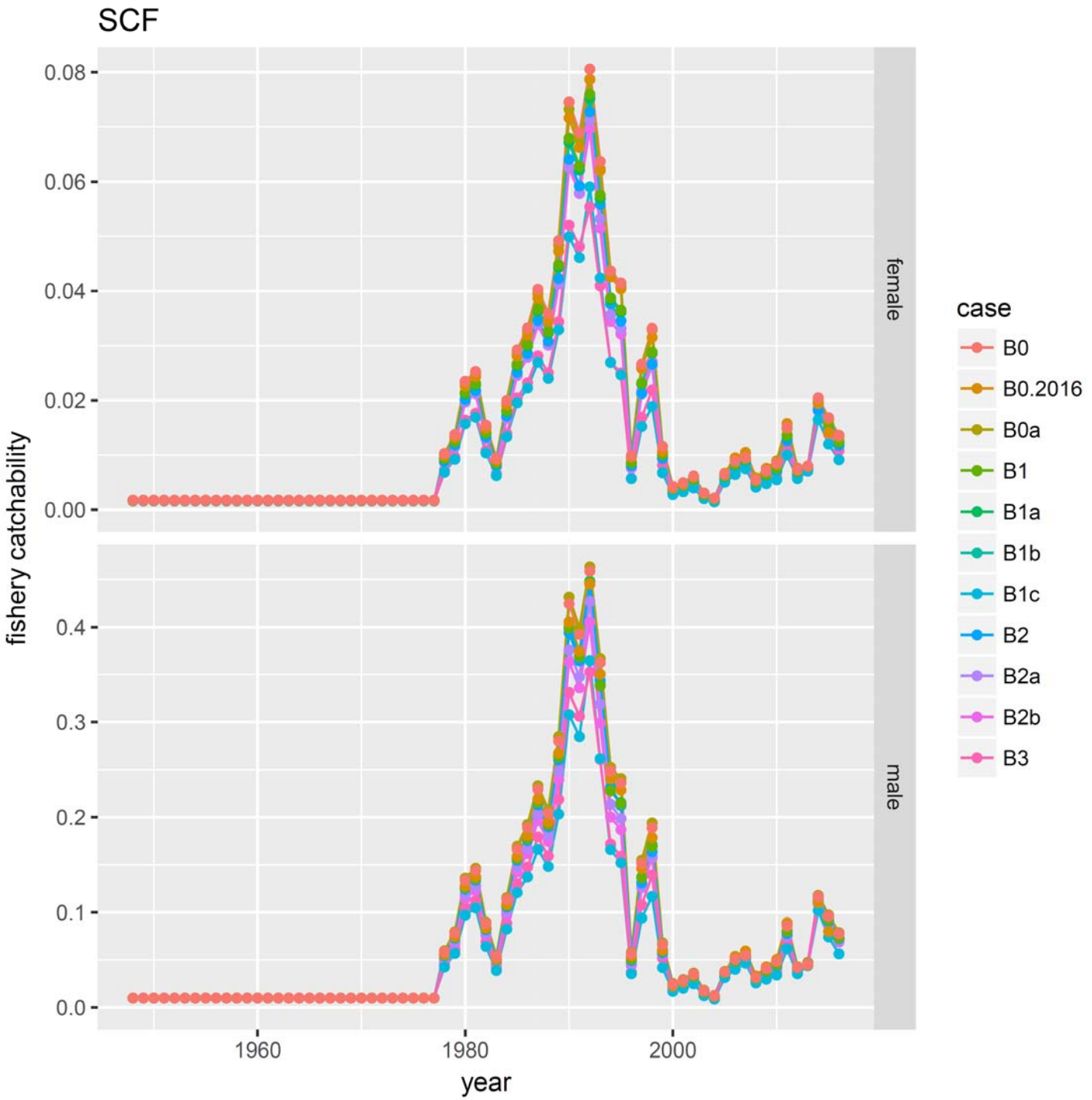
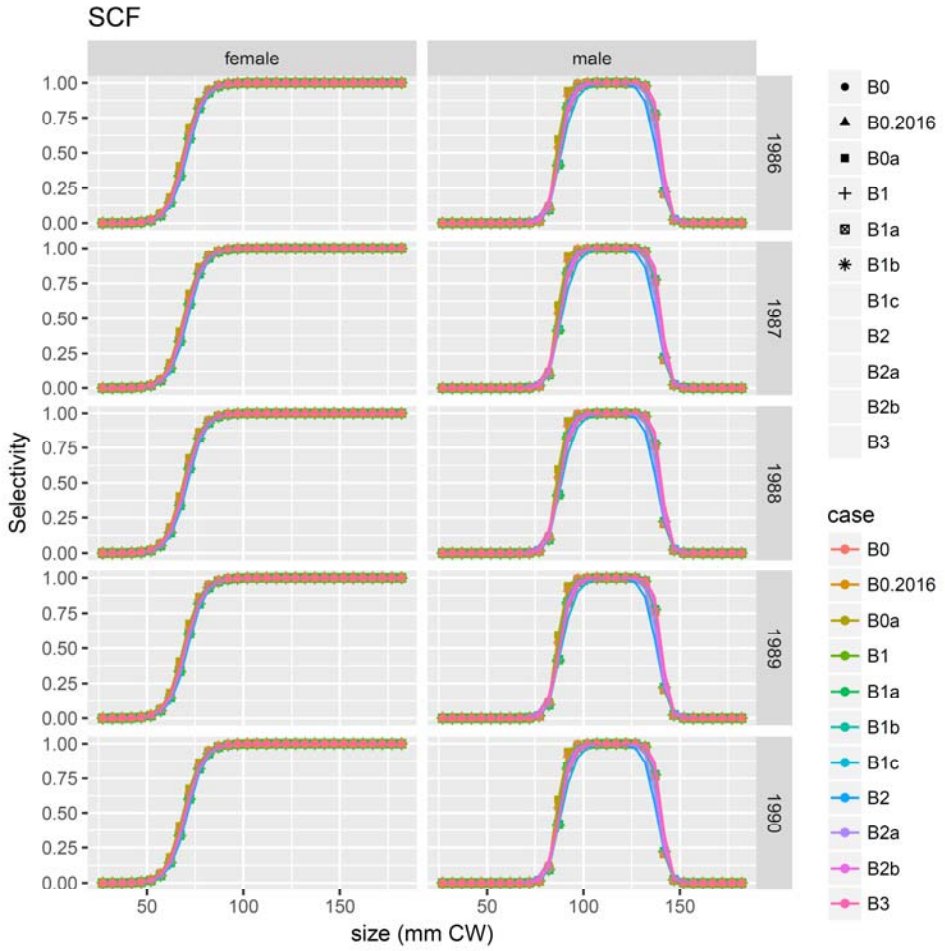


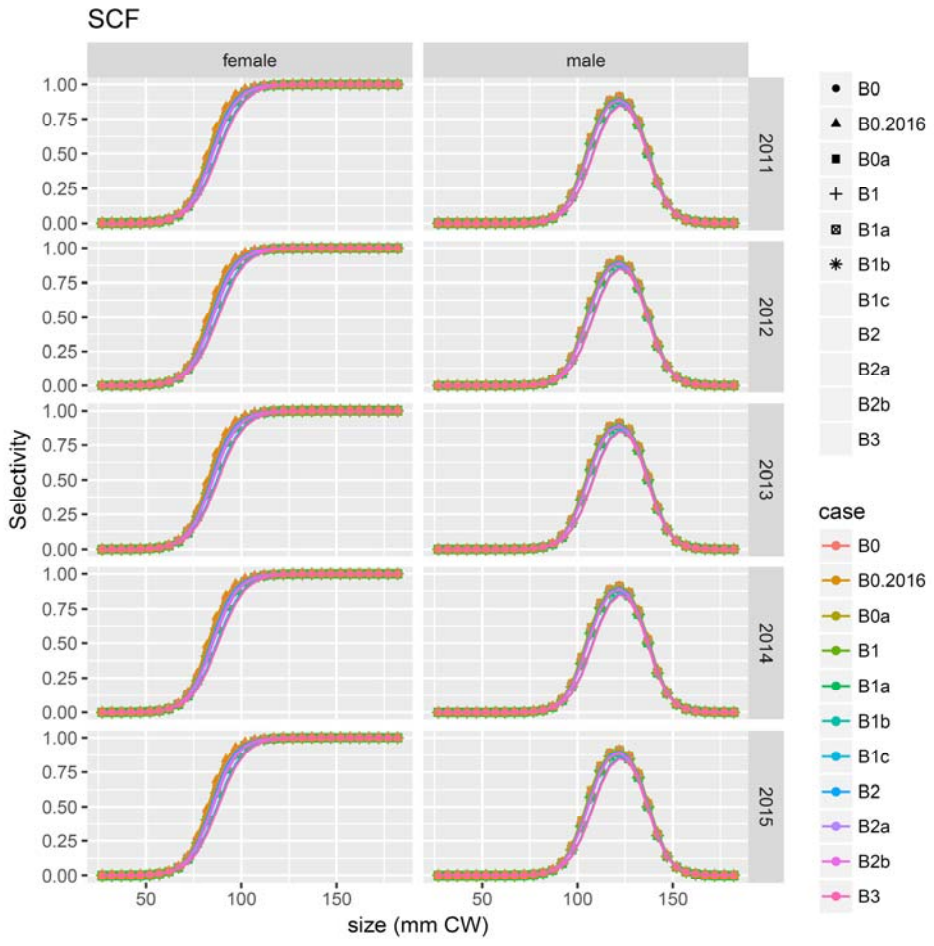


Model


SCF
fishery catchability
0.08
0.06
0.04
0.02
0.00
female
0.4
0.3
0.2
0.1
0.0
male
1960
1980
2000
year
case
B0
B0.2016
B0a
B1
B1a
B1b
B1c
B2
B2a
B2b
B3

Model Comparisons





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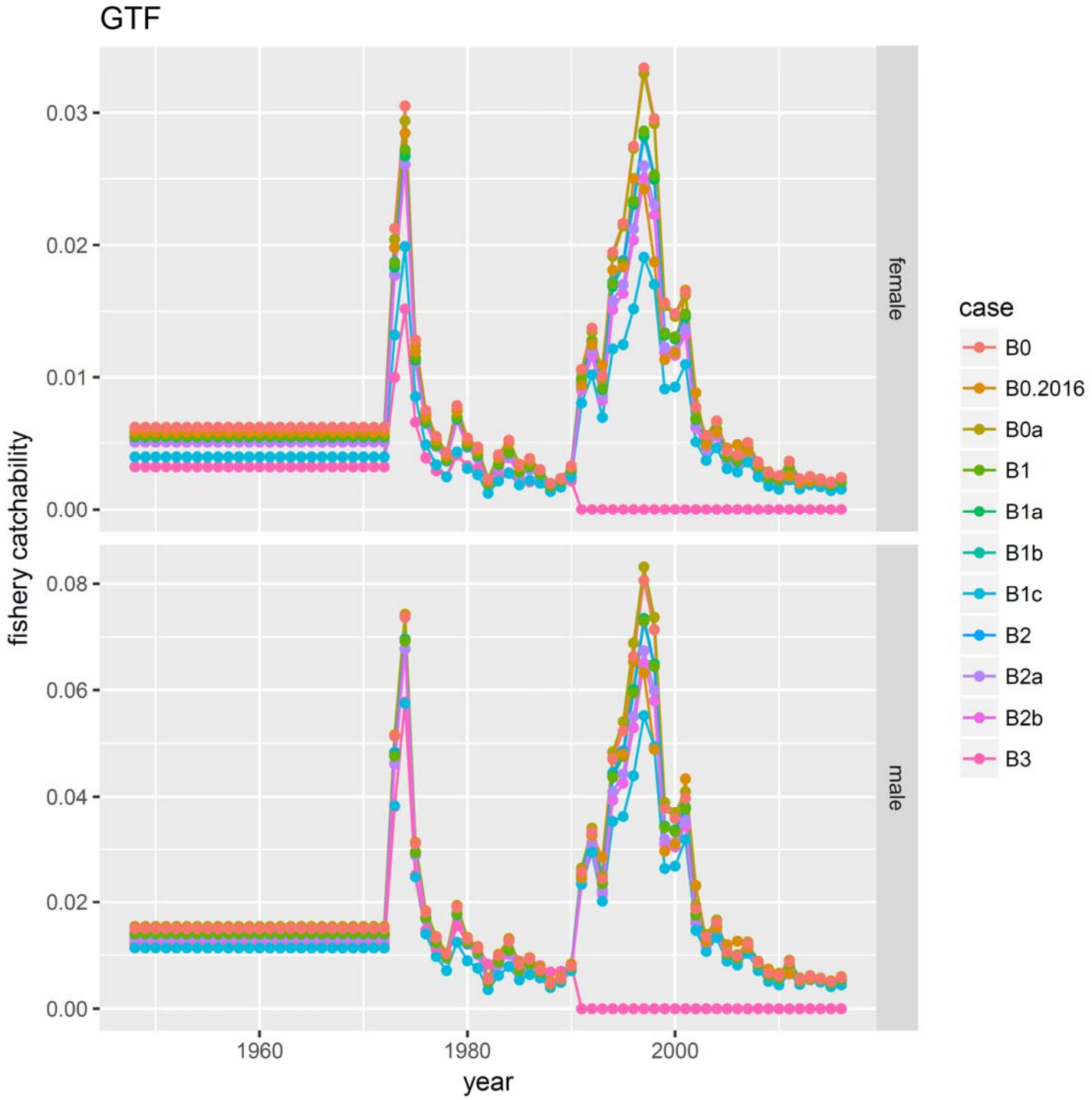
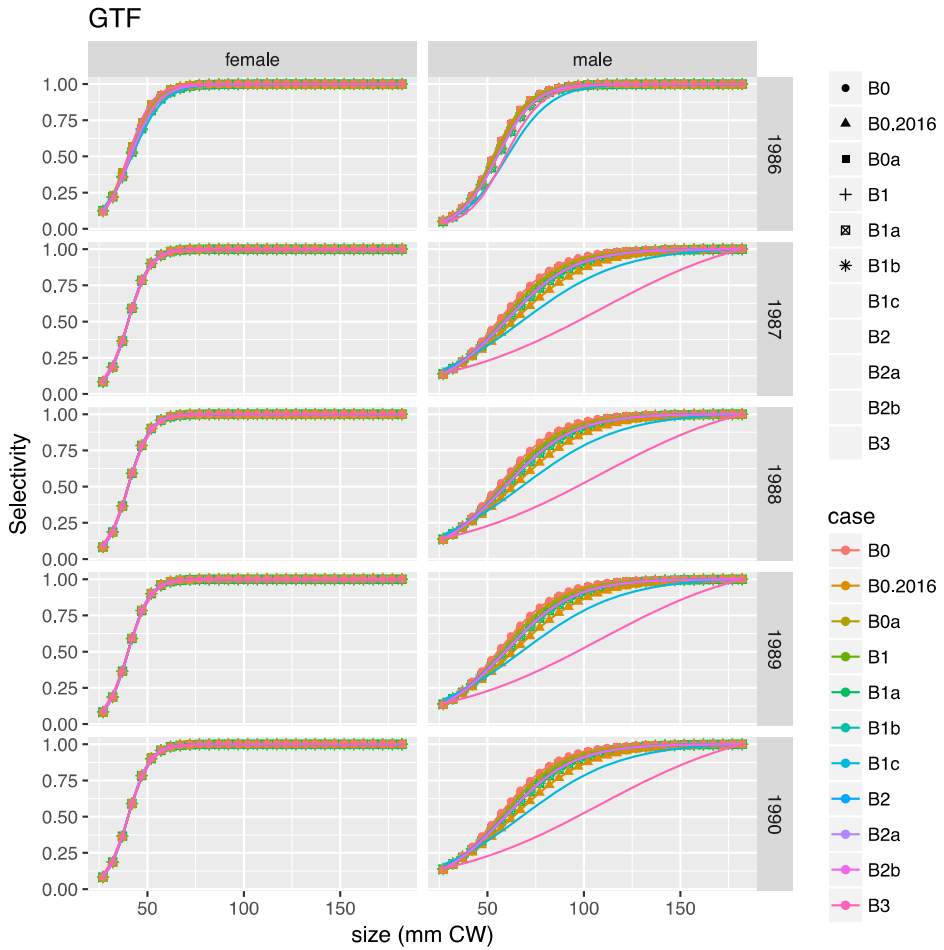
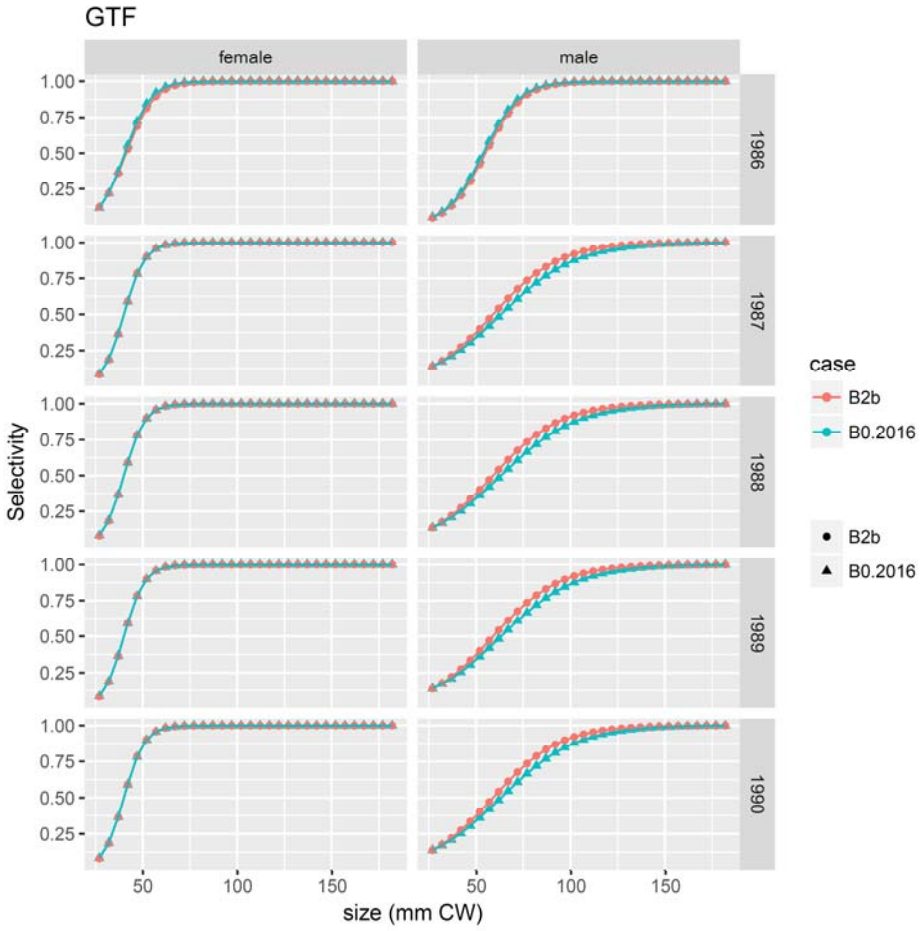


NOAA FISHERIES

Model Comparisons





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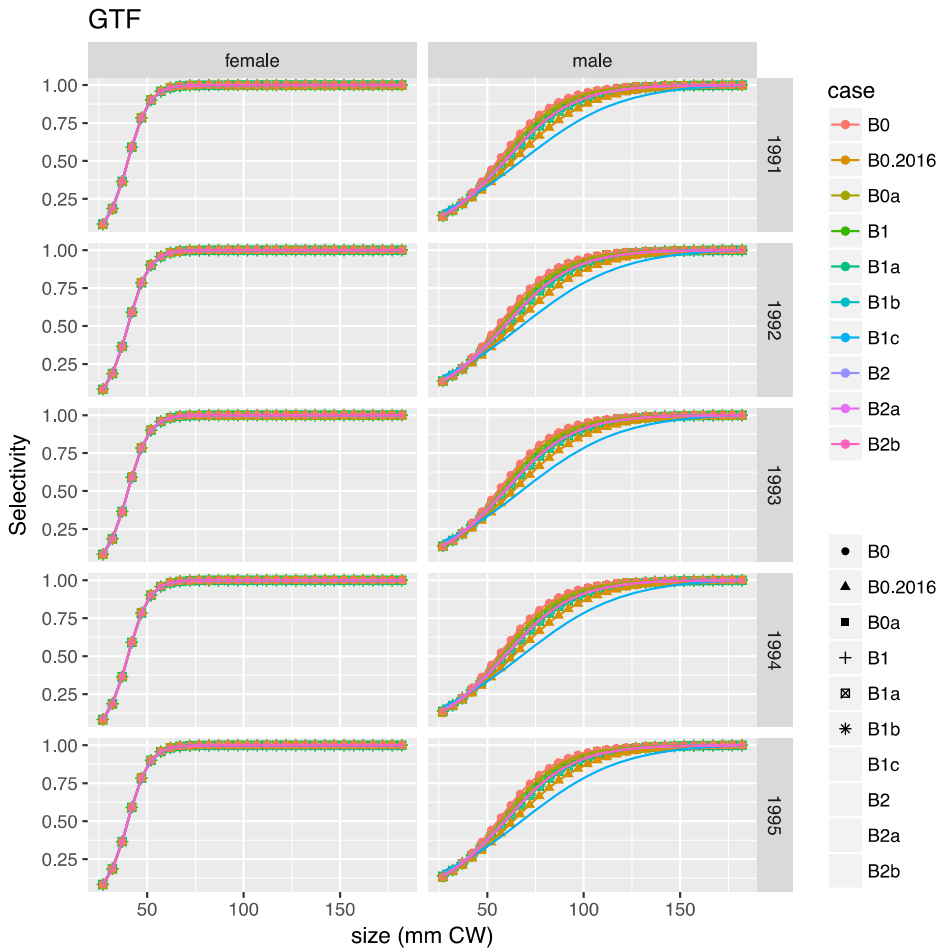
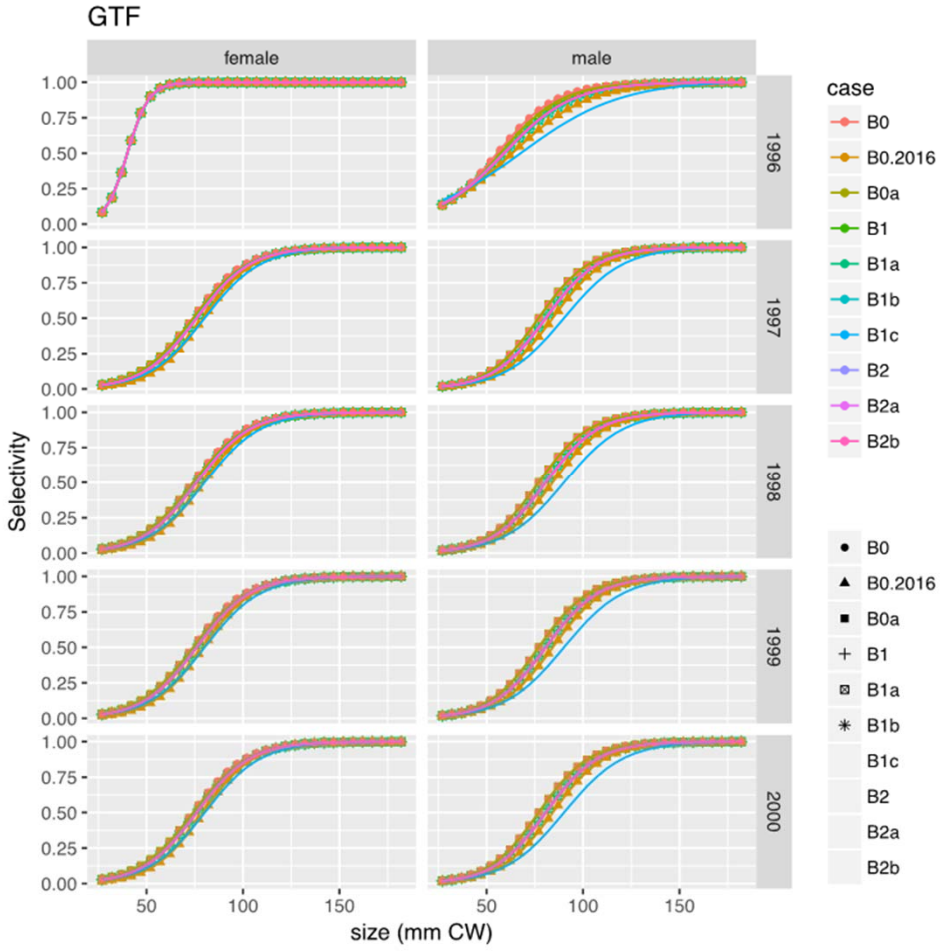
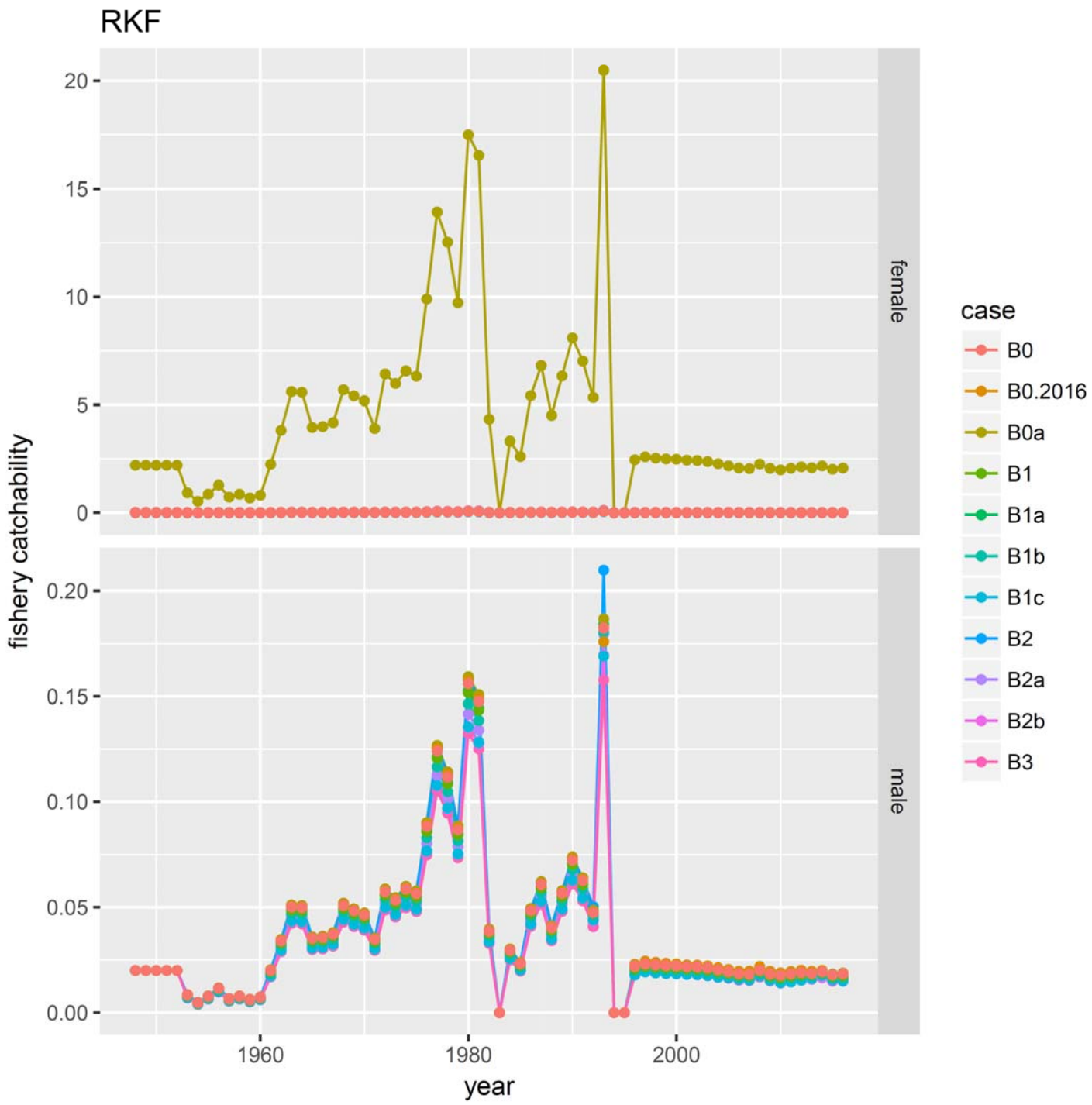


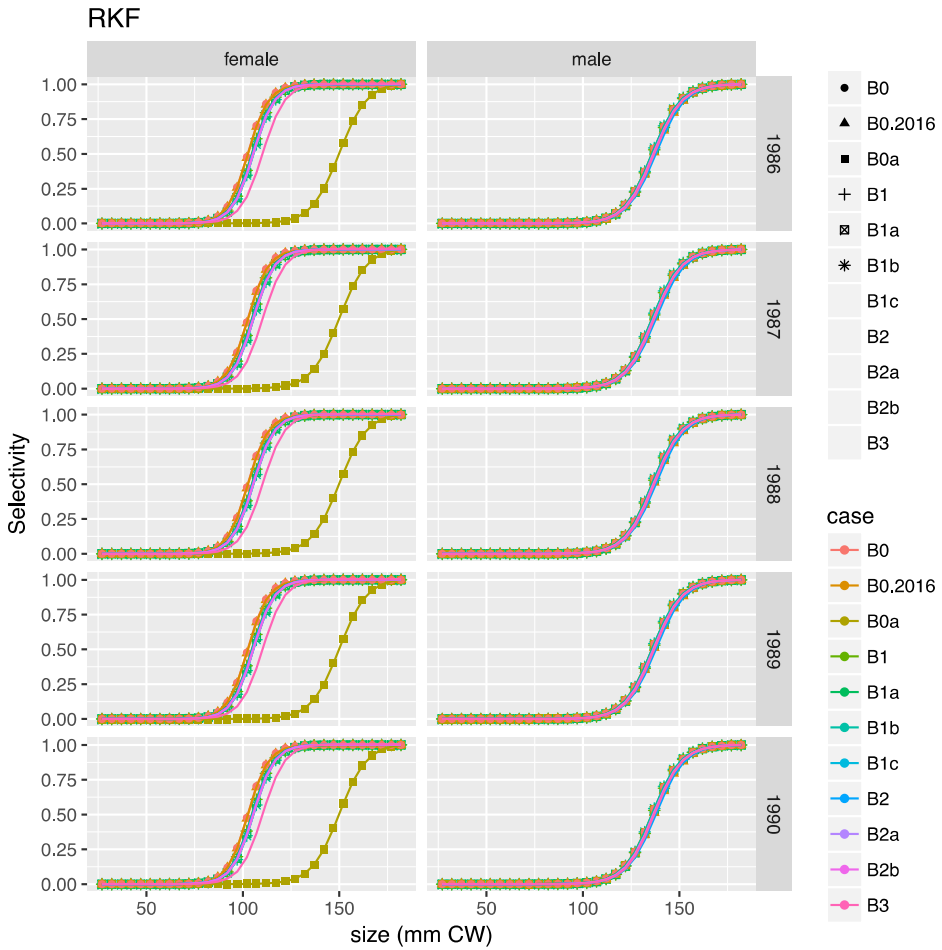


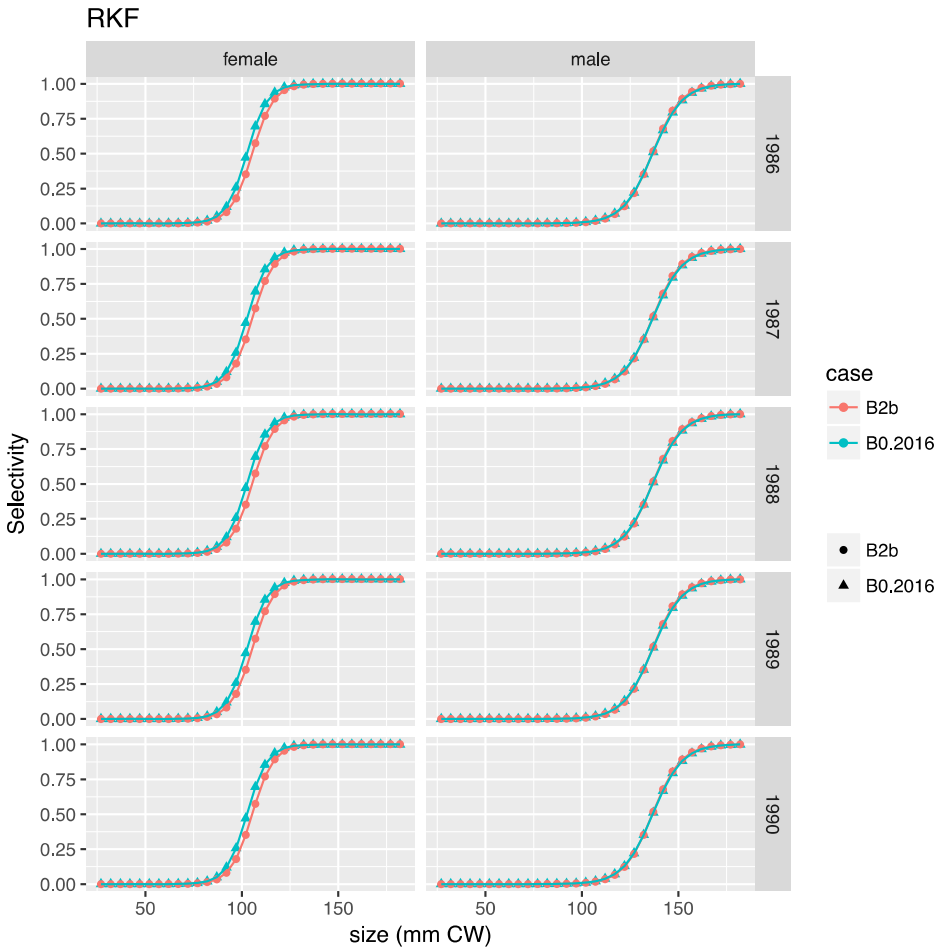
Model Comparisons



NOAA FISHERIES

Model Comparisons





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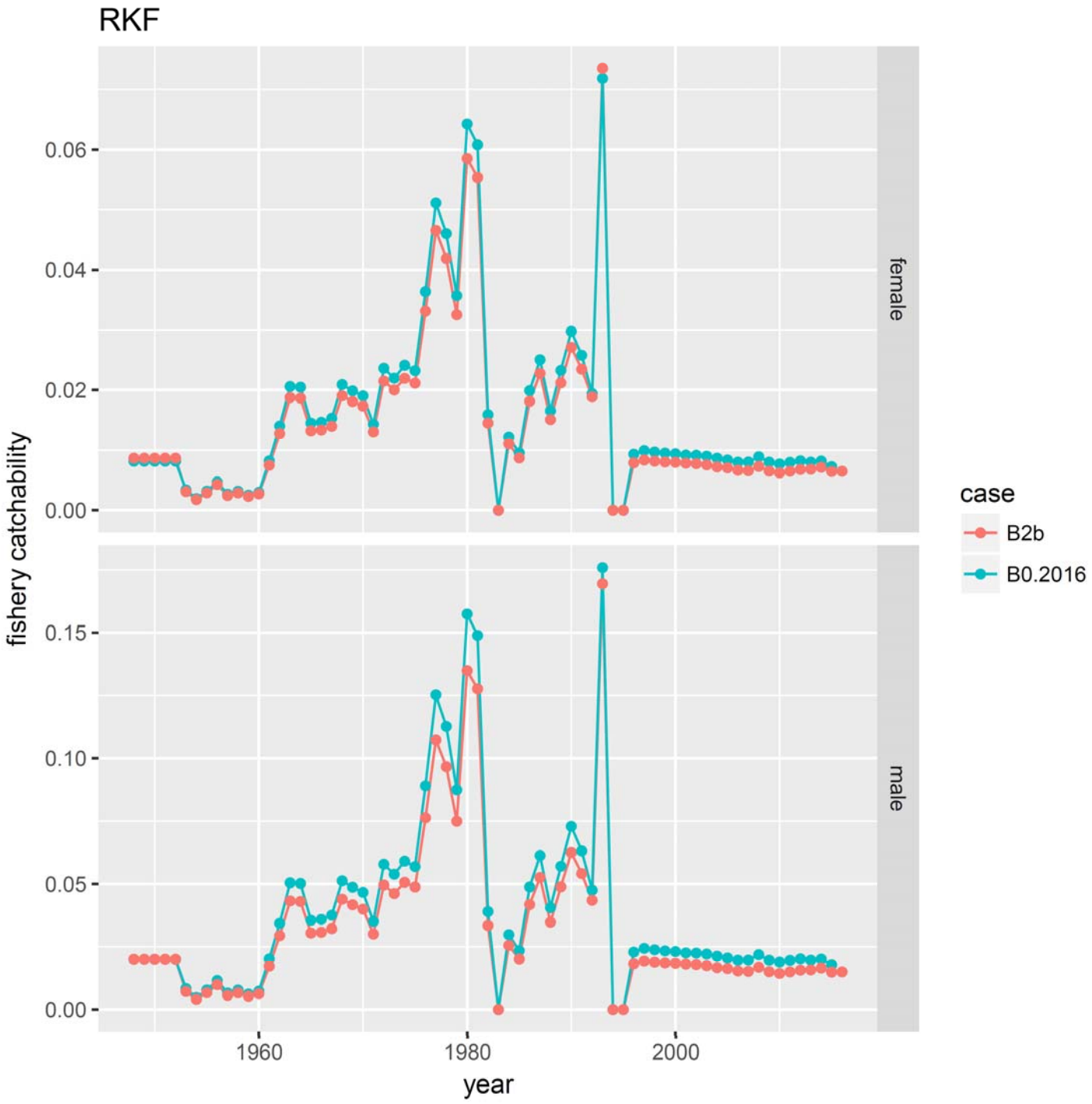
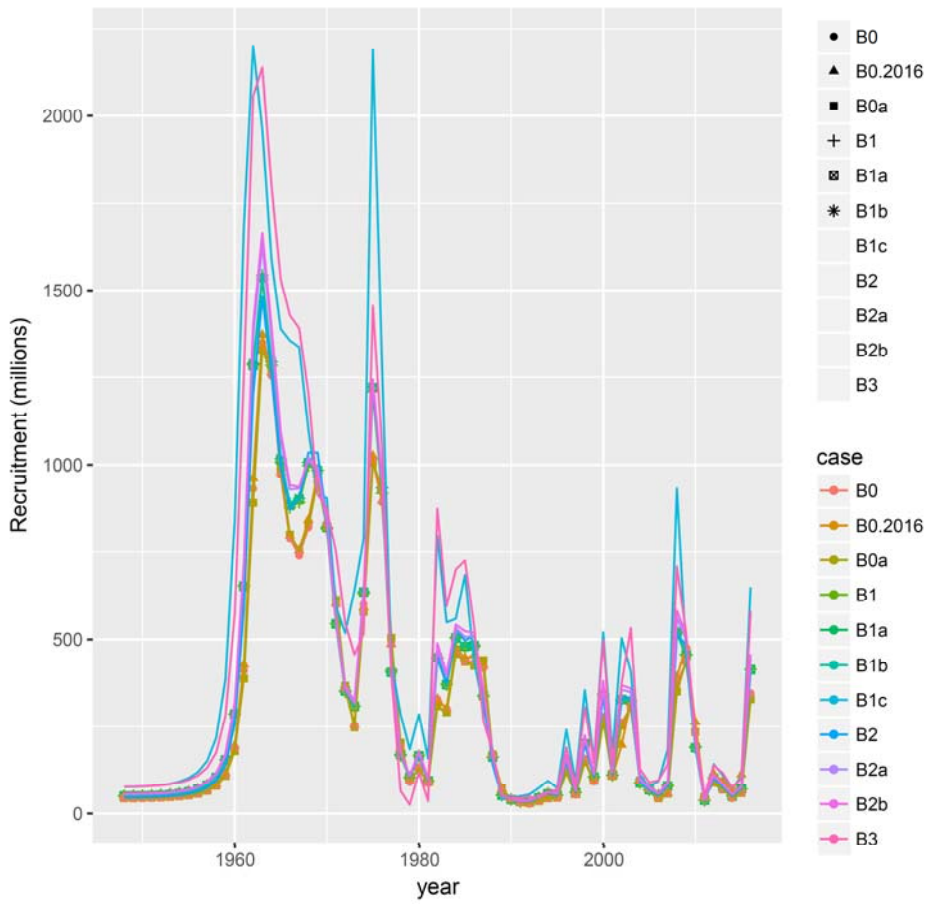
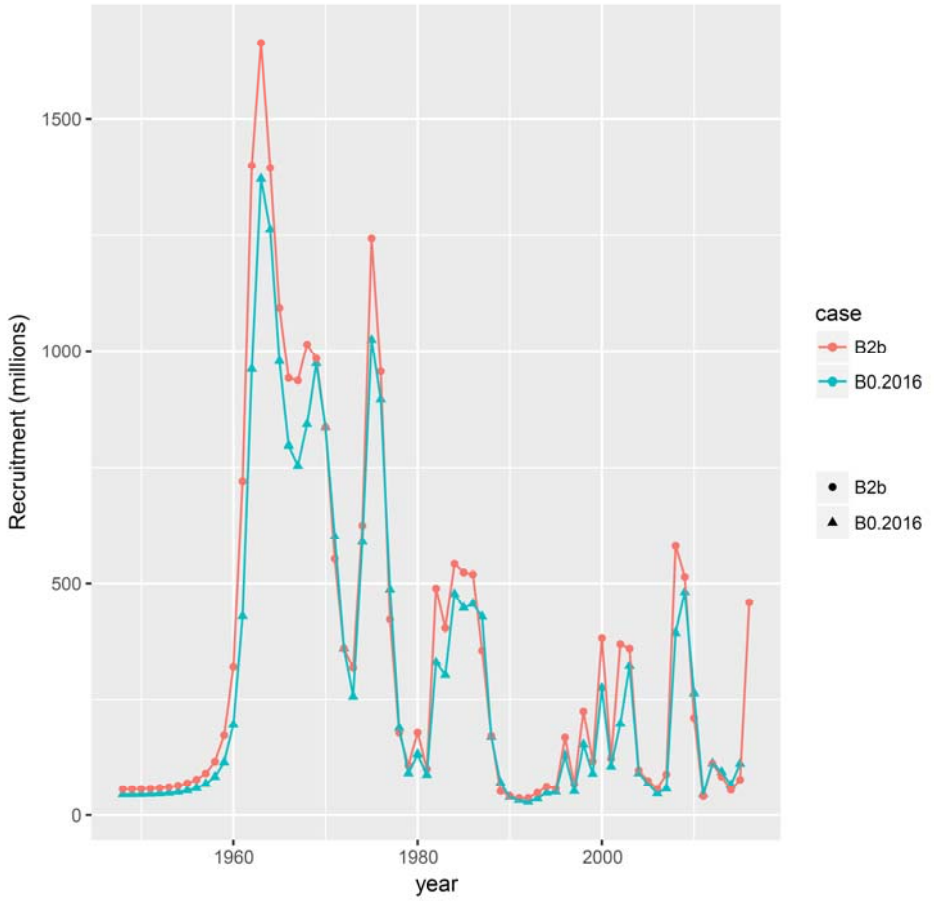


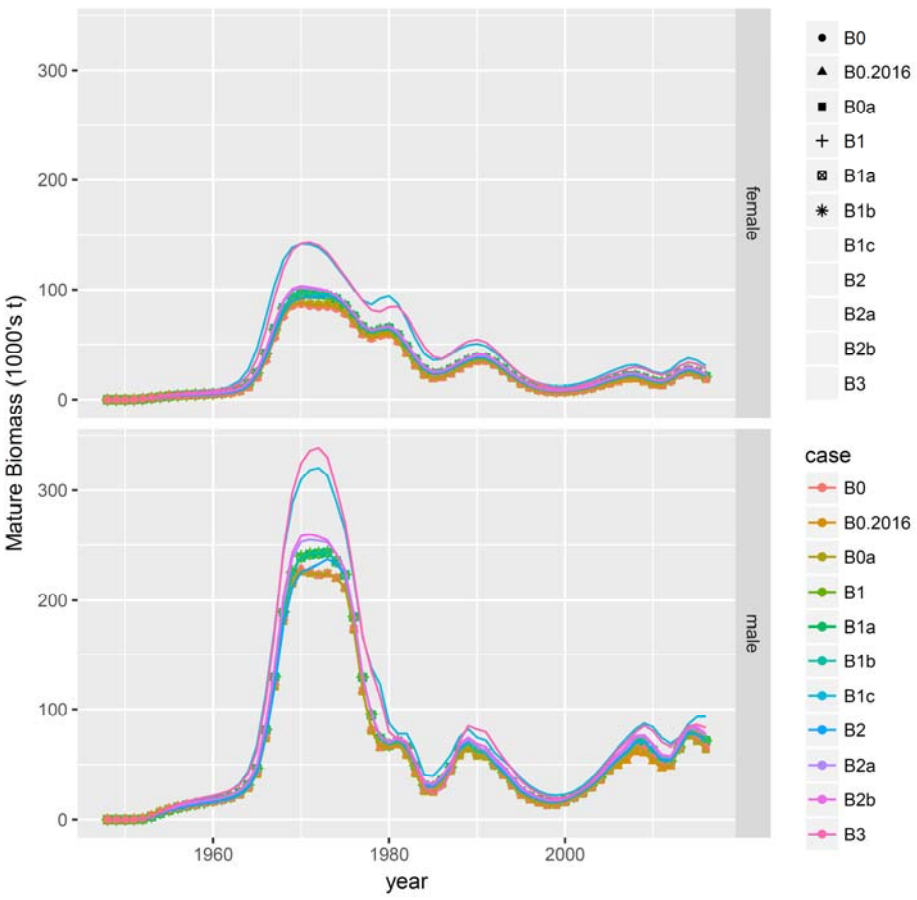
NOAA FISHERIES

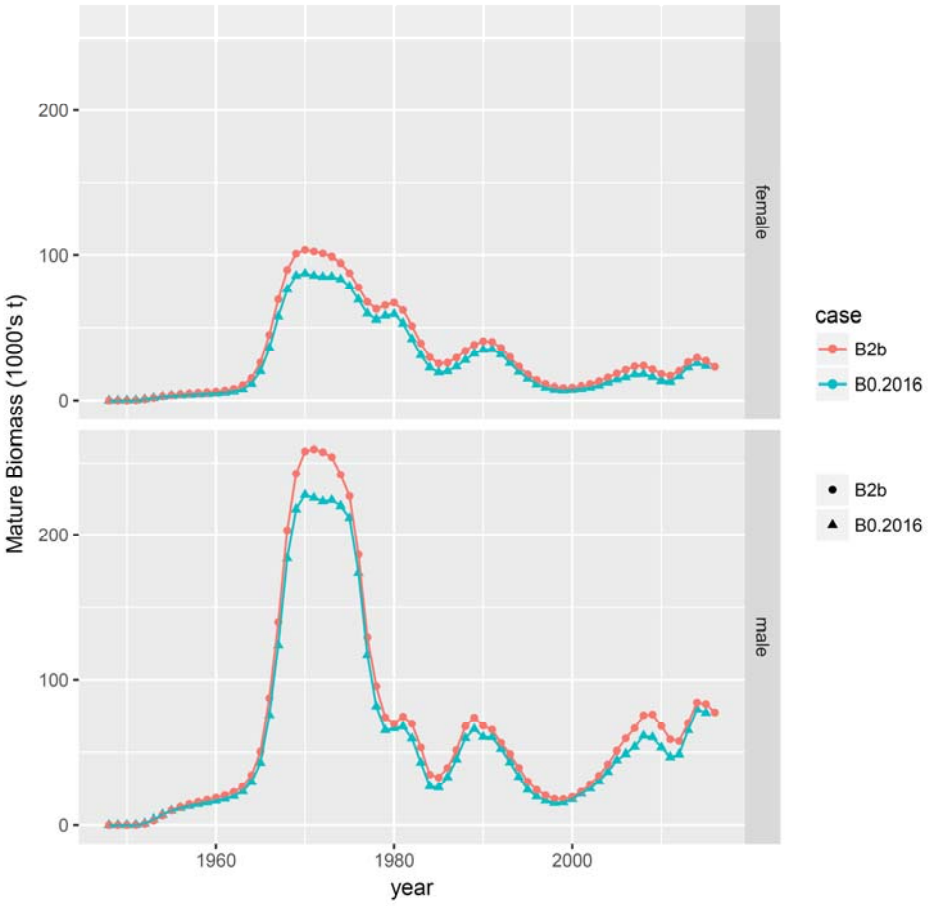
Model Comparisons





Model comparisons

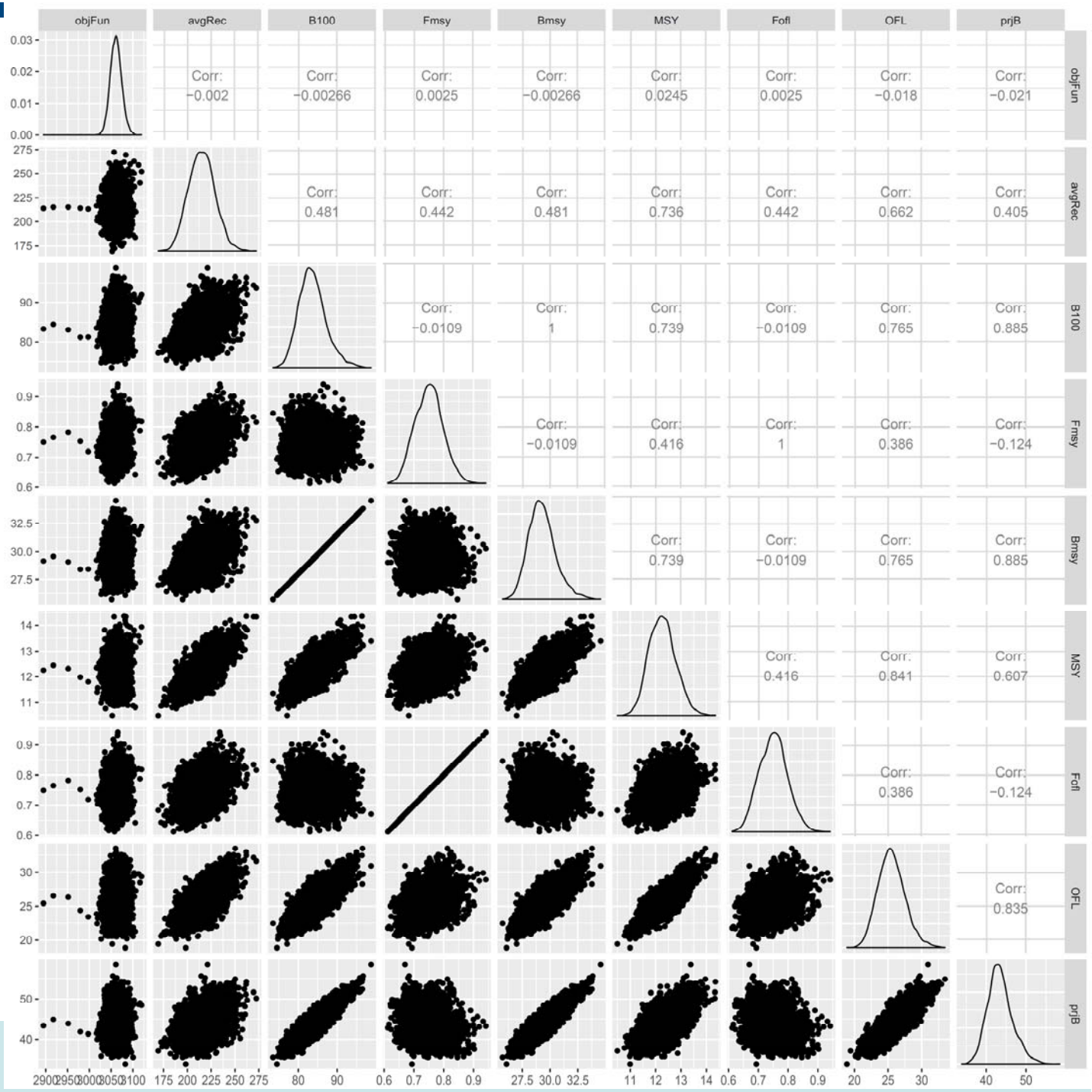




Author's Preferred Model: B2b

- Fits EBS growth data
- Uses new mean growth parameterization (no growth parameters hitting bounds)
- Uses new selectivity parameterization for female RKF (parameters still hitting bounds)
- Estimating retention curves for 3 time blocks
- Estimating max retention rates for 3 time blocks

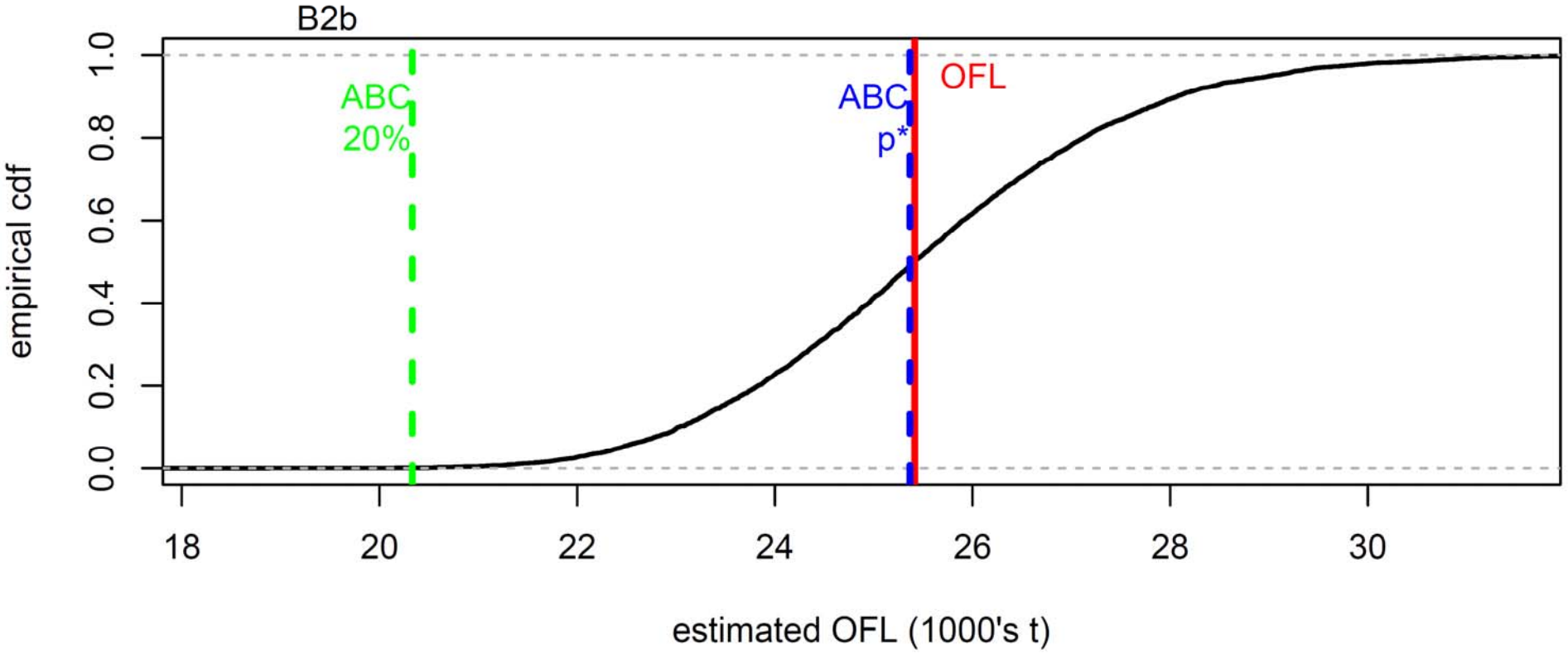
Status Determination & OFL Calculation



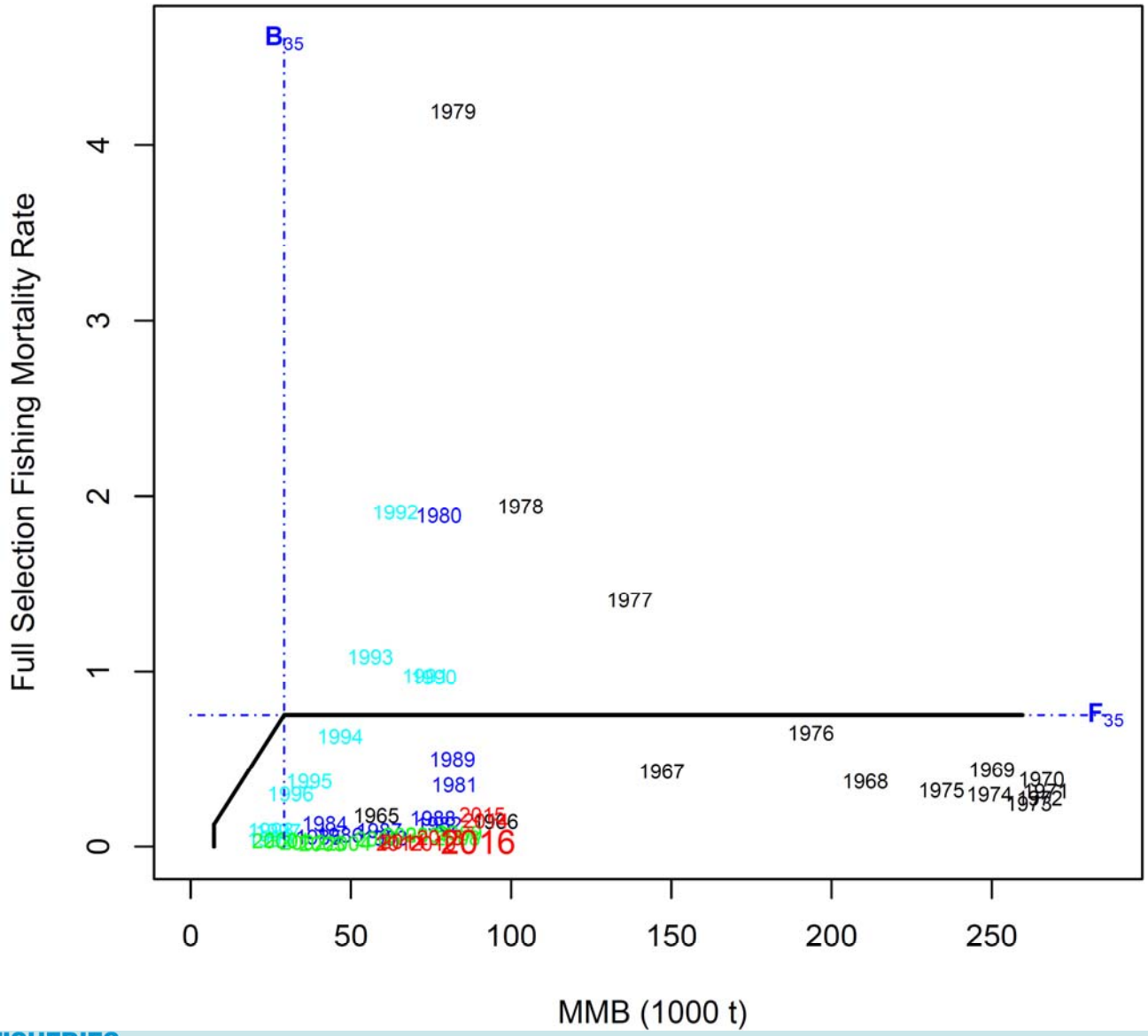
NOAA FISHERIES

Status Determination & OFL Calculation

- F_{MSY} = 0.75 yr^{-1}
- mean recruitment = ?? million
- B_{MSY} = 29.17 thousand t
- 2017/18 MMB-at-mating = 43.31 thousand t
- B/B_{MSY} = 1.49
- Tier = 3a



Quad (Kobe) plot



Management Reference Points

Not overfished
No overfishing

Basis for the OFL

Year	Tier[A]	B_{MSY}[A]	Current MMB[A]	B/B_{MSY}[A]	F_{OFL}[A] (yr^{-1})	Years to define B_{MSY}[A]	Natural Mortality[A,B] (yr^{-1})
2013/14	3a	33.54	59.35	1.77	0.73	1982-2013	0.23
2014/15	3a	29.82	63.80	2.14	0.61	1982-2014	0.23
2015/16	3a	26.79	53.70	2.00	0.58	1982-2015	0.23
2016/17	3a	25.65	45.34	1.77	0.79	1982-2016	0.23
2017/18	3a	29.17	43.31	1.49	0.75	1982-2017	0.23

Management Performance

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2013/14	16.98	72.70[A]	1.41	1.26	2.78	25.35	17.82
2014/15	13.40	71.57[A]	6.85	6.16	9.16	31.48	25.18
2015/16	12.82	73.93[A]	8.92	8.91	11.38	27.19	21.75
2016/17	14.58[C]	80.57[A]	0	0	1.14	25.61	20.49
2017/18		43.31[B]				25.42[C]	20.33[C]

Future Directions

- go back to basics: build model from ground up
- incorporate chela height data directly in model
- incorporate BSFRF survey data
- disaggregate groundfish bycatch (fixed gear, trawl fisheries) in model
- disaggregate East/West directed fisheries in model
- develop more extensive MCMC diagnostics
- start building Gmacs Tanner crab model