BSAI Tanner Crab

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Roadmap for the 2018 SAFE Chapter

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CPT/SSC Comments

May2018 Crab Plan Team Meeting

The CPT outlined a number of alternative models built on the 2017 assessment model (2017AM) as the base model to be evaluated.

Response: The CPT referred to these models as 2018B0, 2018B1, 2018B2, 2018B3, 2018B4 and 2018B5. These models were all run for this assessment, but renamed as 18A, 18B, 18C0, 18C1, 18D0, and 18D1, where "18" refers to the assessment year, A/B/C/D refers to different datasets included in the likelihood, and 0/1 refers to whether (1) or not (0) survey abundance time series were included in the fitting process in addition to survey biomass time series. 2017AM is subsequently referred to herein as 17AM. In addition to the alternative model scenarios requested by the CPT, several additional scenarios were also run: 17AMu, 18C0a, 18C1a, 18C2a, and 18C3a. Scenario 17AMu represents the 2017 assessment model re-run with revised (i.e., "u"pdated) data for the crab fisheries. The "a" in the remaining scenarios refers to ones in which the likelihood component for male maturity ogive data was down-weighted, whereas "2" and "3" refer to fixing the survey catchability and selectivity parameters to match ones from Somerton and Otto (1999)'s underbag experiment.

October 2017 SSC Meeting

Comment: "The SSC endorses all of the CPT recommendations with respect to the poor fits to some of the retained catch time series, poor fits to the size composition data for retained catch and survey data, and issues with the total directed fishery selectivity curve for males (in particular the 1996 'outlier')."

Response: With respect to the 1996 'outlier', this was a result of the combination of a very small sample size for the 1996 size compositions and the using the mean size-st-50%-selected for 1991-1996 as the value for the size-at-50%-selected prior to 1991. Because the sample size for 1996 was small, the 1996 size-at-50%-selected essentially became a free parameter uninformed by the 1996 data but sensitive to changes in the overall likelihood through changes in the mean value. Regarding the other issues, see the responses to CPT comments below.

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.

Changes From 2017 Assessment

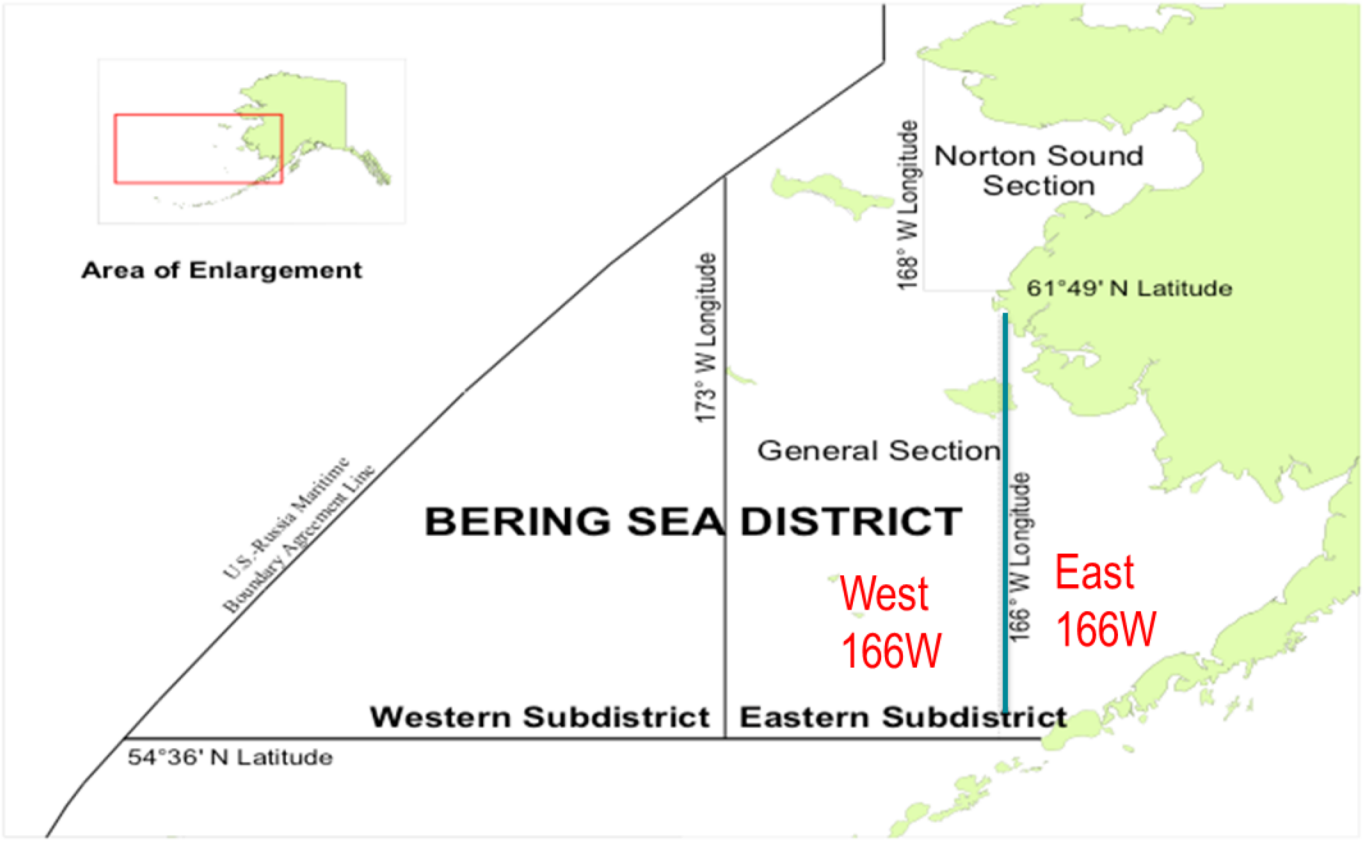
- Changes to model
  - Male maturity data fit in model

- New trawl survey data for 2018
  - annual male maturity ogives (1990+)
  - size compositions by sex, shell condition, maturity
  - male maturity ogives

- New Fishery Data for 2017/18
  - Directed Tanner crab fishery
    - 2017/18 catch and size compositions
  - snow crab pot fishery
    - 20117/18 bycatch, size compositions
  - BBRKC pot fishery
    - 2017/18 bycatch, size compositions
  - groundfish fisheries
    - 2017/18 bycatch, size compositions for combined gear

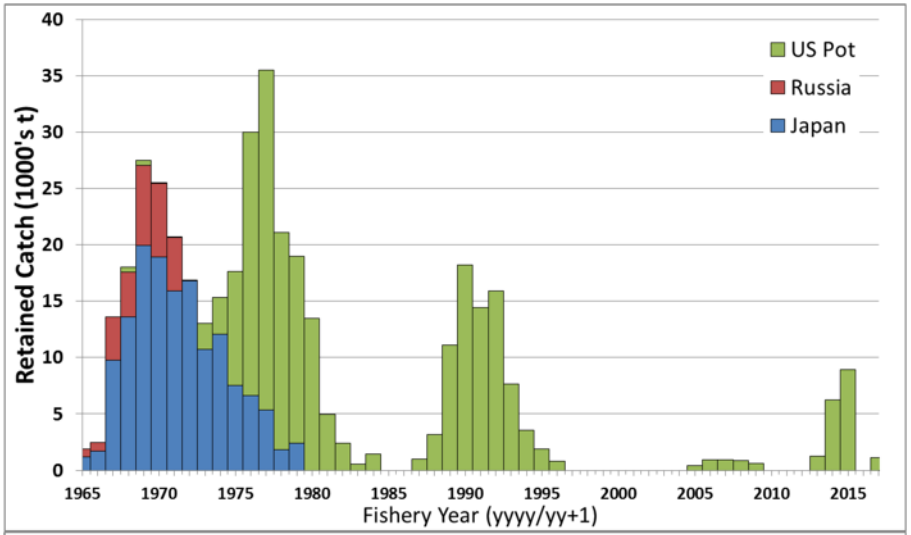
- Revised Crab Fishery Data
  - Tanner crab pot fishery
    - Revised total catch biomass, 1992/93+
  - snow crab pot fishery
    - Revised total catch biomass, 1992/93+
  - BBRKC pot fishery
    - Revised total catch biomass, 1992/93+

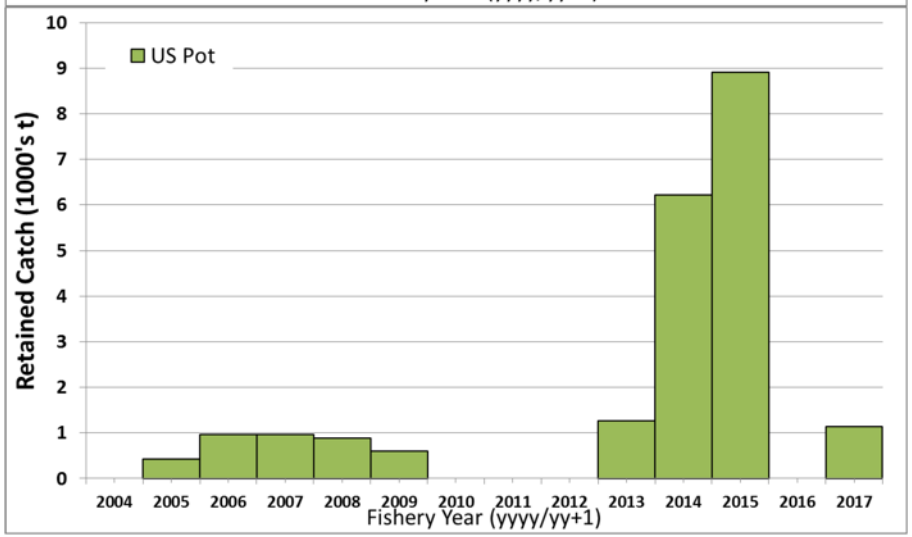
Management Regions



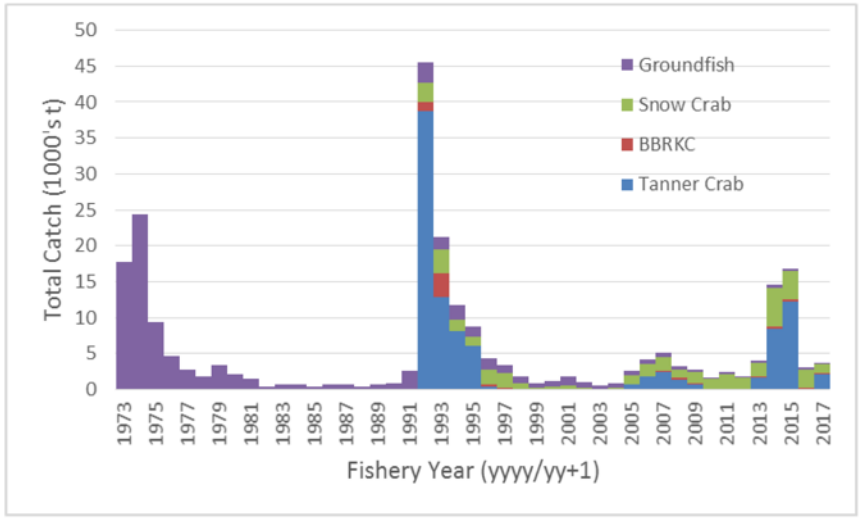
Fishery Trends

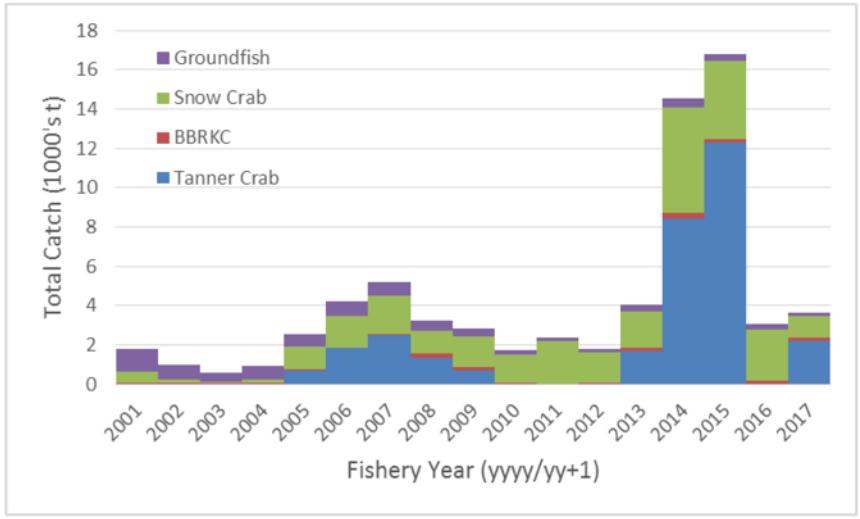
Retained catch



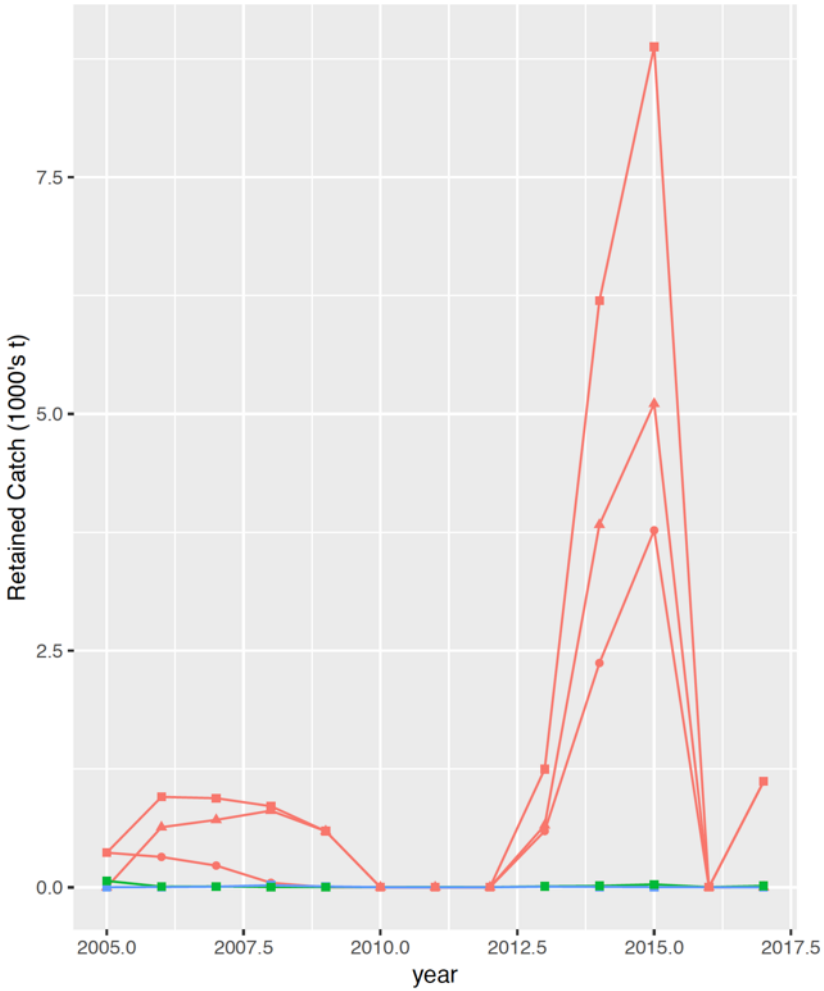


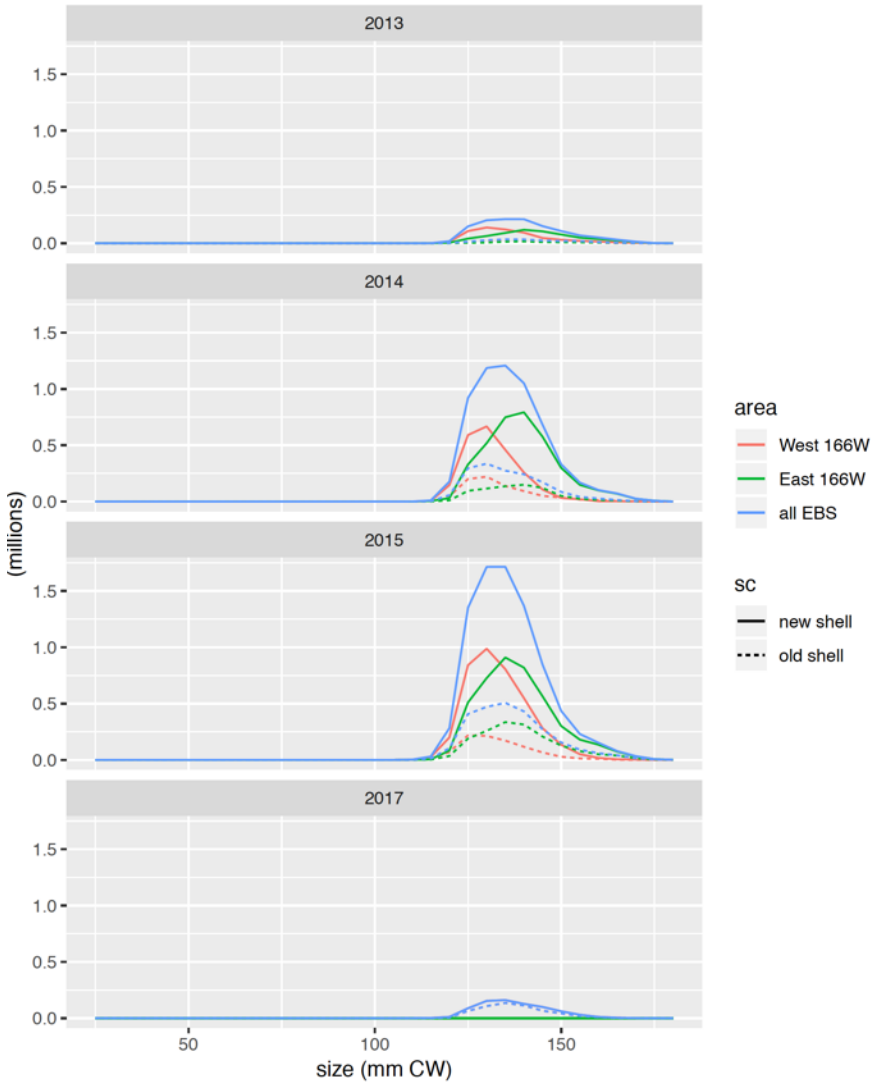
Bycatch



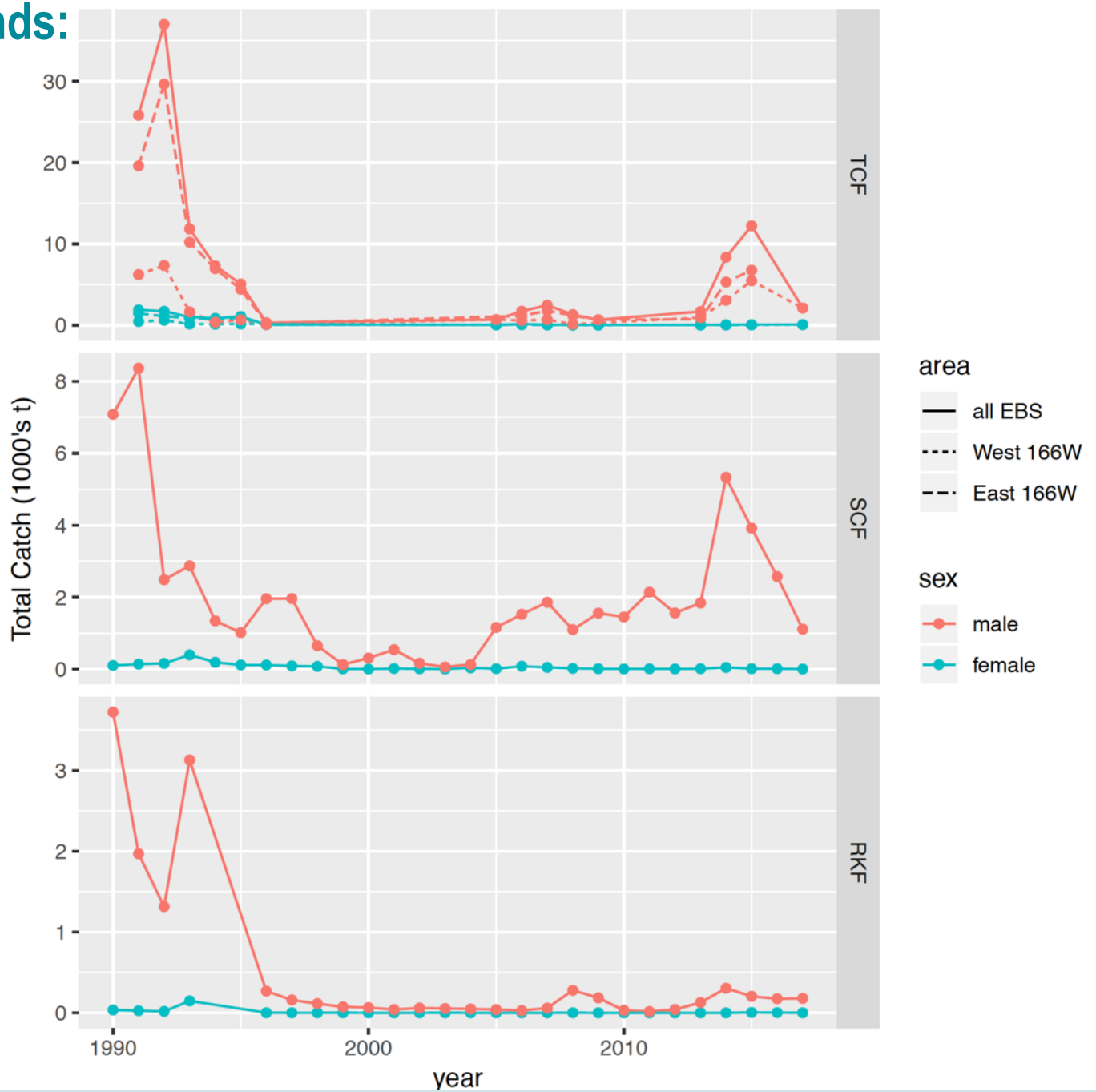


Recent Fishery Trends: Retained Catch



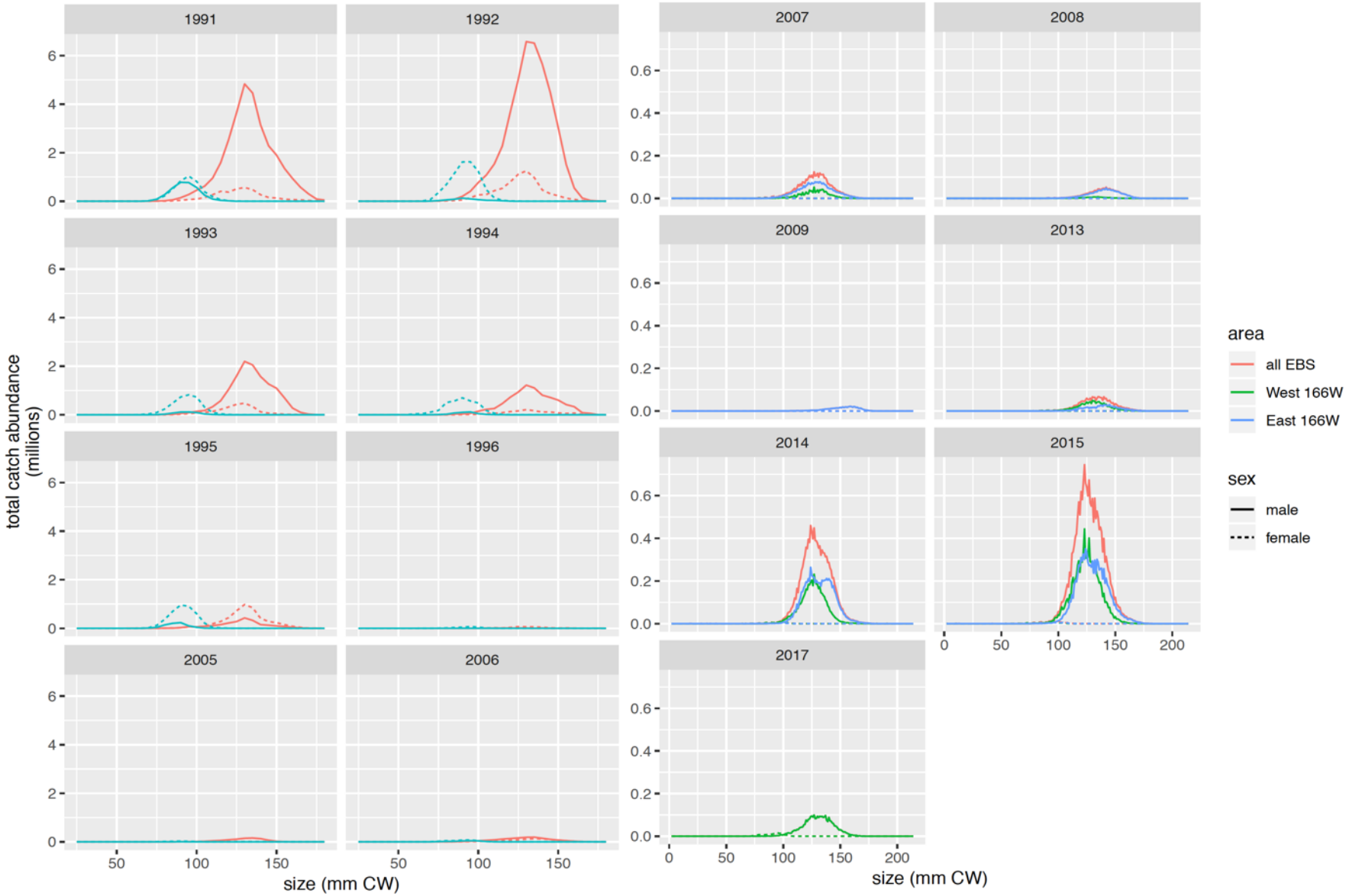


Recent Fishery Trends: Total Catch

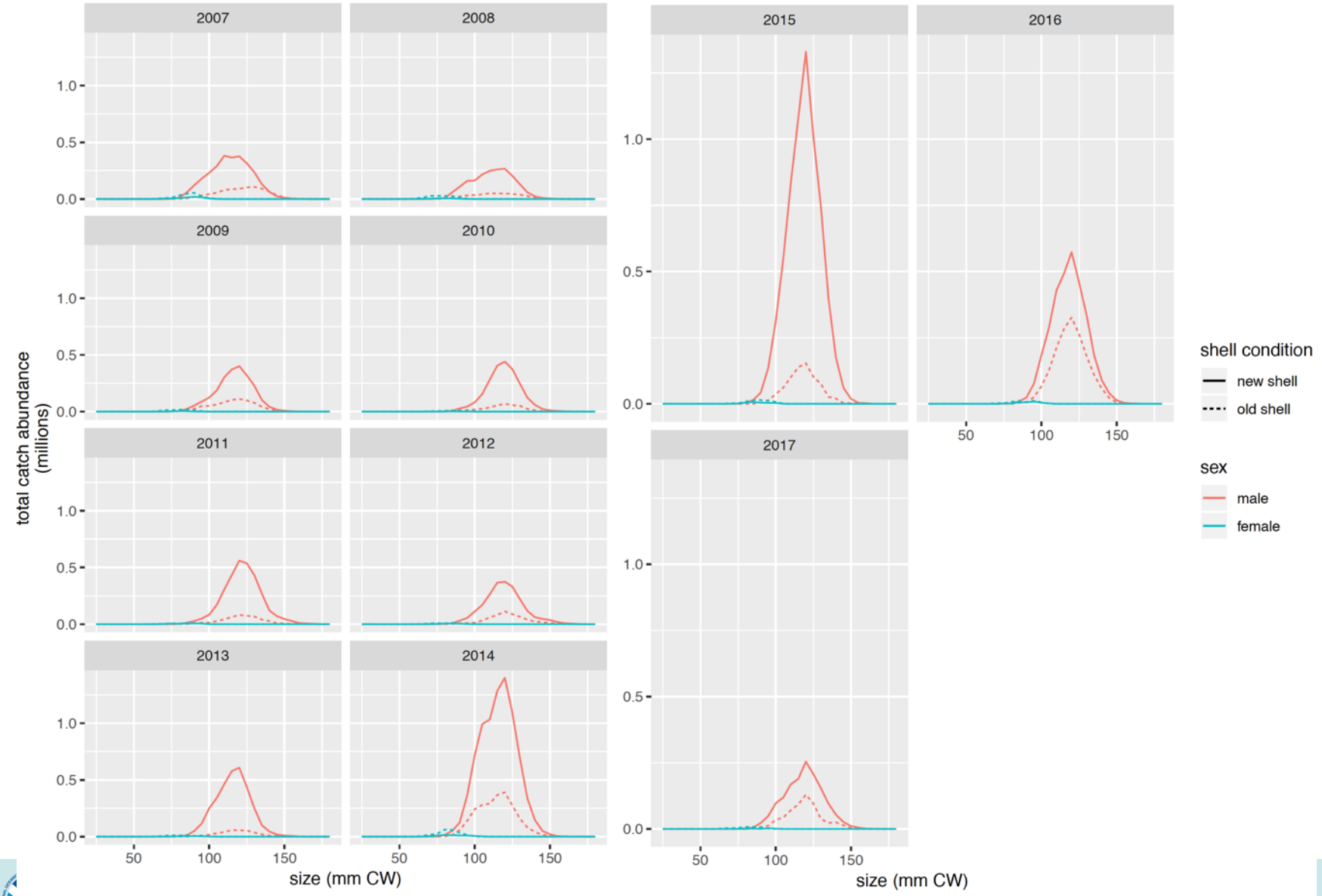


NOAA FISHERIES

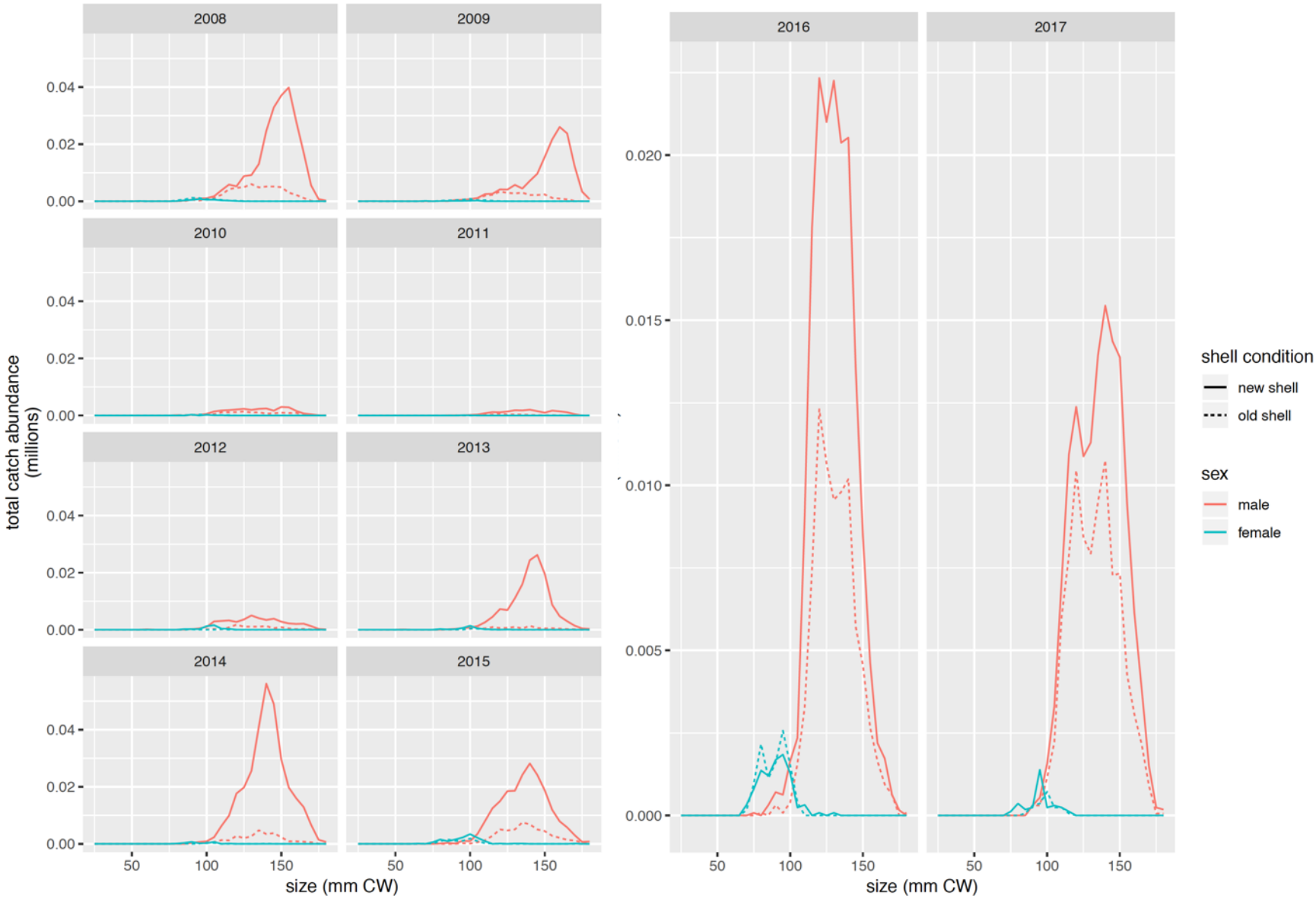
Recent Fishery Trends: Directed Fishery Total Catch Size Comps



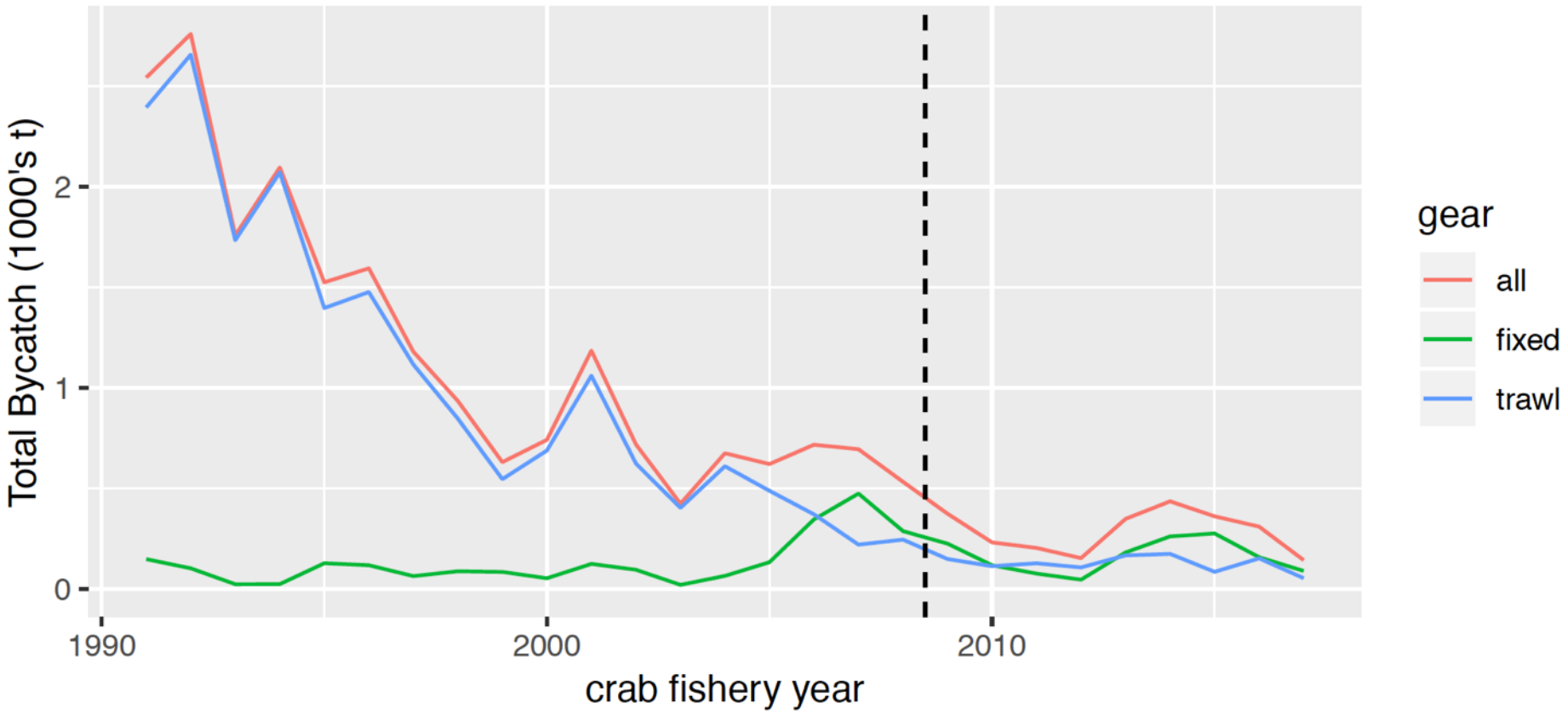
Recent Fishery Trends: Snow Crab Total Catch Size Comps



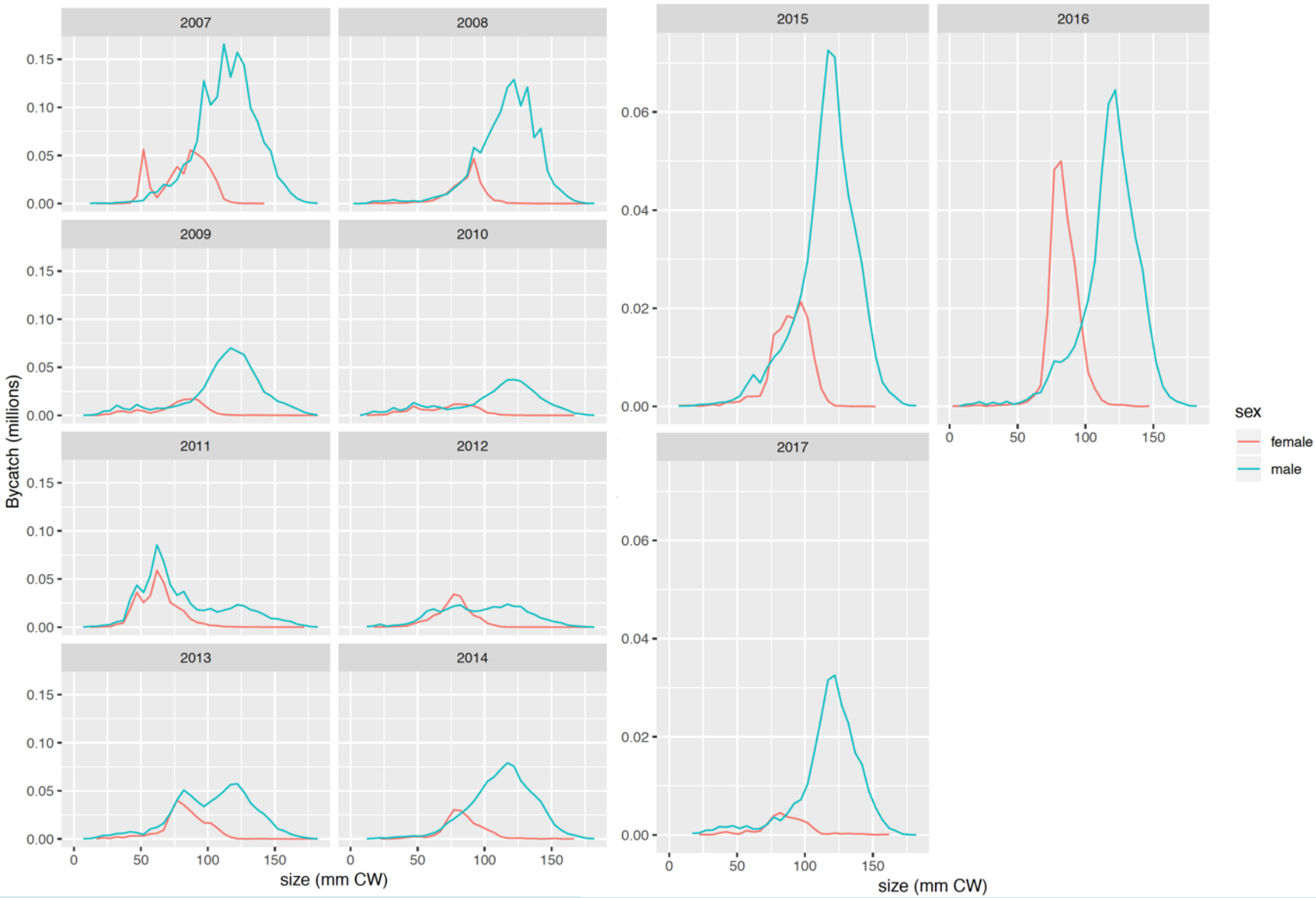
Recent Fishery Trends: BBRKC Total Catch Size Comps



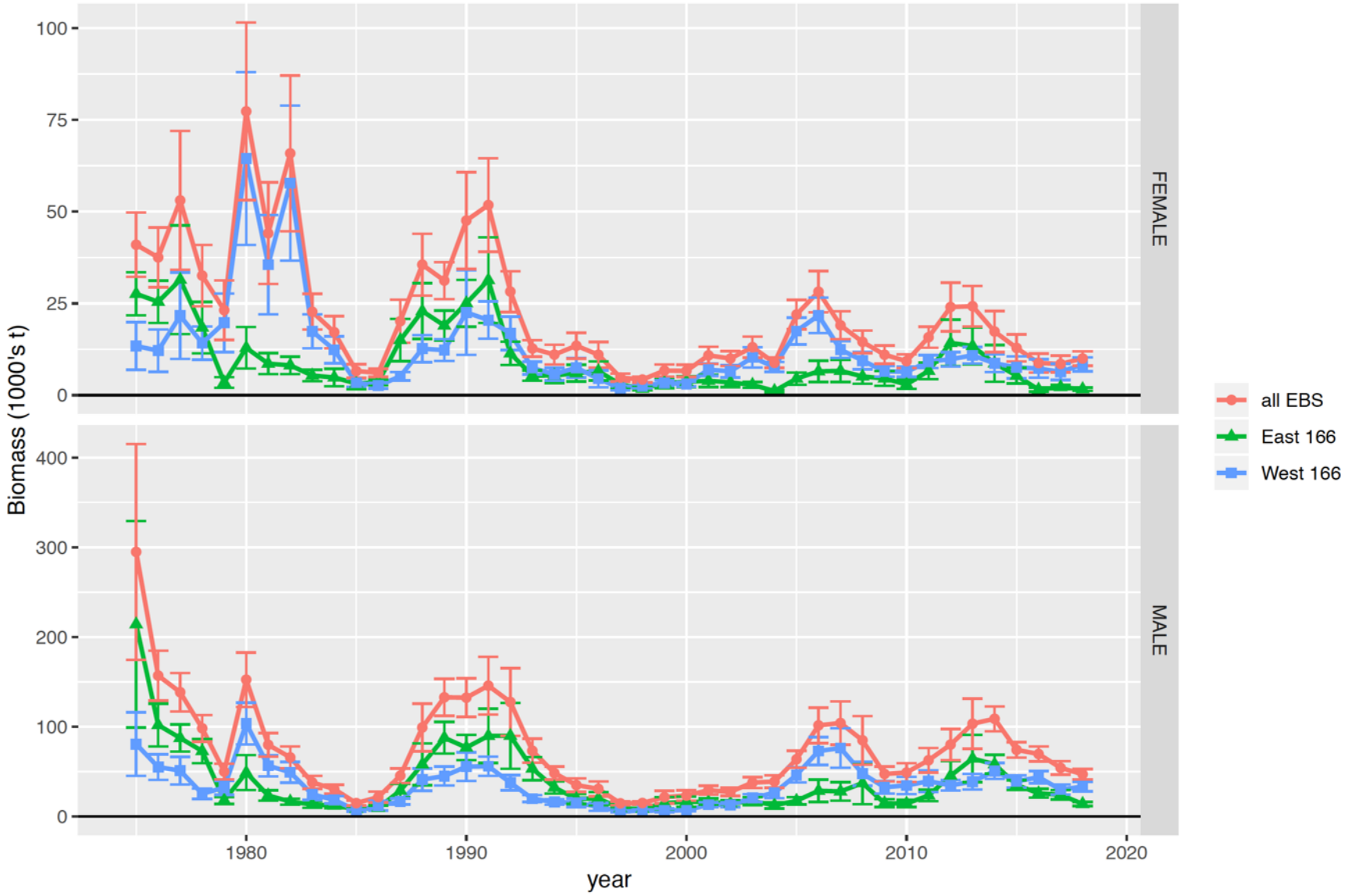
Recent Fishery Trends: Bycatch in the Groundfish Fisheries



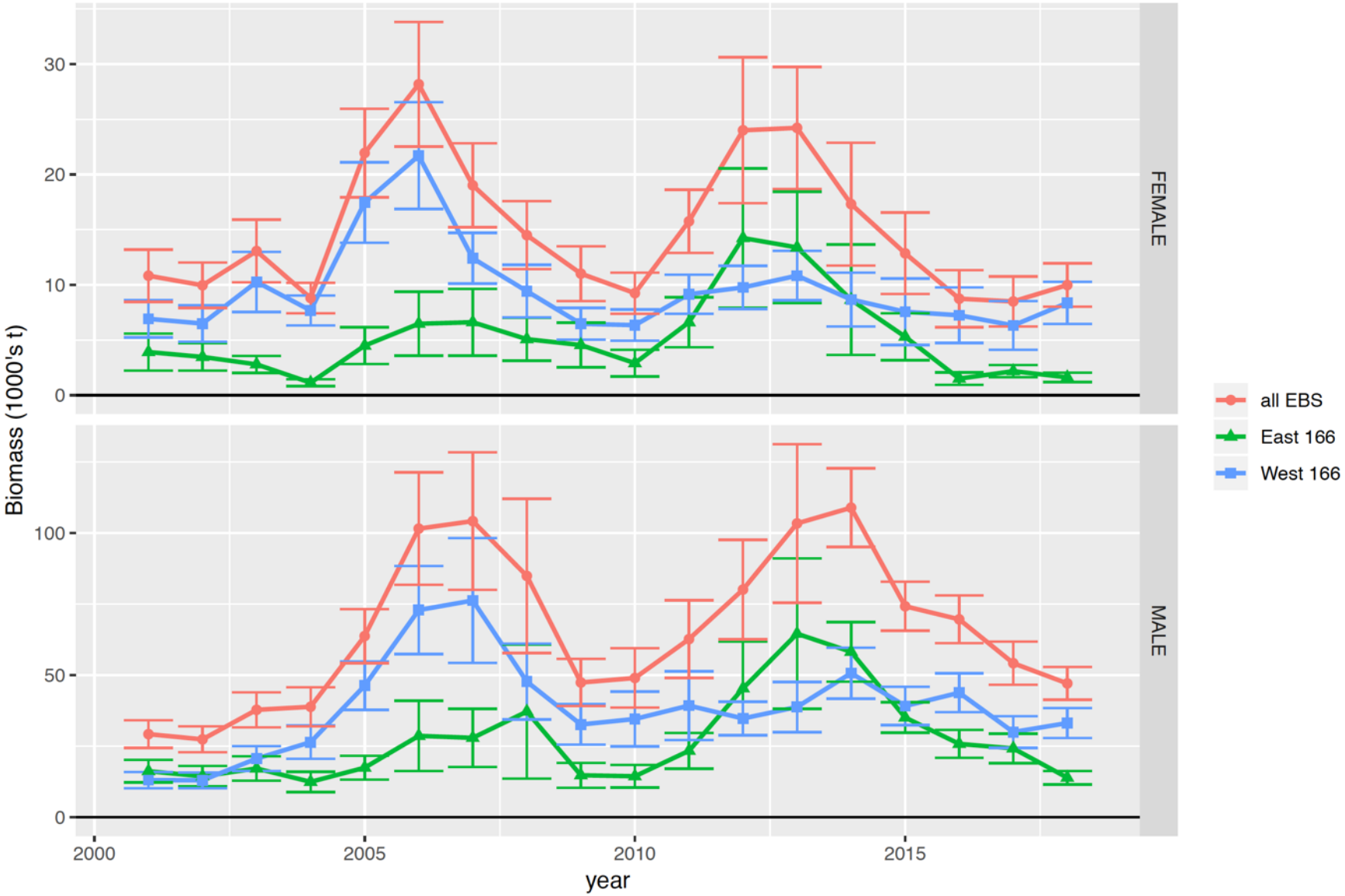
Bycatch Trends in the Groundfish Fisheries



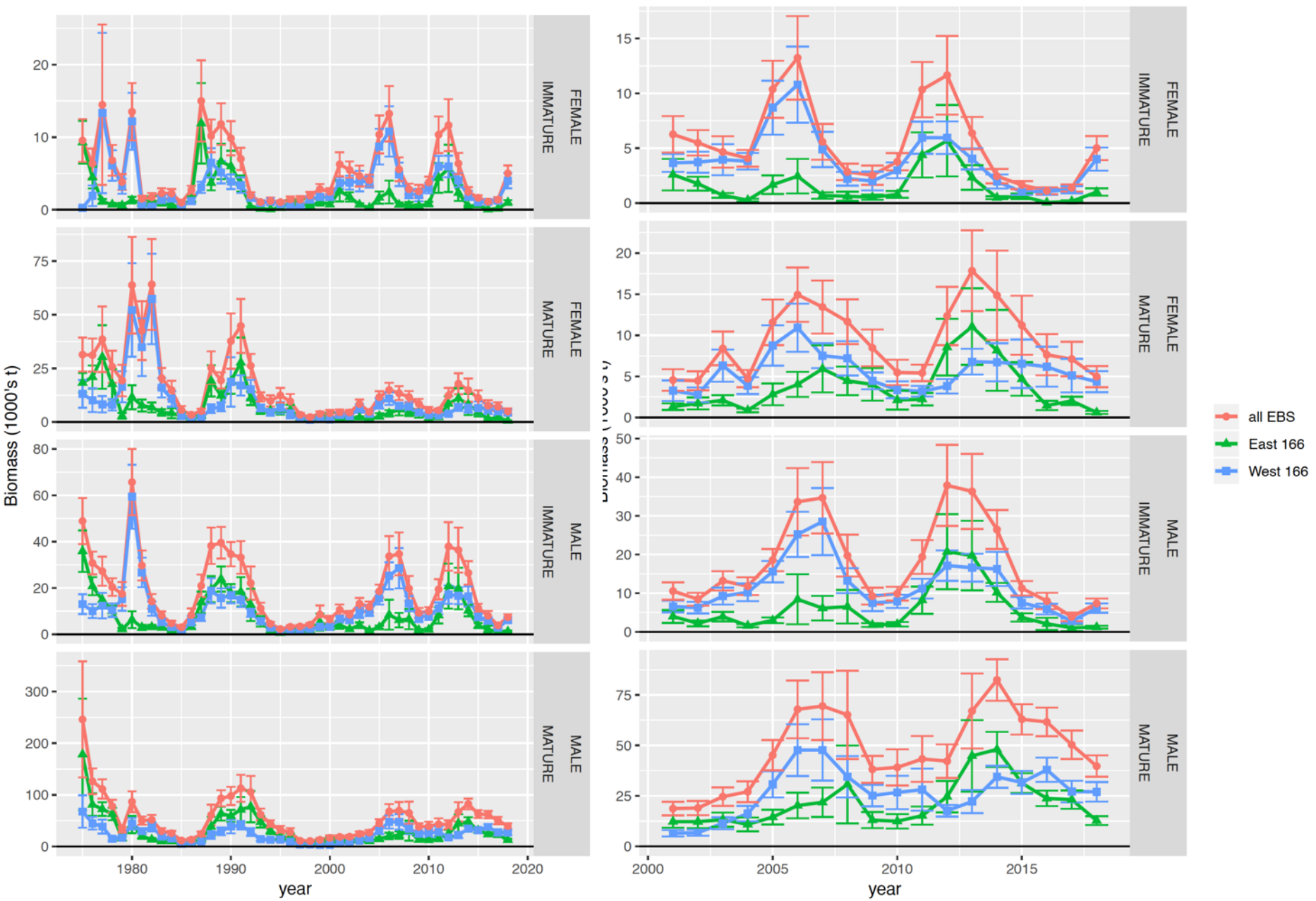
NMFS EBS Trawl Survey Trends



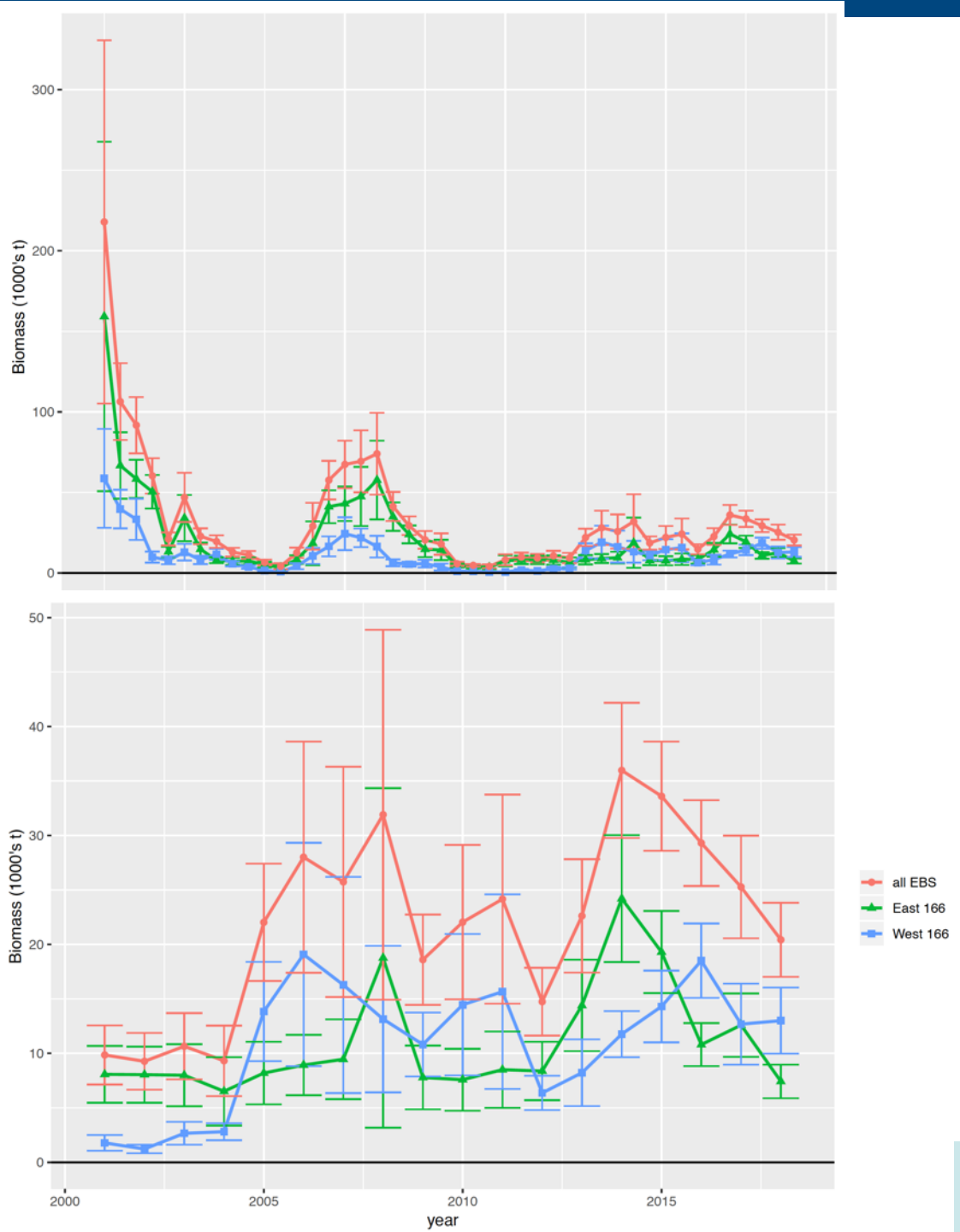
NMFS EBS Trawl Survey Trends (recent)

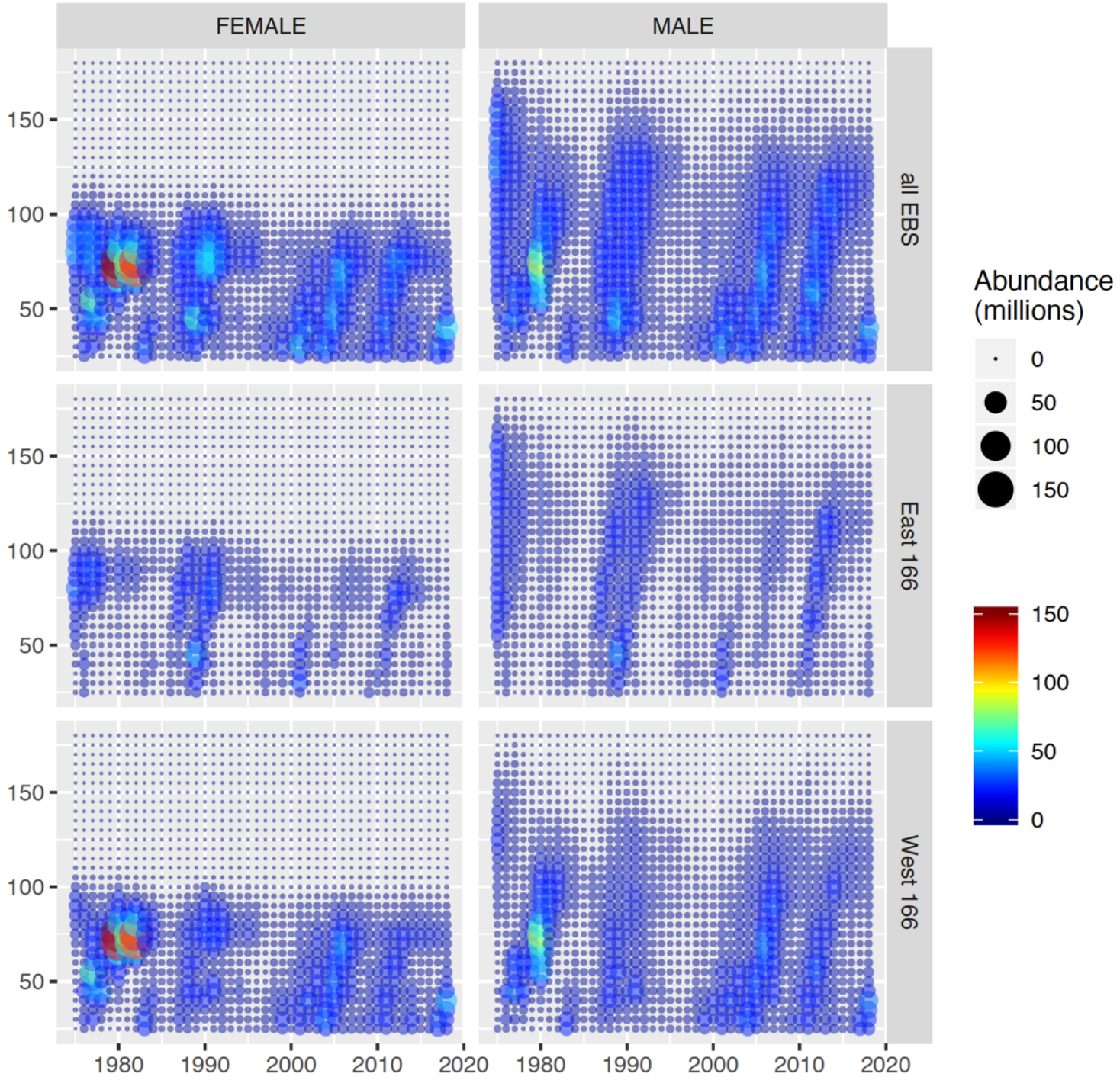


NMFS EBS Trawl Survey Trends

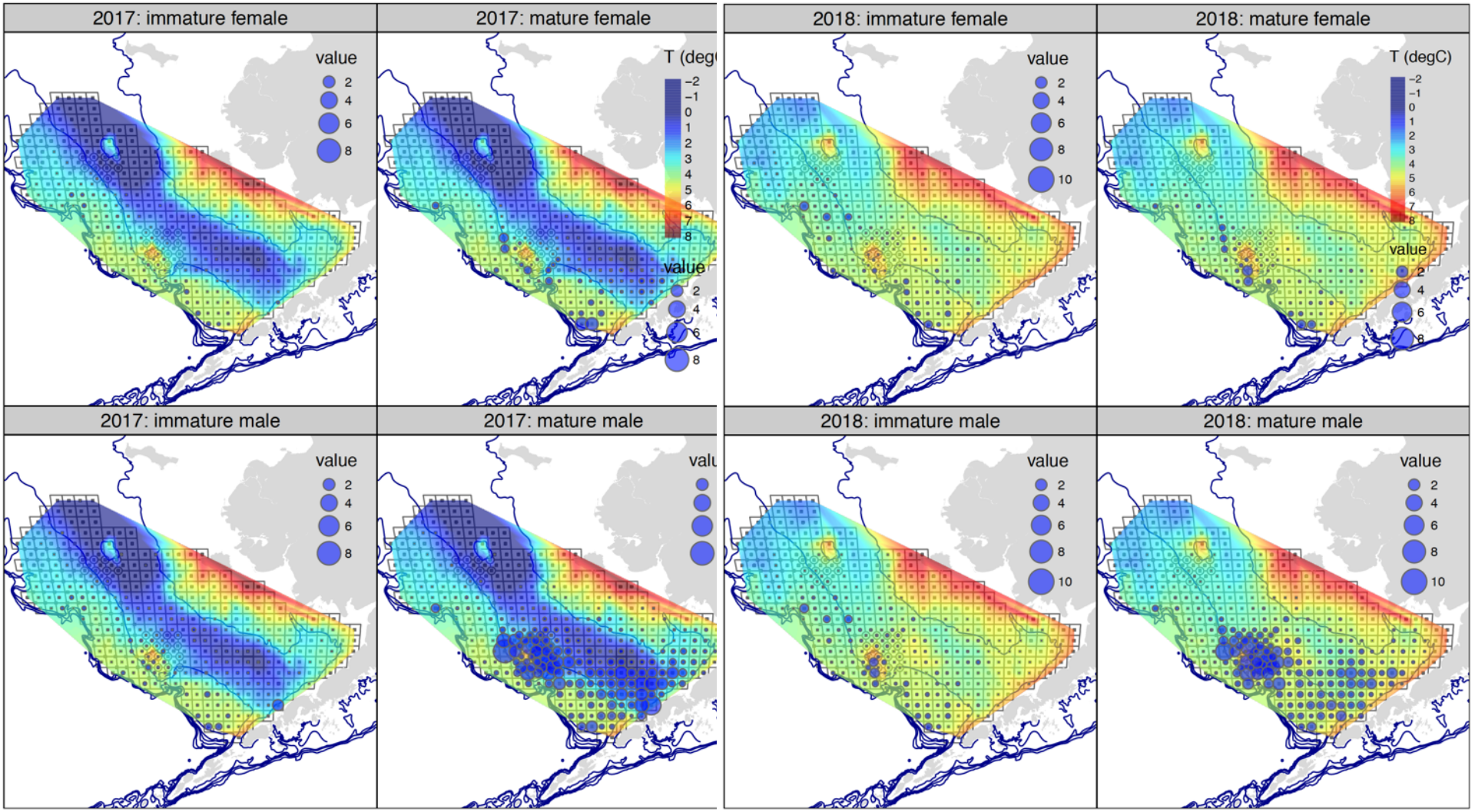


NMFS EBS Trawl Survey Trends: Preferred Males




FEMALE
MALE
all EBS
East 166
West 166
150
100
50
1980
1990
2000
2010
2020
Abundance
(millions)
0
50
100
150

Spatial patterns

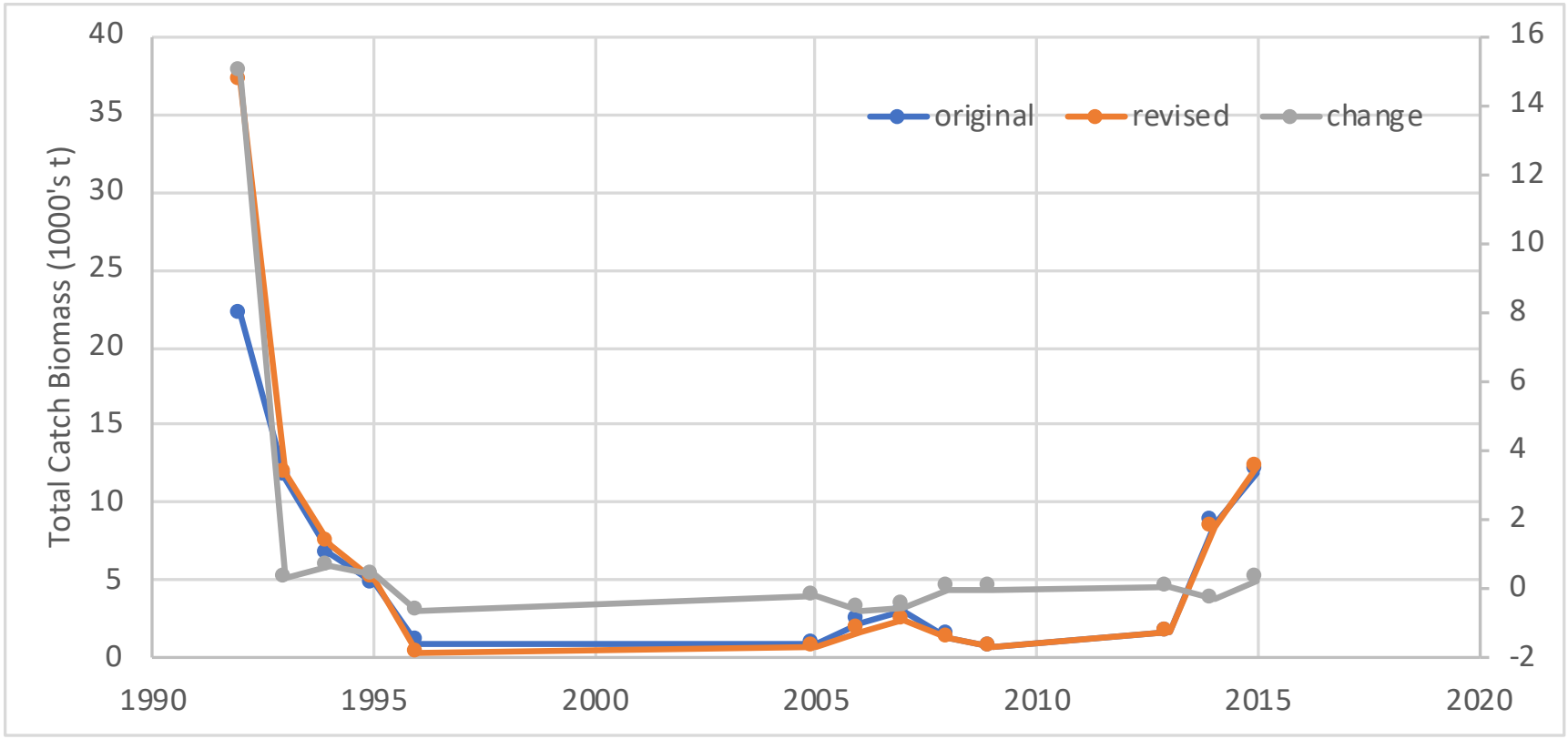


Revisions to Total Catch in the Crab Fisheries

- Previously, Total Catch = Expanded Discard Catch + Retained Catch
  - Discard catch: from at-sea observers classifying discards
    - Expanded Discard Catch = (pots fished)/(pots obs)*(obs discard catch)
    - biomass based on old LW relationships
    - included “summary pot” data?
    - changes in ”target” (total effort, observed pots)?
  - Retained catch: from fish ticket data

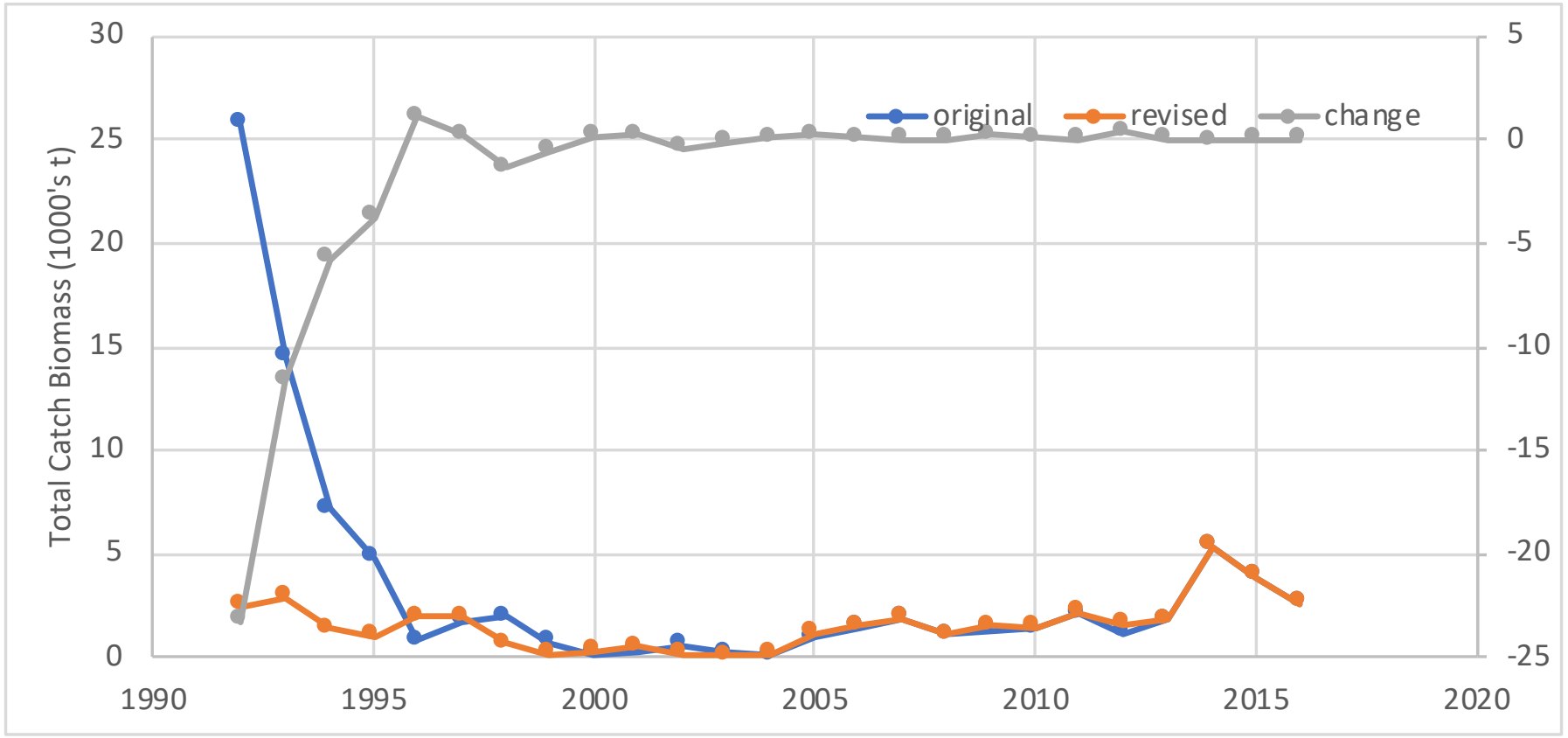
- Now: TC = Expanded Total Catch = (pots fished)/(pots obs)*(obs total catch)
  - observed total catch: from at-sea observers
    - ignores observer discard/retained classification
    - includes only “detail pot” data
    - biomass based on standard LW relationships

Revisions to Total Catch in the Directed Fishery

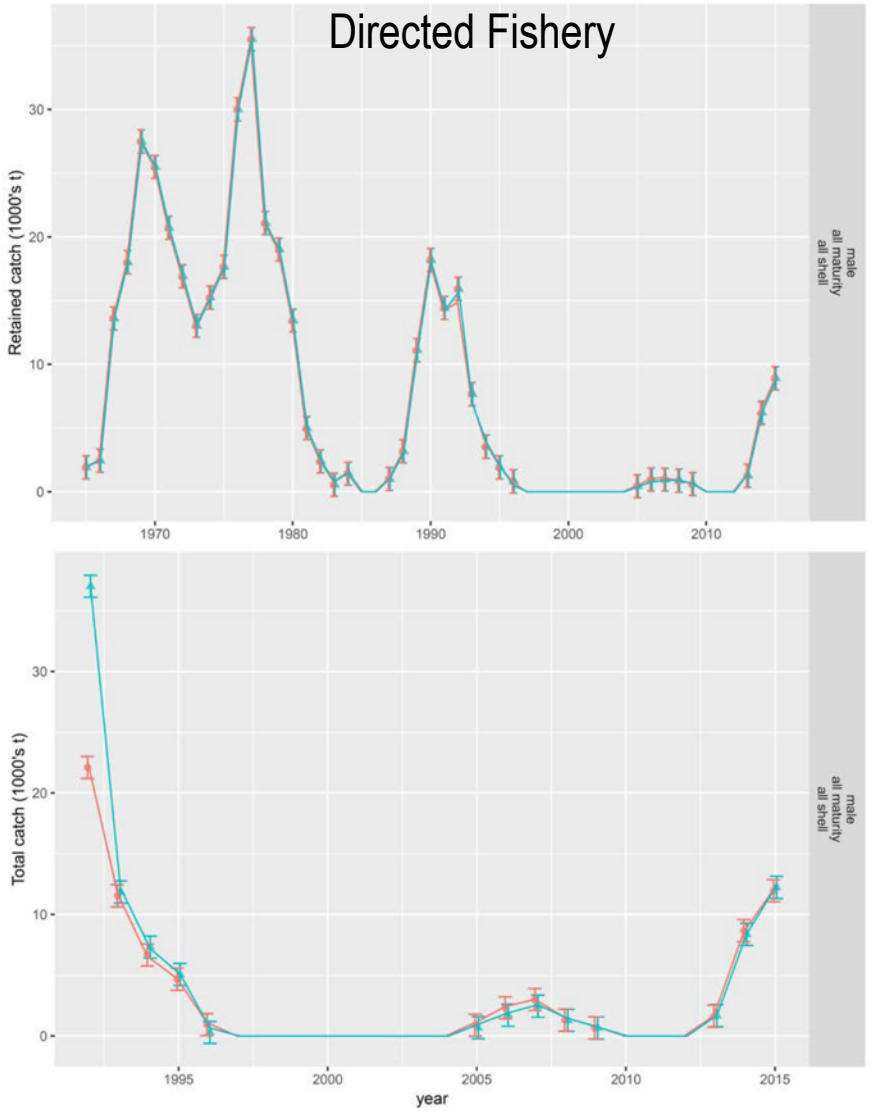


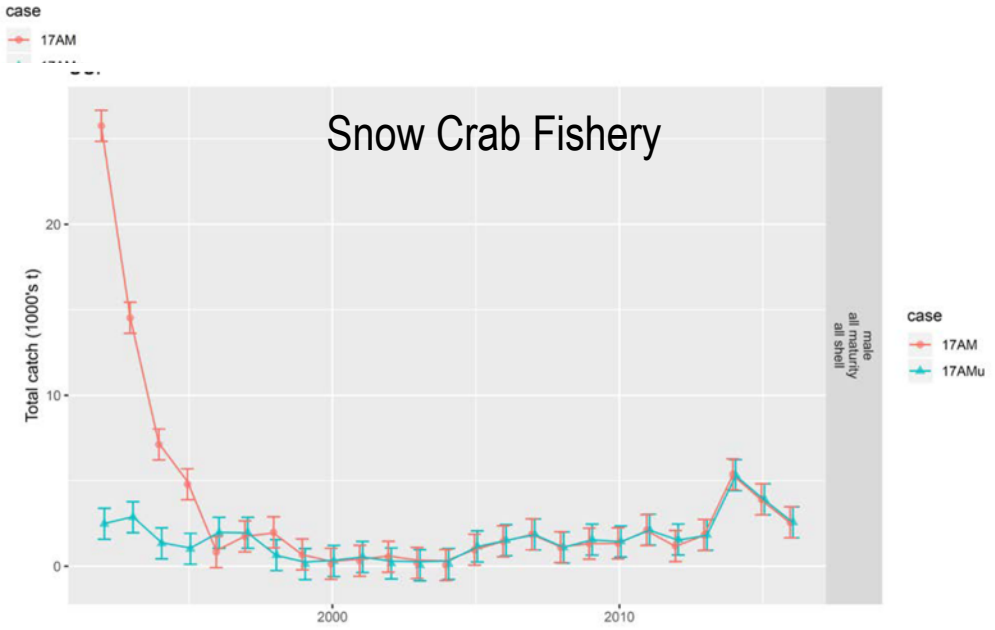
- 2016: fishery closed

Revisions to Total (By)Catch in the Snow Crab Fishery

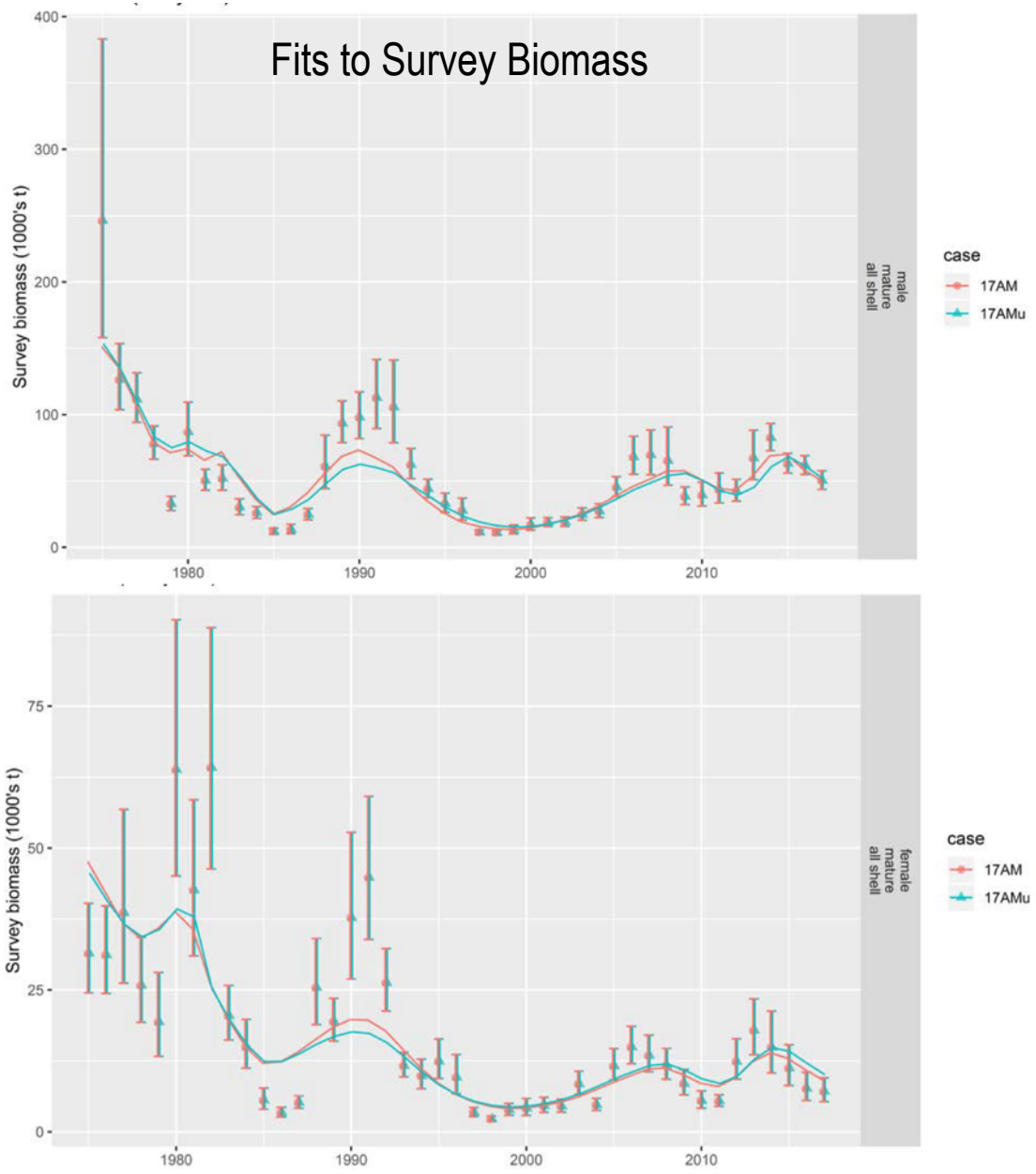


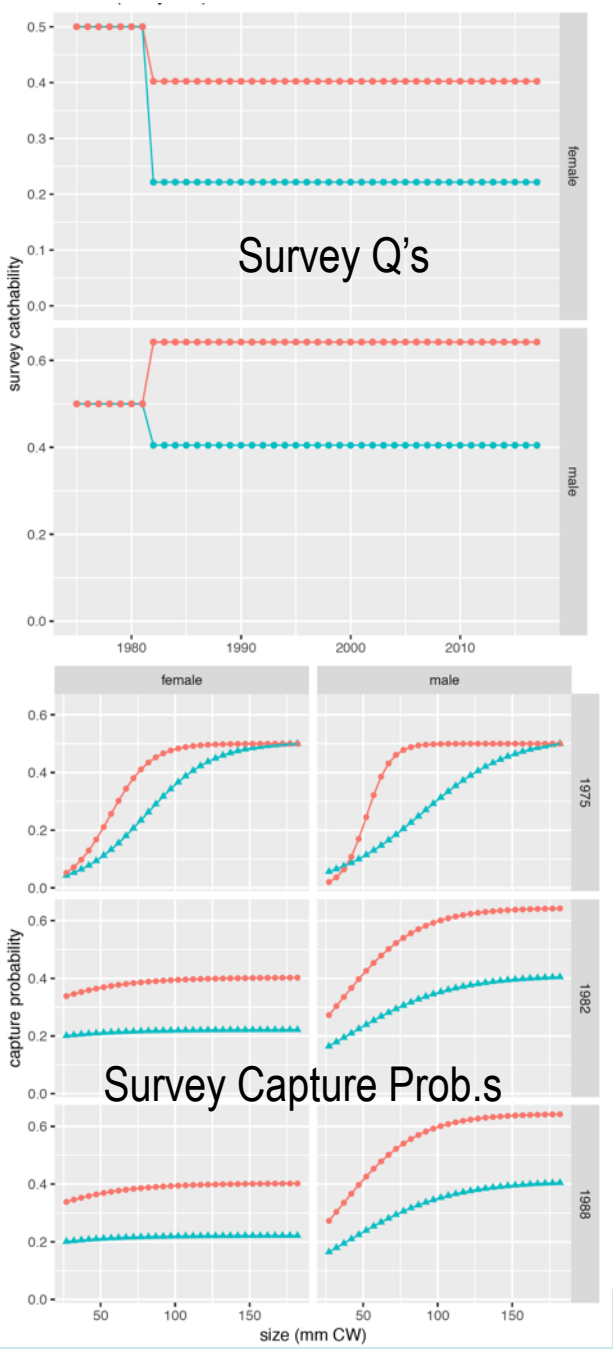
Effects on Assessment Model Results



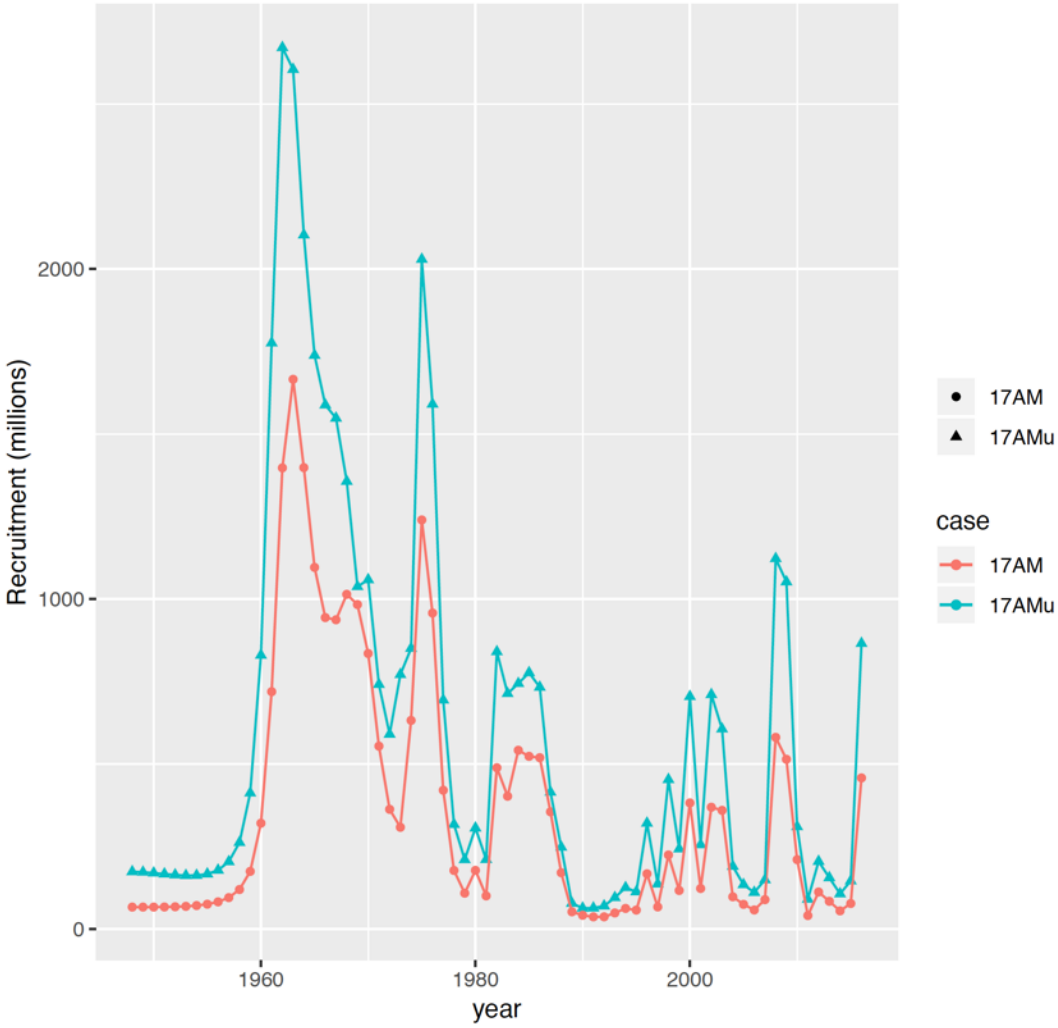


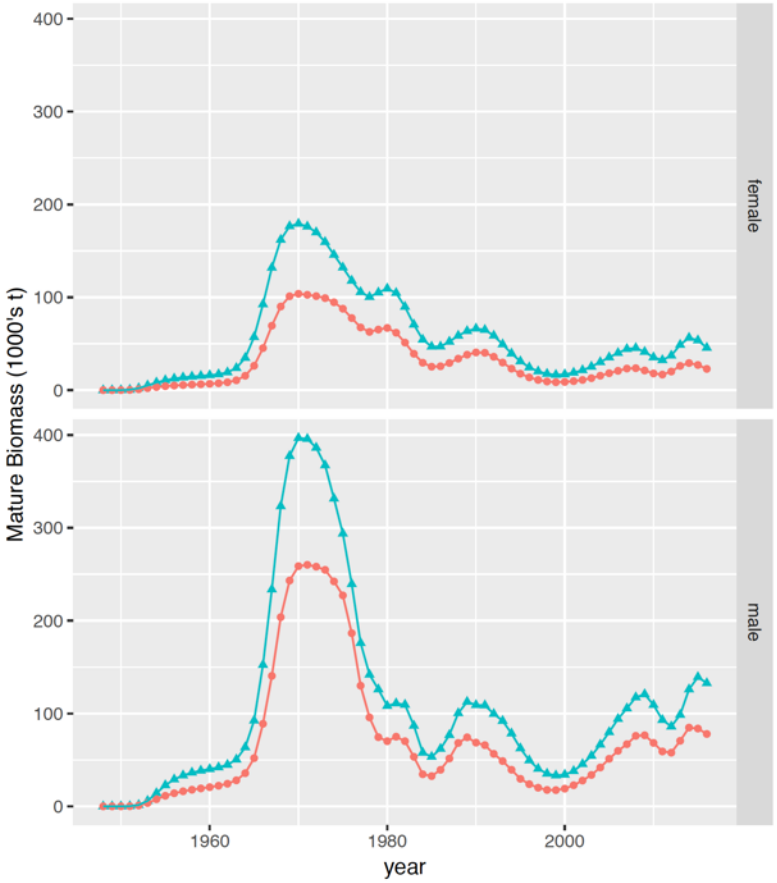
Effects on Assessment Model Results



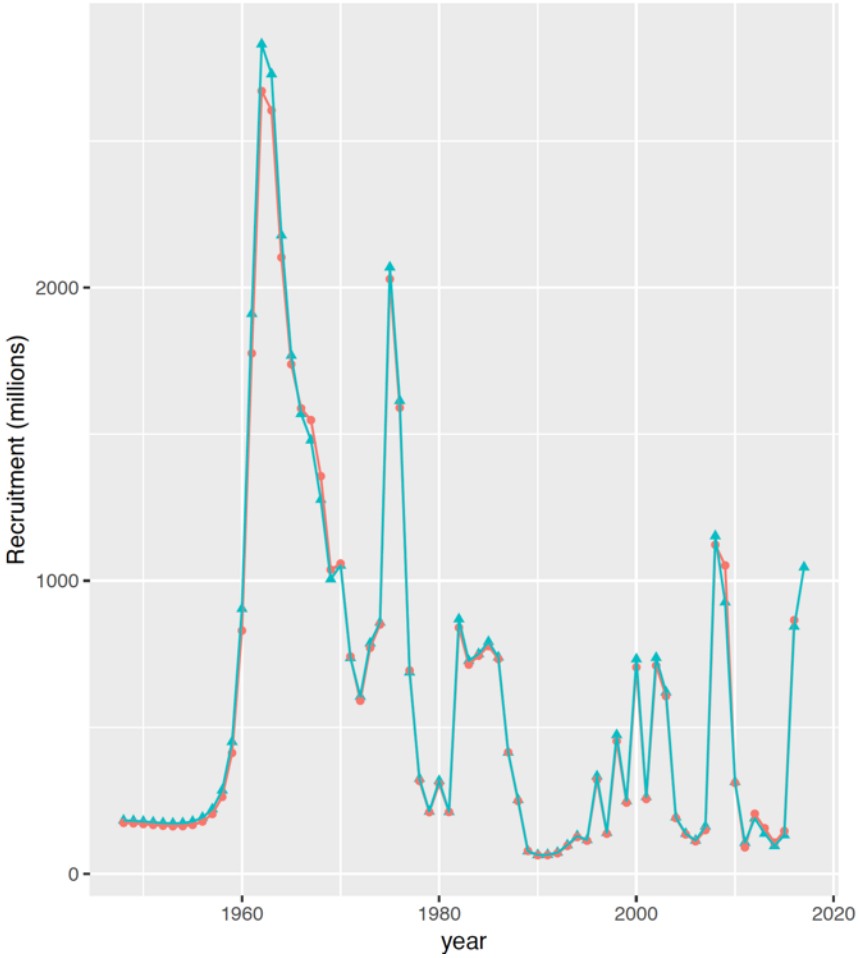


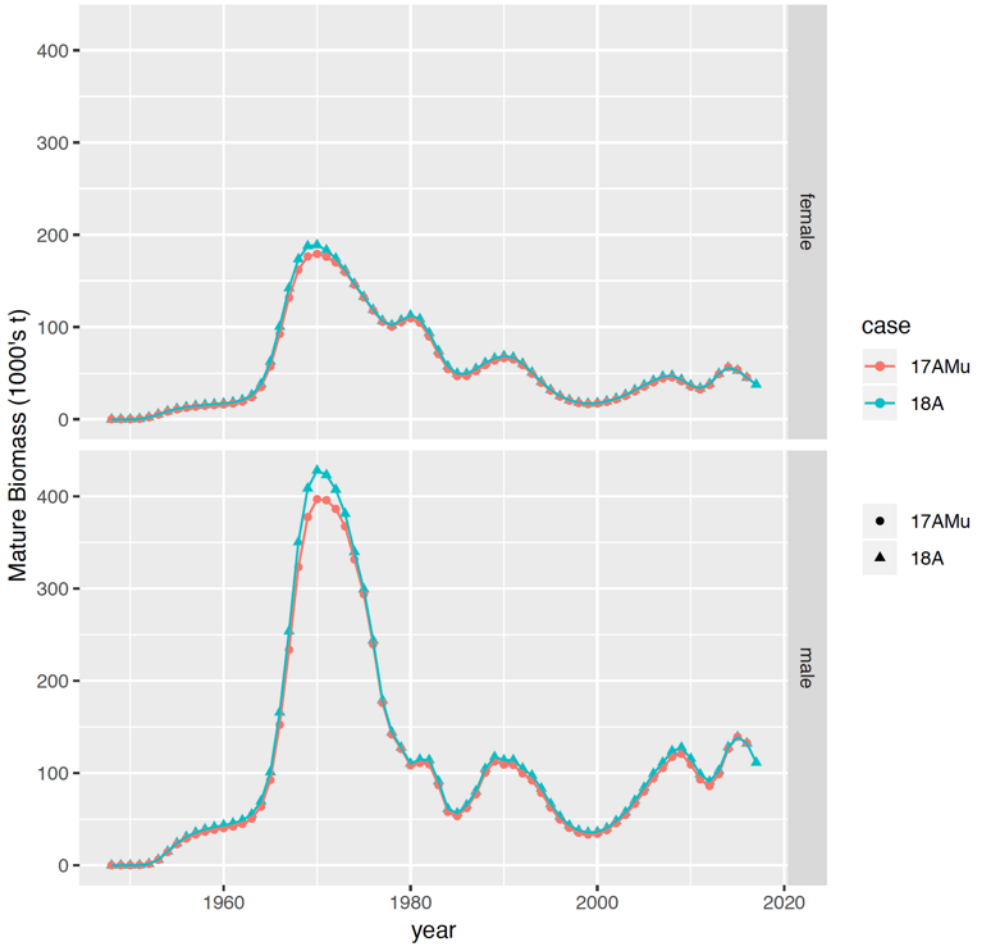
Effects on Assessment Model Results





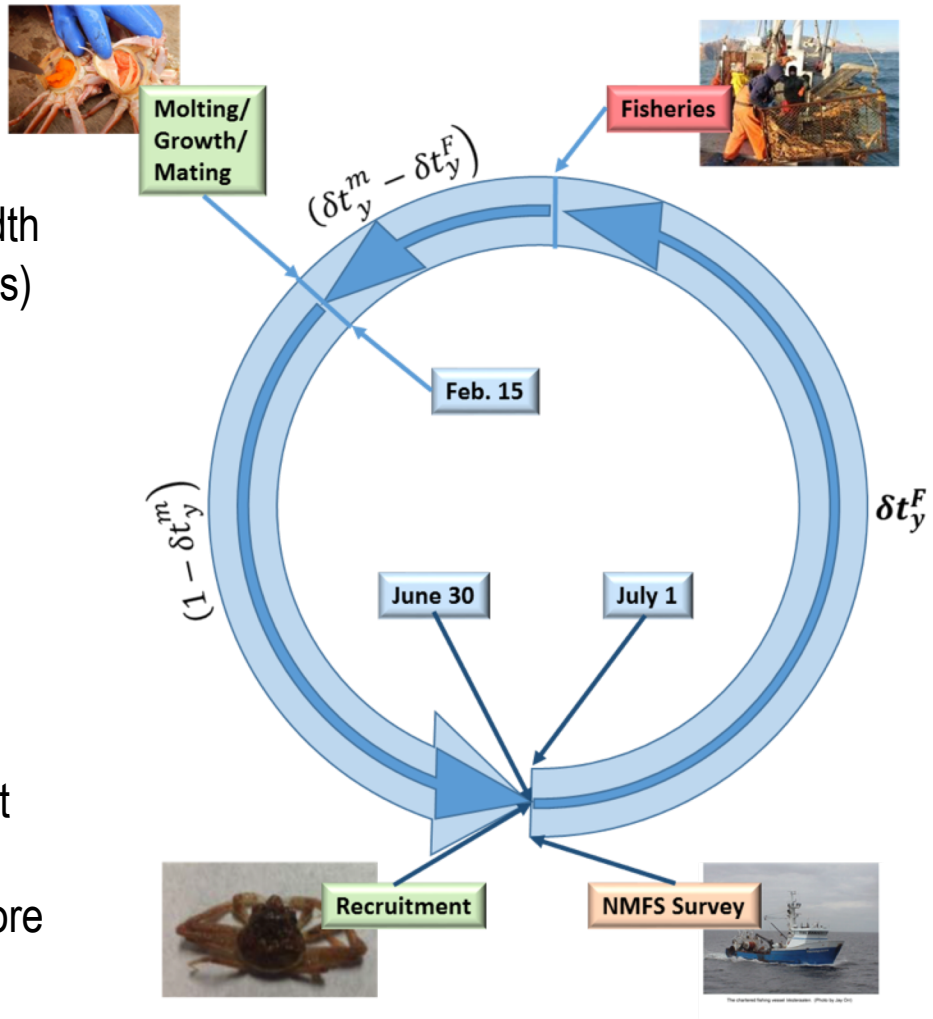
Assessment Model Results: 2017 to 2018



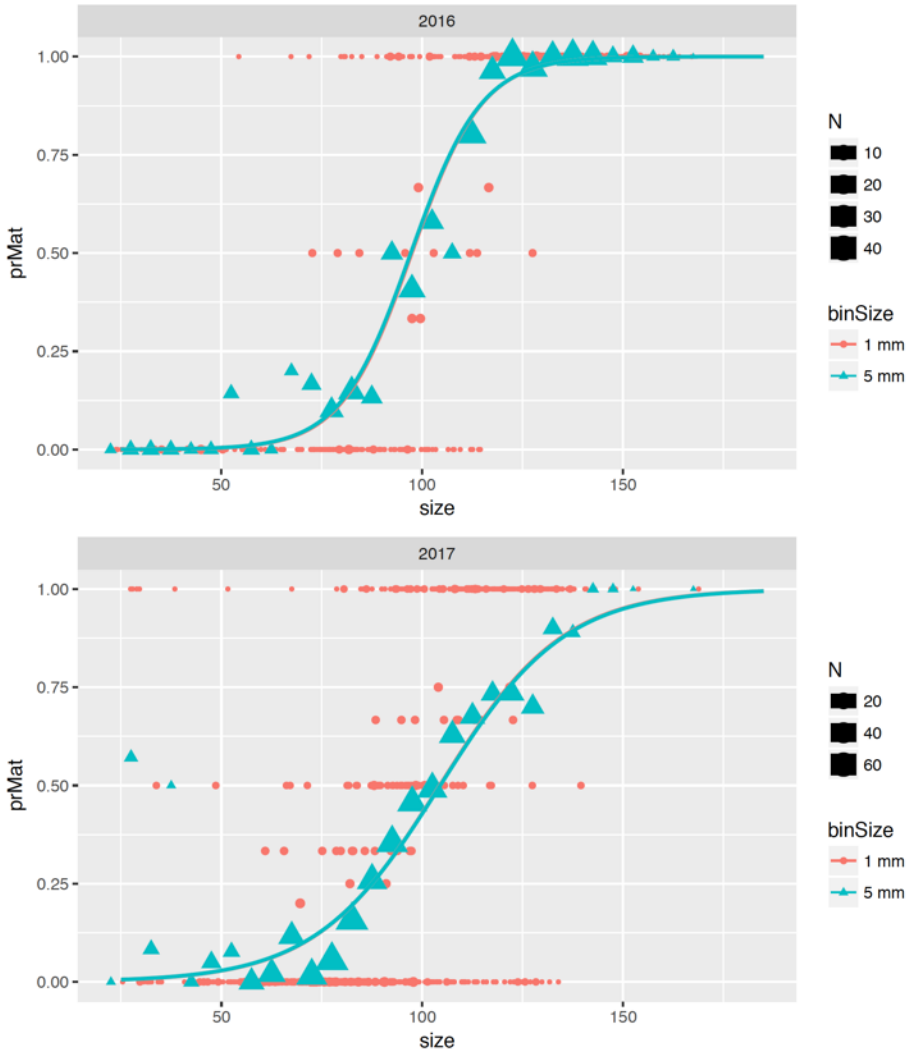


Tier 3 stage/size-based population dynamics model

- 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



New data type: male maturity ogives (based on chela heights)



Male maturity ogives (based on chela heights)

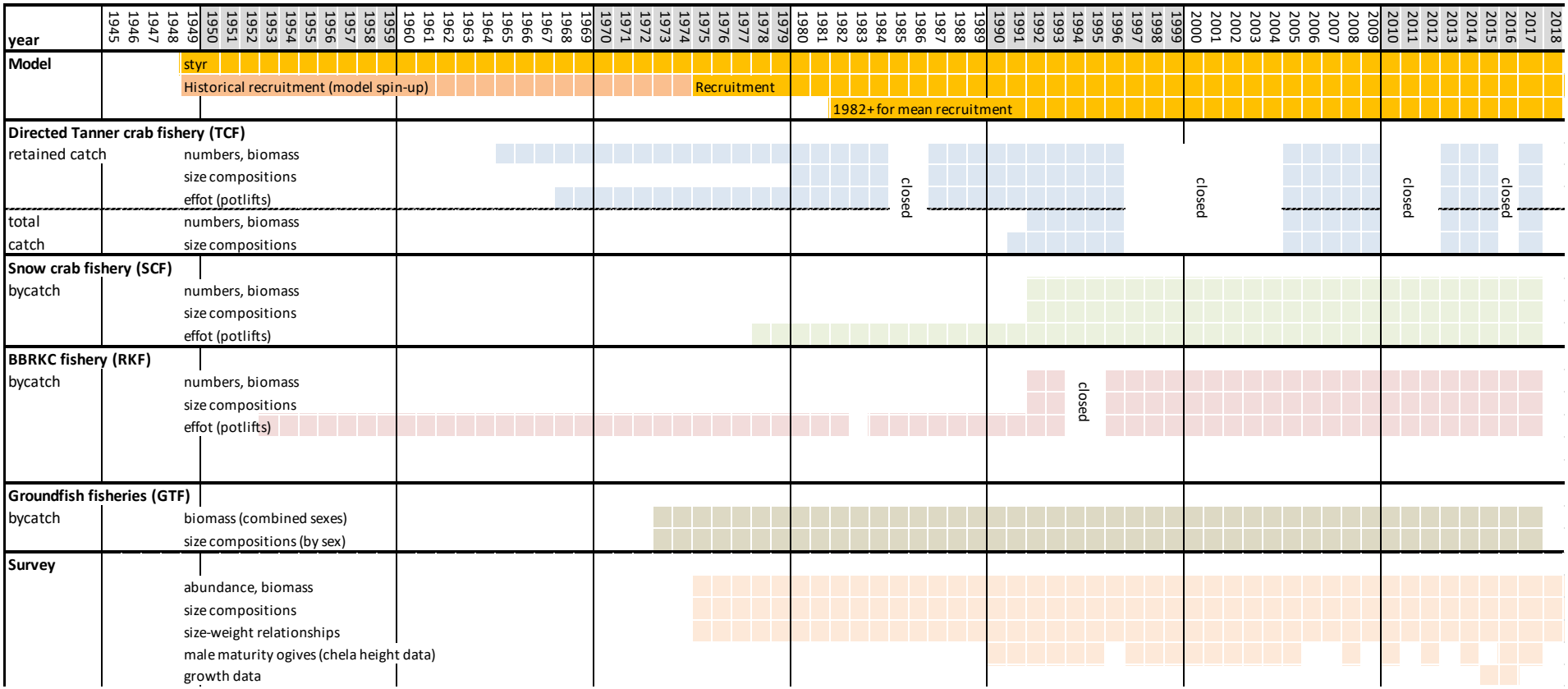
- size-specific maturity ogives based on classifying new shell male crab by measured chela height-to-carapace width (CH:CW) ratios can be included in model likelihood
- eliminates need to classify male crab by maturity "outside" the model

$$L_m = \sum_{y,z} n_{y,z} \cdot \left\{ p_{y,z}^{obs} \cdot \ln\left(p_{y,z}^{mod} + \delta\right) + \left(1 - p_{y,z}^{obs}\right) \cdot \ln\left(1 - p_{y,z}^{mod} + \delta\right) \right\}$$

$$p_{y,z}^{obs} = \frac{n_{y,z,ns,mat}^{obs}}{n_{y,z,ns,mat}^{obs} + n_{y,z,ns,imm}^{obs}}$$

$$p_{y,z}^{mod} = \frac{n_{y,z,ns,mat}^{mod}}{n_{y,z,ns,mat}^{mod} + n_{y,z,ns,imm}^{mod}}$$

Model Data Coverage



2017 Assessment 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
		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,	estimated sex/maturity state-specific multipliers on base rate
	1985-2016	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

2017 Assessment Model

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, 1991-1996, 2005-2009, 2013-2015	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

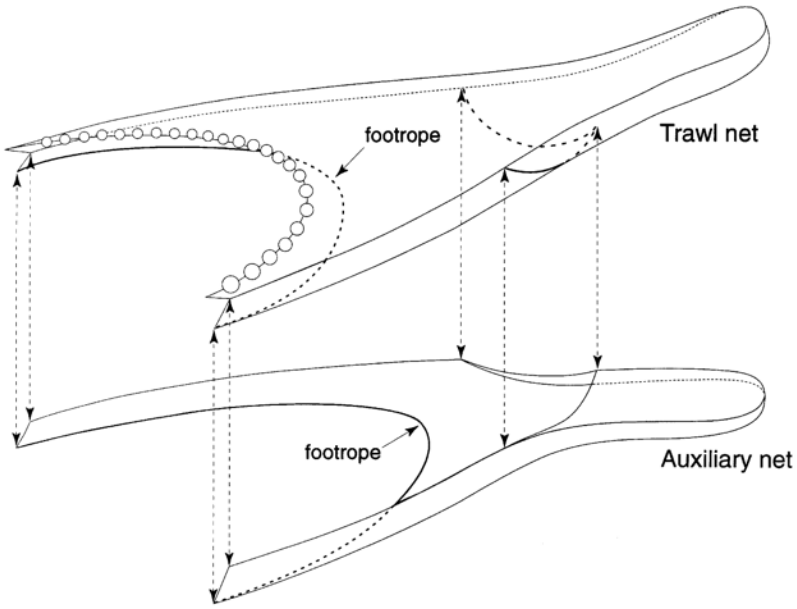
2017 Assessment Model

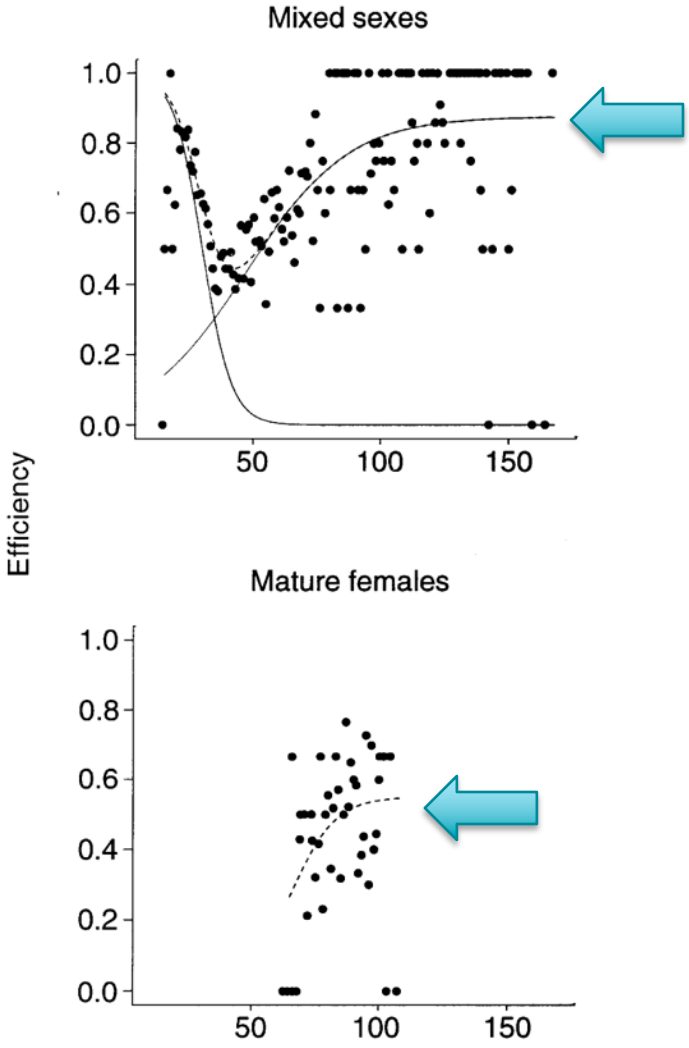
Fishery/process	time blocks	description
RKF	bycatch in BBRKC fishery	
capture rates	pre-1952	nominal rate on males
	1953-1991	extrapolated from effort
	1992-2016	male ln-scale mean + annual devs
	1949-2016	ln-scale female offset
male selectivity	1949-1996	ascending logistic
	1997-2004	ascending logistic
	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

Alternative Model Scenarios

model scenario	number of parameters	description
17AM (B2b)	344	2017 assessment model
17AMu	344	17AM with updated crab fishery data
18A (B0)	357	17AMu with 2017/18 fishery data and 2018 NMFS survey data
18B (B1)	340	18A with fits to male maturity ogives. Reduced number of molt-to-maturity parameters (17 fewer)
18C0 (B2)	340	Fitting male maturity ogives, survey biomass by sex, size compositions for males by shell condition and by maturity state and shell condition for females
18C0a	340	18C0, but reduced weight (/100) on fitting male maturity ogives
18C1 (B4)	340	18C0, but also fitting survey abundanceby sex
18C1a	340	18C1, but reduced weight (/100) on fitting male maturity ogives
18C2a	334	18C1a, but fixing sex-specific survey Q's and selectivity functions for 1982+ based on Somerton and Otto (1999)'s underbag experiment
18C3a	334	18C2a, but fixing survey Q's 1982+ based only on Somerton and Otto (1999)'s male catchability from the underbag experiment
18D0 (B3)	340	Fits to male maturity ogives, survey biomass by sex, and size compositions for males aggregated over shell condition and by maturity state for females
18D1 (B5)	340	18D0, but also fitting survey abundance by sex

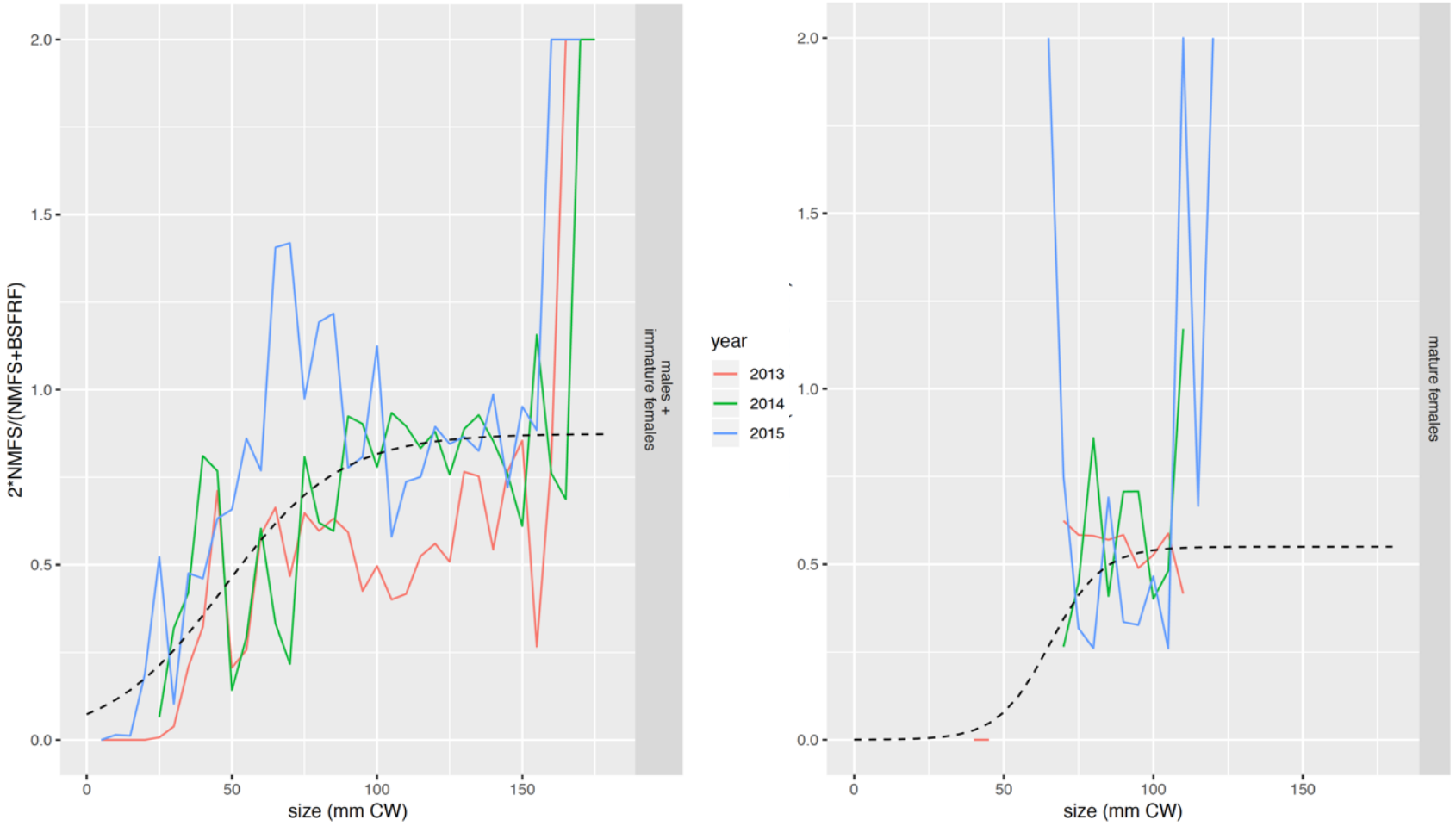
The “Underbag” Experiment





- Somerton and Otto, Fish. Bull.,1999
- Results used as priors on survey Q’s
- 18C2a: fixes Q, selectivity
  - mature males, immature females = “mixed sexes”
  - mature females = “mature females”
- 18C3a: fixes Q, selectivity
  - all crab = “mixed sexes”

Author's Preferred Model: Support from BSFRF SBS data for fixing survey catchability/selectivity using the underbag experiment



Fits to Data: 17AM, 17AMu, 18A

Name	Component	Type	Distribution	Likelihood
17AM, 17AMu, 18A	TCF: retained catch	abundance	--	--
		biomass	norm2	males only
		size comp.s	multinomial	males only
	TCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	SCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	RKF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	GTF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	NMFS survey	abundance	--	--
		biomass	lognormal	by sex, for mature crab only
		size comp.s	multinomial	by sex/maturity
		chela height data	--	--
	growth data	EBS only	gamma	by sex

Fits to Data: 18B

Name	Component	Type	Distribution	Likelihood
18B	TCF: retained catch	abundance	--	--
		biomass	norm2	males only
		size comp.s	multinomial	males only
	TCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	SCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	RKF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	GTF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	NMFS survey	abundance	--	--
		biomass	lognormal	by sex, for mature crab only
		size comp.s	multinomial	by sex/maturity
		chela height data	binomial	for males
	growth data	EBS only	gamma	by sex

Fits to Data: 18C0, 18C0a

Name	Component	Type	Distribution	Likelihood
18C0, 18C0a	TCF: retained catch	abundance	--	--
		biomass	norm2	males only
		size comp.s	multinomial	males only
	TCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	SCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	RKF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	GTF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	NMFS survey	abundance	--	--
		biomass	lognormal	by sex, all crab
		size comp.s	multinomial	males: by shell condition females: by maturity state, shell condition
		chela height data	binomial	for males
	growth data	EBS only	gamma	by sex

Fits to Data: 18C1, 18C1a, 18C2a, 18C3a

Name	Component	Type	Distribution	Likelihood
18C1, 18C1a, 18C2a, 18C3a	TCF: retained catch	abundance	--	--
		biomass	norm2	males only
		size comp.s	multinomial	males only
	TCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	SCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	RKF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	GTF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	NMFS survey	abundance	lognormal	by sex, all crab
		biomass	lognormal	by sex, all crab
		size comp.s	multinomial	males: by shell condition females: by maturity state, shell condition
		chela height data	binomial	for males
	growth data	EBS only	gamma	by sex

Fits to Data: 18D0

Name	Component	Type	Distribution	Likelihood
18D0	TCF: retained catch	abundance	--	--
		biomass	norm2	males only
		size comp.s	multinomial	males only
	TCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	SCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	RKF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	GTF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	NMFS survey	abundance	lognormal	--
		biomass	lognormal	by sex, all crab
		size comp.s	multinomial	males: summe over shell cond. females: by maturity state
		chela height data	binomial	for males
	growth data	EBS only	gamma	by sex

Fits to Data: 18D1

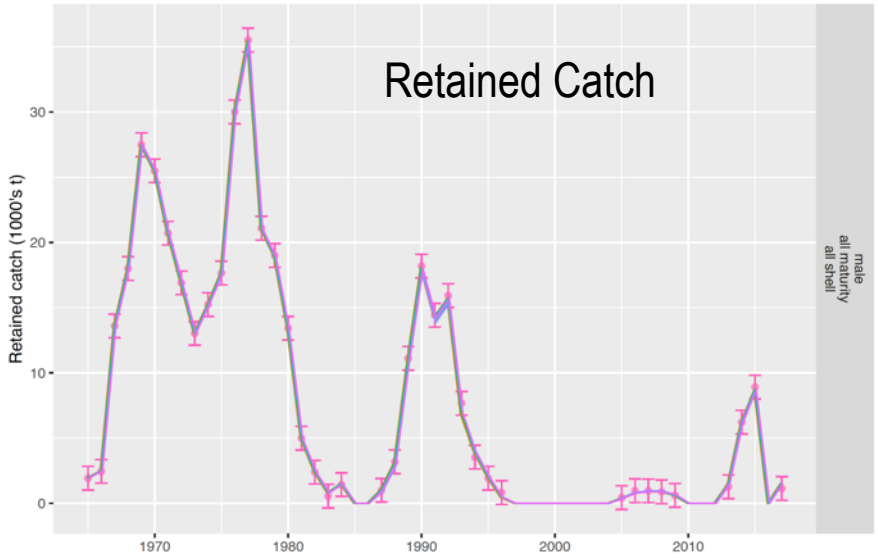
Name	Component	Type	Distribution	Likelihood
18D1	TCF: retained catch	abundance	--	--
		biomass	norm2	males only
		size comp.s	multinomial	males only
	TCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	SCF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	RKF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	GTF: total catch	abundance	--	--
		biomass	norm2	by sex
		size comp.s	multinomial	by sex
	NMFS survey	abundance	lognormal	by sex, all crab
		biomass	lognormal	by sex, all crab
		size comp.s	multinomial	males: summed over shell cond. females: by maturity state
		chela height data	binomial	for males
	growth data	EBS only	gamma	by sex

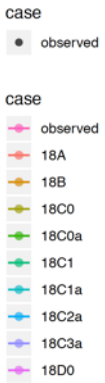
Model Scenarios

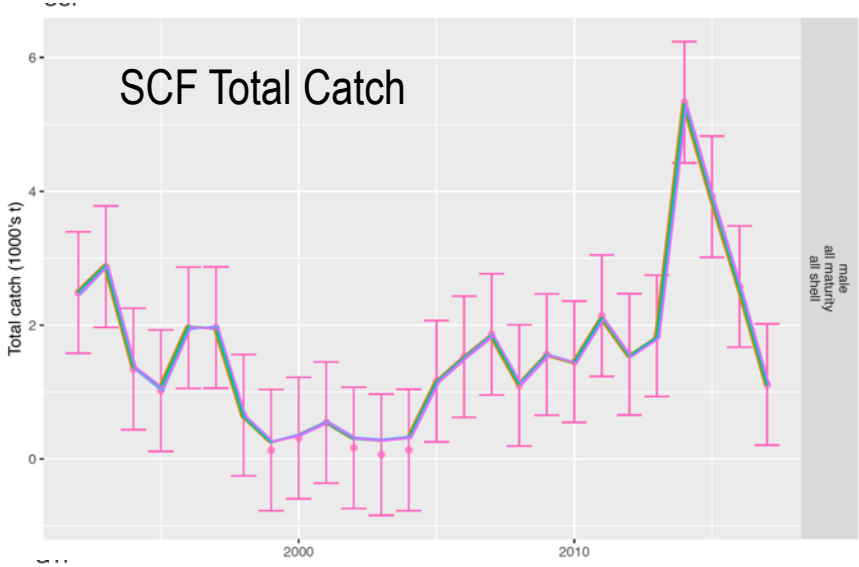
Model Scenario	average recruitment millions	Final MMB 1000's t	B0 1000's t	Bmsy 1000's t	Fmsy	MSY 1000's t	Fofl	OFL 1000's t	projected MMB 1000's t	projected MMB / Bmsy
17AM (B2b)	213.96	80.58	83.34	29.17	0.75	12.26	0.75	25.42	43.32	1.49
17AMu	371.11	136.48	111.38	38.98	1.25	18.03	1.25	50.85	63.55	1.63
18A	391.22	114.10	120.00	42.00	1.22	19.24	1.22	42.01	53.87	1.28
18B	464.60	124.18	130.45	45.66	2.61	22.35	2.61	55.40	48.01	1.05
18C0	536.07	122.84	124.39	43.54	3.06	24.32	3.04	56.15	43.25	0.99
18C0a	366.37	99.63	100.92	35.32	1.07	18.13	1.07	35.44	46.25	1.31
18C1	540.64	128.64	129.28	45.25	2.79	25.90	2.78	58.26	45.12	1.00
18C1a	404.67	110.14	109.74	38.41	1.14	20.41	1.14	39.87	49.67	1.29
18C2a	199.49	50.12	63.01	22.05	0.91	11.54	0.91	16.76	24.06	1.09
18C3a	188.34	49.93	63.61	22.26	0.79	10.84	0.79	15.93	25.44	1.14
18D0	503.62	145.40	149.02	52.16	2.64	24.09	2.64	65.30	57.35	1.10

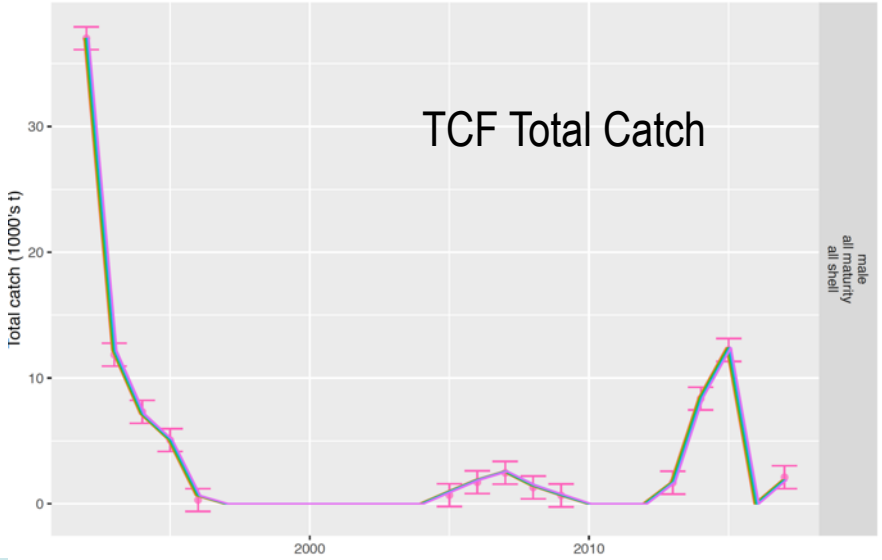
18D1: did not converge

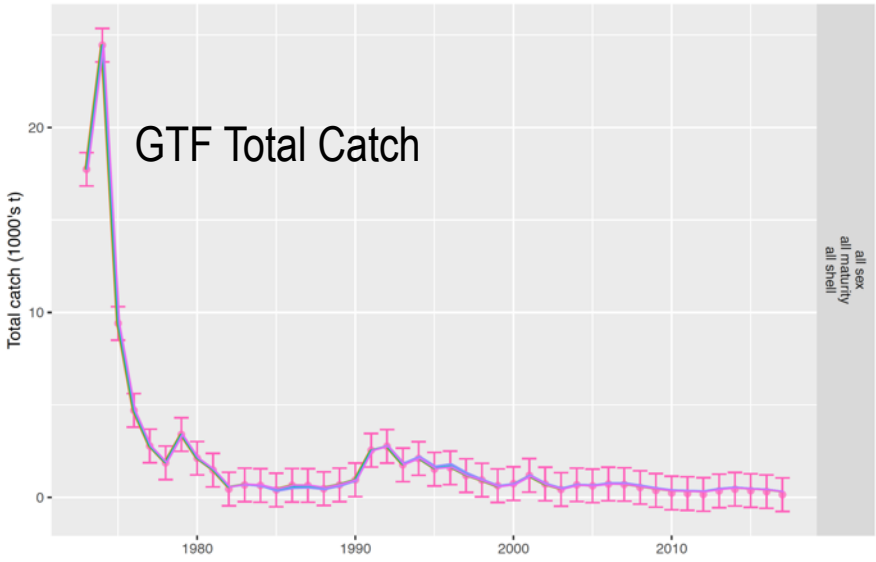
2018 Model Scenario Results: Fits to Male Catch Biomass











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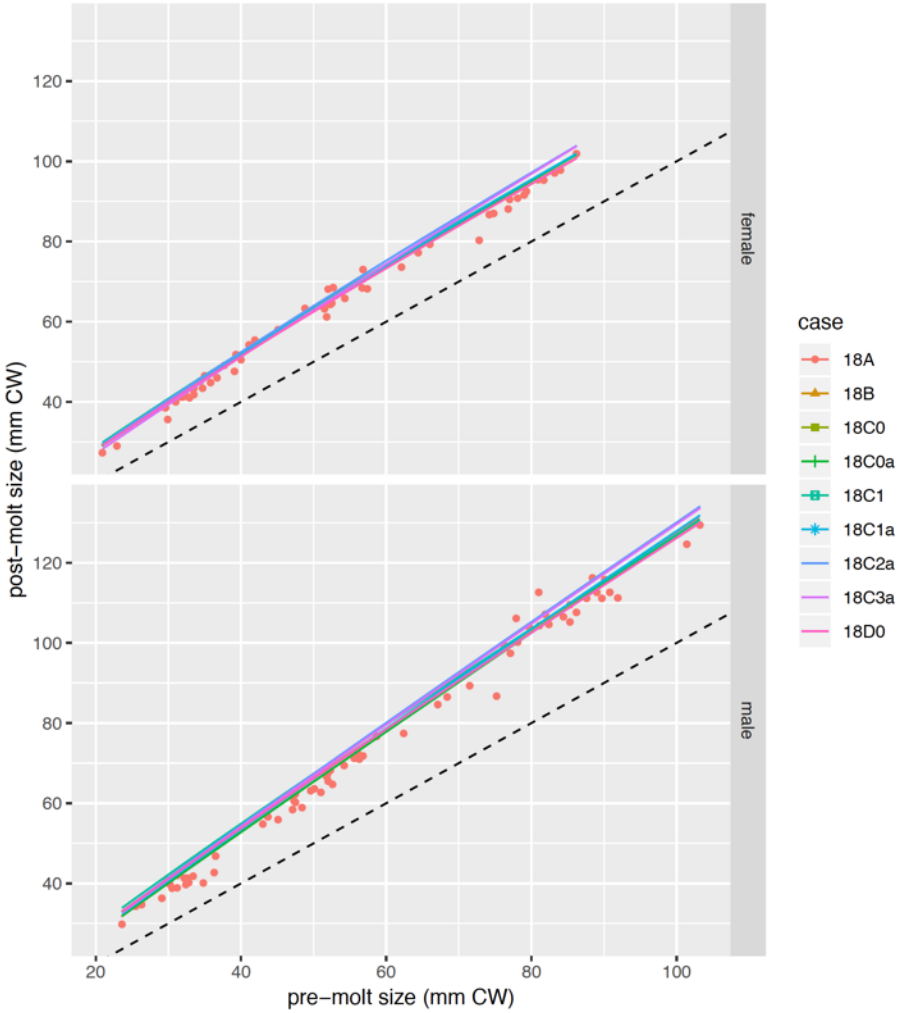
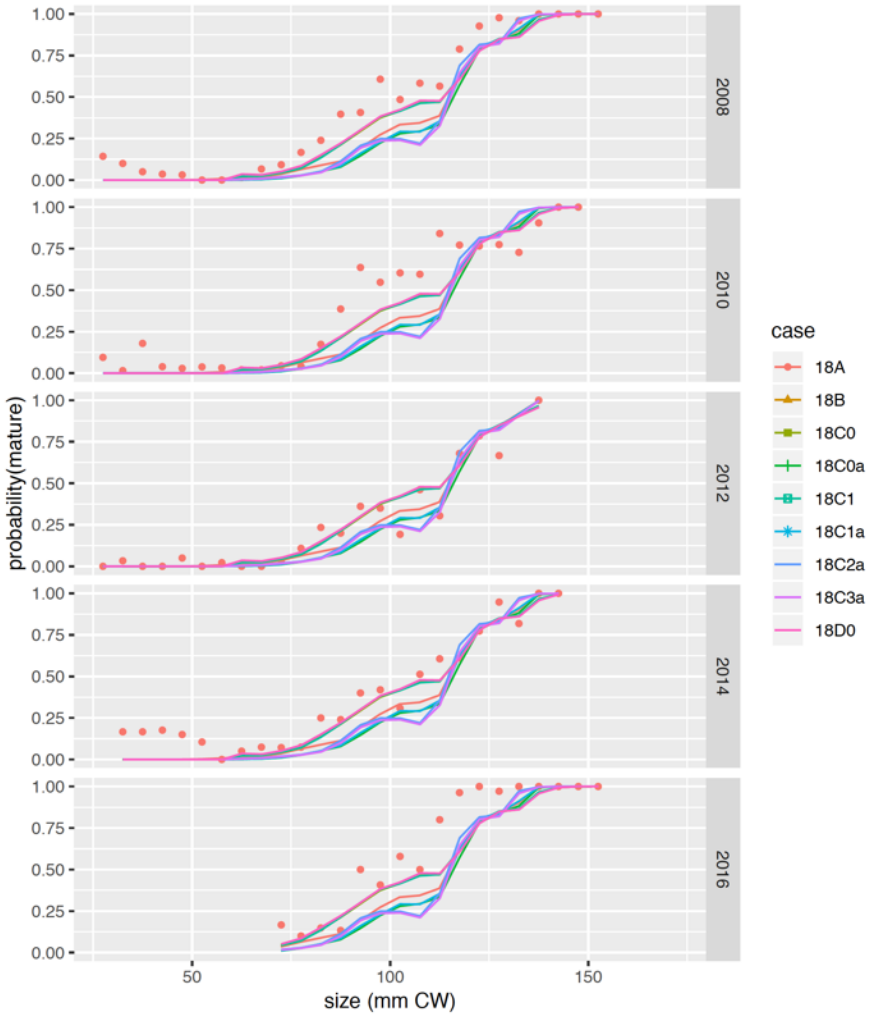
2018 Model Scenario Results: Fits to "Other" Data

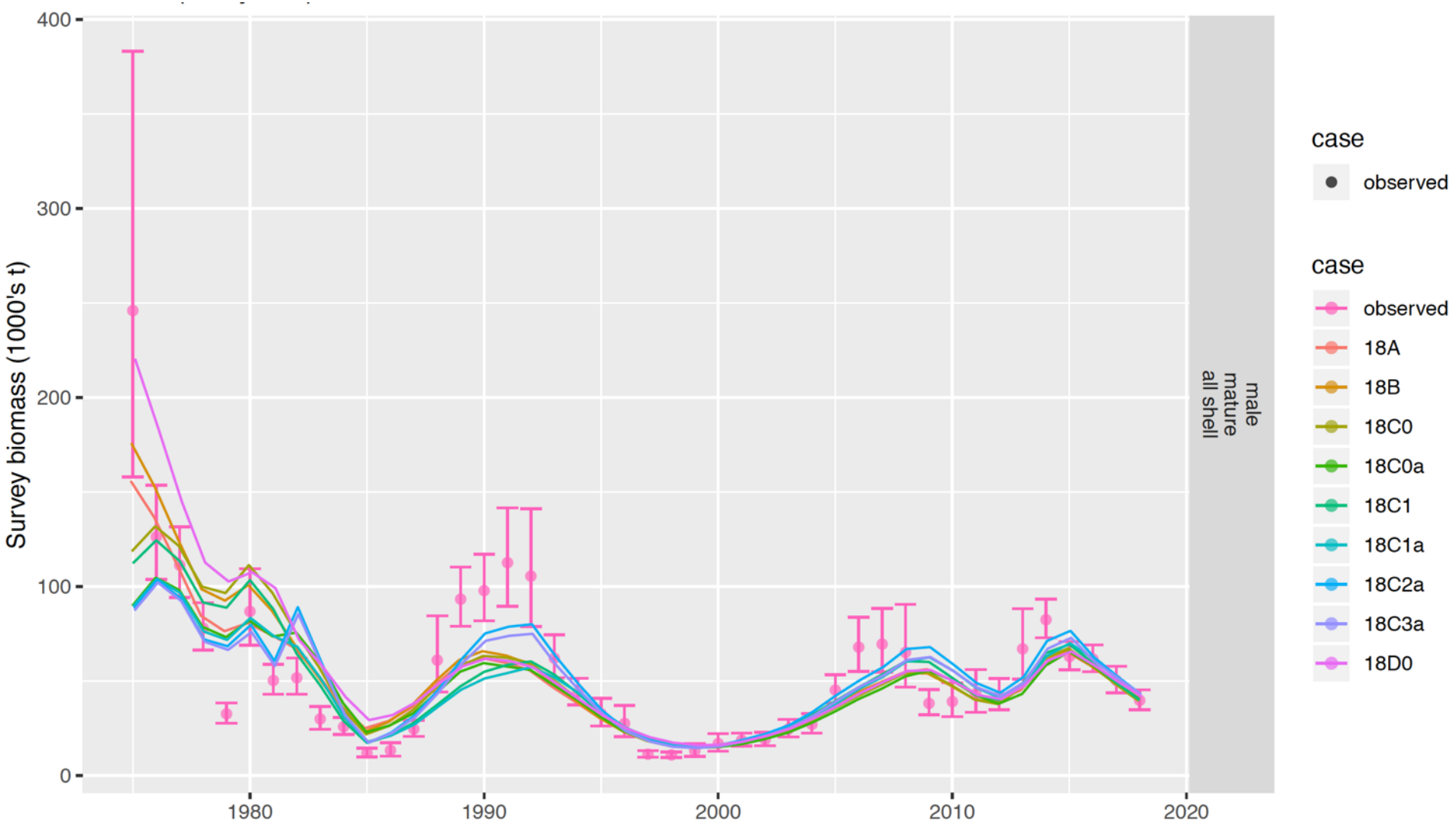
Growth Data



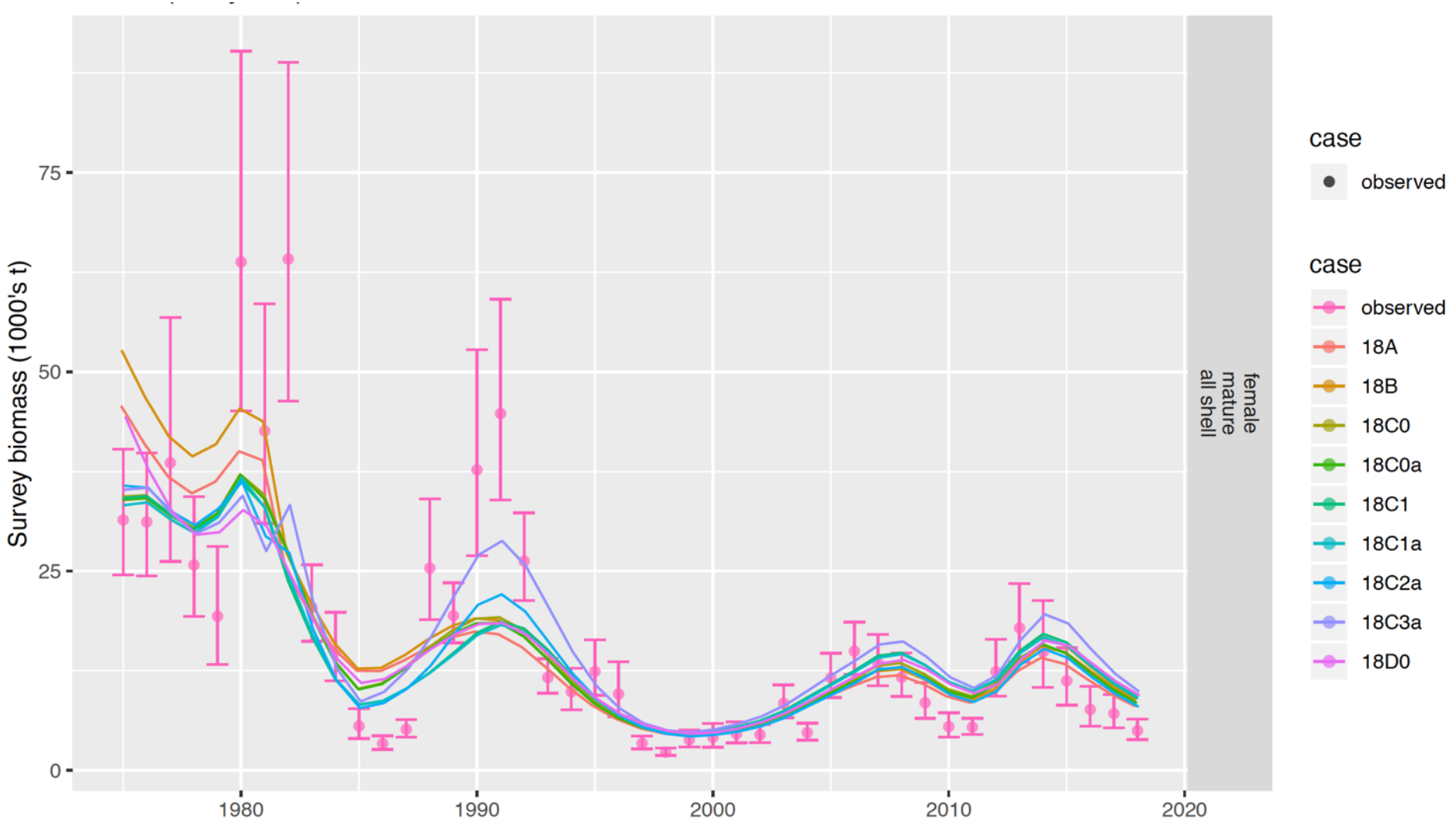
Maturity Ogive Data



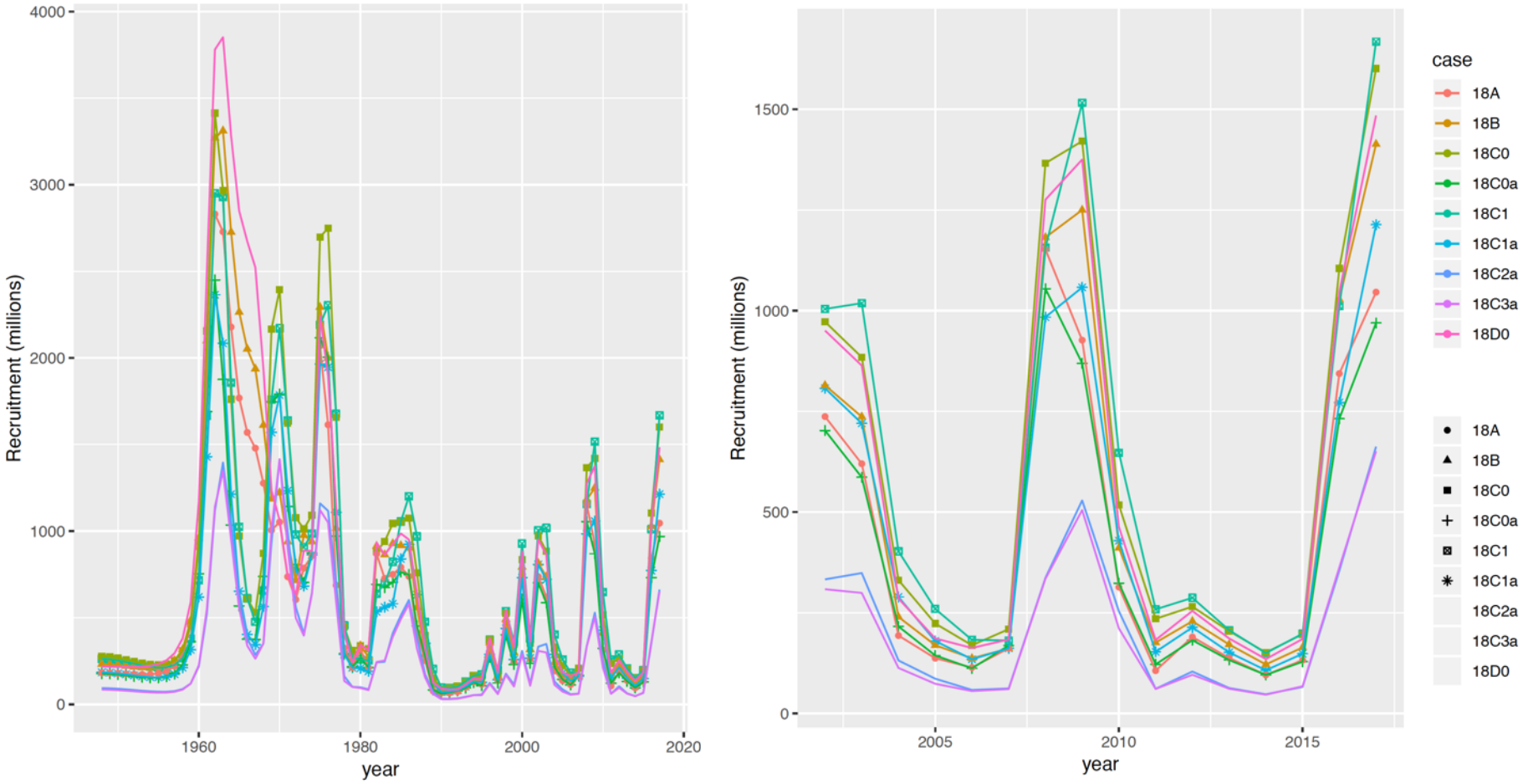
2018 Model Scenario Results: Fits to NMFS Survey Biomass



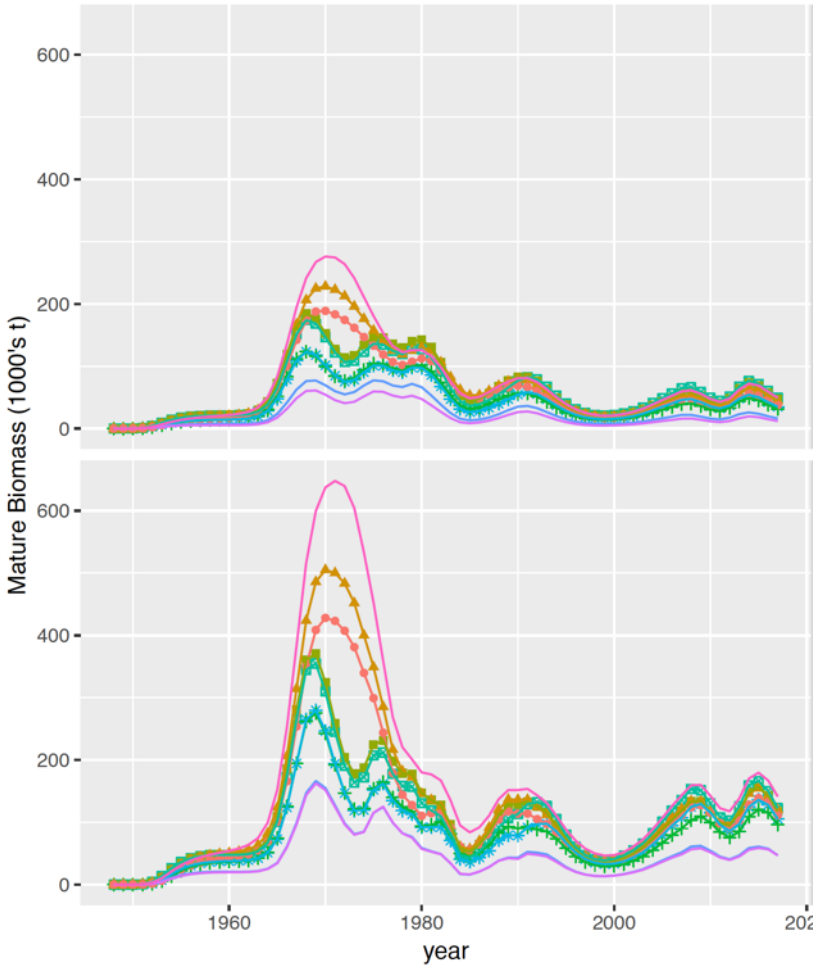
2018 Model Scenario Results: Fits to NMFS Survey Biomass

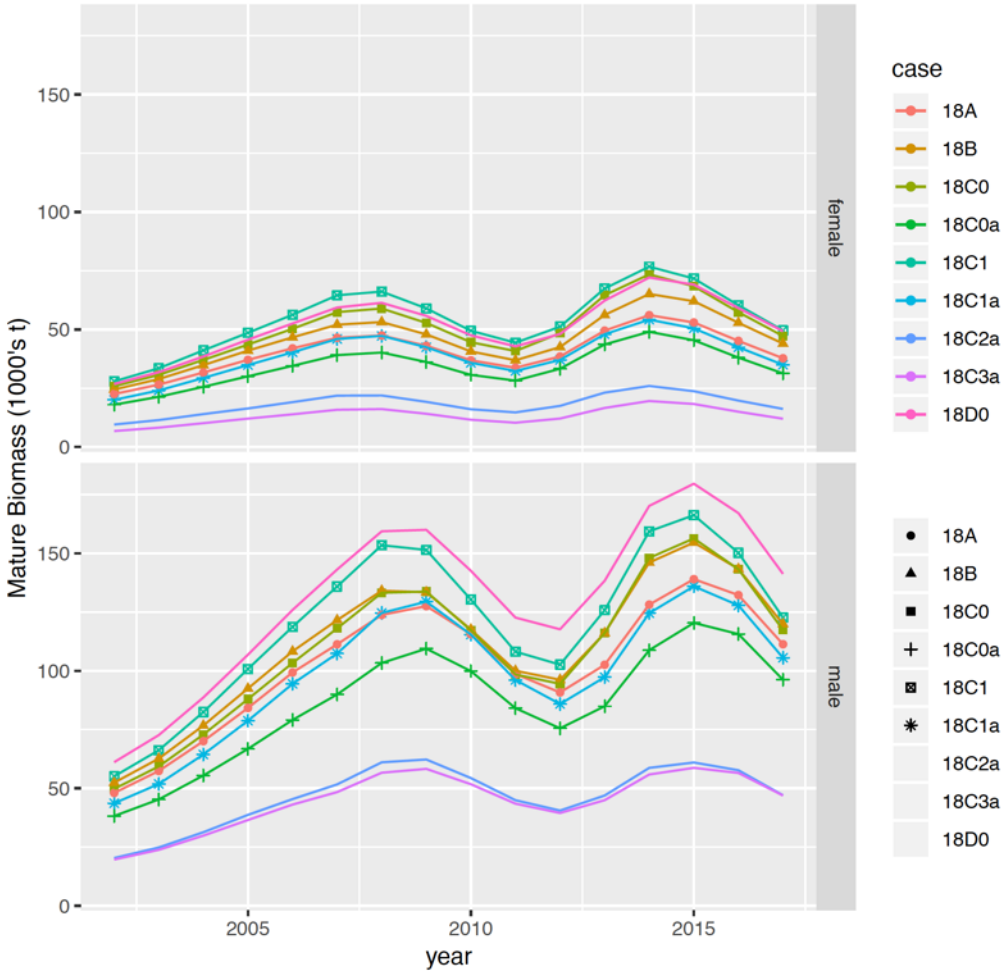


2018 Model Scenario Results: Recruitment

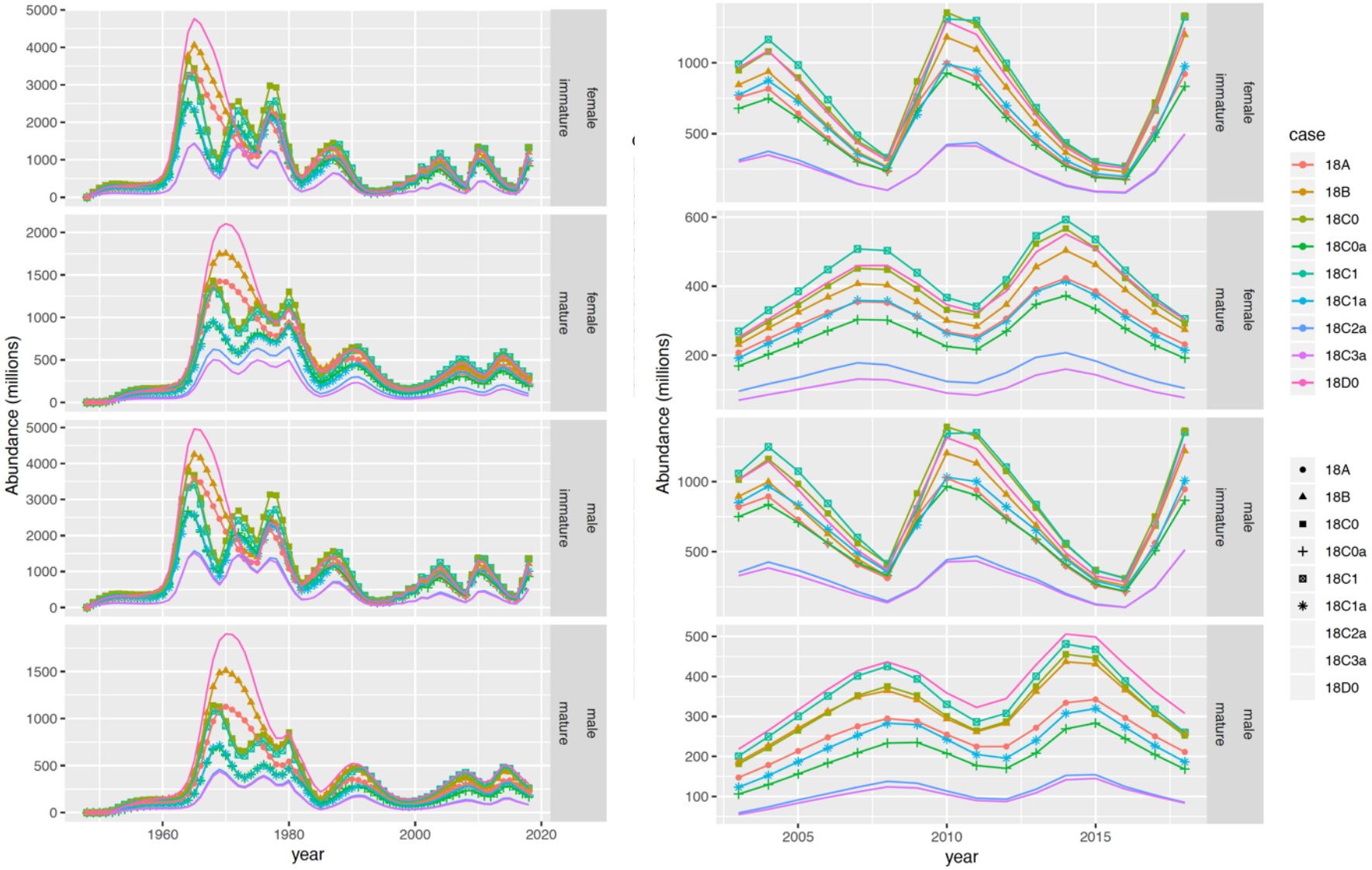


2018 Model Scenario Results: Mature Population Biomass



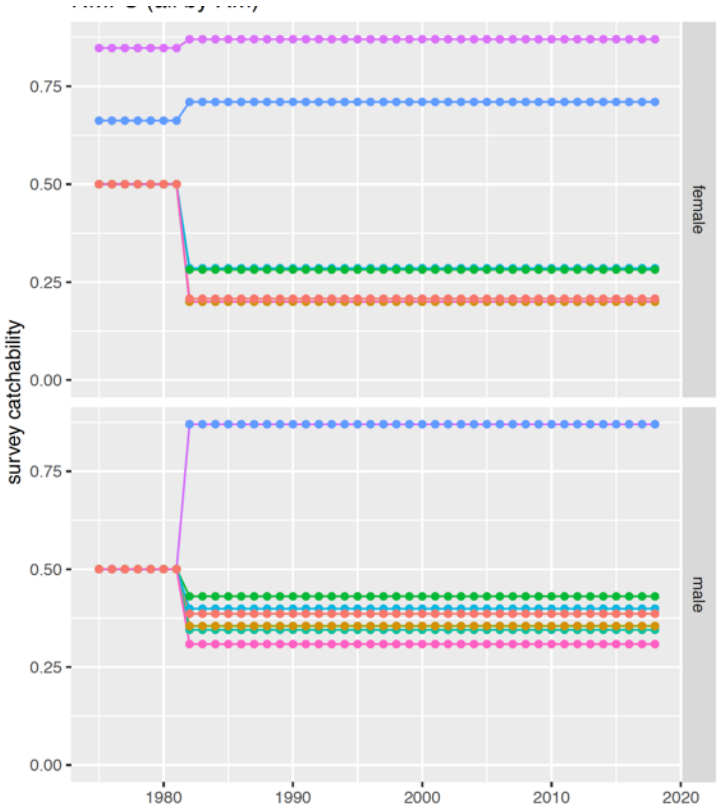


2018 Model Scenario Results: Population Abundance

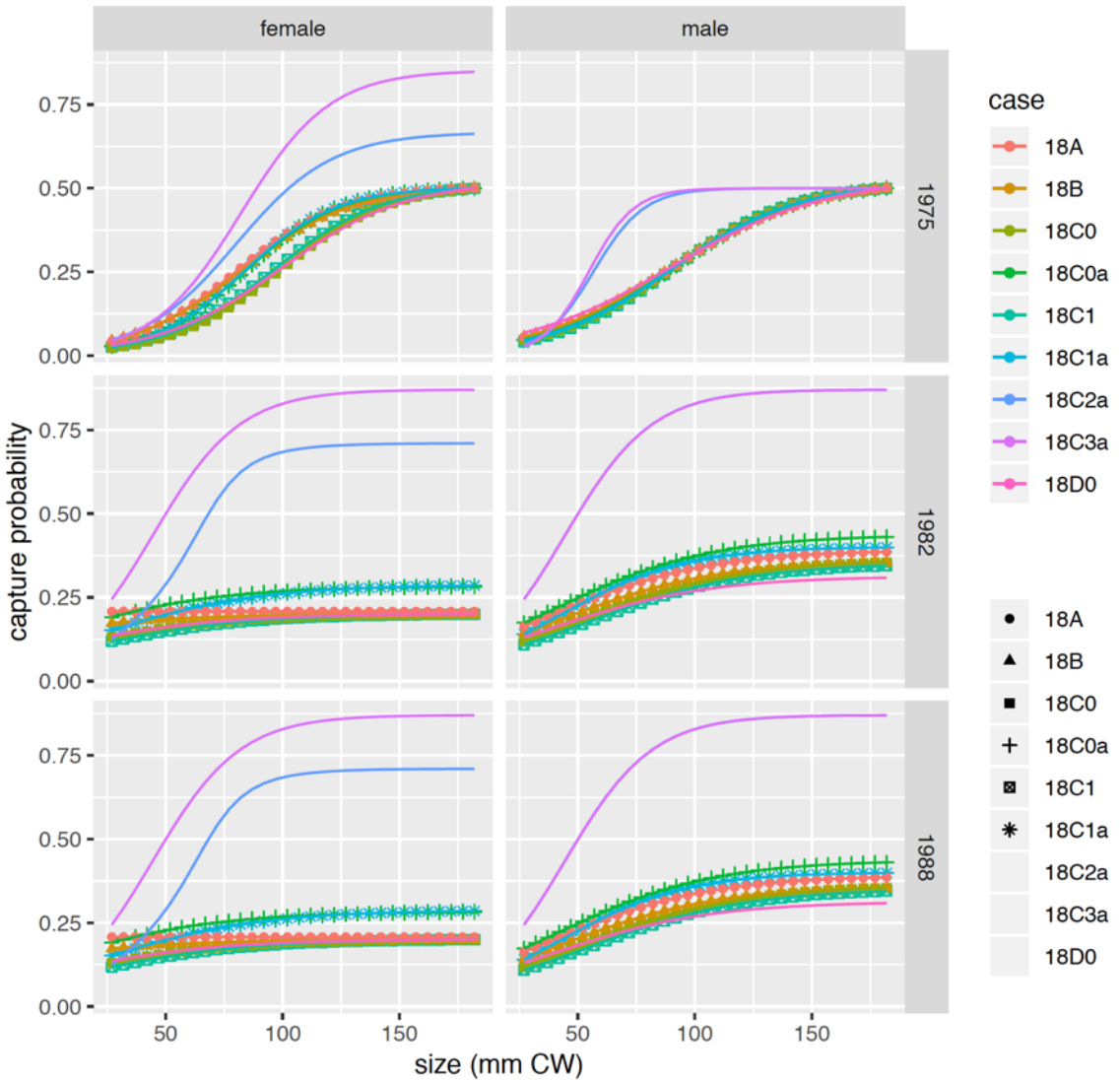


2018 Model Scenario Results: Survey Characteristics

Fully-selected Catchability



Capture Probabilities



Average RMSEs for different fishery data components

catch.type	data.type	fit.type	x	18A	18B	18C0	18C0a	18C1	18C1a	18C2a	18C3a	18D0
total catch	abundance	BY_TOTAL	all sexes	1.19	1.34	1.33	1.18	1.28	1.17	1.27	1.31	1.41
	biomass	BY_TOTAL	all sexes	0.06	0.06	0.06	0.07	0.06	0.07	0.09	0.10	0.06
	n.at.z	BY_XE	female	374.07	370.62	392.96	401.93	386.04	394.18	390.27	378.12	364.70
			male	371.14	318.81	313.14	342.07	313.58	352.02	310.12	313.03	332.45
total catch	abundance	BY_X	female	26.16	24.43	27.50	31.38	30.15	33.22	25.63	243.70	25.37
			male	19.04	18.12	18.30	19.27	18.48	19.34	19.74	19.86	18.31
	biomass	BY_X	female	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01
			male	0.17	0.17	0.17	0.17	0.17	0.17	0.19	0.19	0.17
	n.at.z	BY_X	female	50.27	49.28	50.43	51.18	49.65	49.89	51.16	42.02	53.59
			male	67.04	67.88	67.46	64.88	68.12	66.73	65.41	64.38	69.35
total catch	abundance	BY_X	female	12.21	12.73	12.31	13.38	11.70	12.71	11.12	14.30	12.20
			male	2.71	2.69	2.68	2.70	2.70	2.71	3.01	2.95	2.67
	biomass	BY_X	female	0.09	0.09	0.09	0.08	0.09	0.08	0.05	0.07	0.09
			male	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.07
	n.at.z	BY_X	female	69.38	71.22	69.80	68.30	70.41	69.35	72.79	74.39	69.30
			male	346.62	351.28	341.70	333.22	311.33	309.99	270.11	280.42	361.13
retained catch	abundance	BY_X	female	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			male	3.99	3.98	4.04	4.06	4.06	4.03	4.46	4.50	3.94
	biomass	BY_X	female	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			male	0.19	0.19	0.17	0.19	0.16	0.17	0.24	0.26	0.18
	n.at.z	BY_X	male	527.37	403.22	407.14	537.08	412.10	548.23	463.03	460.23	416.42
total catch	abundance	BY_X	female	70.98	56.84	61.45	74.72	66.15	80.57	58.00	59.75	66.17
			male	1.16	1.09	1.11	1.20	1.12	1.20	1.10	1.09	1.06
	biomass	BY_X	female	0.28	0.28	0.30	0.30	0.31	0.31	0.28	0.28	0.29
			male	0.19	0.18	0.18	0.20	0.18	0.19	0.20	0.20	0.18
	n.at.z	BY_X	female	184.36	185.71	192.13	189.51	199.10	196.16	205.96	201.38	187.44
			male	346.02	413.43	410.06	337.85	405.06	334.33	317.20	309.97	406.67

Average RMSEs for different survey data components

fleet	catch.type	data.type	fit.type	x	18A	18B	18C0	18C0a	18C1	18C1a	18C2a	18C3a	18D0
NMFS (all by XM)	index catch	abundance	BY_XM	female	2.93	2.99	2.74	2.76	2.46	2.48	2.44	2.67	2.79
				male	3.05	3.13	3.05	3.15	2.65	2.78	2.55	2.68	3.32
		biomass	BY_X_MATONLY	female	2.37	2.43	2.28	2.25	2.30	2.29	2.03	2.37	2.42
				male	2.42	2.47	2.56	2.48	2.40	2.41	2.11	2.06	2.88
		n.at.z	BY_XME	female	425.44	400.73	400.38	403.24	317.22	335.14	414.03	226.70	370.93
				male	456.14	520.94	513.95	393.65	495.45	388.14	323.05	324.67	518.19
NMFS (females by XM)	index catch	abundance	BY_X	female	3.02	3.01	2.72	2.78	2.36	2.40	2.47	2.49	2.75
				male	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		biomass	BY_X	female	2.48	2.50	2.30	2.31	2.22	2.23	2.05	2.26	2.40
				male	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		n.at.z	BY_X_ME	female	172.54	170.56	220.98	229.80	148.23	160.05	191.31	119.83	191.30
NMFS (females by XMS)	index catch	abundance	BY_X	female	3.02	3.01	2.72	2.78	2.36	2.40	2.47	2.49	2.75
				male	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		biomass	BY_X	female	2.48	2.50	2.30	2.31	2.22	2.23	2.05	2.26	2.40
				male	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		n.at.z	BY_XM_SE	female	174.26	177.28	208.97	211.05	186.43	198.27	203.21	145.63	177.33
NMFS (males by X)	index catch	abundance	BY_X	female	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				male	3.48	3.48	3.38	3.39	2.76	2.82	2.77	2.86	3.51
		biomass	BY_X	female	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				male	2.57	2.58	2.67	2.62	2.38	2.42	2.25	2.18	2.85
		n.at.z	BY_X	male	203.11	189.35	191.12	201.79	189.09	193.18	159.00	154.78	191.06
NMFS (males by XS)	index catch	abundance	BY_X	female	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				male	3.48	3.48	3.38	3.39	2.76	2.82	2.77	2.86	3.51
		biomass	BY_X	female	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				male	2.57	2.58	2.67	2.62	2.38	2.42	2.25	2.18	2.85
		n.at.z	BY_X_SE	male	254.38	284.67	328.50	234.20	326.16	248.80	225.49	210.51	251.80

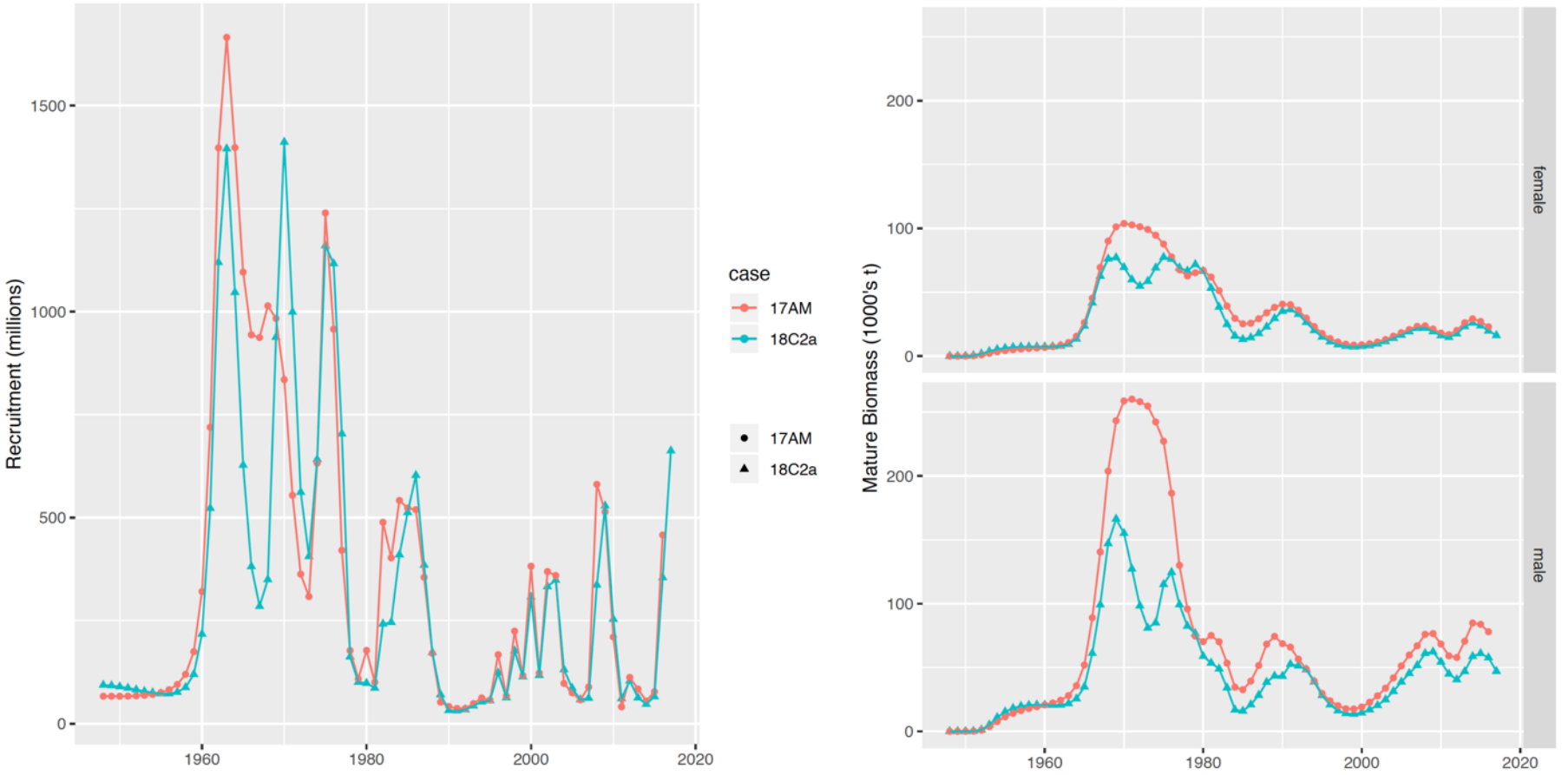
- "fleet" = dataset
- X = sex, M = maturity state, S = shell condition

Author's Preferred Model: 18C2a—best of the not very good?

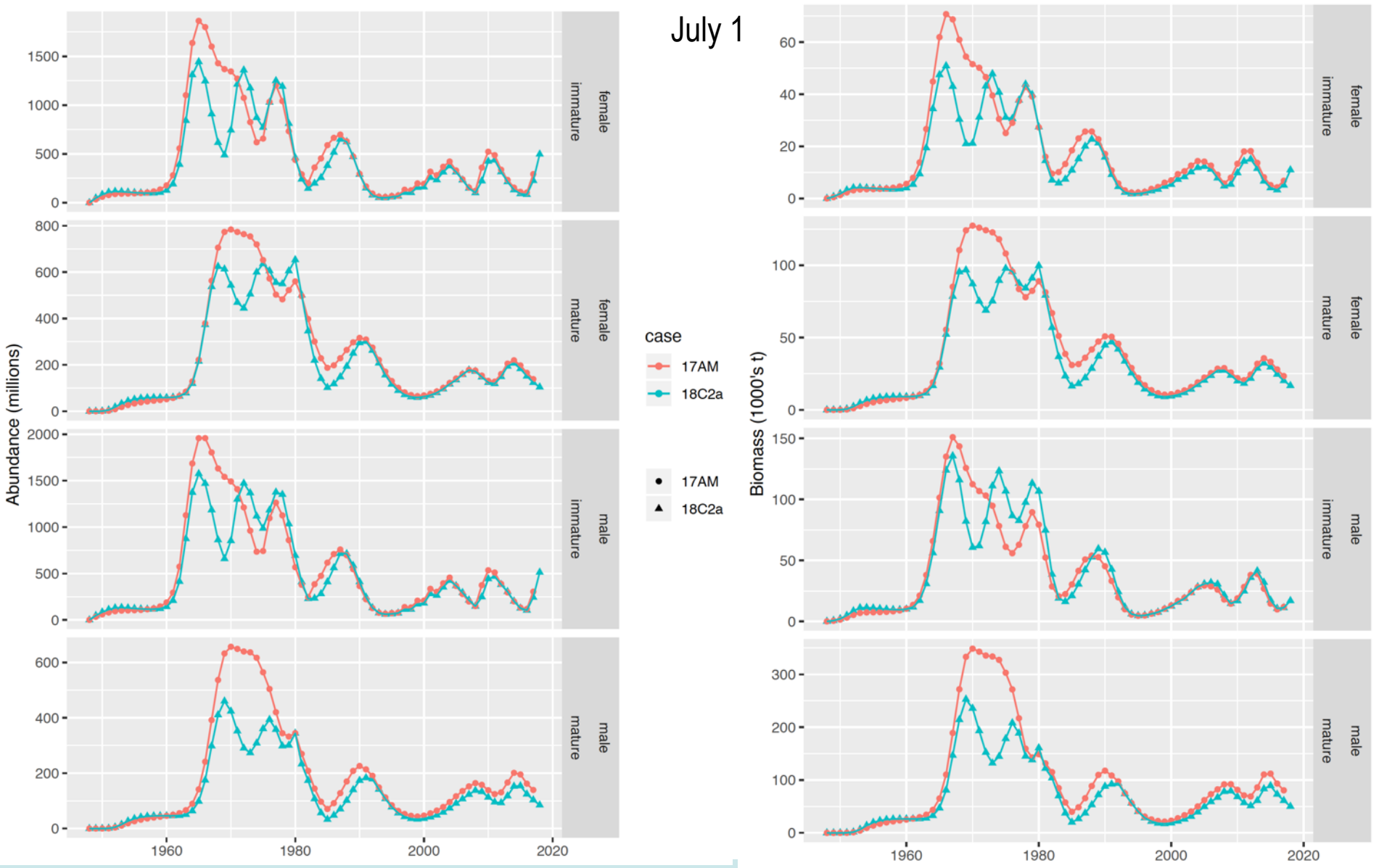
- Fixes NMFS trawl survey catchability and selectivity based on Somerton and Otto (1999) "underbag" experiment
  - BSFRF SBS data provides some support for this
- Provides reasonable fits to data
- Provides most reasonable characterization of stock productivity
- Fits to most dis-aggregated datasets
  - male survey size compositions fit by shell condition
  - female survey size compositions fit by maturity state and shell condition

Author's Preferred Model: Comparison with 17AM

Feb. 15



Author's Preferred Model: Comparison with 17AM



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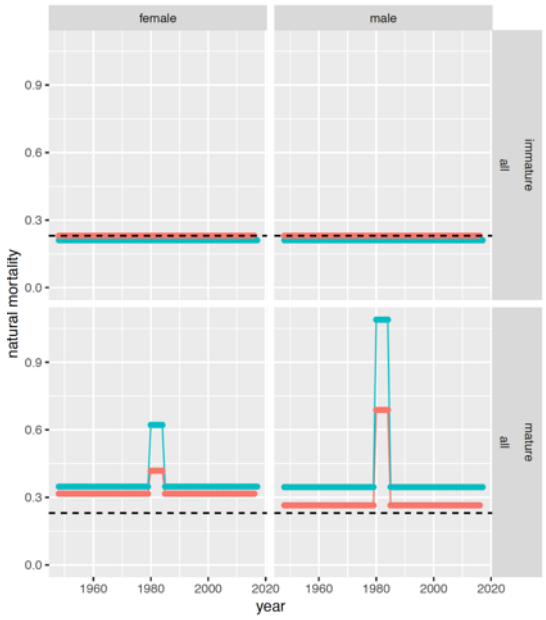
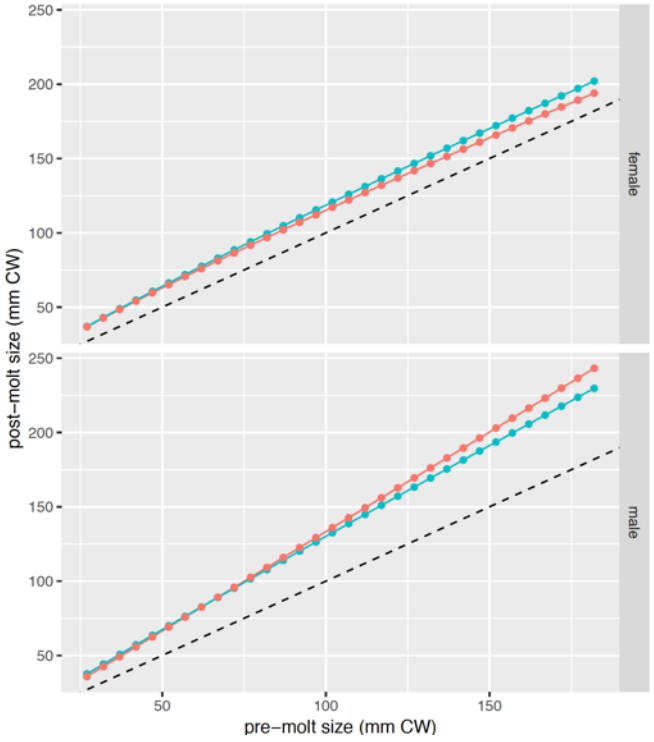
Author's Preferred Model: Comparison with 17AM

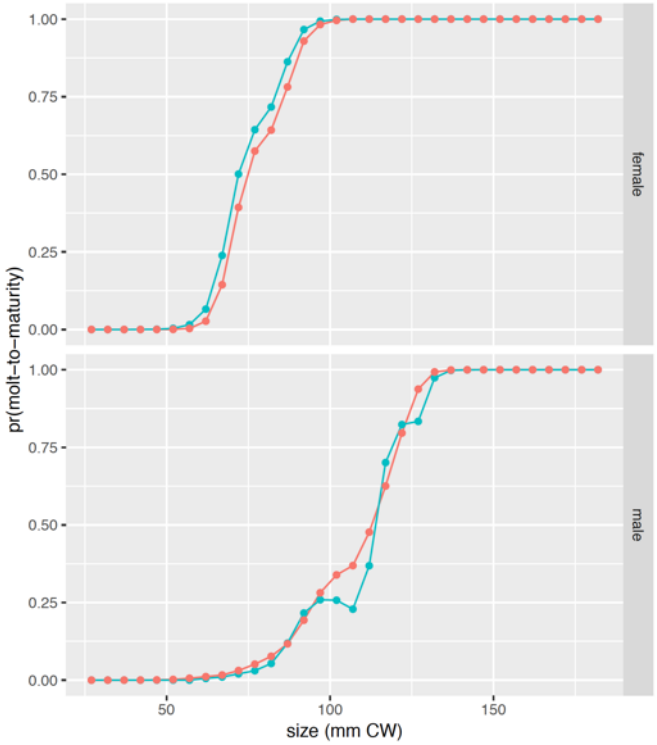
natural mortality



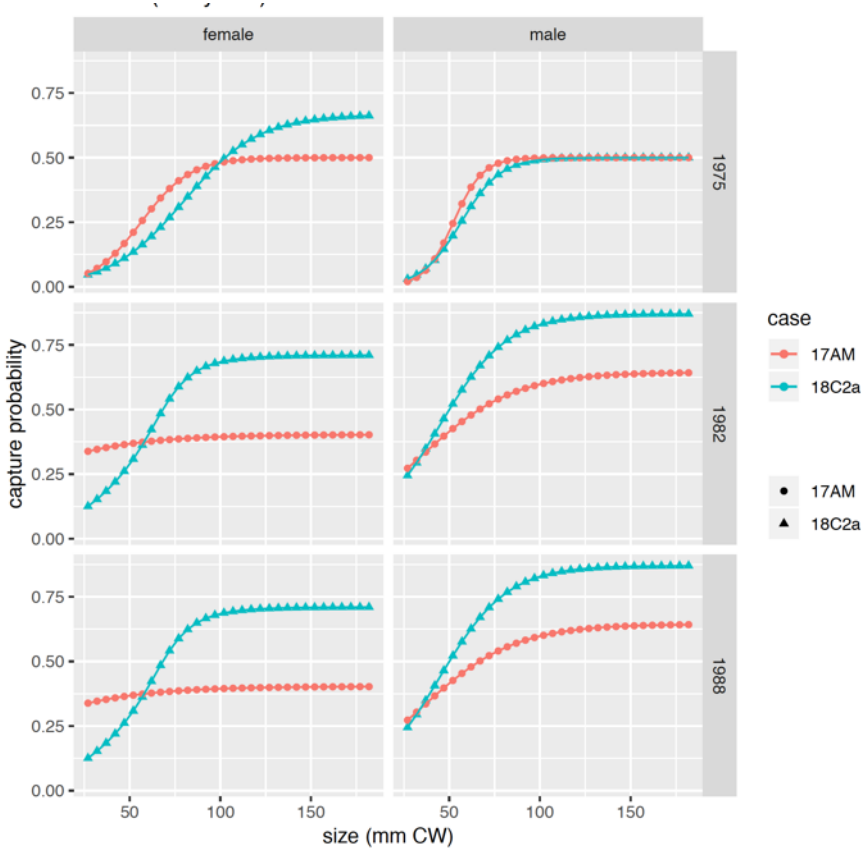
growth

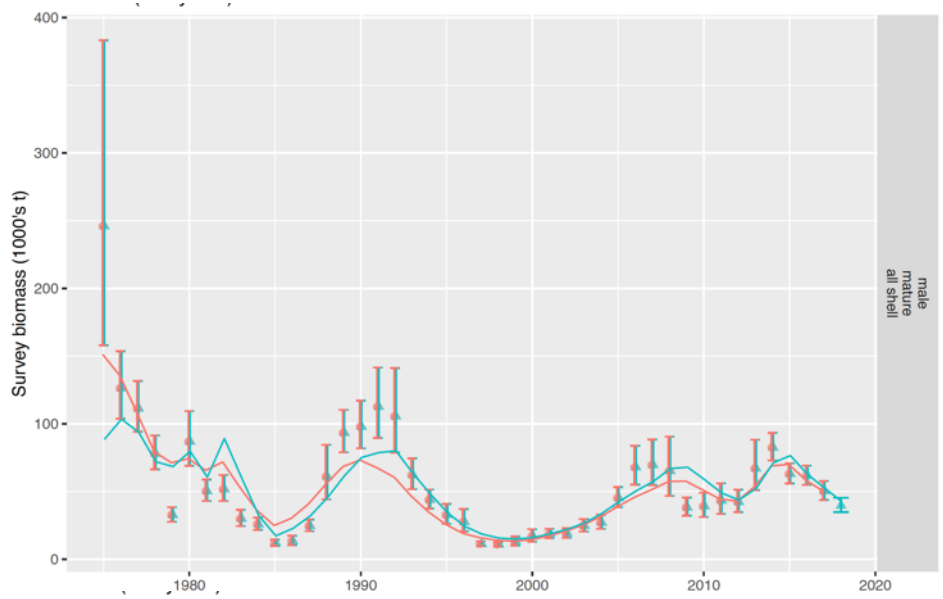


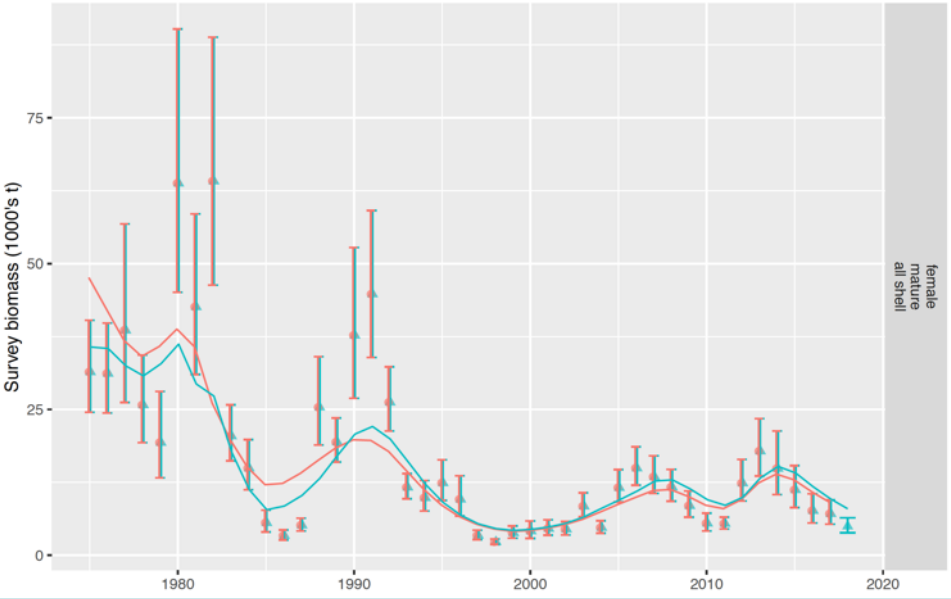
Pr(terminal molt | size)



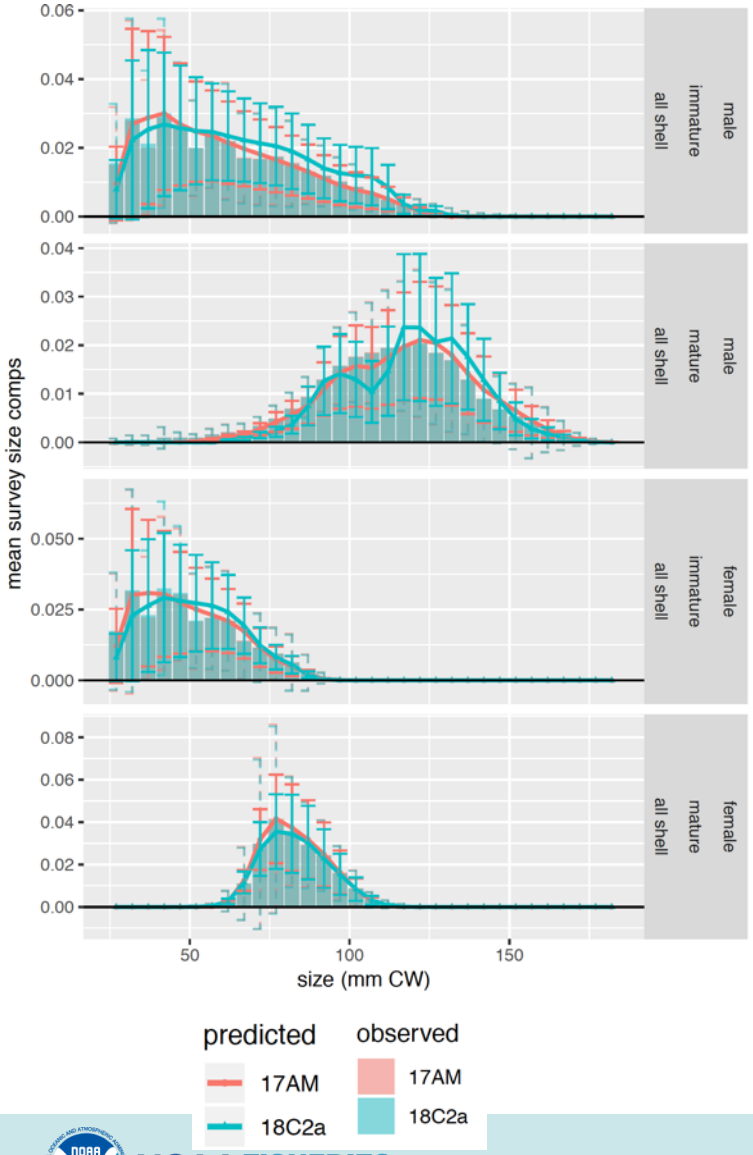
Author's Preferred Model: Comparison with 17AM

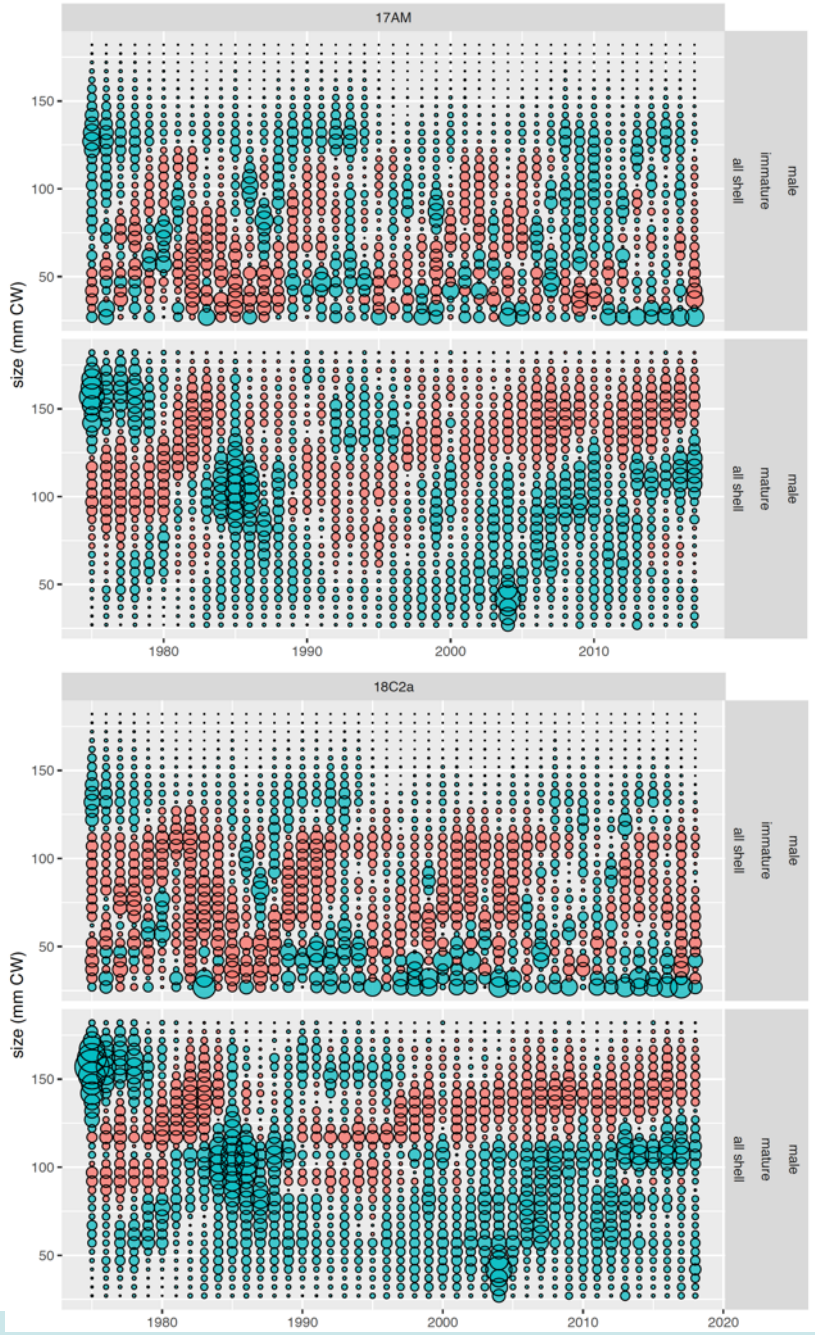




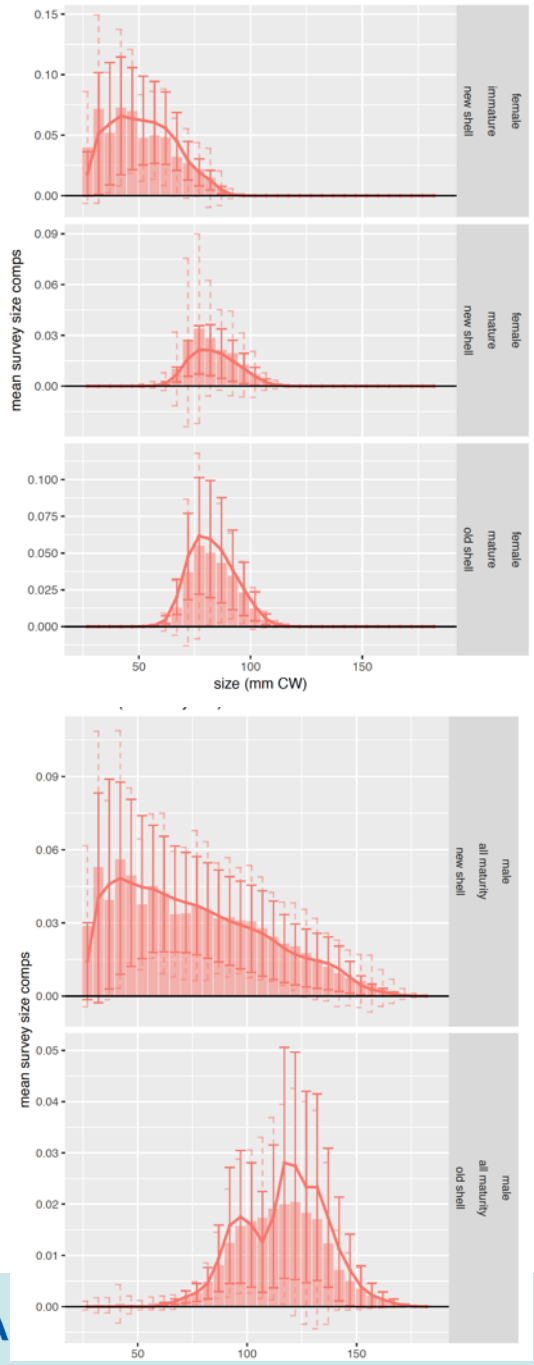


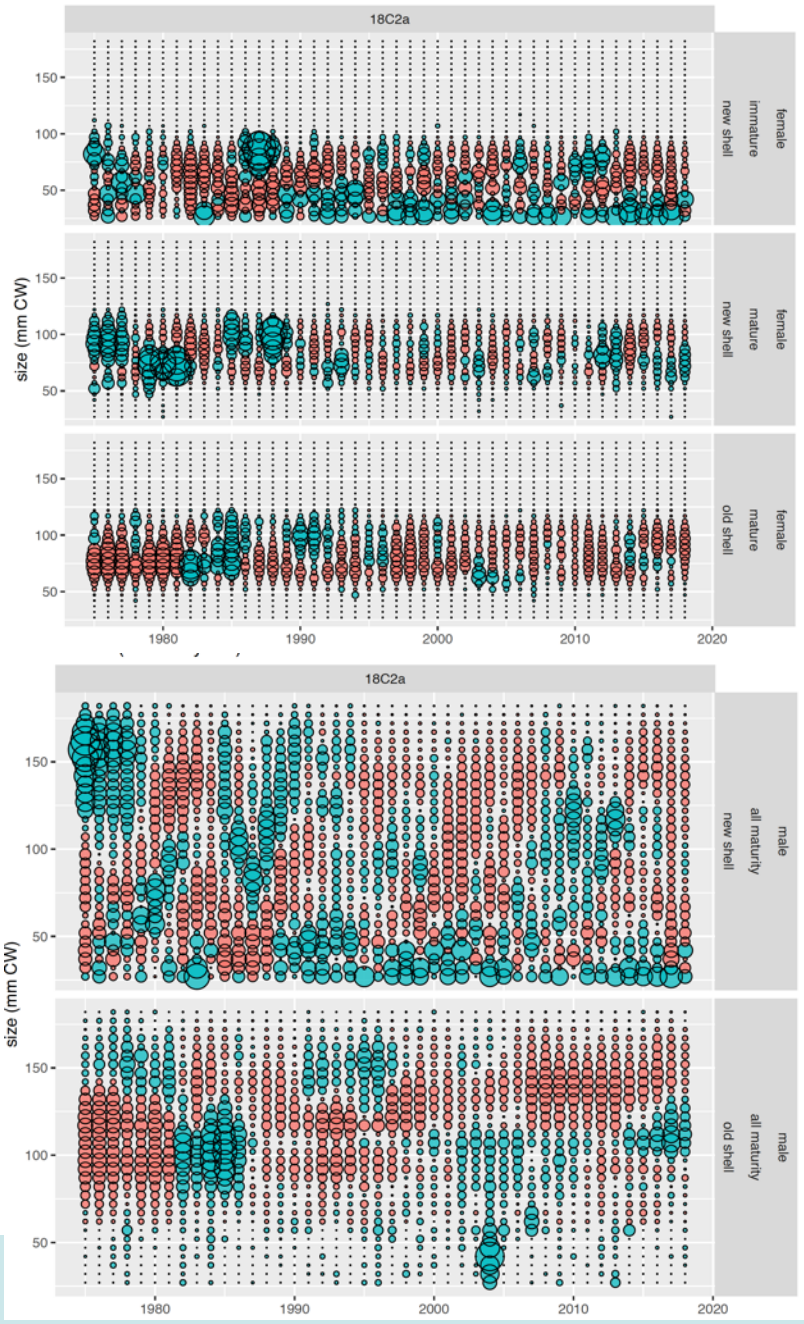
Author's Preferred Model: Comparison with 17AM





NOAA FISHERIES

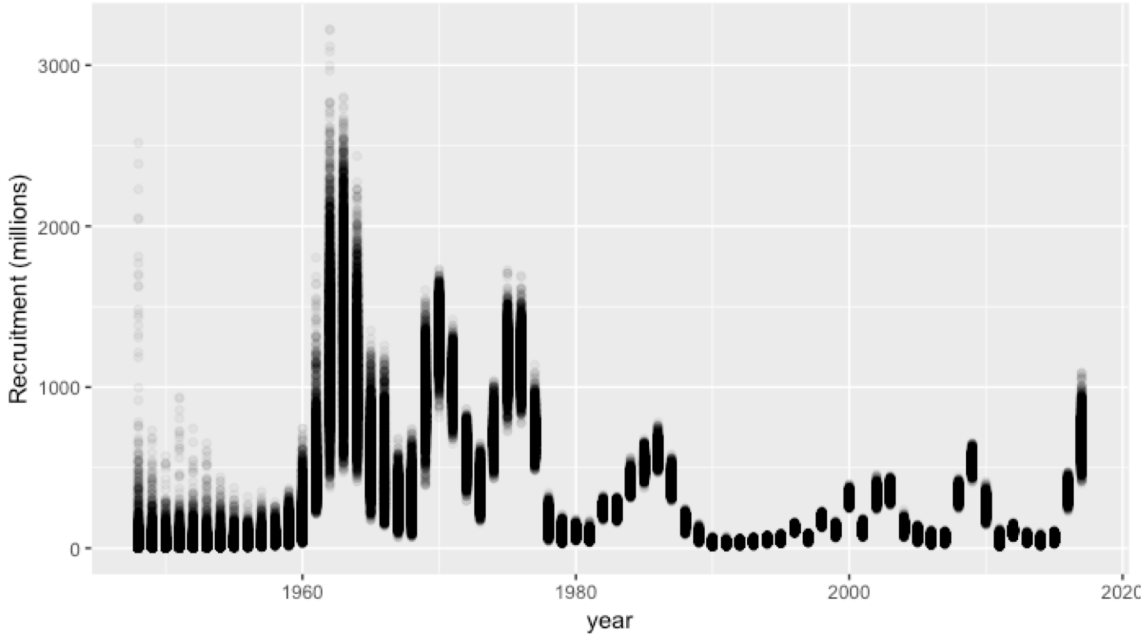

mean survey size comps
size (mm CW)
female immature new shell
female mature new shell
female mature old shell
male all maturity new shell
male all maturity old shell

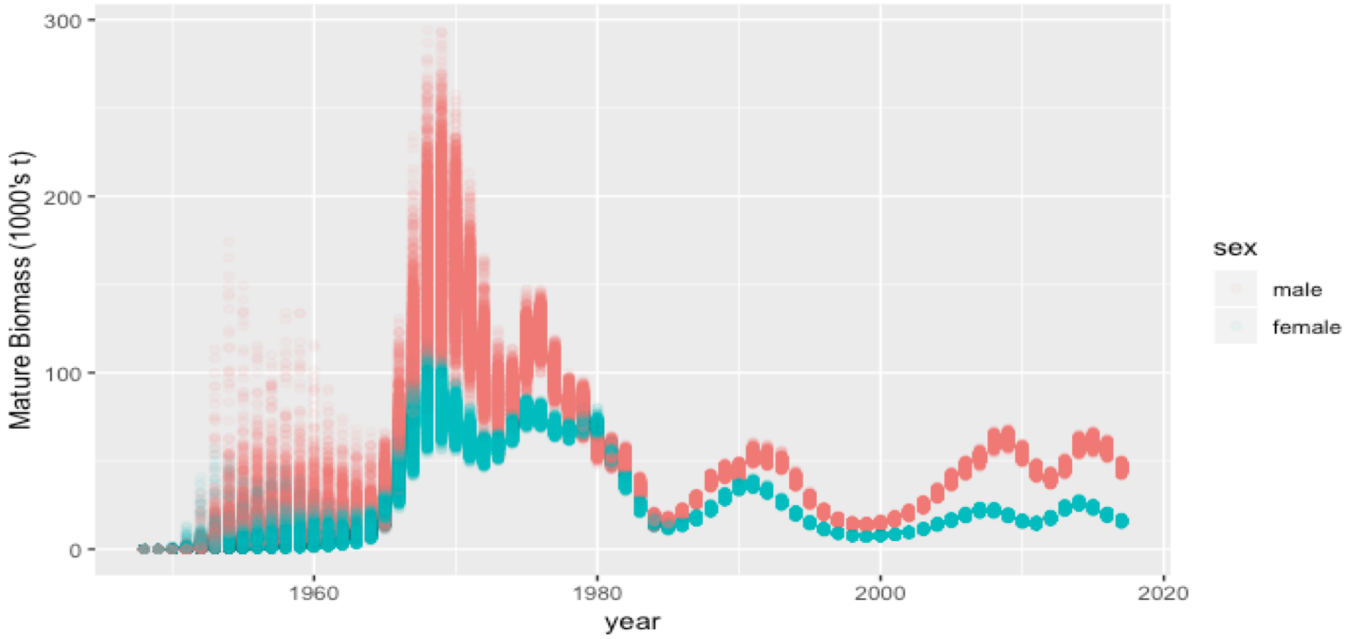

18C2a
size (mm CW)
female immature new shell
female mature new shell
female mature old shell
male all maturity new shell
male all maturity old shell


sign
<0
>0
val
0.0
2.5
5.0
7.5

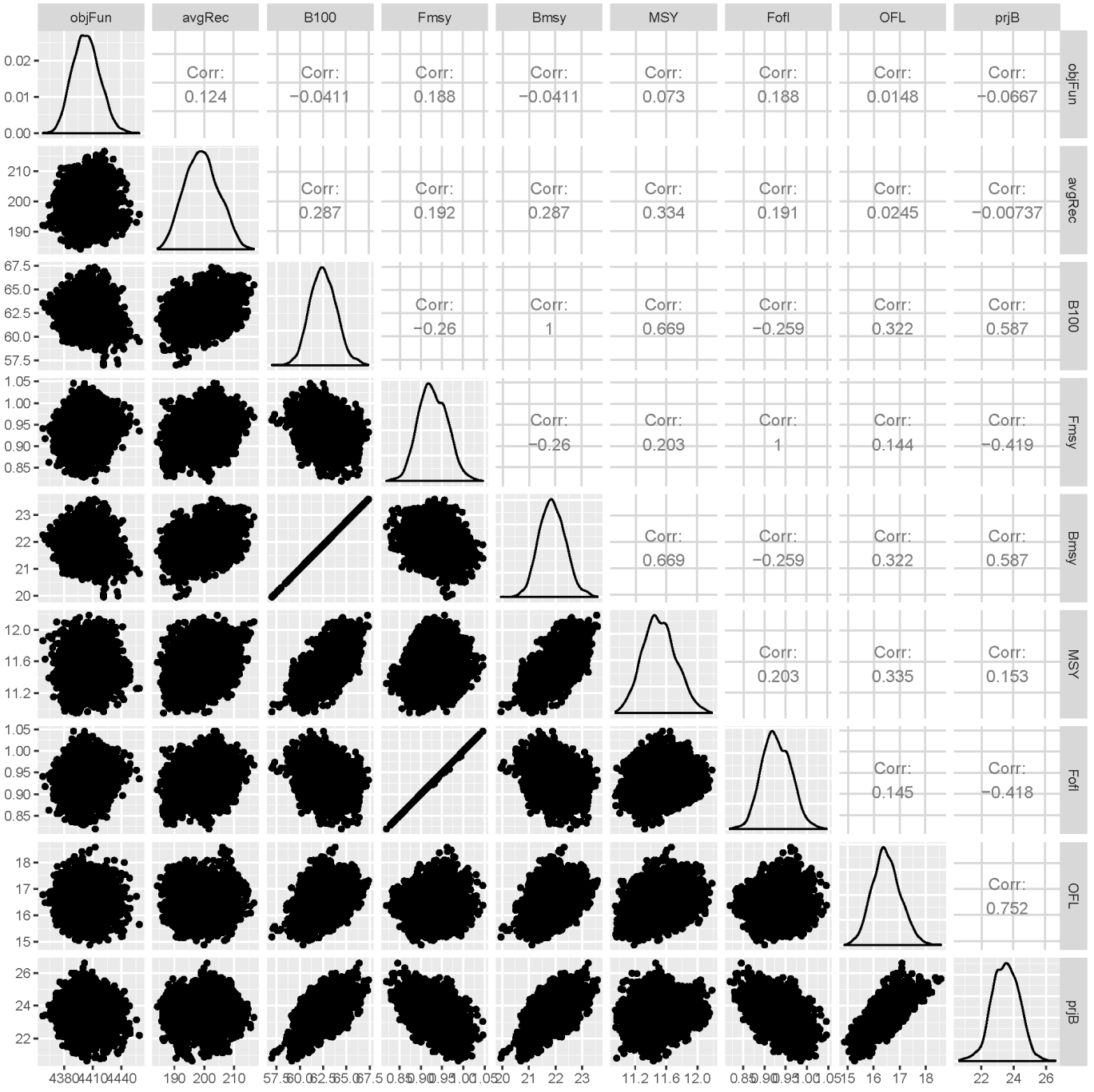
NOAA

Author's Preferred Model: MCMC Results





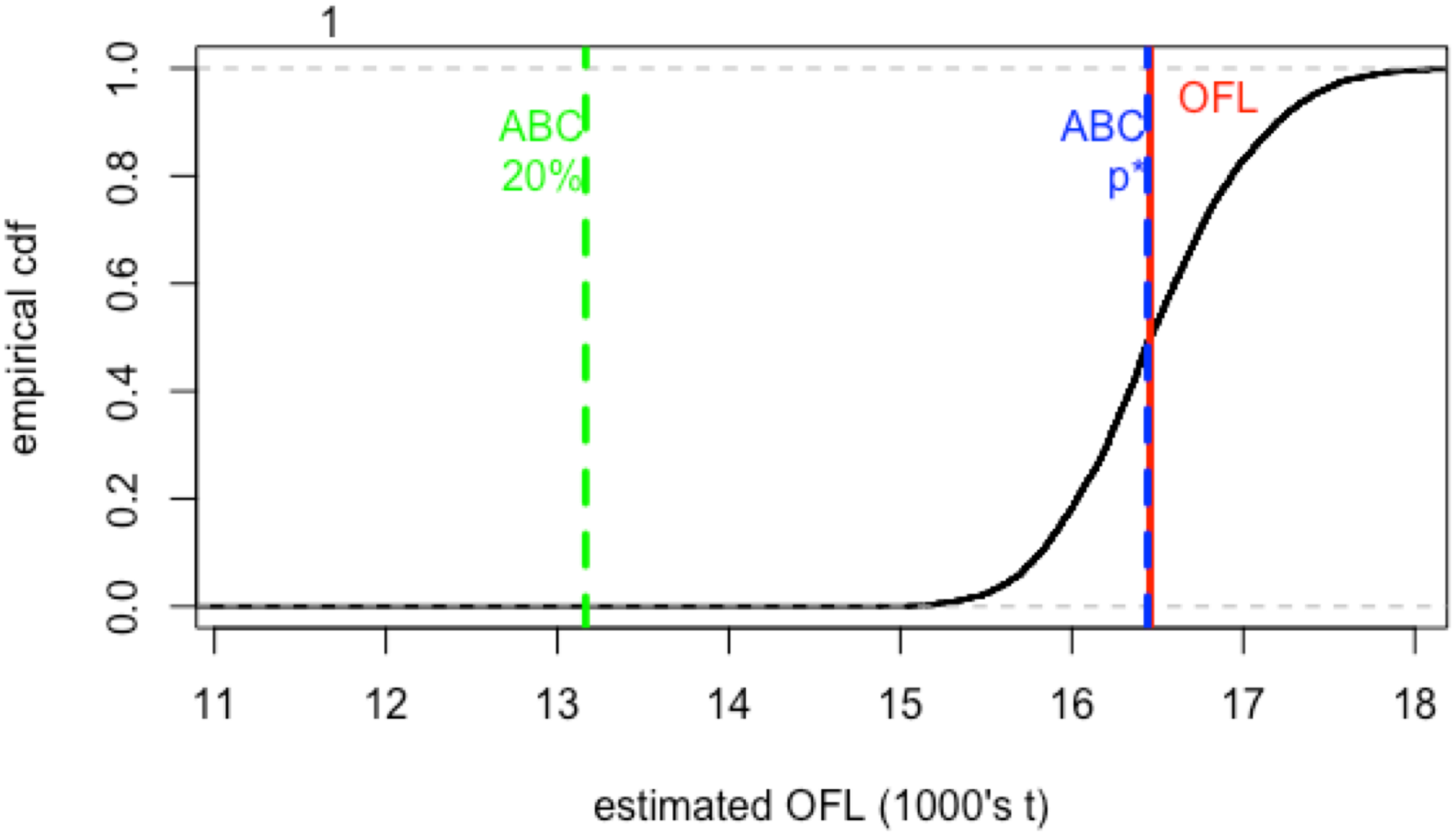
Status Determination & OFL Calculations



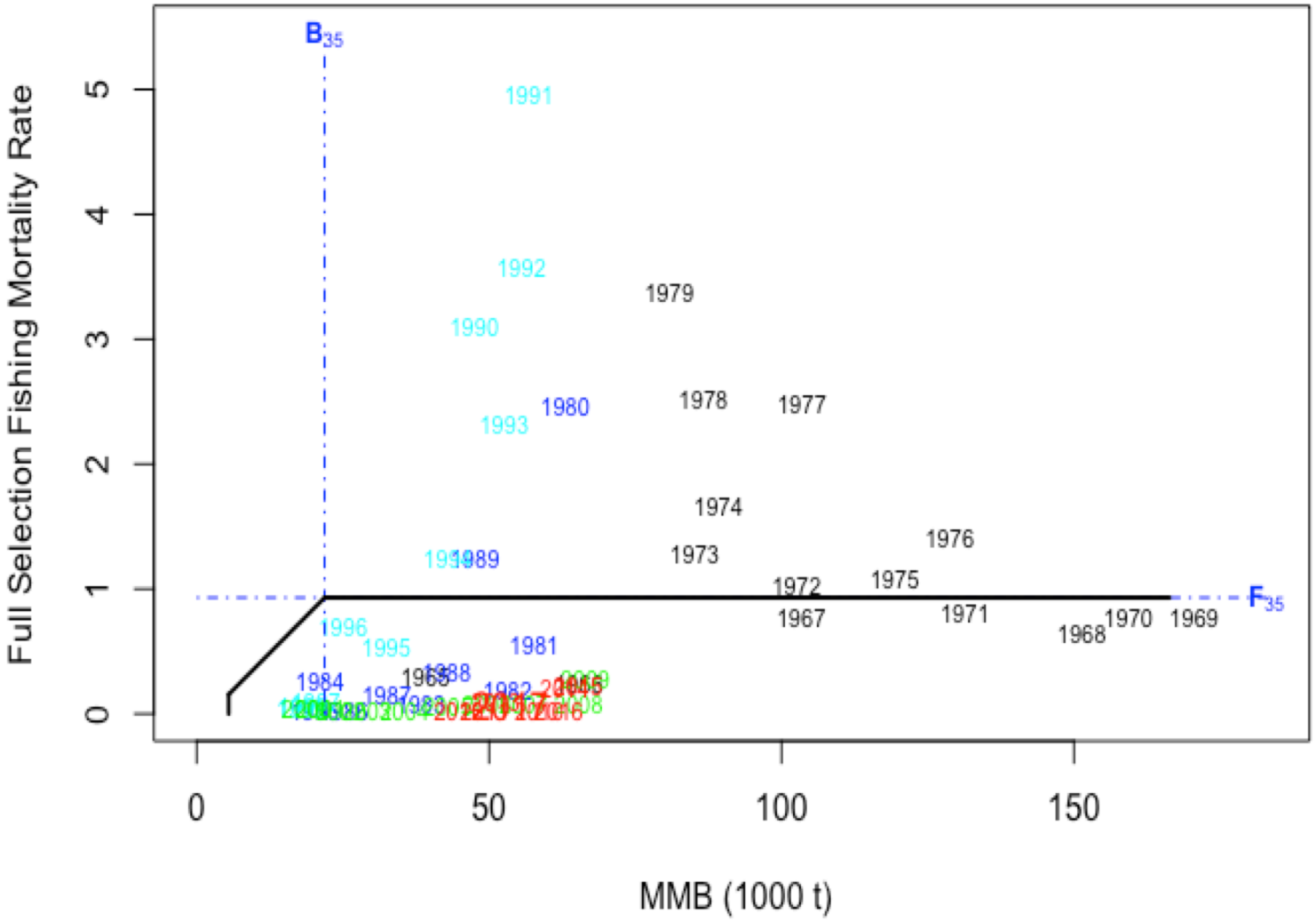
NOAA FISHERIES

Status Determination & OFL Calculation

- F_{MSY} = 0.93 yr^{-1}
- mean recruitment = 199 million
- B_{MSY} = 21.87 thousand t
- 2018/19 MMB-at-mating = 23.53 thousand t
- B/B_{MSY} = 1.08
- Tier = 3a



Quad (Kobe) plot



Management Reference Points

Not overfished
No overfishing

Basis for the OFL

(a) in 1000's t.

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
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	77.96 [A]	0.00	0.00	1.14	25.61	20.49
2017/18	10.93[C]	43.31[A]	1.13	1.13	2.39[C]	25.42	20.33
2018/19		23.53[B,C]				16.76[C]	13.41[C]

Management Performance

a) in 1000's t.

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})
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	47.04	1.49	0.75	1982-2017	0.23
2018/19	3a	21.87	23.53	1.08	0.93	1982-2018	0.23

Future Directions

- incorporate BSFRF SBS index survey data
- develop more extensive MCMC diagnostics
- go back to basics (again): build model from ground up
  - explore M / growth / maturity covariation
  - explore size-dependent M
- determine appropriate likelihood weightings for growth, male maturity data
- start building Gmacs Tanner crab model
- disaggregate East/West directed fisheries in model