2019 Tanner Crab Stock Assessment

William Stockhausen

AFSC/NMFS/NOAA

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Overview

- Directed fishery closed in eastern management area
- TAC: 1,106 t. Retained catch: 1,107 t
- NMFS EBS survey results
  - mature male biomass: 20,100 t (-50%)   immature male biomass: 8,540 t (+16%)
  - mature female biomass: 4,800 t (-2%)   immature female biomass: 4,900 t (-2%)

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2015/16	12.82	73.93	8.92	8.91	11.38	27.19	21.75
2016/17	14.58	77.96	0.00	0.00	1.14	25.61	20.49
2017/18	15.15	64.09	1.13	1.13	2.37	25.42	20.33
2018/19	20.54	82.61	1.11	1.11	1.90	20.87	16.70
2019/20		39.55				28.86	23.09

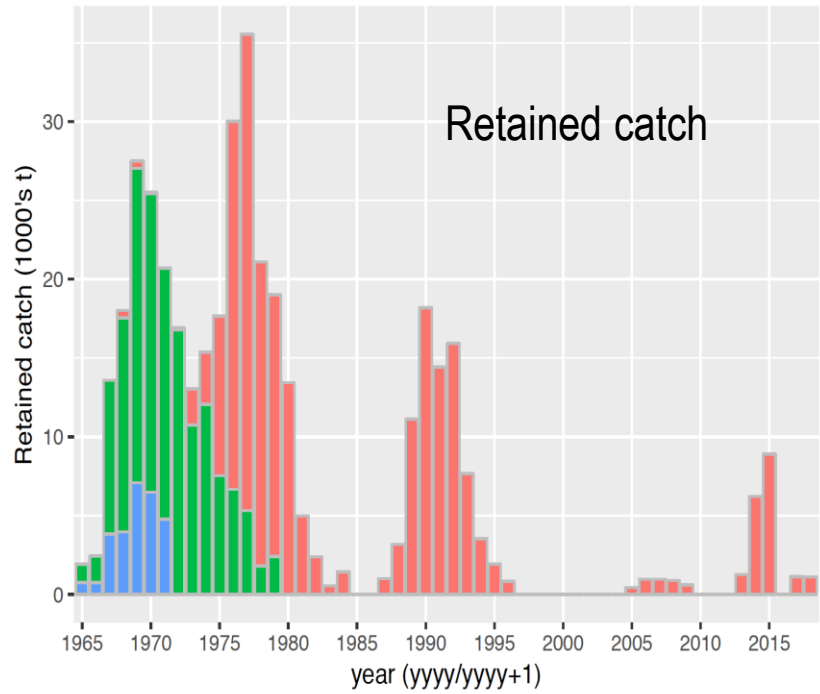- Stock in Tier 3**b.**   • Not overfished. Overfishing did not occur.

Fishery Trends

Management Regions

Fishery trends
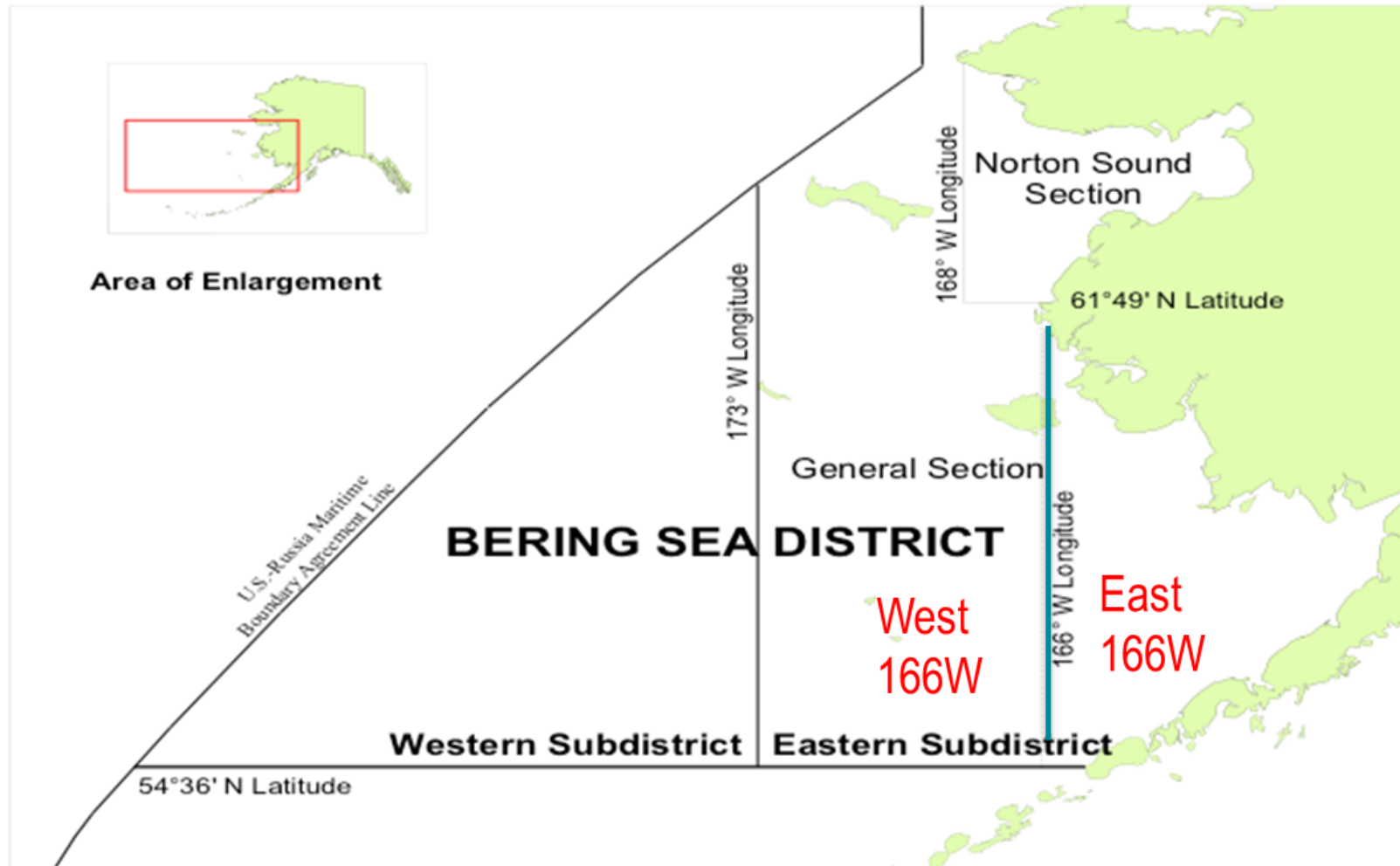
Retained catch
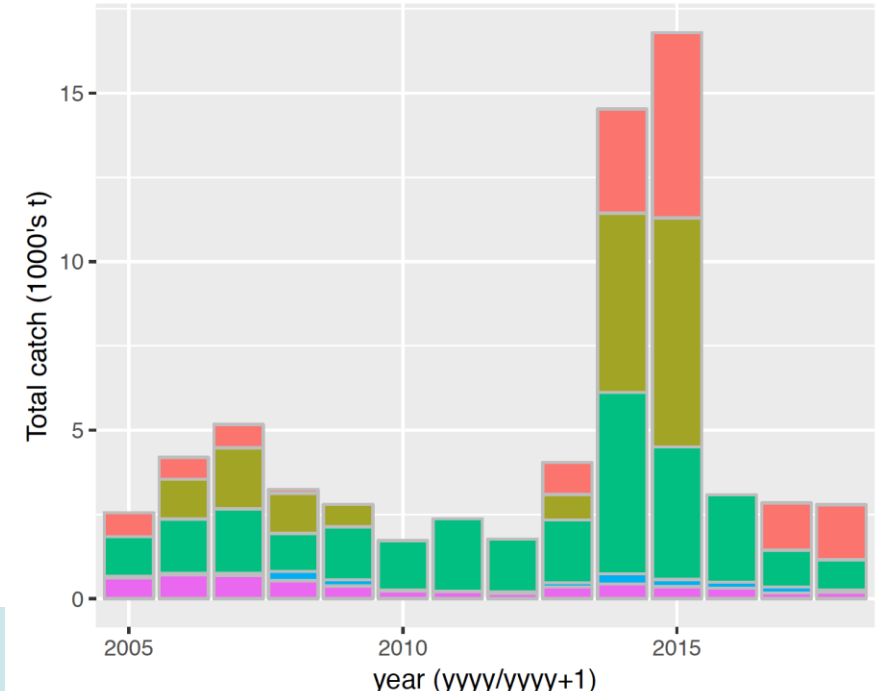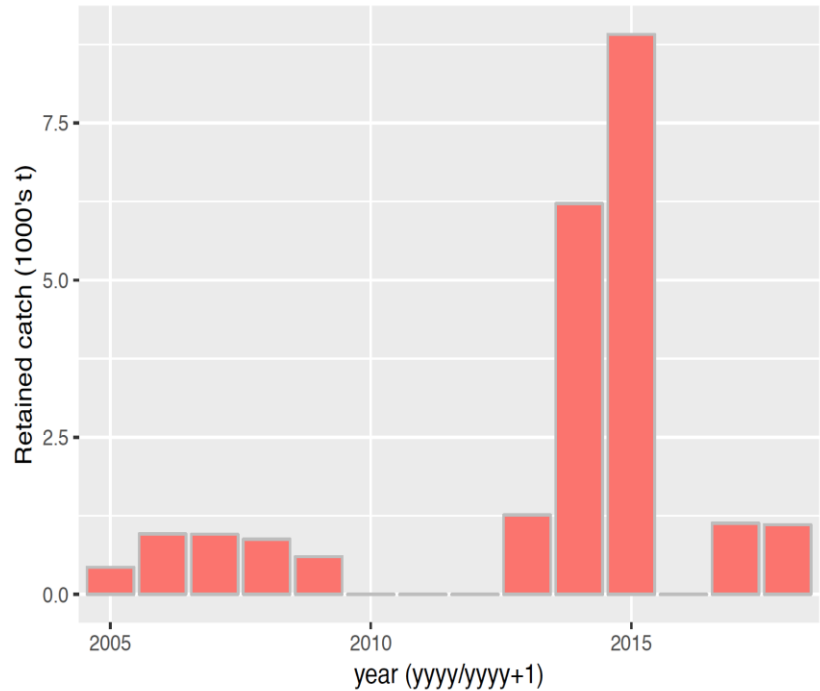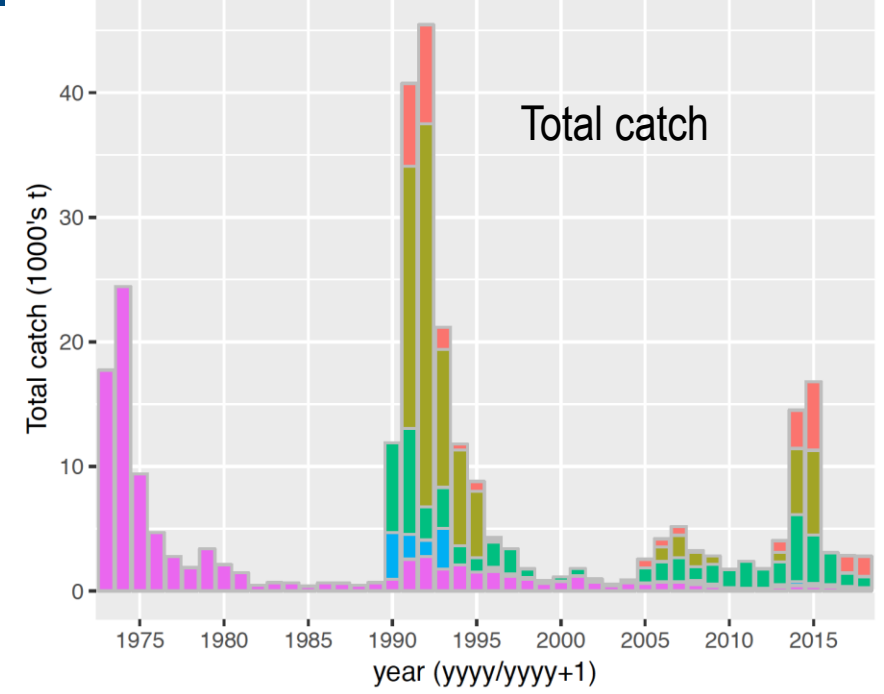
Total catch

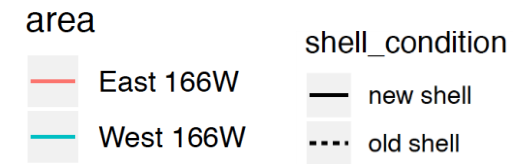# Bycatch in the groundfish fisheries
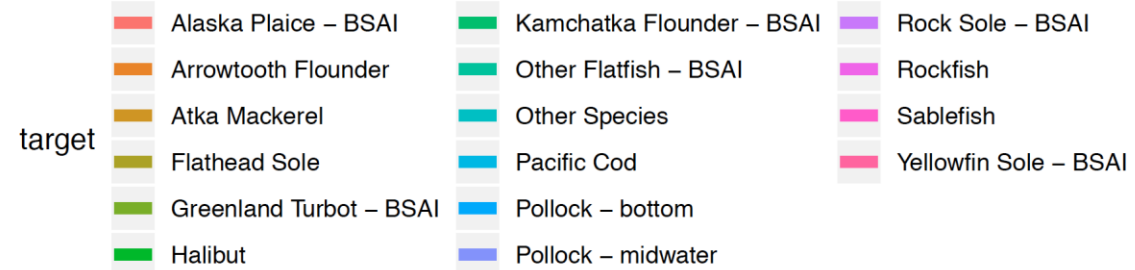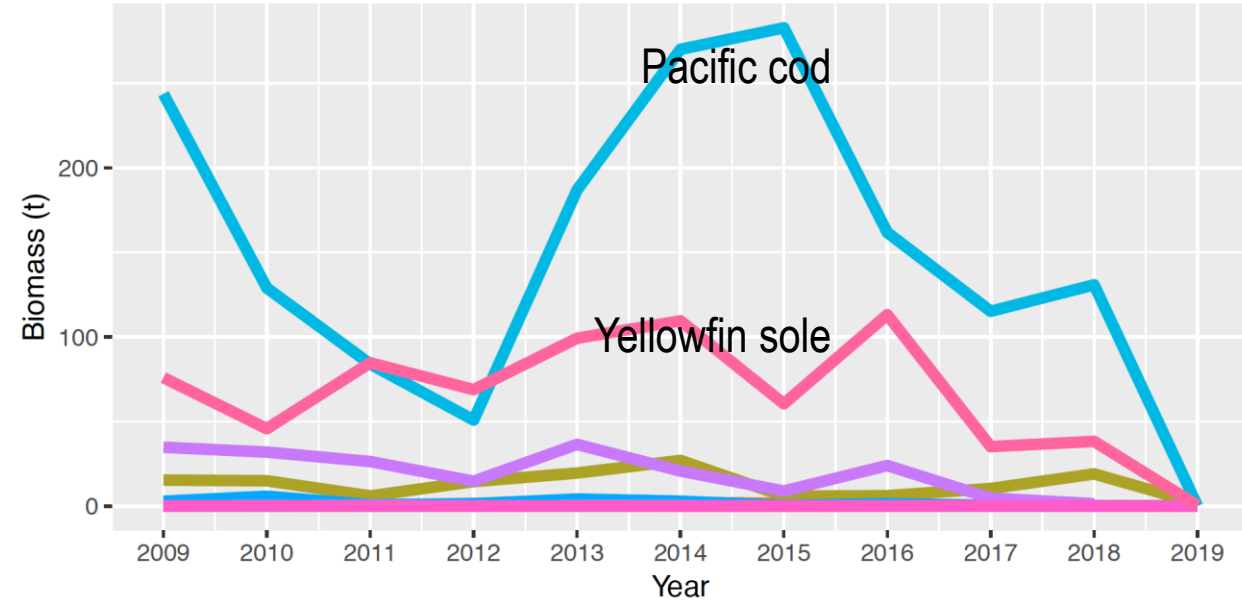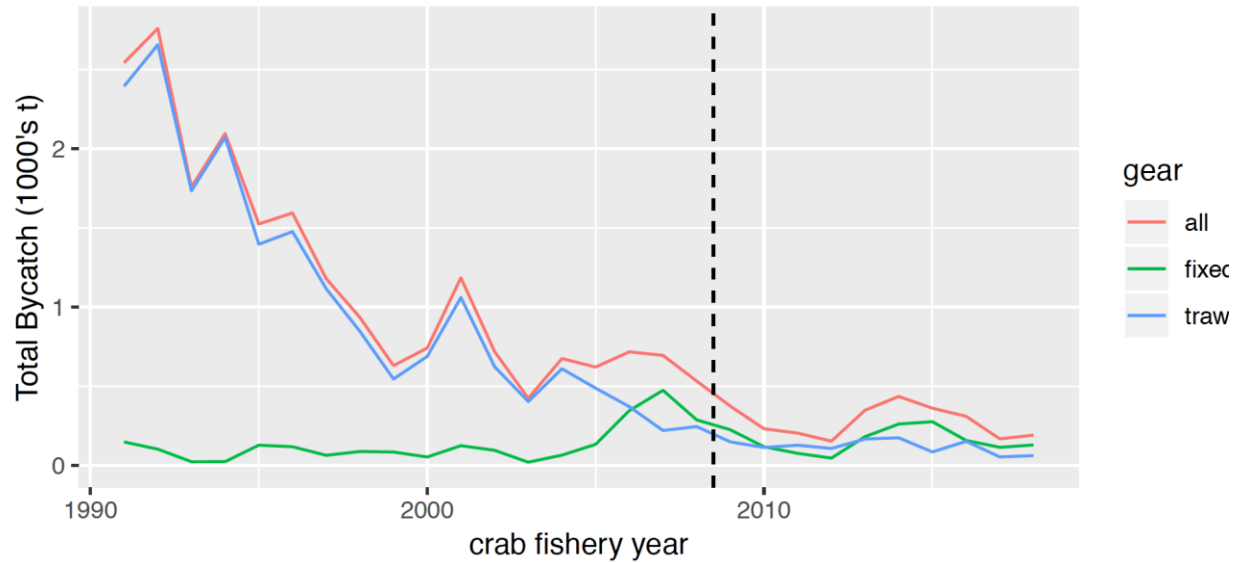
Retained catch size compositions in the directed fishery
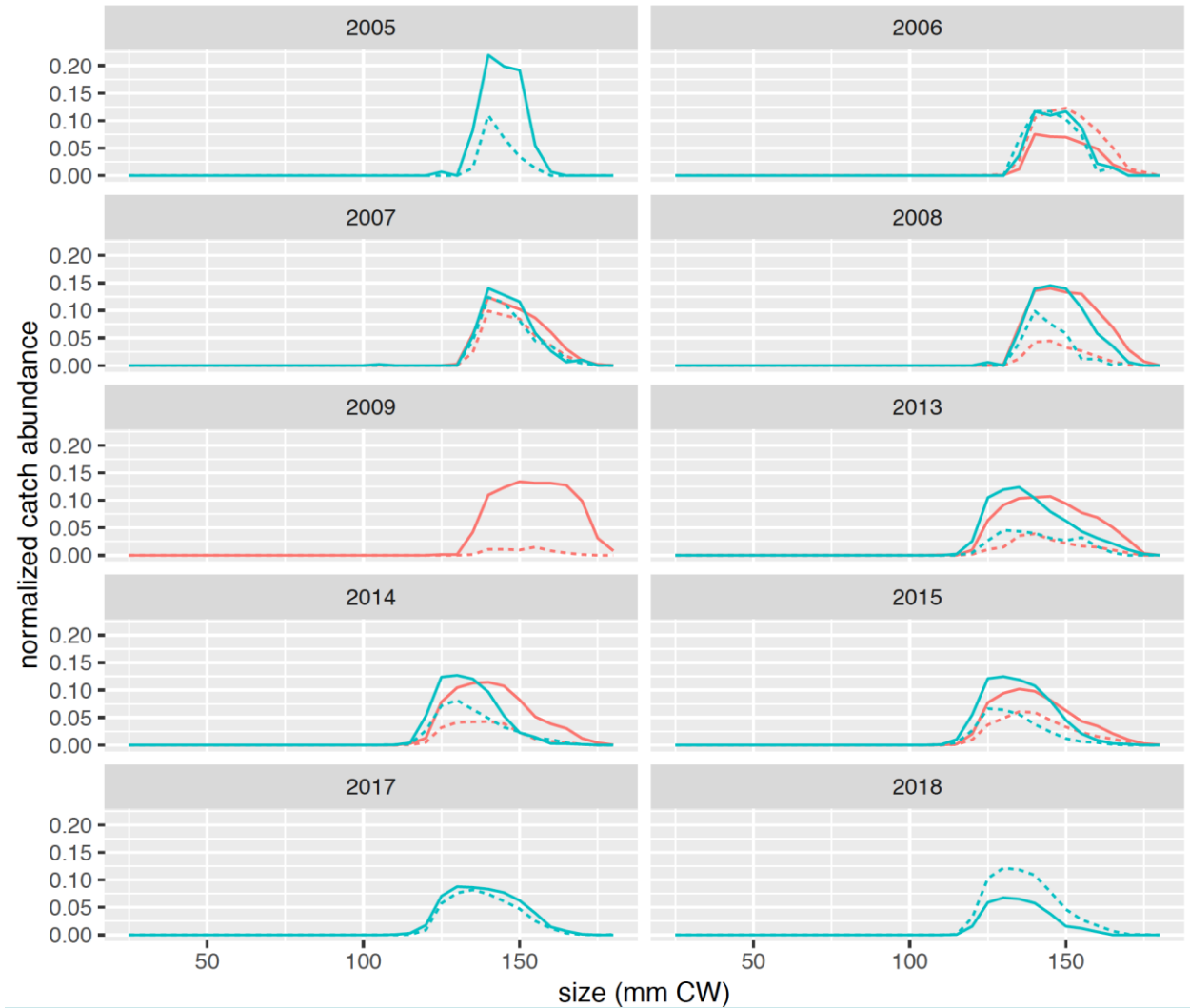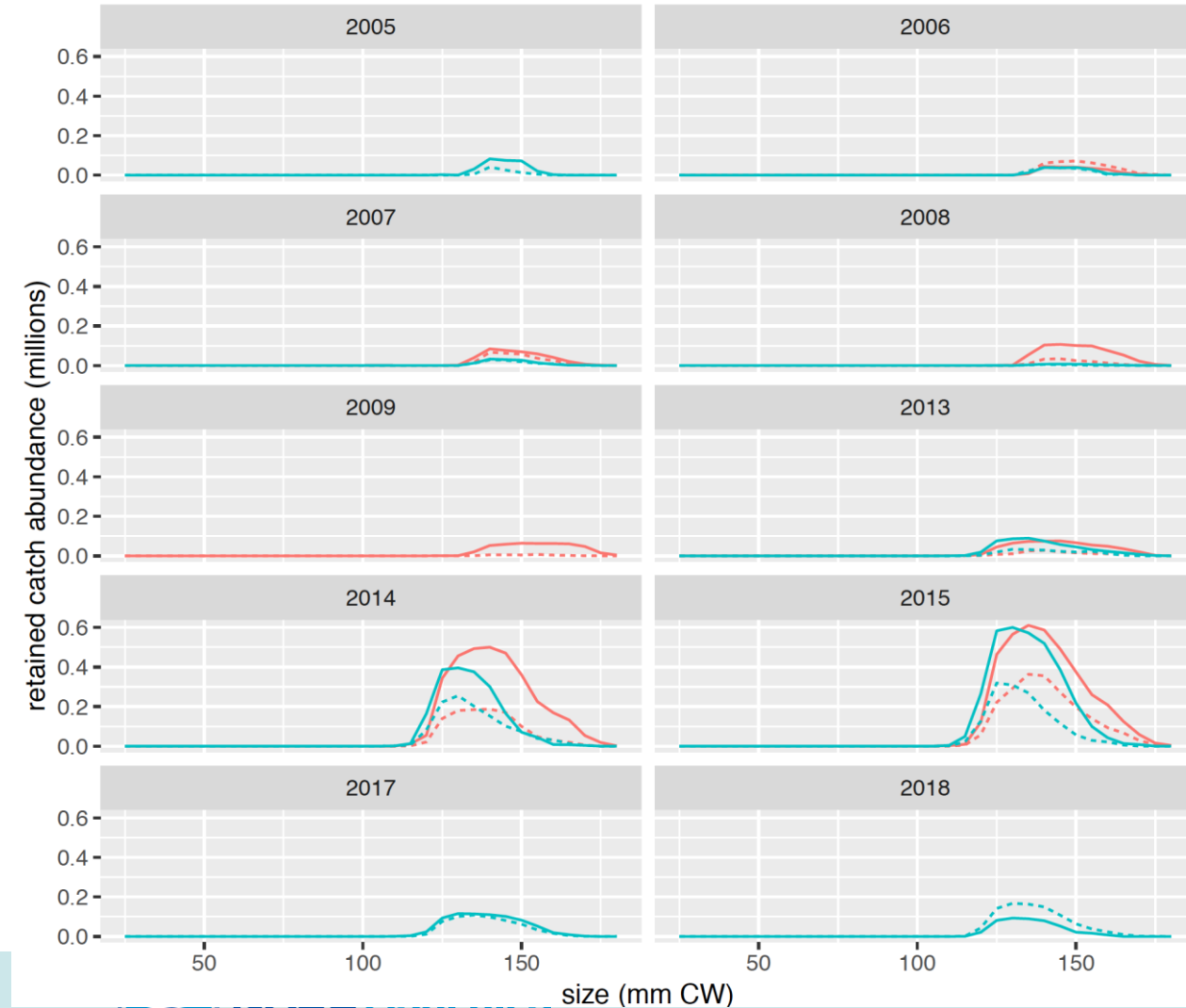
Total catch size compositions for males in the crab fisheries
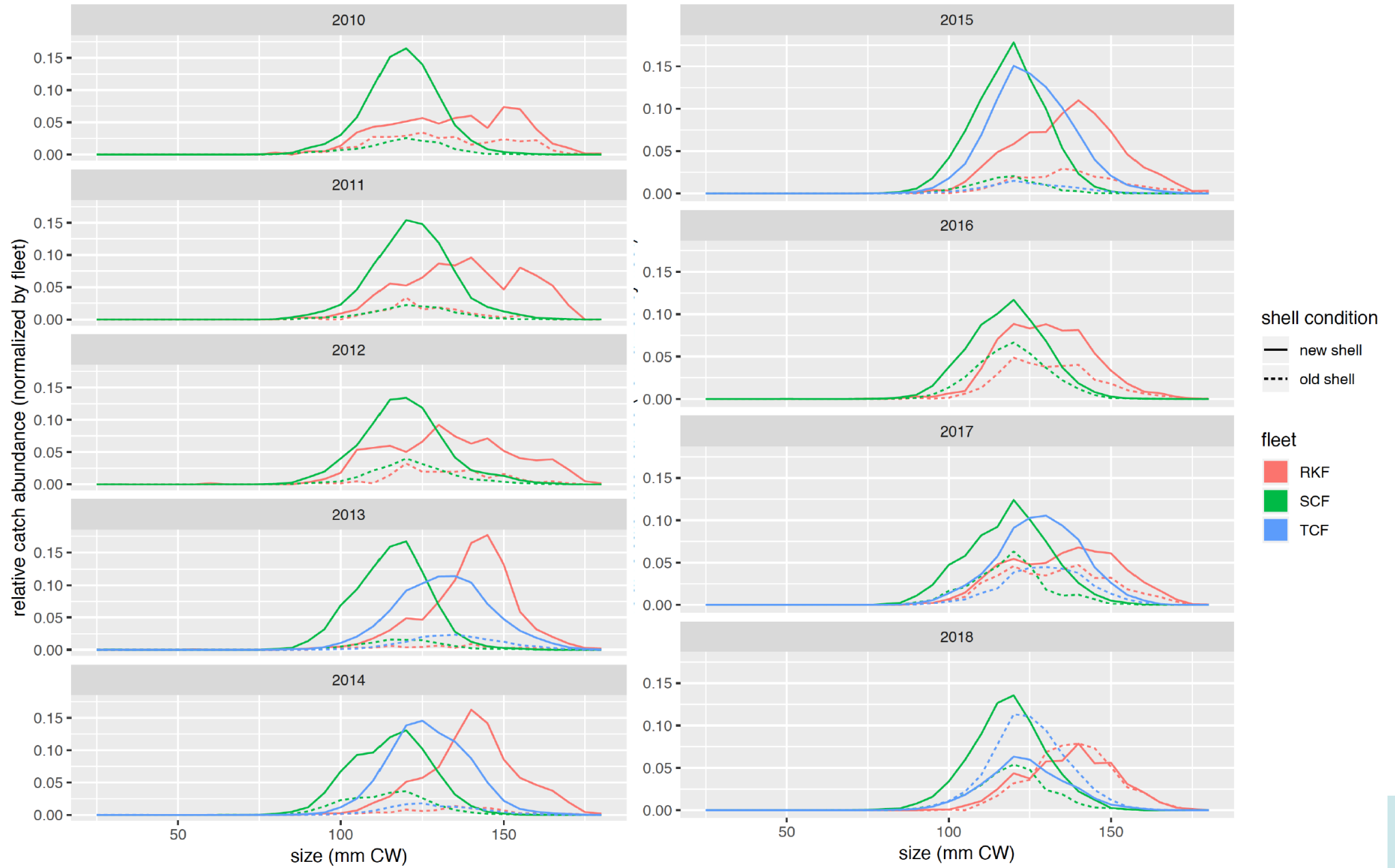
Survey Trends

NMFS EBS Survey Trends
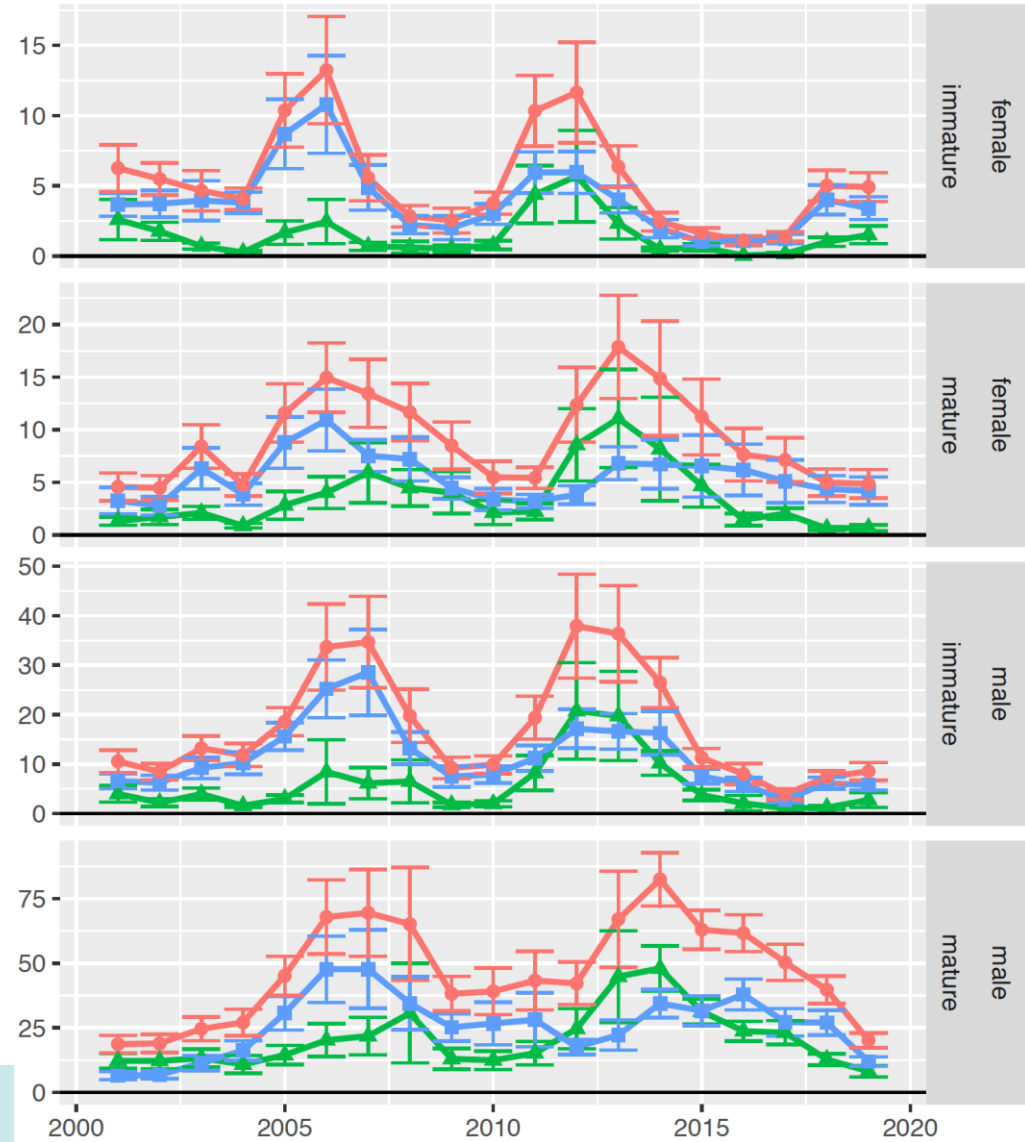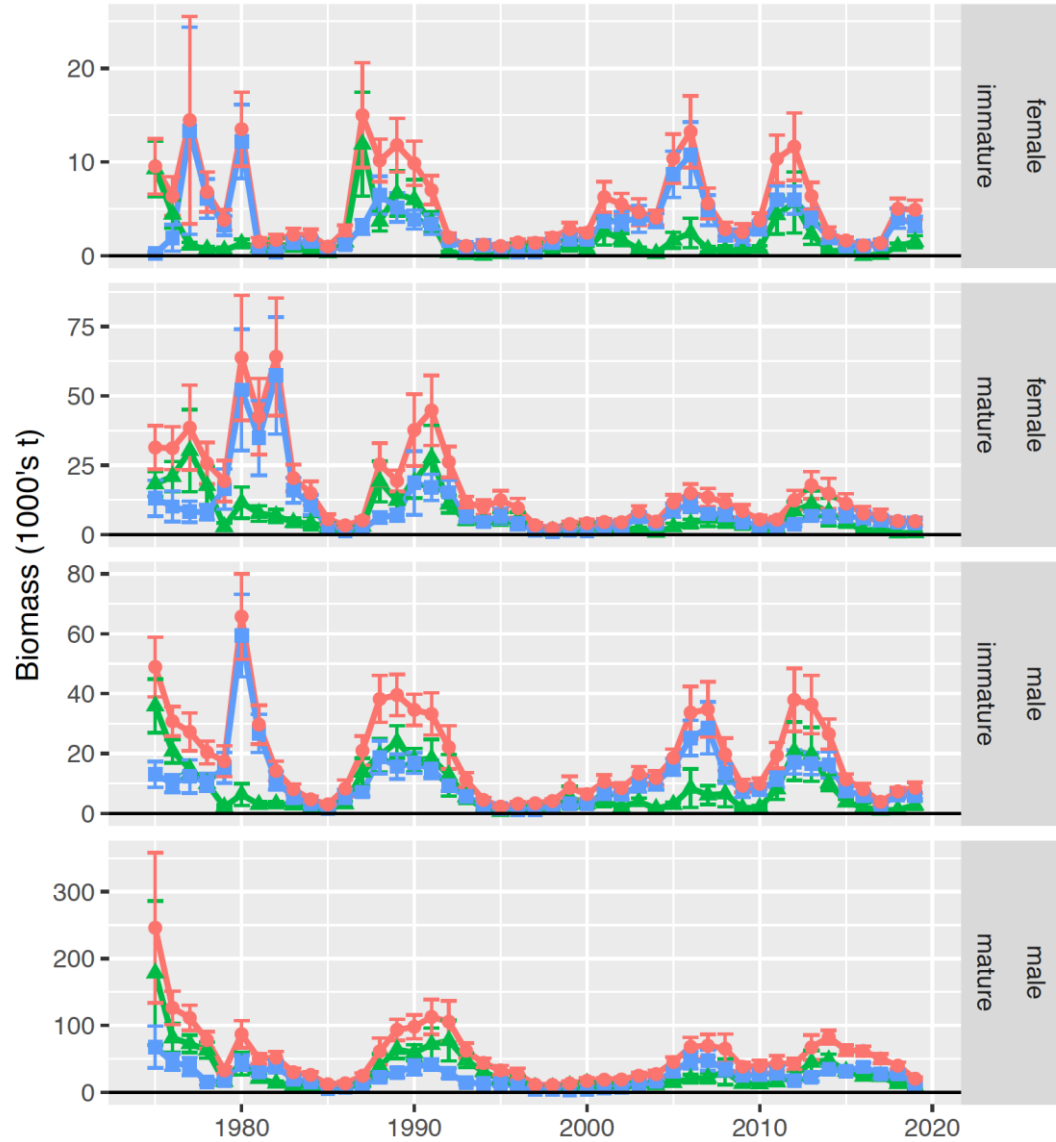
Legal Male Trends in the NMFS EBS Survey
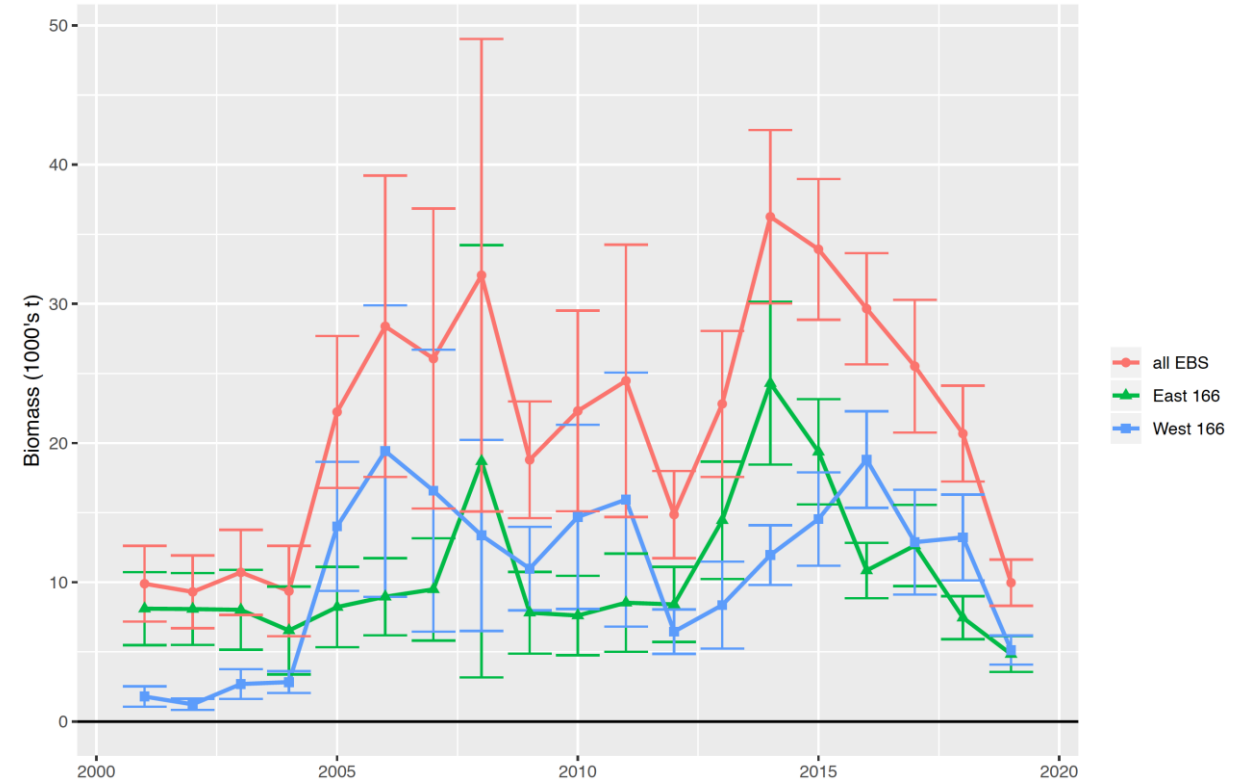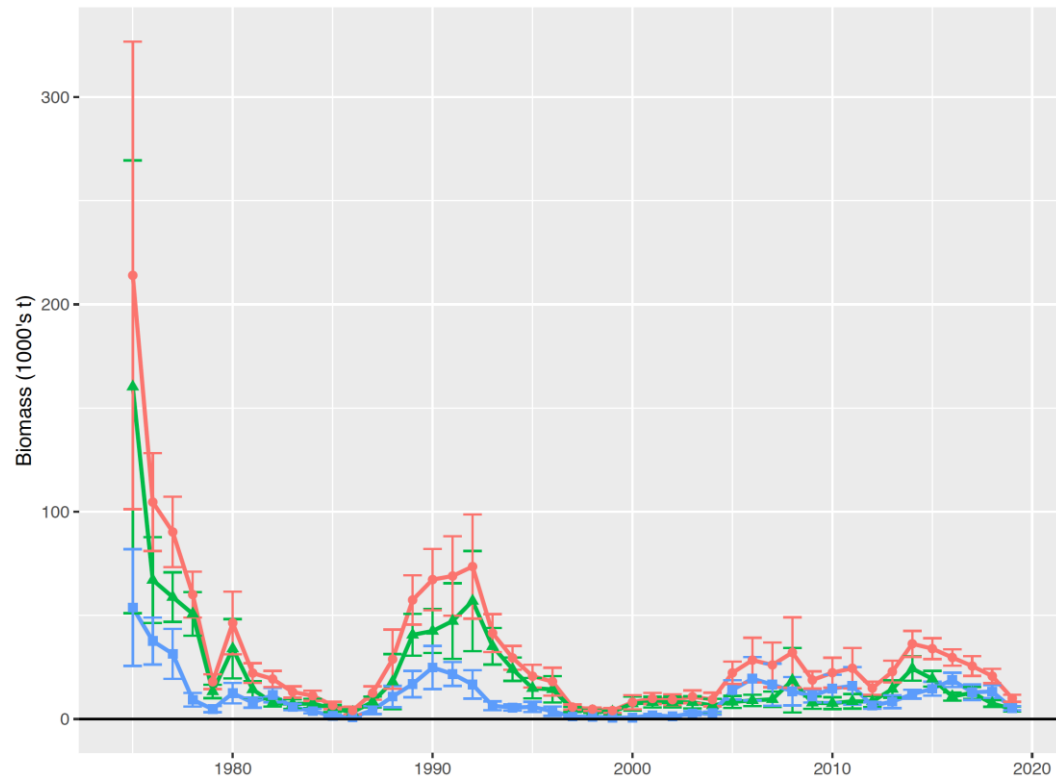
NMFS EBS Survey Size Compositions

2017: immature female — 2017: mature female — 2018: immature female — 2018: mature female — 2019: immature female — 2019: mature female

2017: immature male — 2017: mature male — 2018: immature male — 2018: mature male — 2019: immature male — 2019: mature male
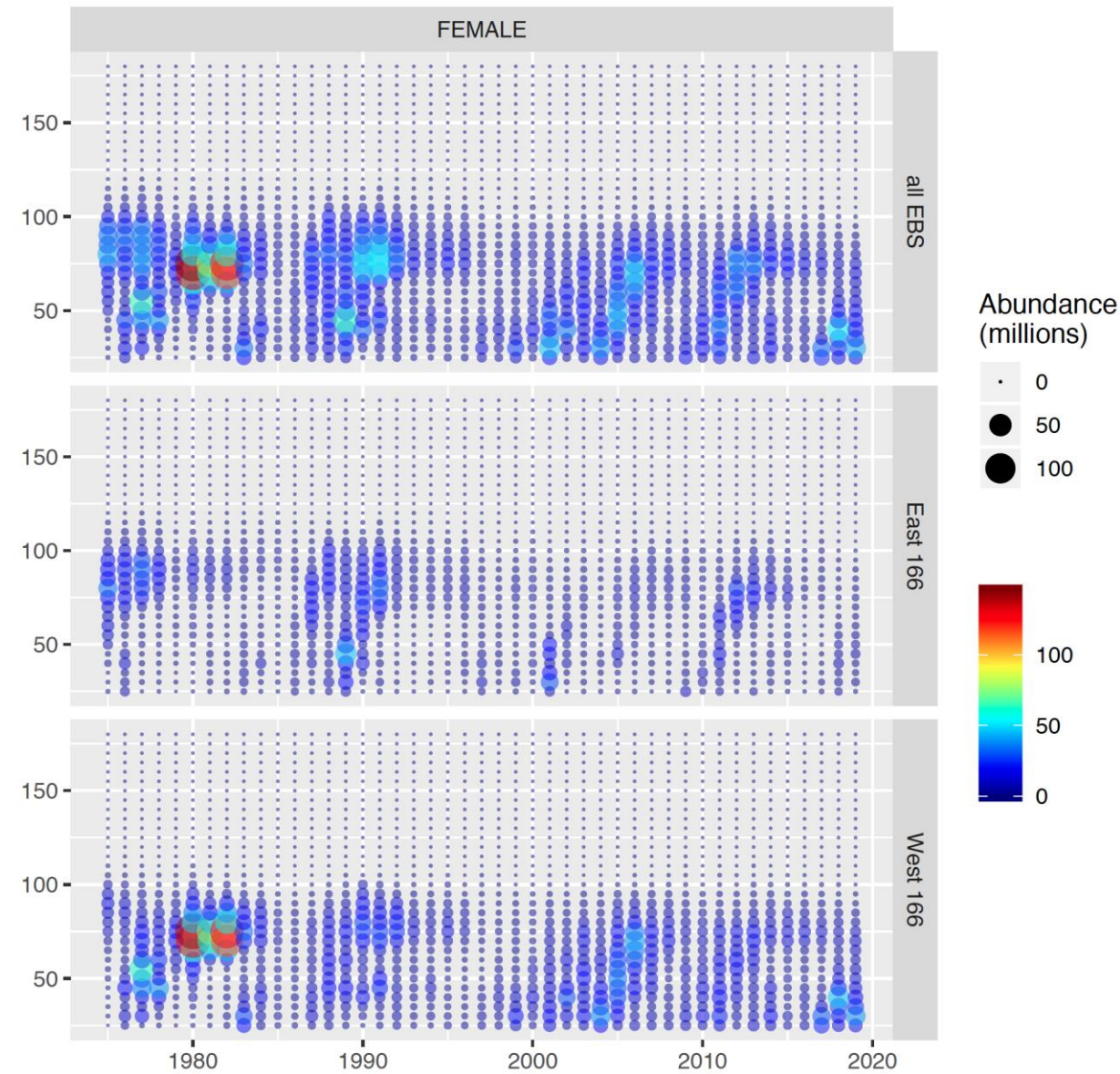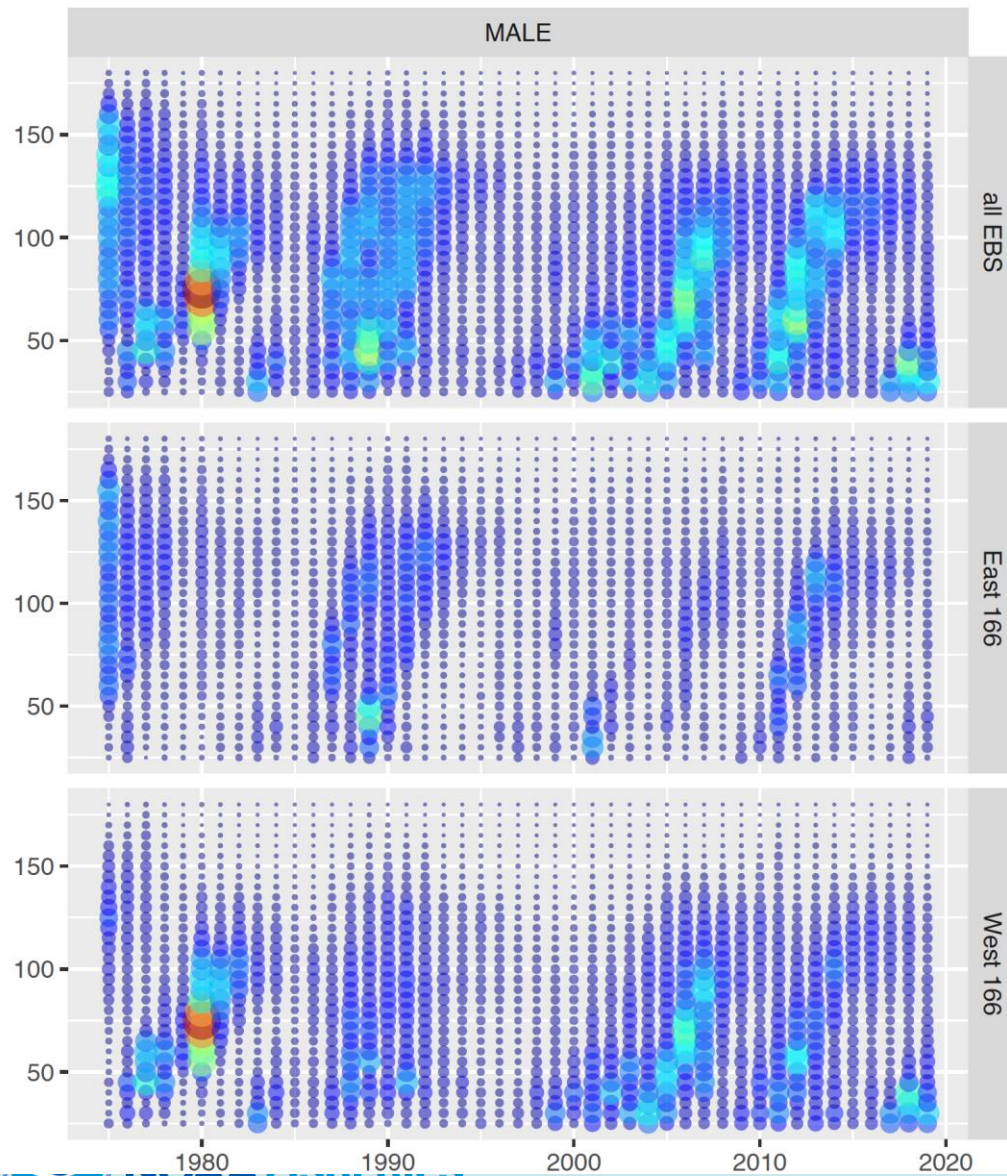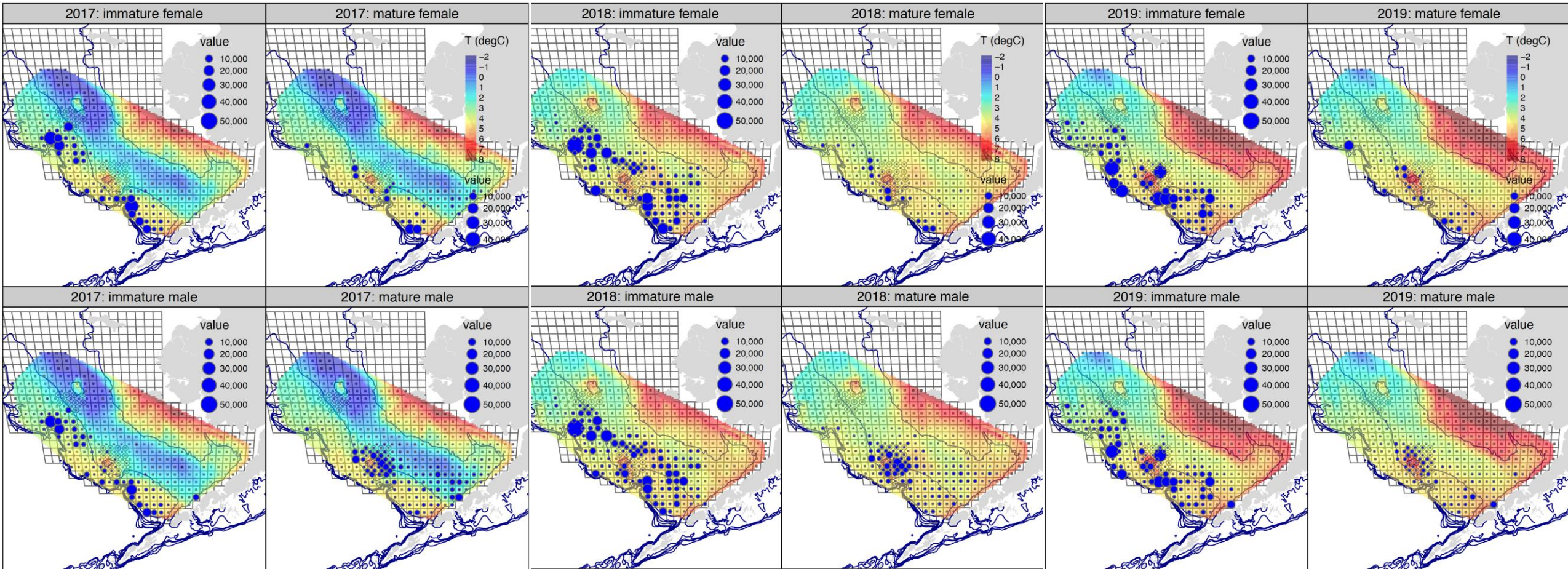
Assessment Model

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
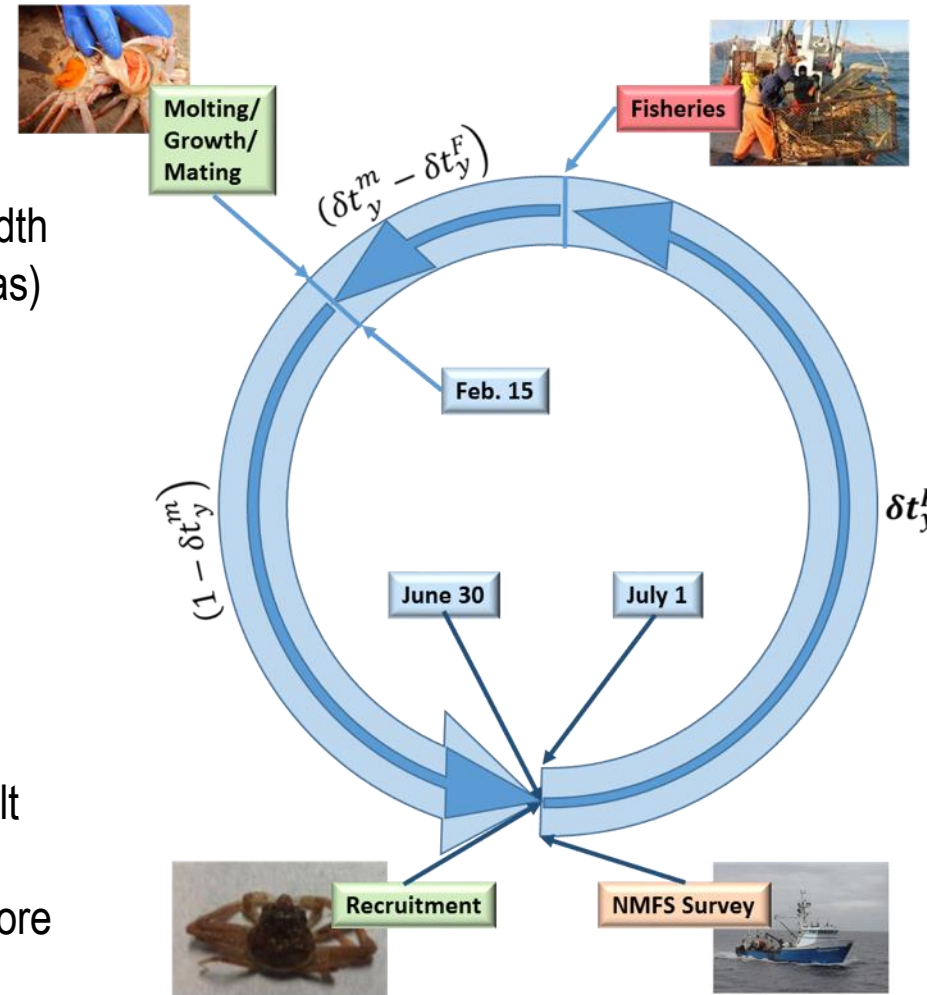
Model scenarios

model scenario	number of parameters	scenario description
M19F00	357	2018 assessment model (18AM17)
M19F00a	357	M19F00 with revised ADFG data for 1990+ crab fisheries
M19F01	363	M19F00a updated for 2018/19 (base model for 2019)
M19F02	363	M19F01 + 2006+ observed male maturity data
M19F03	343	M19F02 - male maturity characterized by Rugolo/Turnock maturity ogive
M19F04	628	M19F01 + 2013-2017 BSFRF/NMFS side-by-side data
M19F05	608	M19F03 + 2013-2017 BSFRF/NMFS side-by-side data

Base model: population processes

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+	ln-scale mean + annual devs
Growth	1949+	sex-specific
		mean post-molt size: power function of pre-molt size
		post-molt size: gamma distribution conditioned on pre-molt size
Maturity	1949+	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+	priors on multipliers based on uncertainty in max age
	1980-1984	estimated "enhanced mortality" period multipliers

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Base model: fishery characteristics

Fishery/process	time blocks	description
TCF	**directed Tanner crab fishery**	
capture rates	pre-1965	male nominal rate
	1965+	male ln-scale mean + annual devs
	1949+	ln-scale female offset
male selectivity	1949-1990	ascending logistic
	1991-1996	annually-varying ascending logistic
	2005+	annually-varying ascending logistic
female selectivity	1949+	ascending logistic
male retention	1949-1990, 1991-1996, 2005-2009, 2013-2015, 2017	ascending logistic
SCF	**bycatch in snow crab fishery**	
capture rates	pre-1978	nominal rate on males
	1979-1991	extrapolated from effort
	1992+	male ln-scale mean + annual devs
	1949+	ln-scale female offset
male selectivity	1949-1996	dome-shaped
	1997-2004	dome-shaped
	2005+	dome-shaped
female selectivity	1949-1996	ascending logistic
	1997-2004	ascending logistic
	2005+	ascending logistic

Base model: fishery characteristics

Fishery/process	time blocks	description
RKF	**bycatch in BBRKC fishery**	
capture rates	pre-1952	nominal rate on males
	1953-1991	extrapolated from effort
	1992+	male ln-scale mean + annual devs
	1949+	ln-scale female offset
male selectivity	1949-1996	ascending logistic
	1997-2004	ascending logistic
	2005+	ascending logistic
female selectivity	1949-1996	ascending logistic
	1997-2004	ascending logistic
	2005+	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

Base model: NMFS survey characteristics

process	time blocks	description
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

Model Datasets

Model/data timelines

Total catch biomass of Tanner crab in the directed and snow crab fisheries
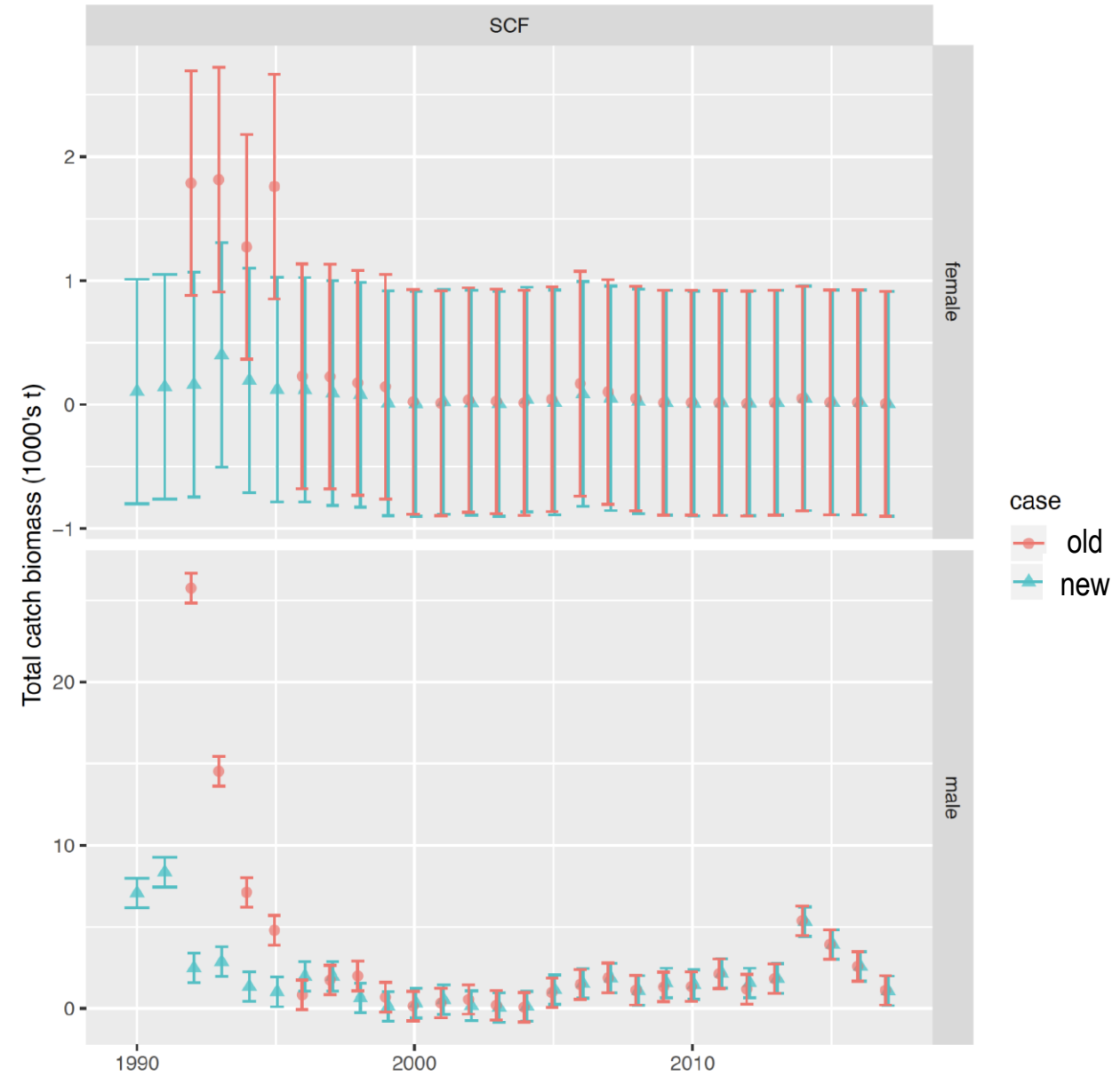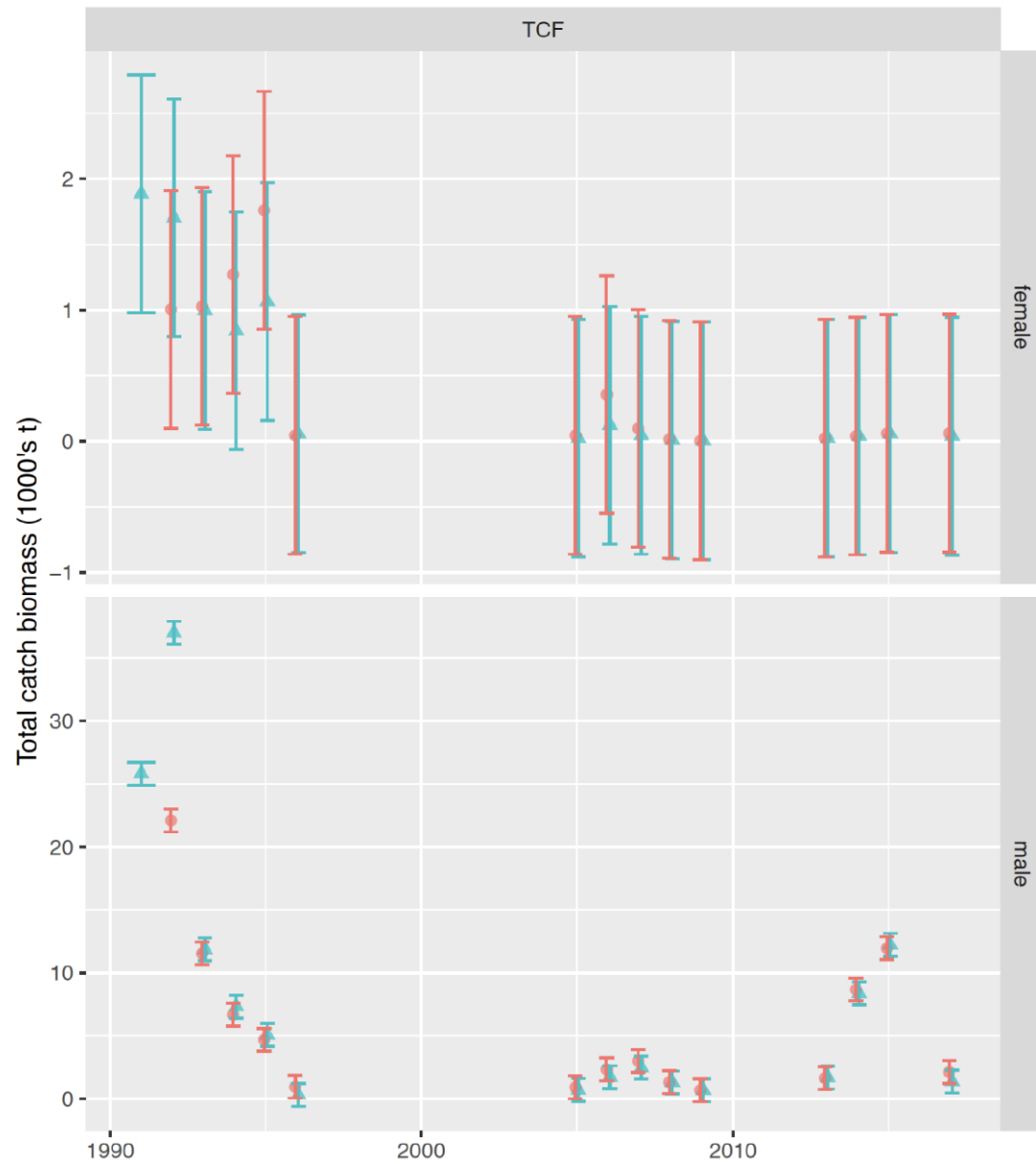
Molt Increment Data

- 33 new male observations
- 58 new female observations
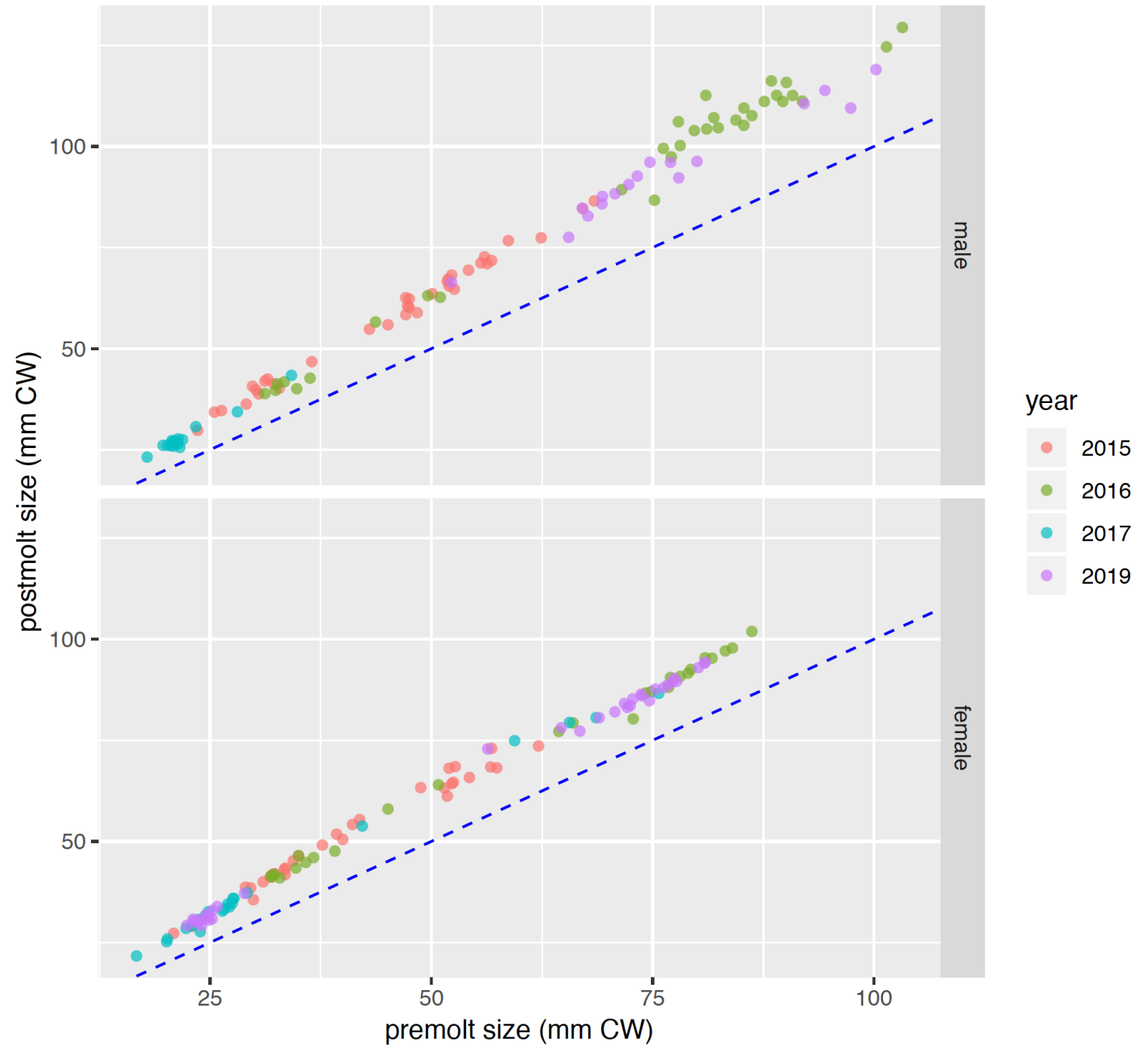
Male Maturity Ogive Data

- NMFS EBS survey collections
  - since 2006, CH to 0.1 mm

- Maturity classification based on CH:CW ratios (J.Richar, NMFS)

- Ratio of new shell mature males to all new shell males

- 10mm CW size bins
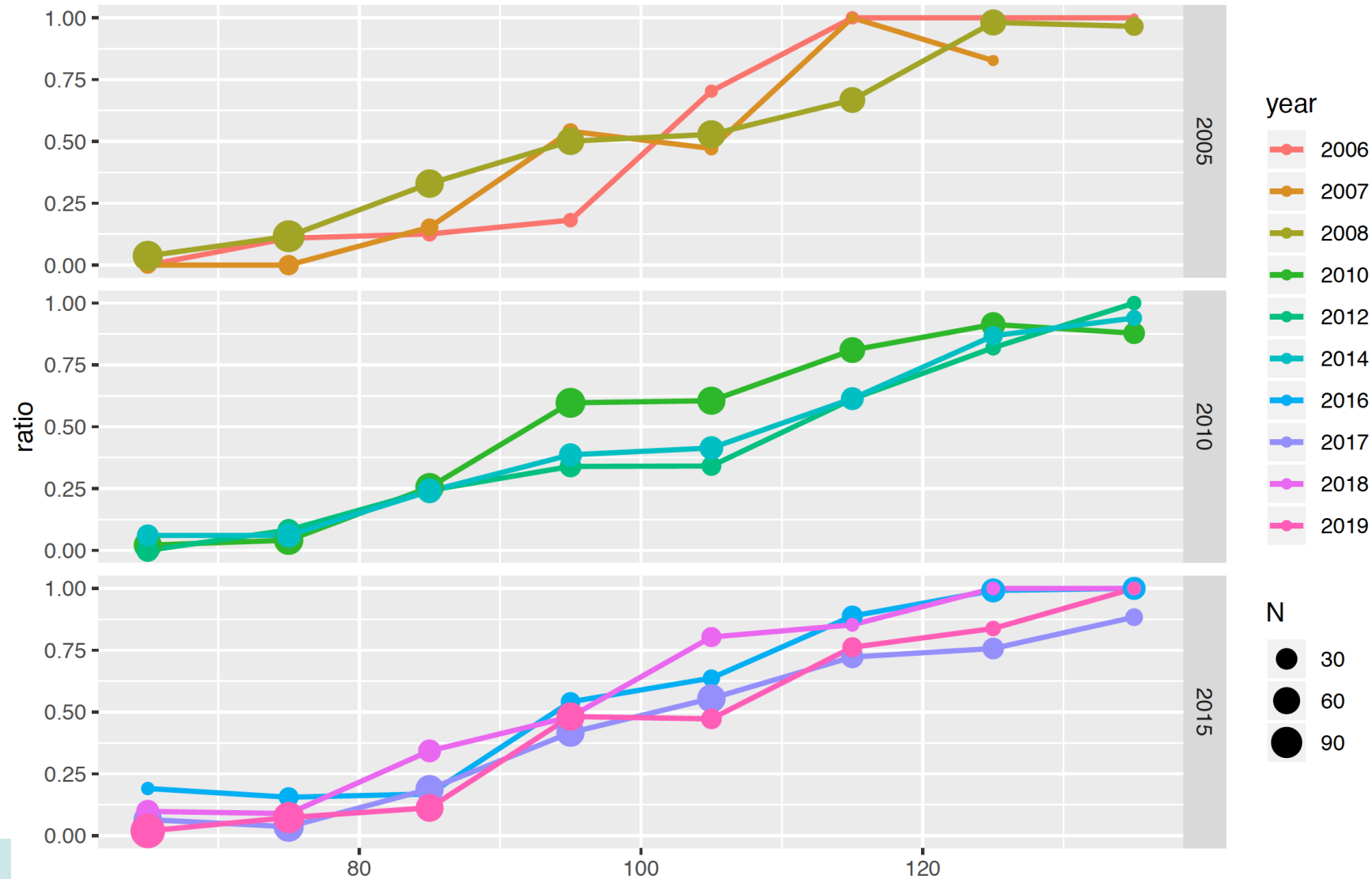
BSFRF/NMFS side-by-side (SBS) catchability studies

- BSFRF and NMFS conducted side-by-side haul studies to better characterize catchability for Tanner crab
  - 2013-2017
  - 2018 (not yet available)

- NMFS hauls
  - 83-112 trawl gear
  - 30 min. tow

- BSFRF hauls
  - modified nephrops trawl gear
  - 5 min. tow
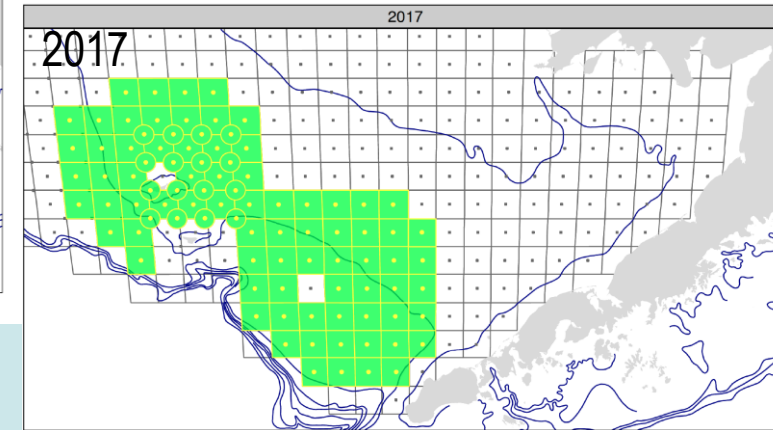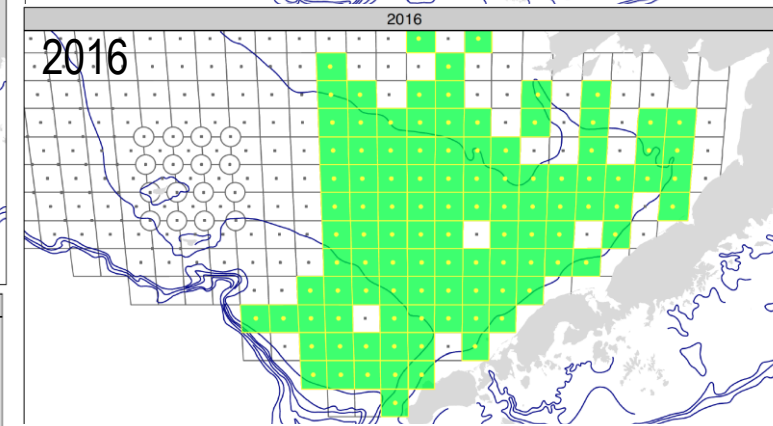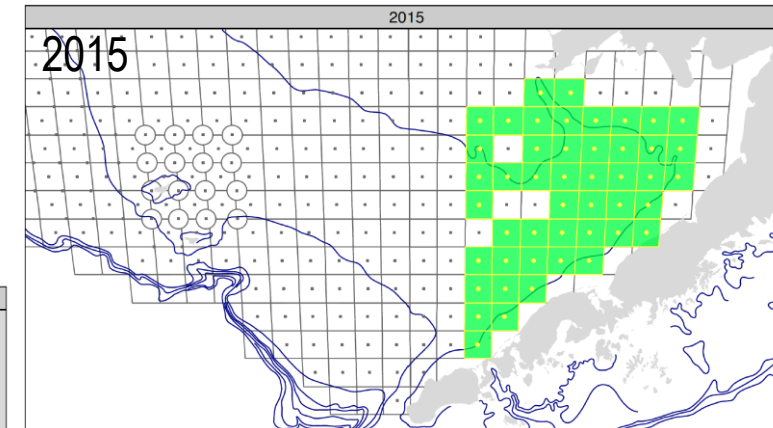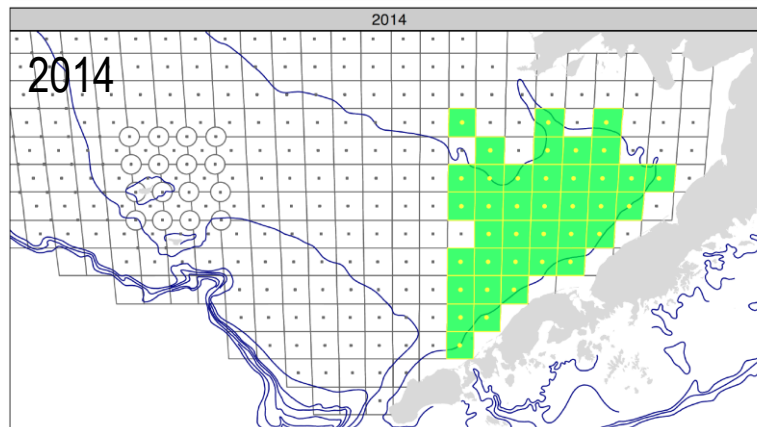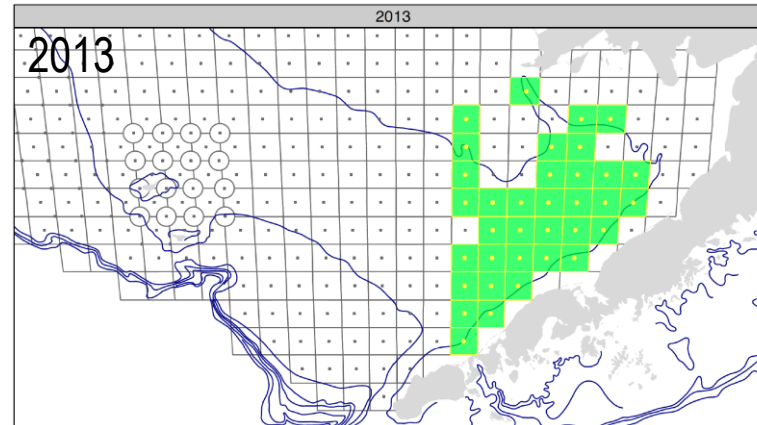
SBS catchability studies: area-swept abundance
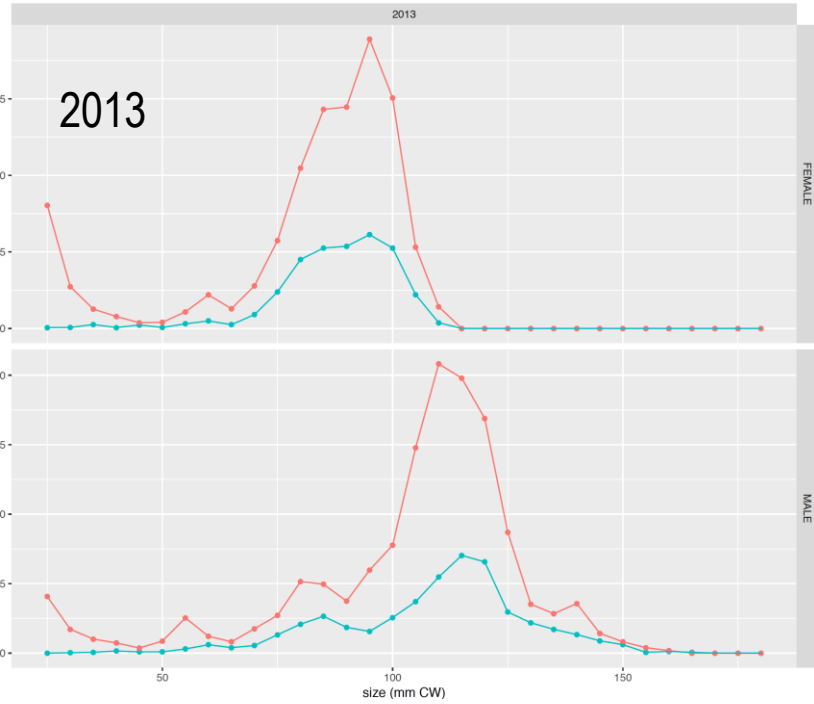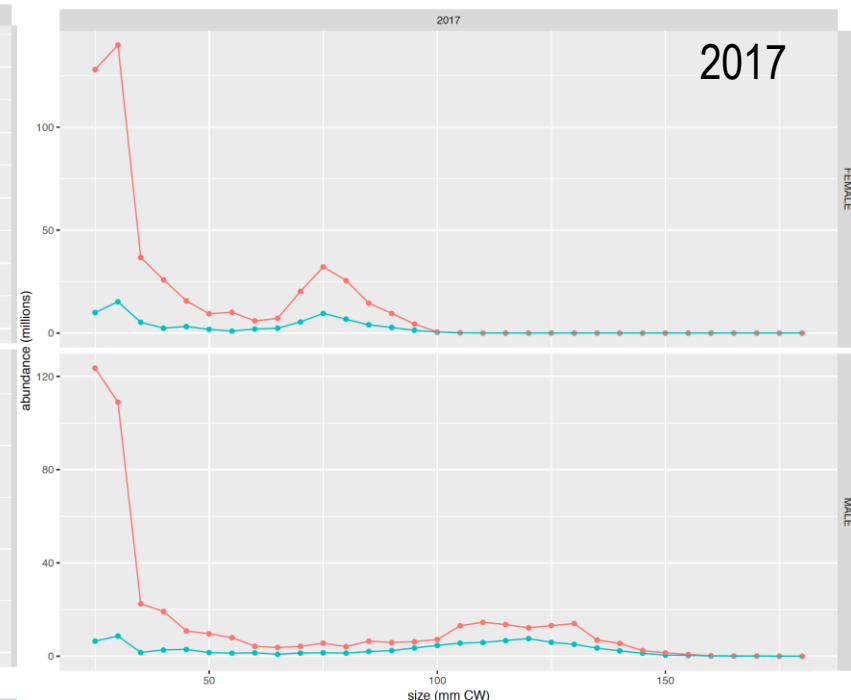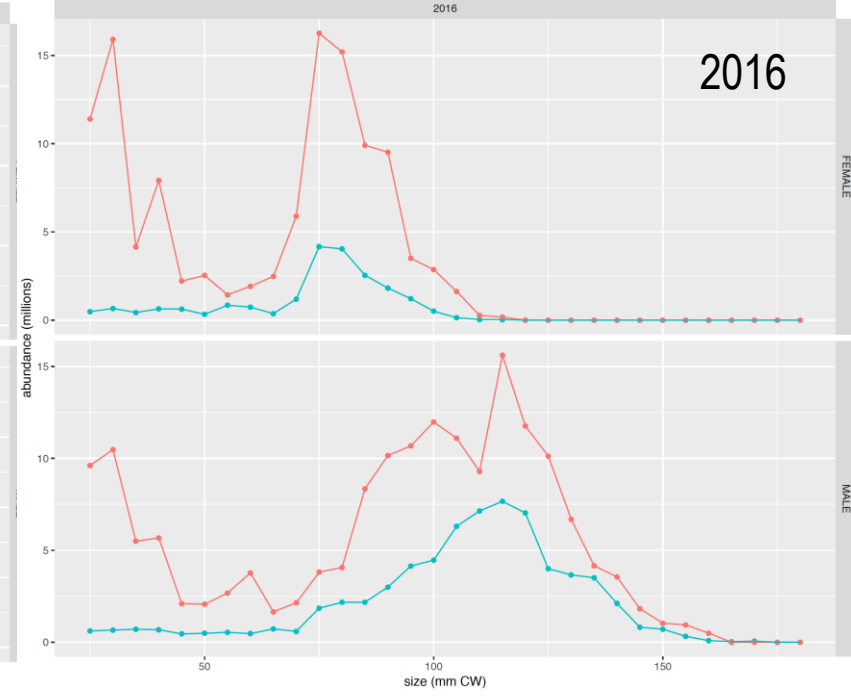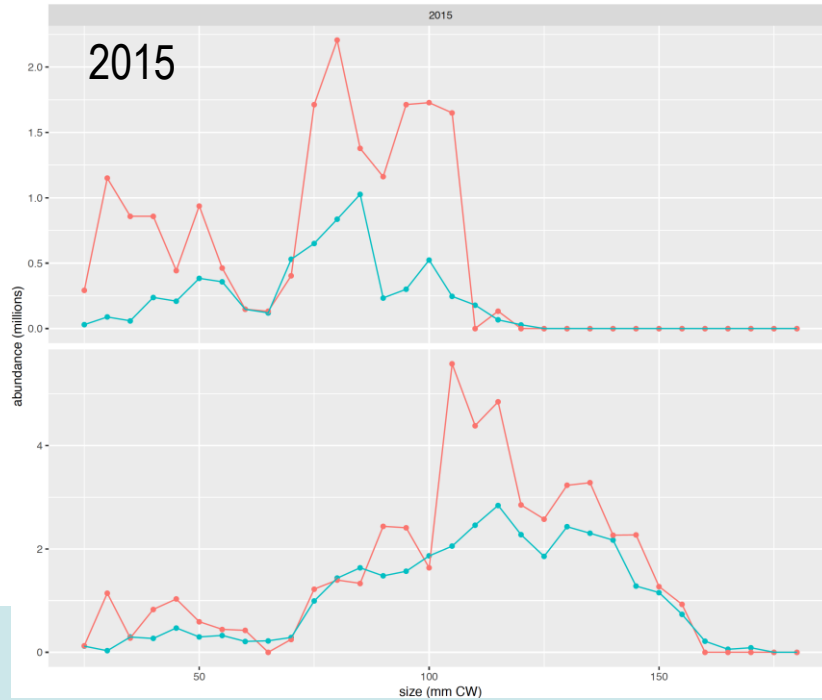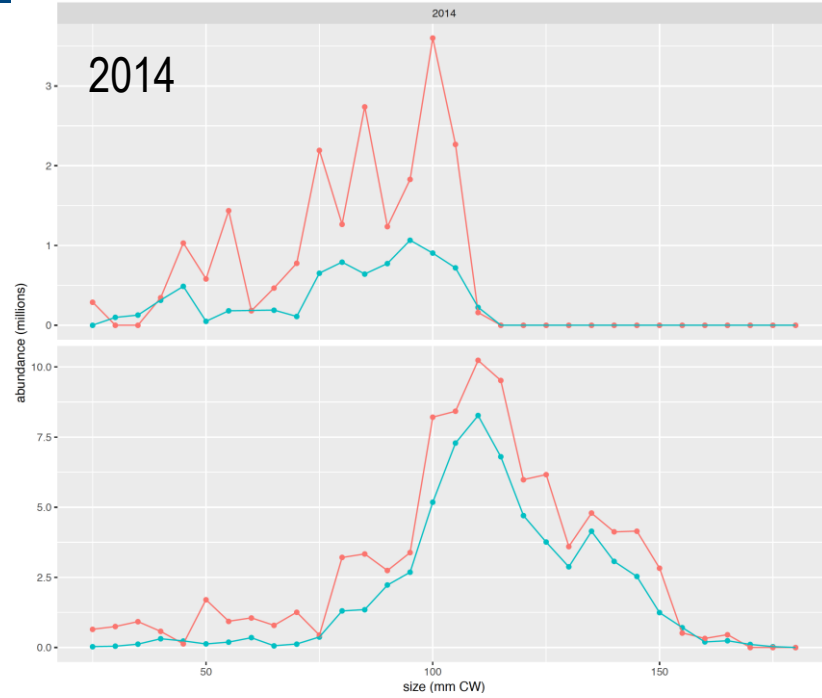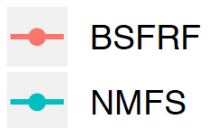
SBS catchability studies: empirical catchability

empirical estimate for q:

- males: ~0.6
- females: ~0.4

$$q_x \cdot S_{x,z}^{NMFS} = \frac{NMFS(z)}{BSFRF(z)}$$
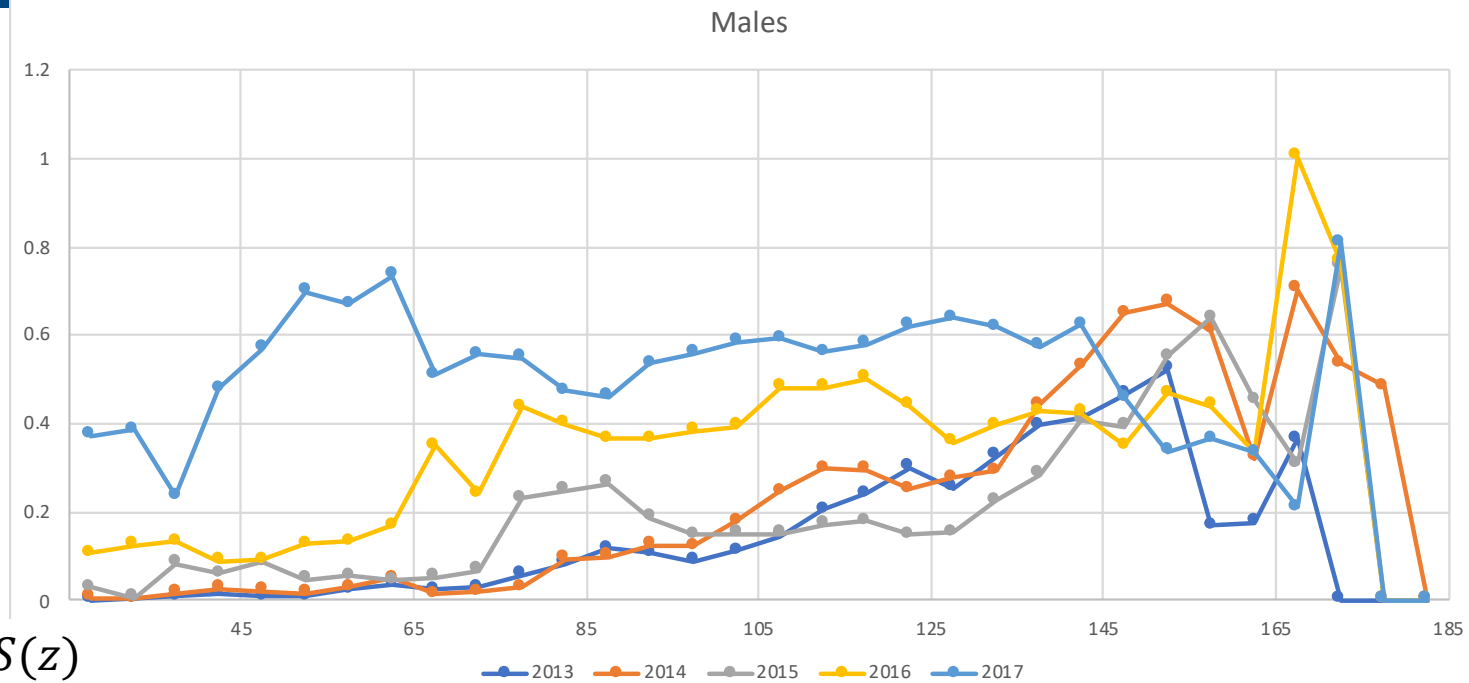

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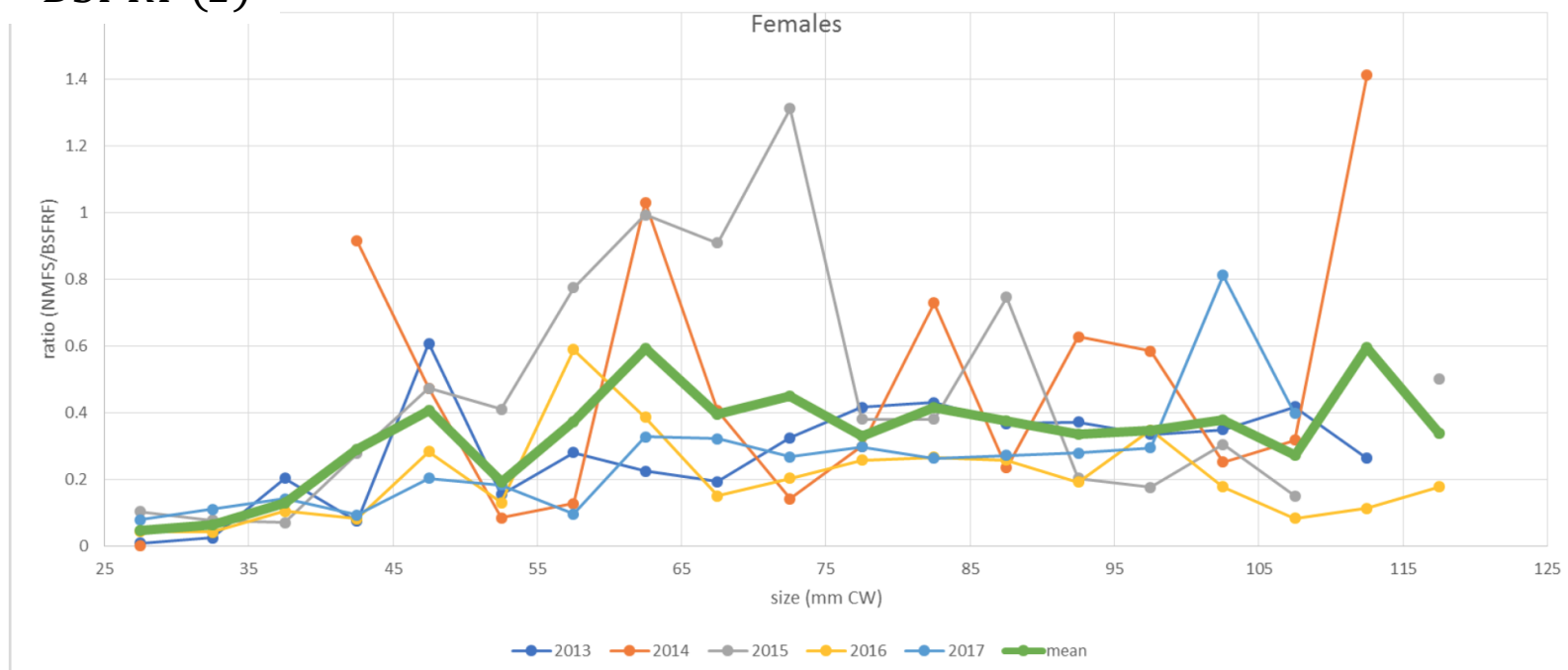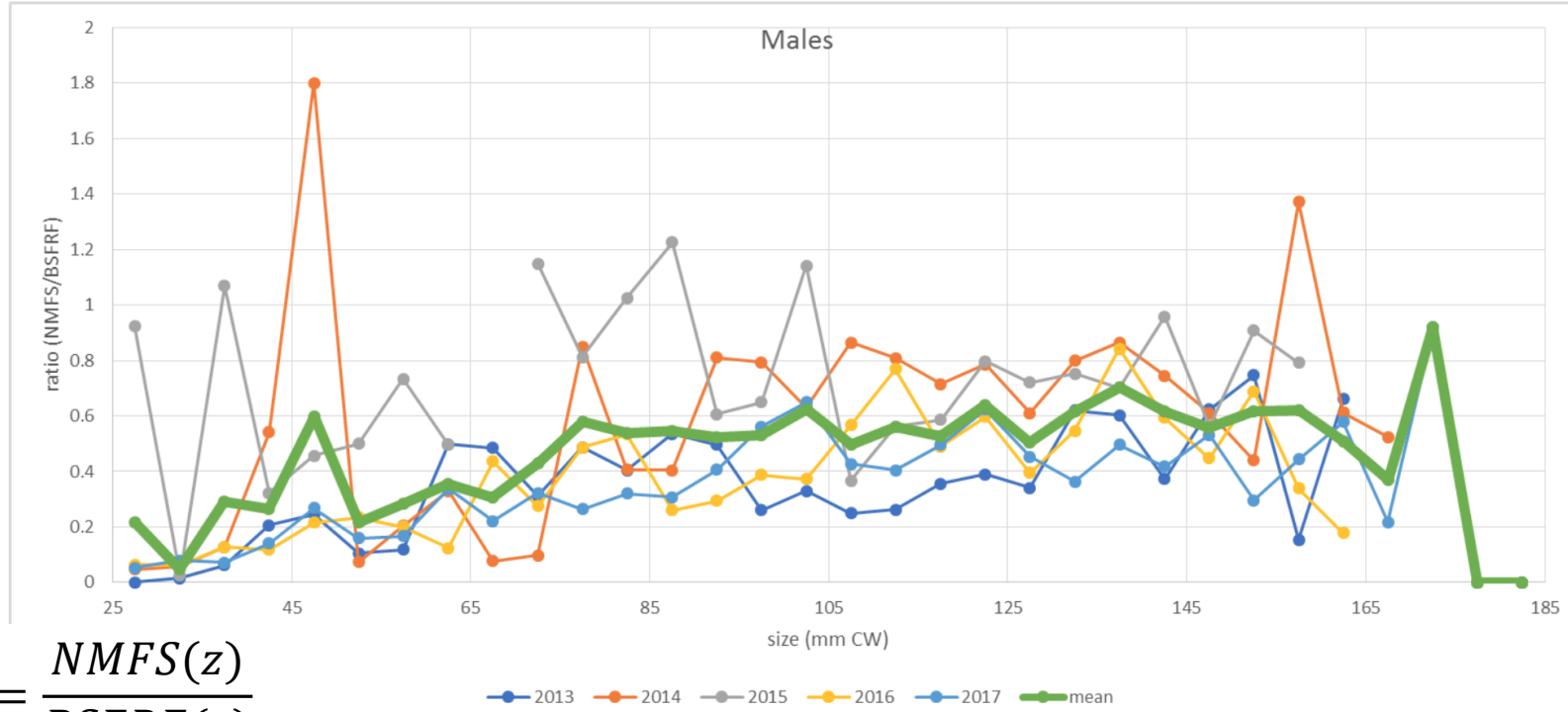
SBS catchability studies: empirical availability

empirical estimate for availability:

- not logistic

$$A_{x,z} = \frac{NMFS\ SBS(z)}{NMFS\ EBS(z)}$$

Males

Females
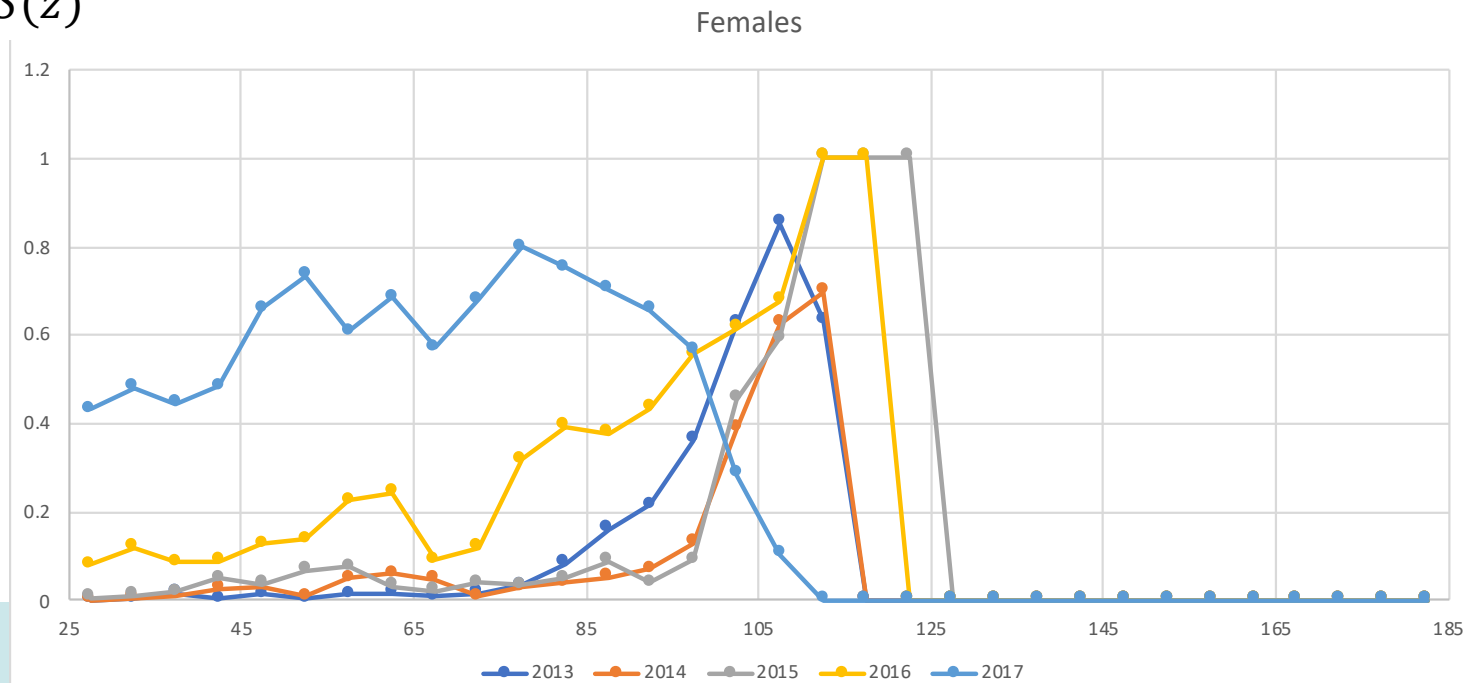
Model Performance

Model scenario highlights

- 5 scenarios evaluated for 2019
  - Crab fishery data updated 1990-2019
  - All fit new molt increment data
  - Some fit maturity ogive data
  - Some fit BSFRF-NMFS SBS data
- All scenarios fit fishery very well
- All scenarios fit survey data reasonably well
- Lower estimates for NMFS survey catchability, selectivity
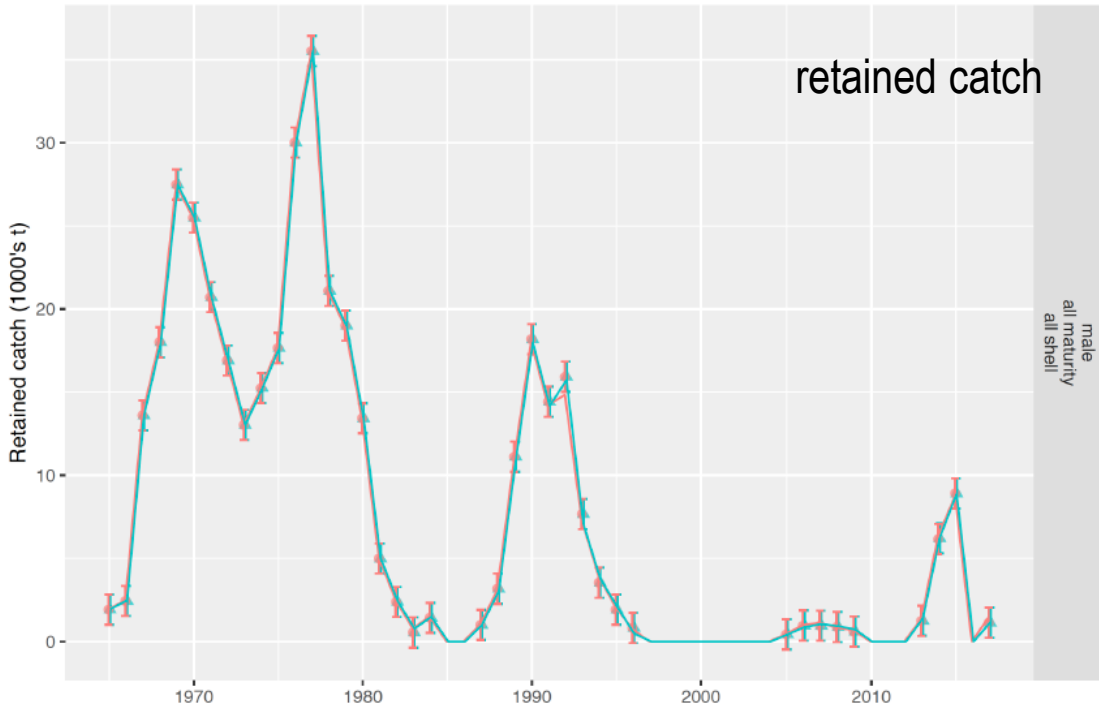- Higher recruitment estimates

Model performance

| model scenario	number of parameters	objective function value	max gradient	Jitter runs	# runs converged to MLE	scenario description
M19F00	357	2,962.17	0.0004	--	--	2018 assessment model (18AM17)
M19F00a	357	3,025.43	0.0003	--	--	M19F00 with revised ADFG data for 1990+ crab fisheries
M19F01	363	3,368.11	0.0002	3,000	94	M19F00a updated for 2018/19 (base model for 2019)
M19F02	363	3,521.89	0.0004	--	--	M19F01 + 2006+ observed male maturity data
M19F03	343	3,467.75	0.0013	3,000	72	M19F02 - male maturity characterized by Rugolo/Turnock maturity ogive
M19F04	628	3,578.47	0.0004	3,000	7	M19F01 + 2013-2017 BSFRF/NMFS side-by-side data
M19F05	608	3,674.61	0.0004	3,000	5	M19F03 + 2013-2017 BSFRF/NMFS side-by-side data

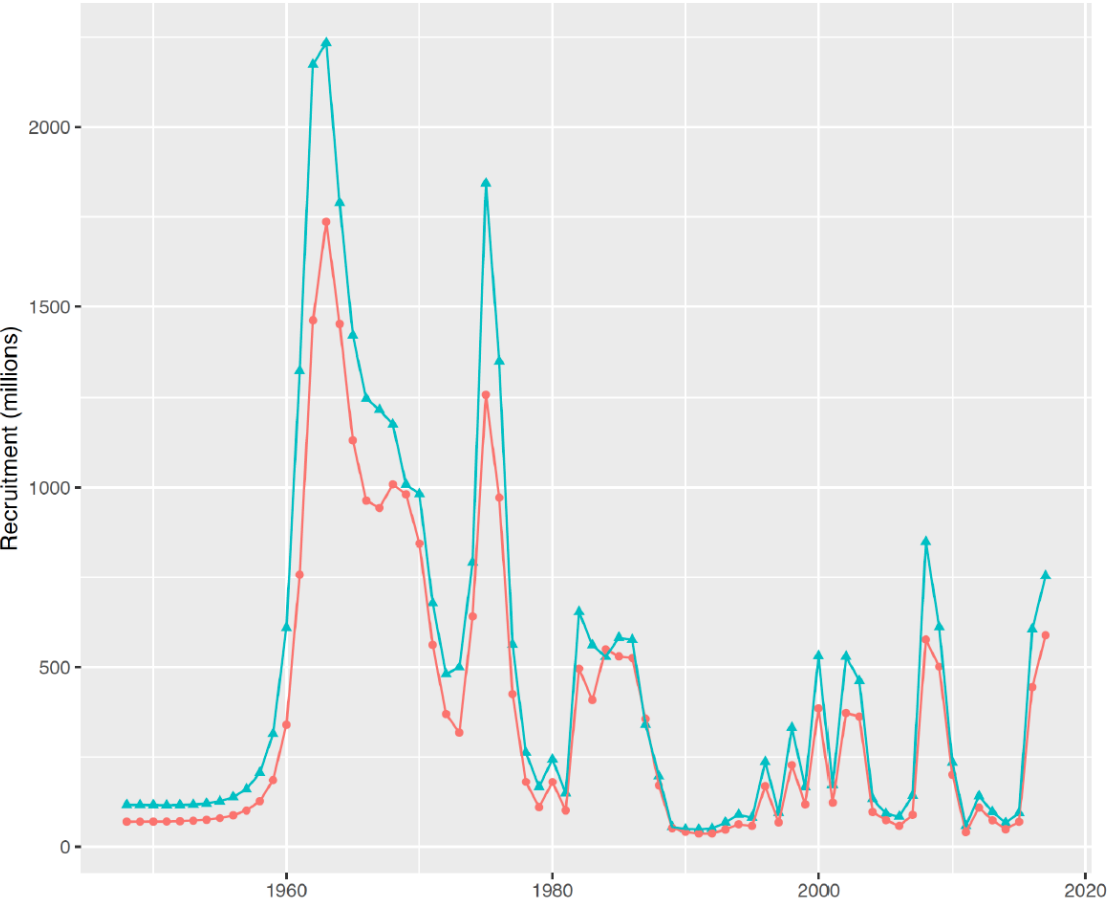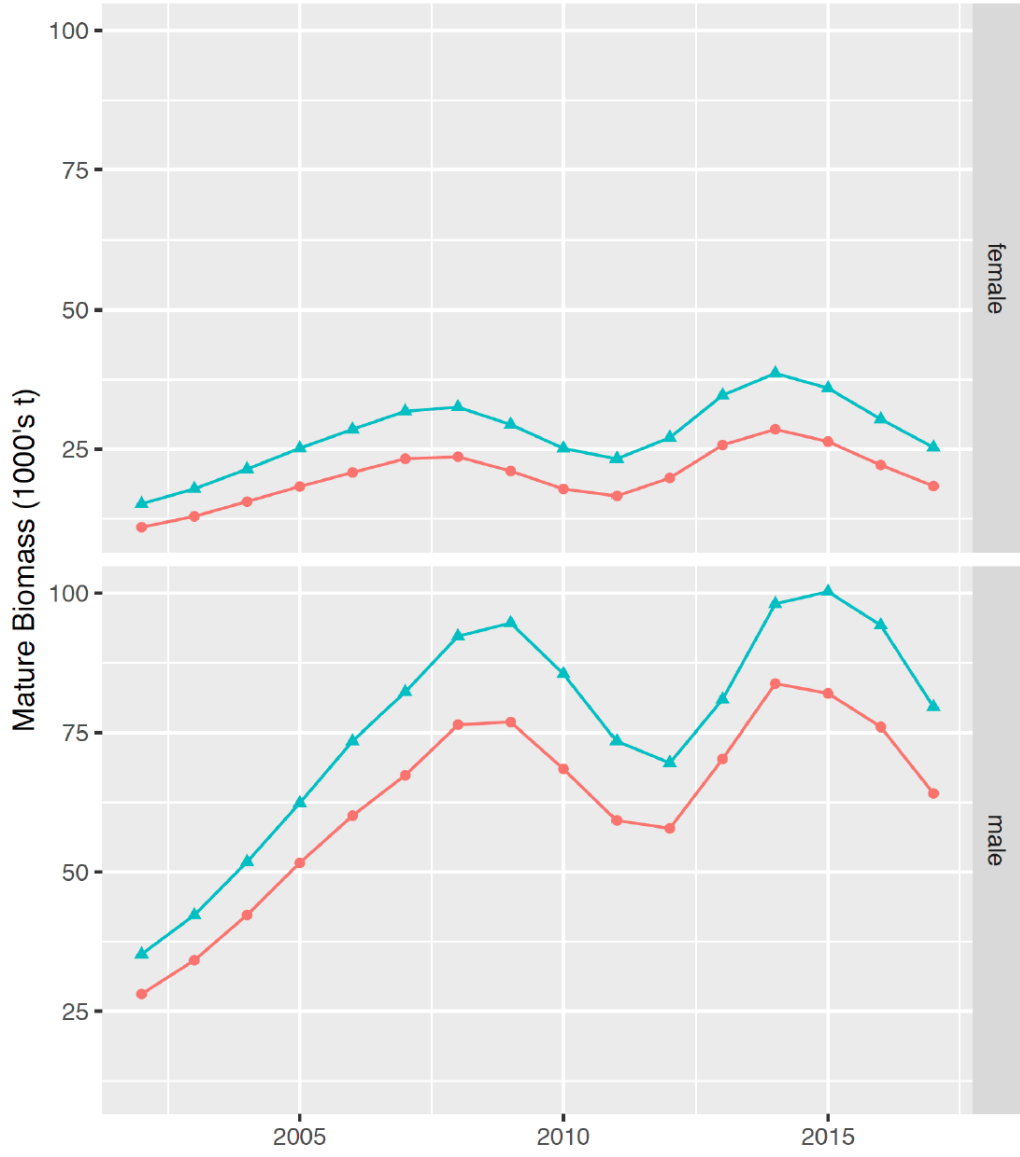# M19F00 vs. M19F00a: Effects of revised fishery data
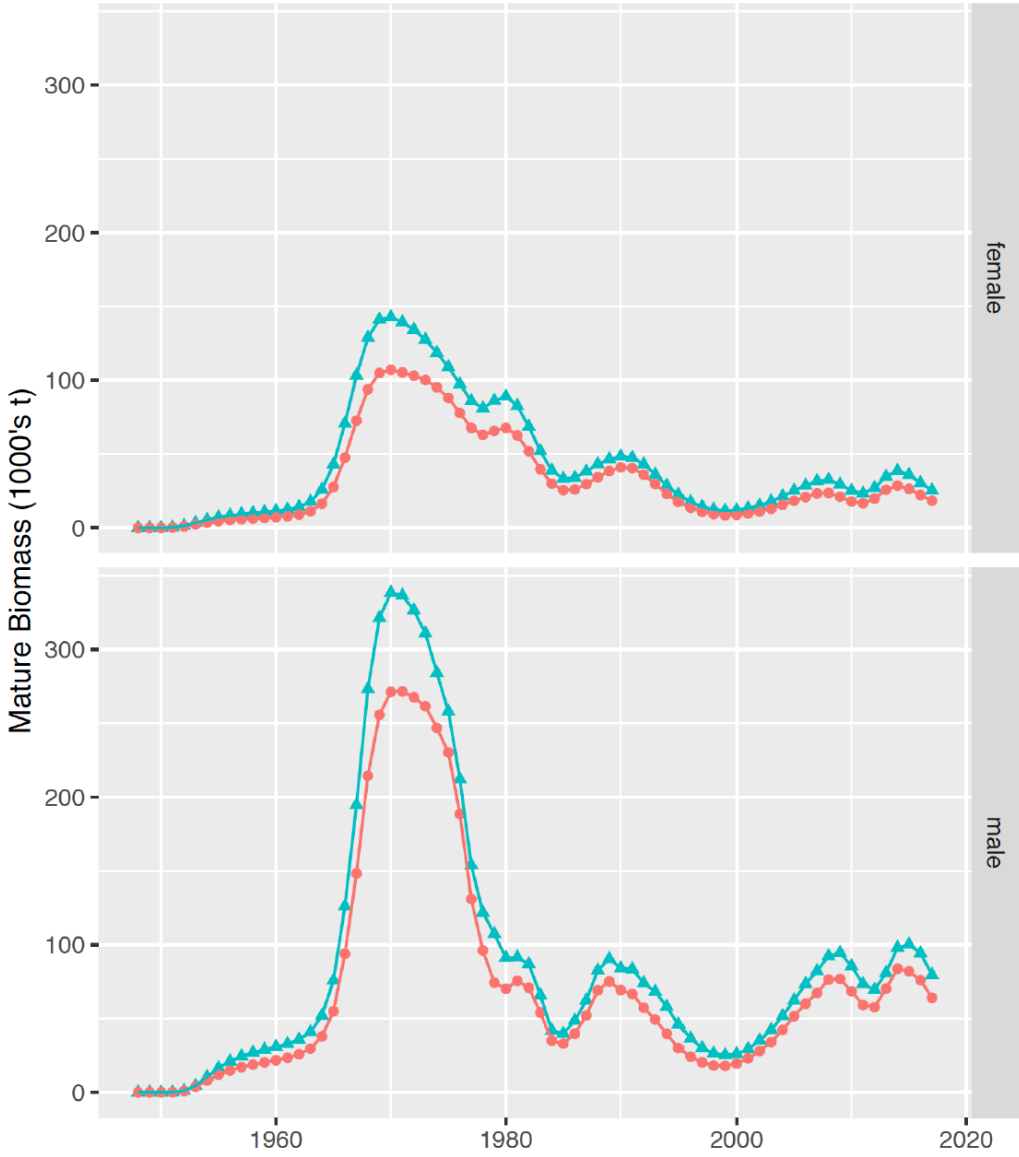
Fits to male catch data
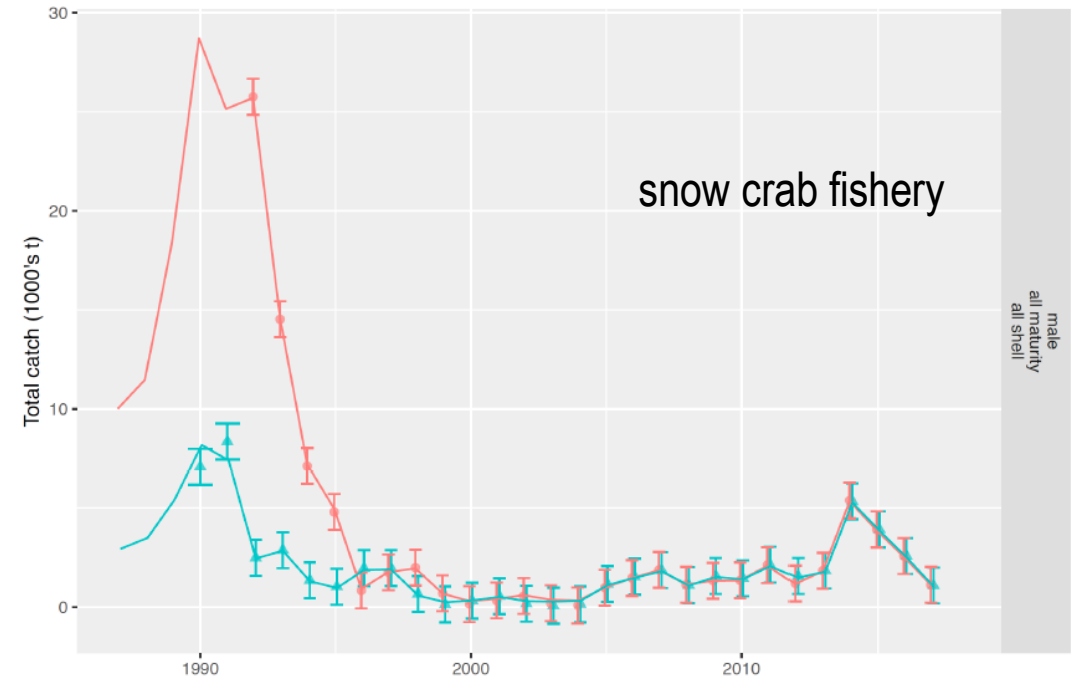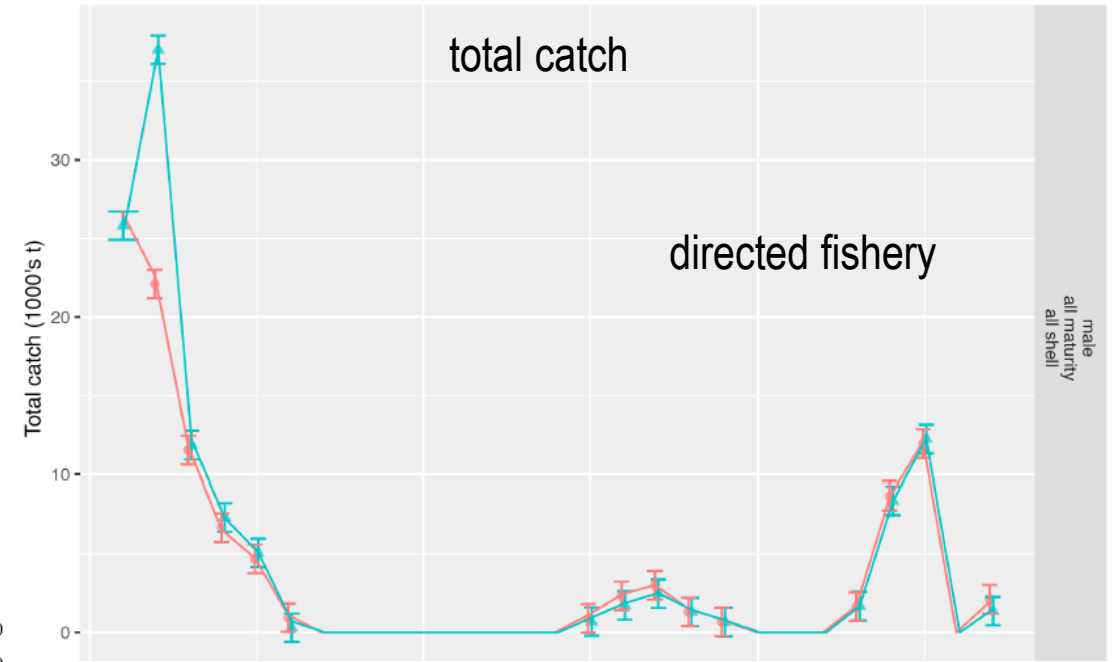
Model processes: NMFS survey
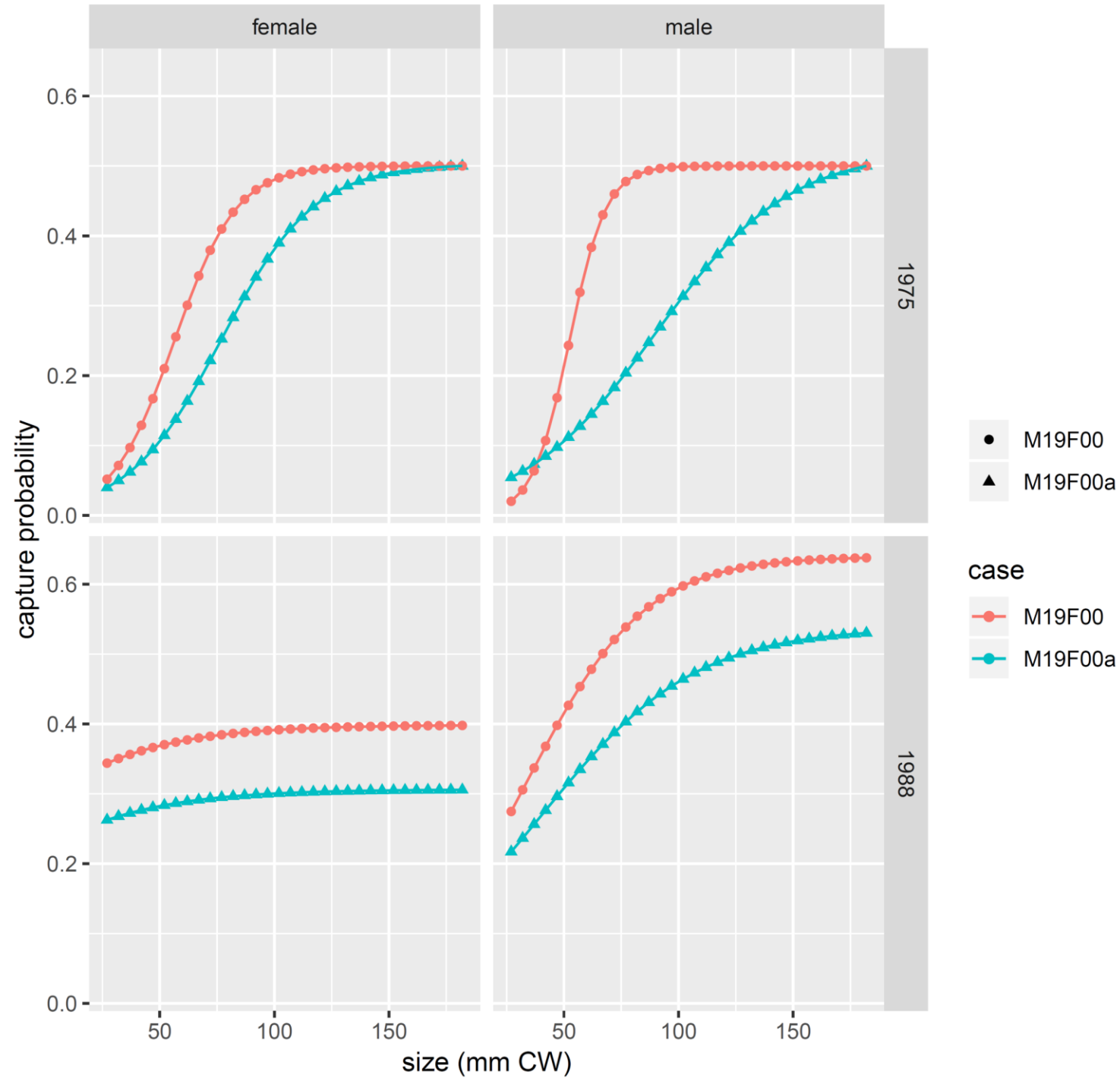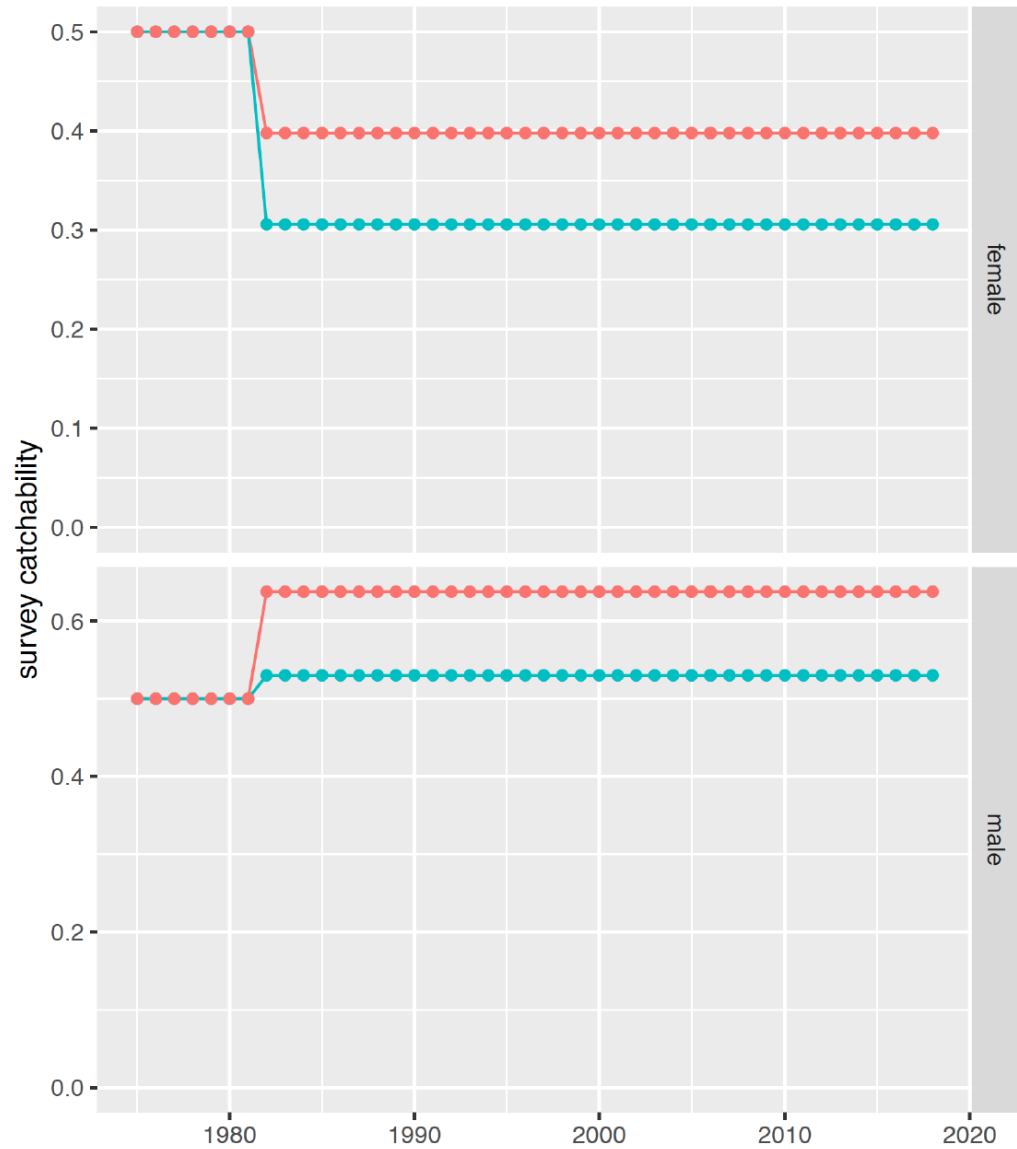
Model recruitment estimates
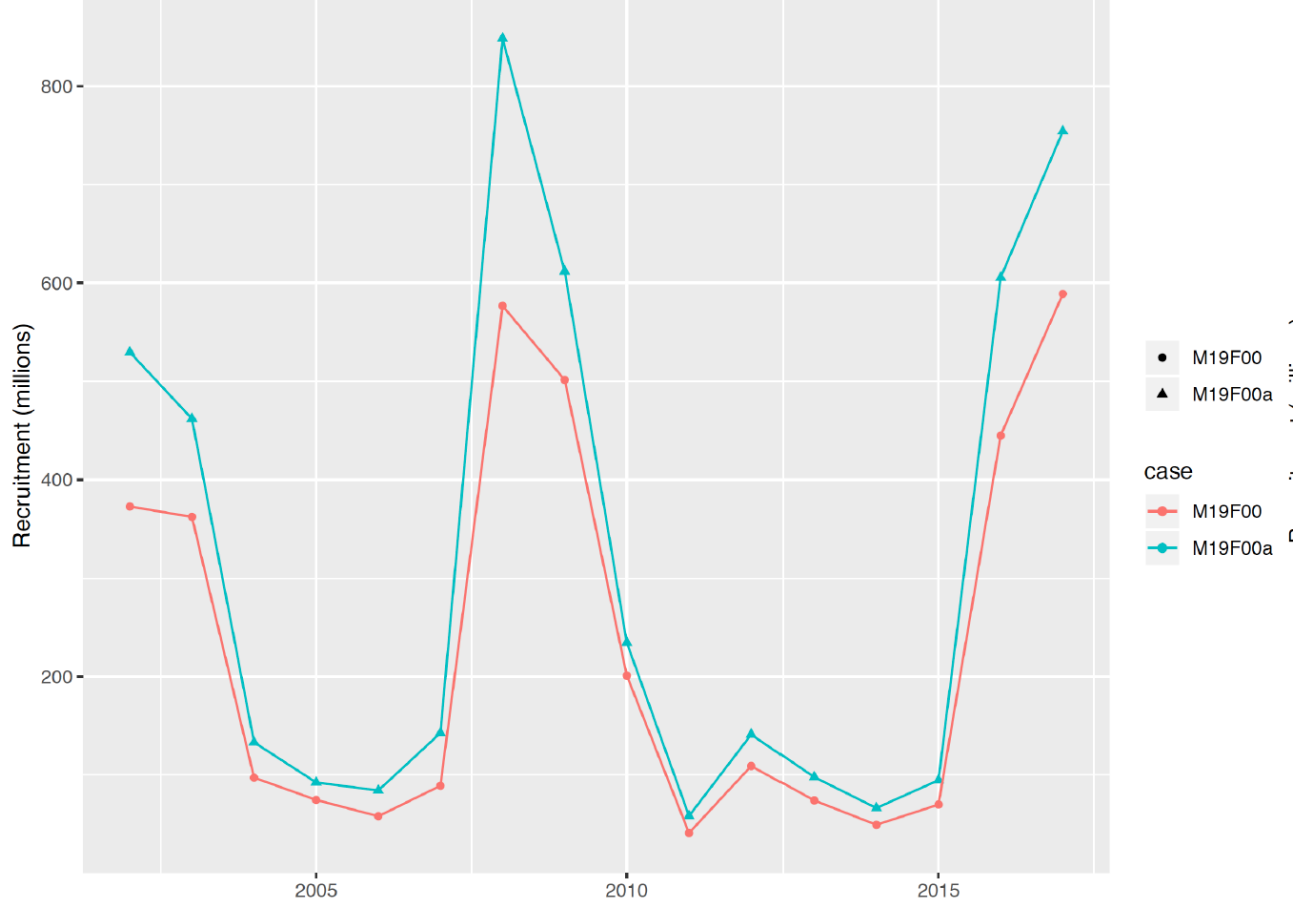
# Model population estimates

Changes in management quantities

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
M19F00	223.63	66.64	86.55	30.29	0.74	12.75	0.74	20.87	35.95	1.19
M19F00a	284.28	82.05	94.24	32.99	0.89	14.58	0.89	27.90	41.52	1.26

Results from M19F0X Scenarios

Directed fishery: fits to male catch data
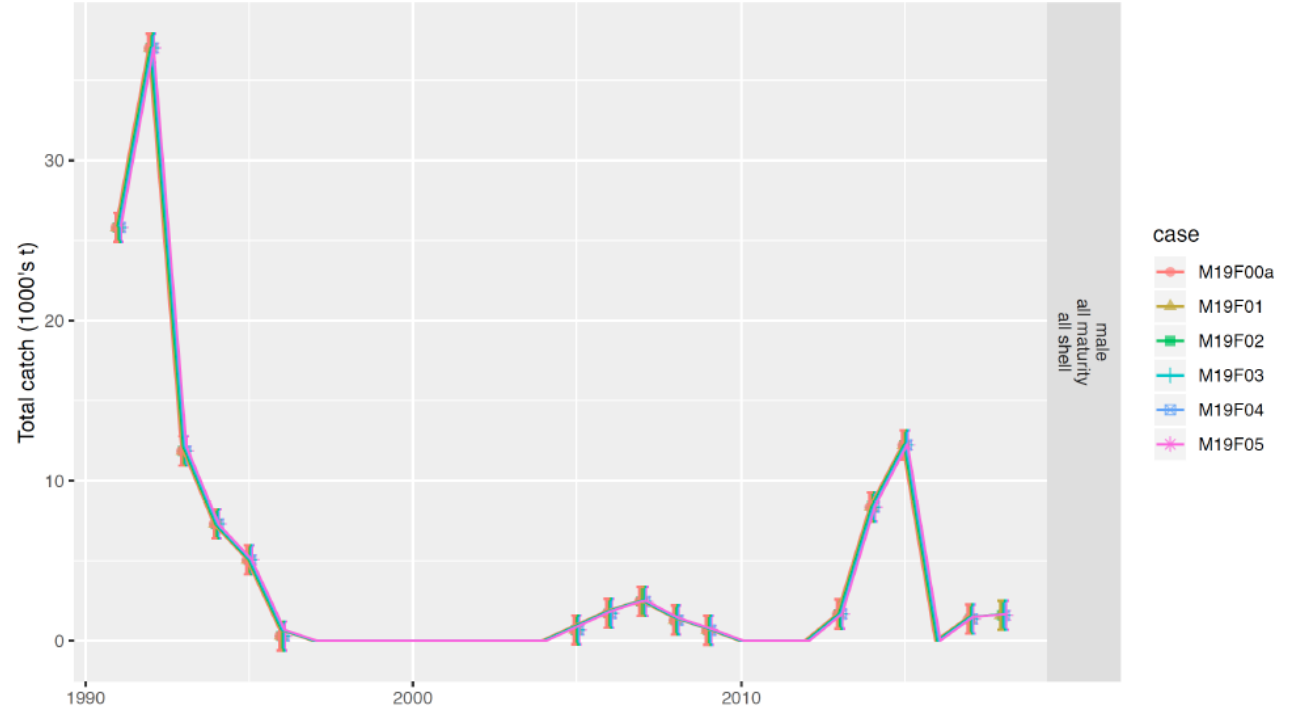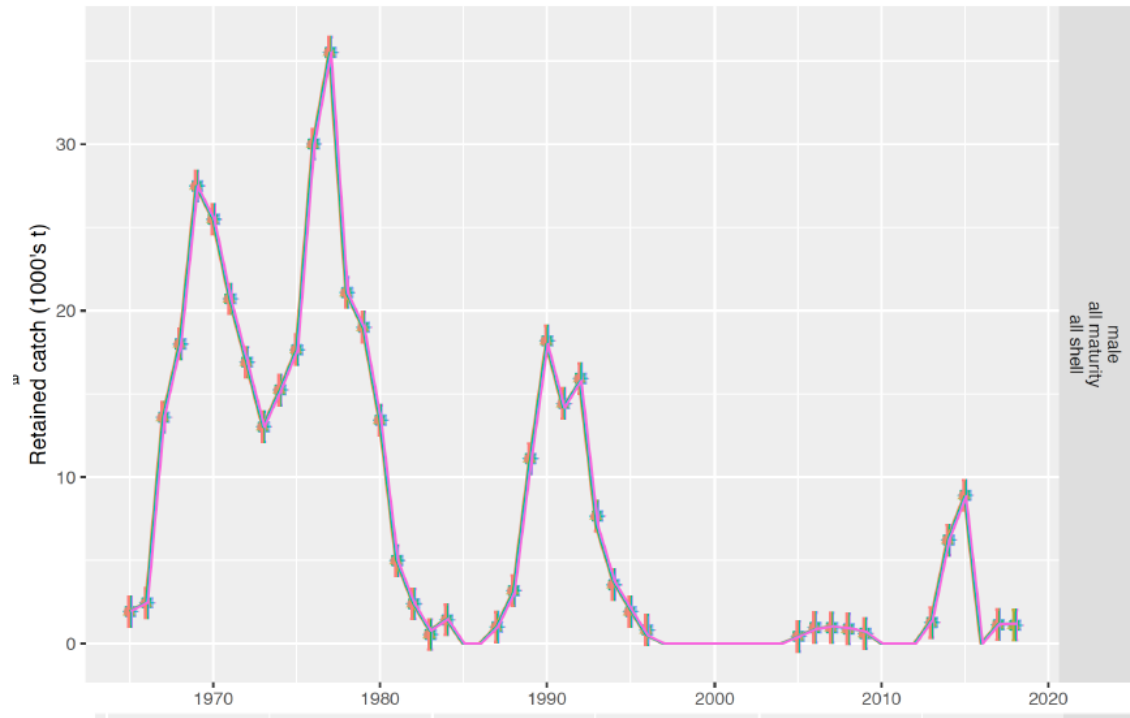
Marginal fits to fishery size compositions: directed fishery
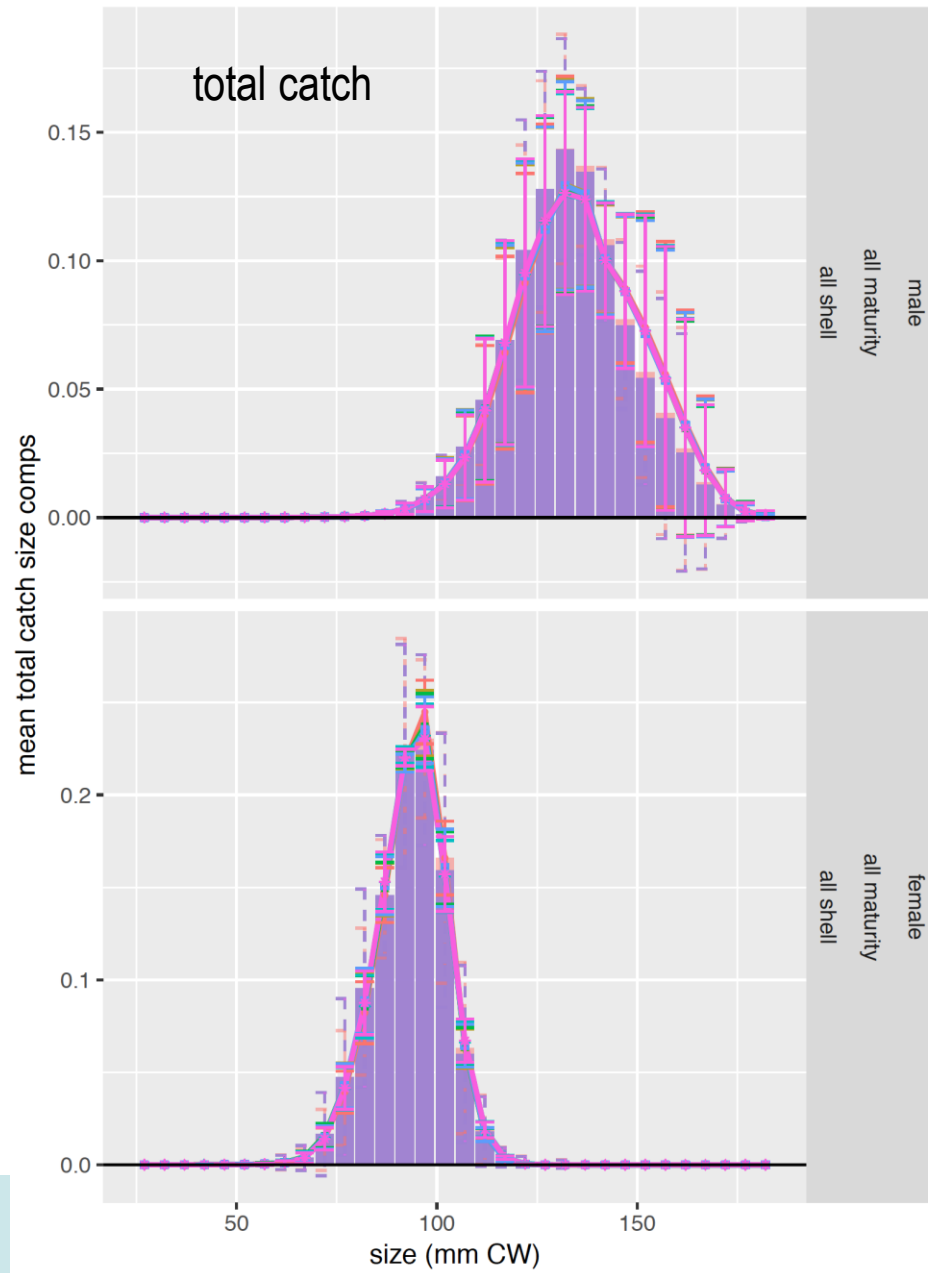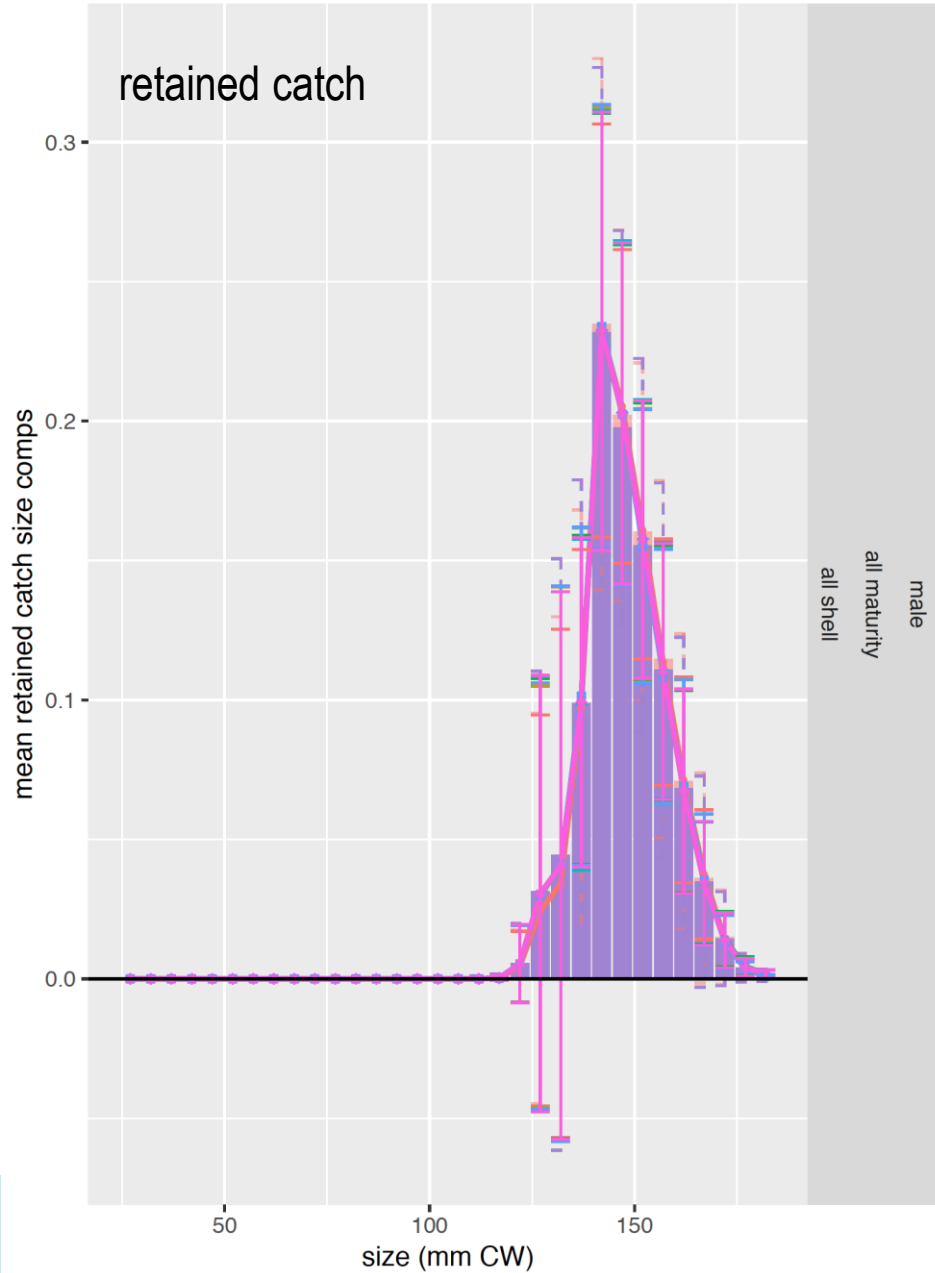
Fits to NMFS EBS mature male survey biomass
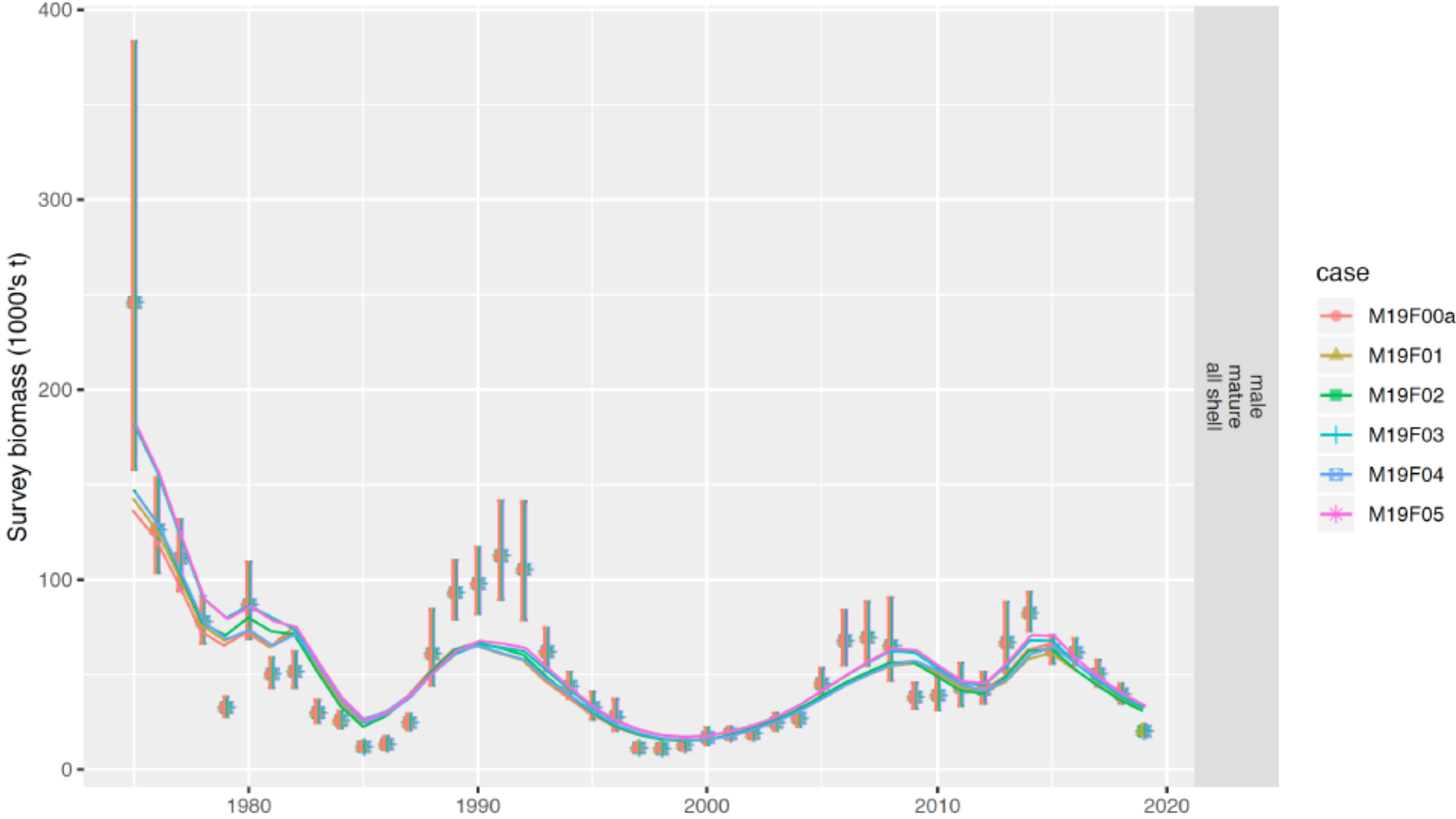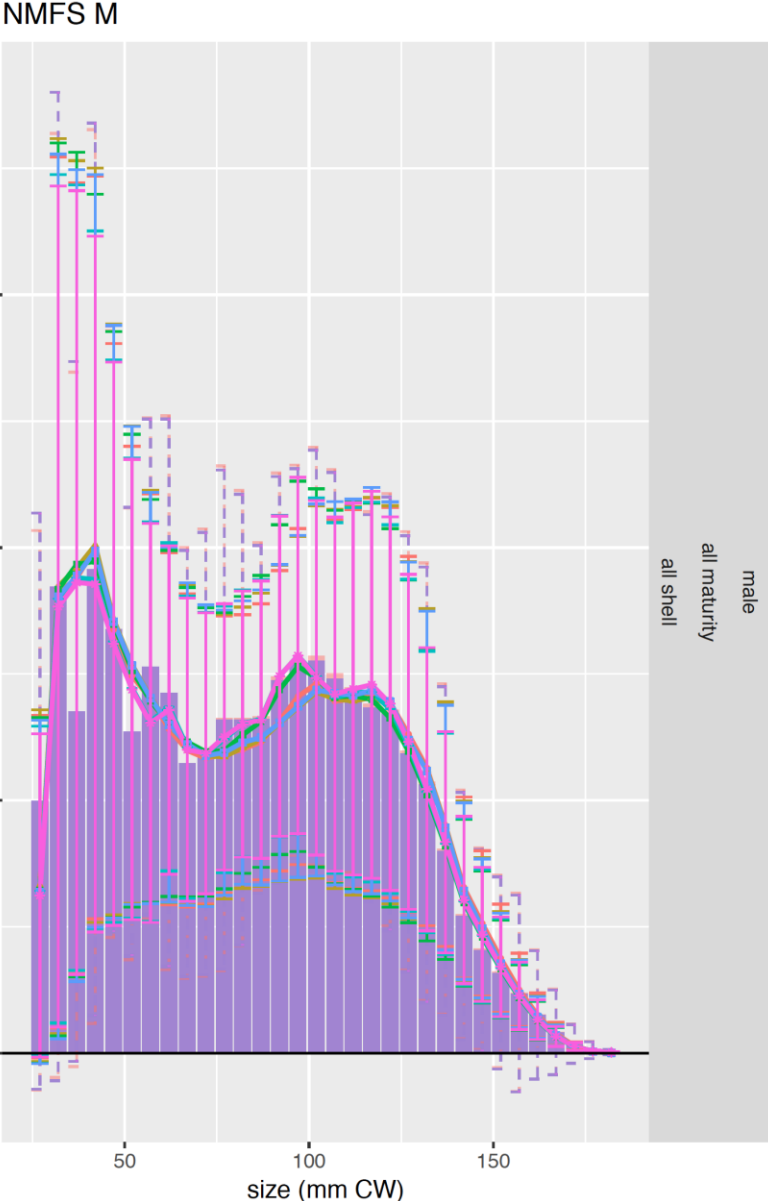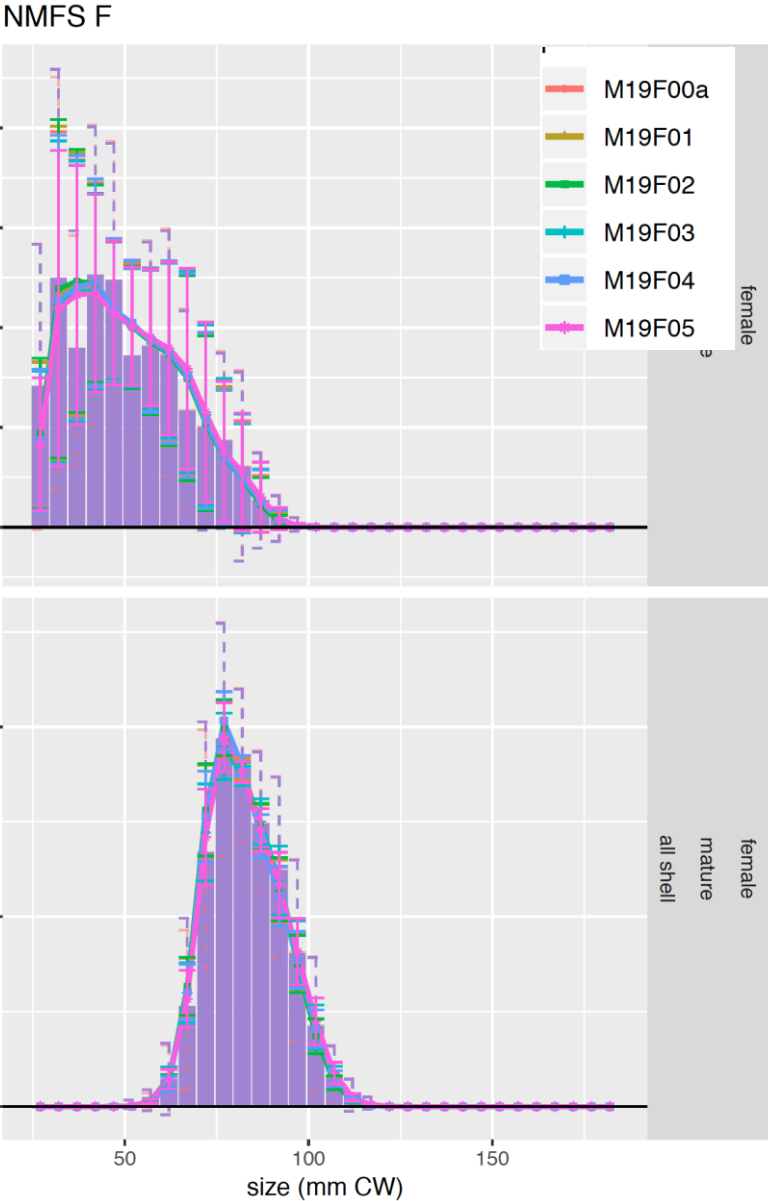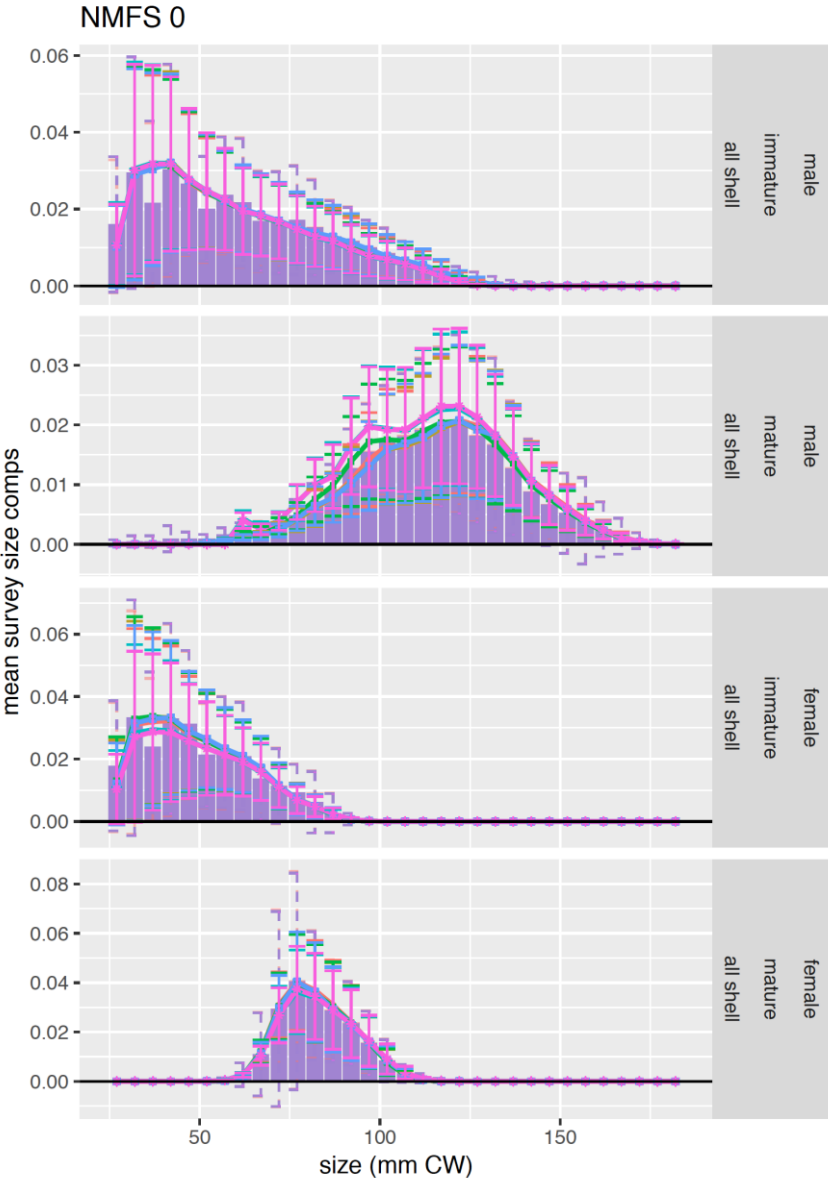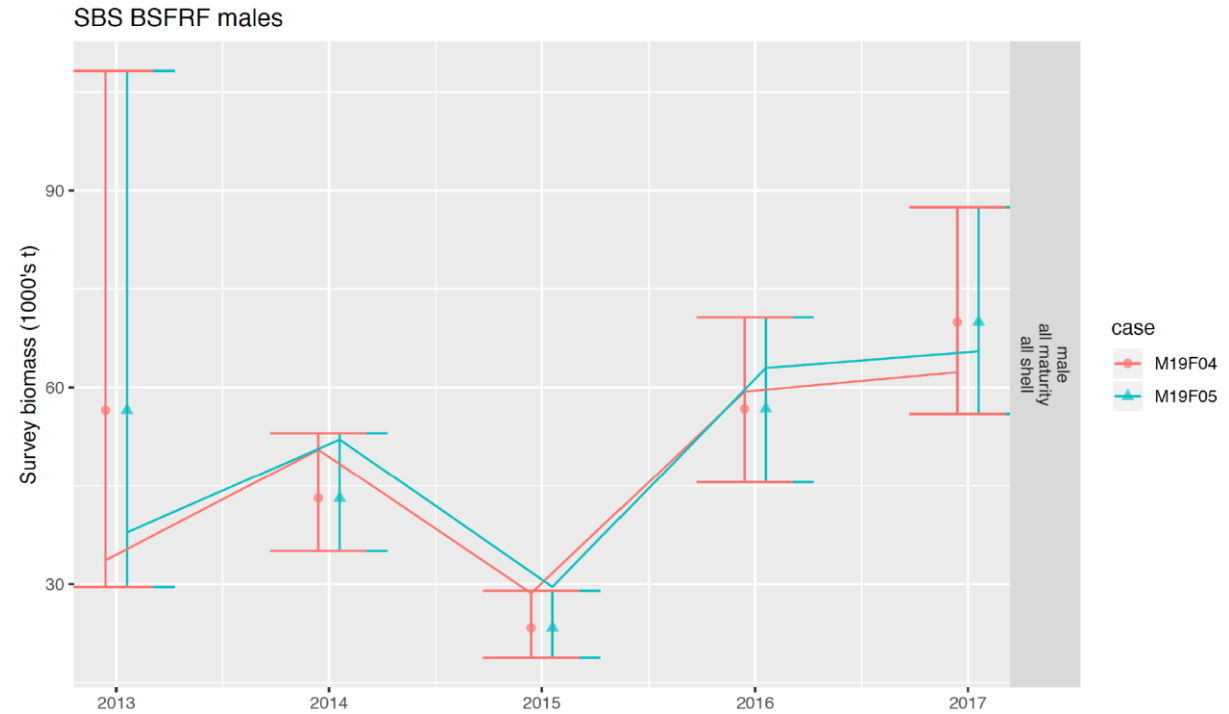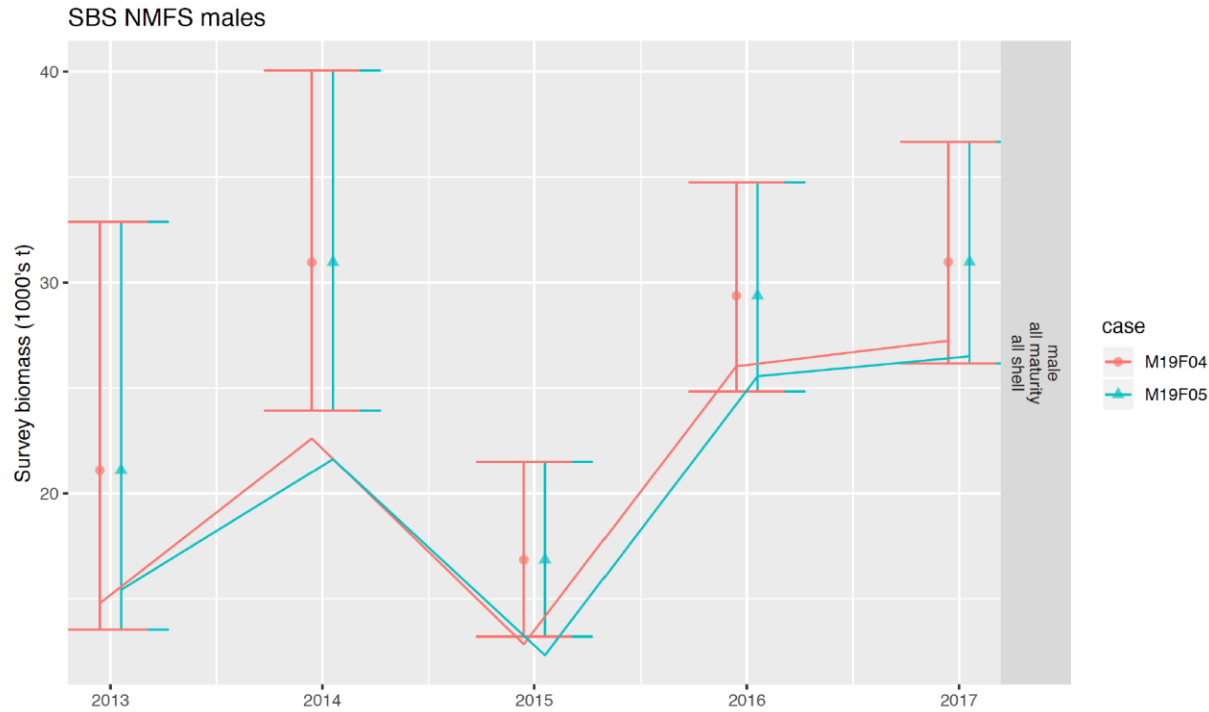
Fits to NMFS EBS mature female survey biomass
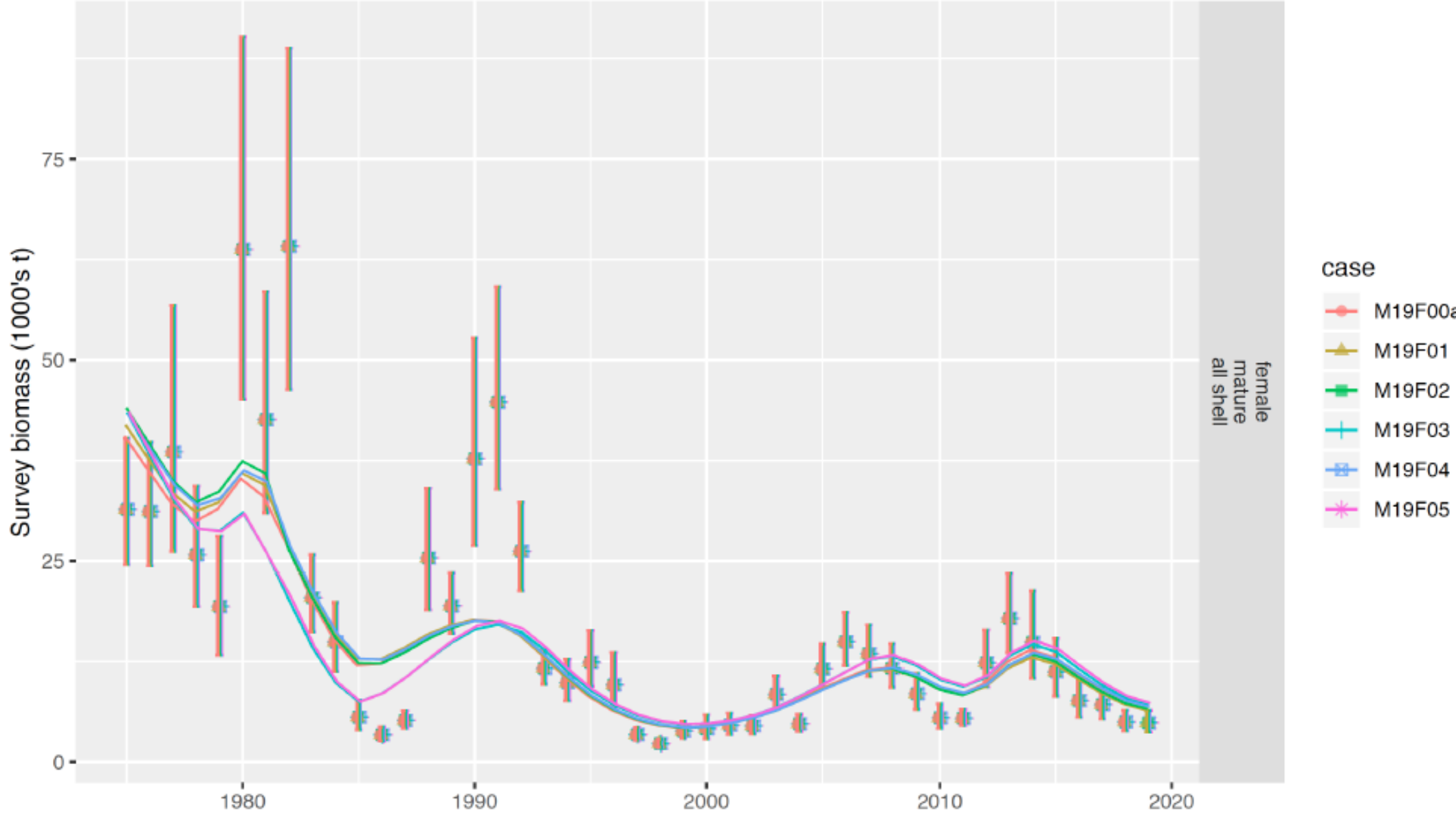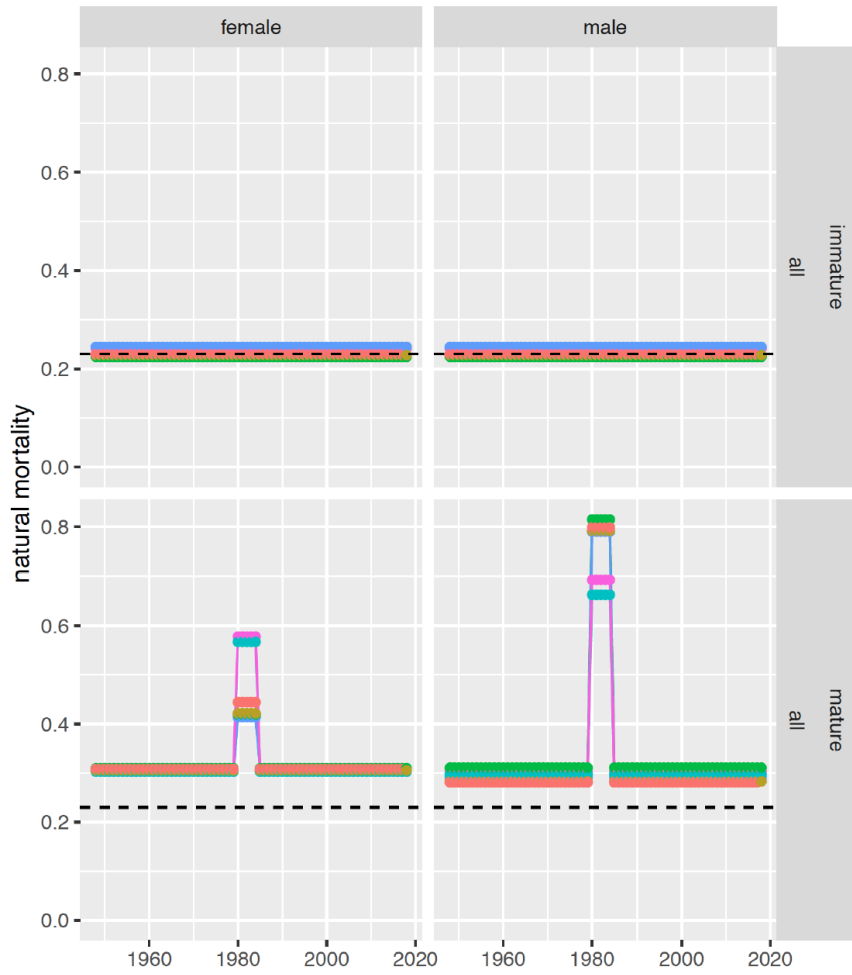
Marginal fits to NMFS survey size compositions

Fits to SBS male survey biomass

Estimated model processes
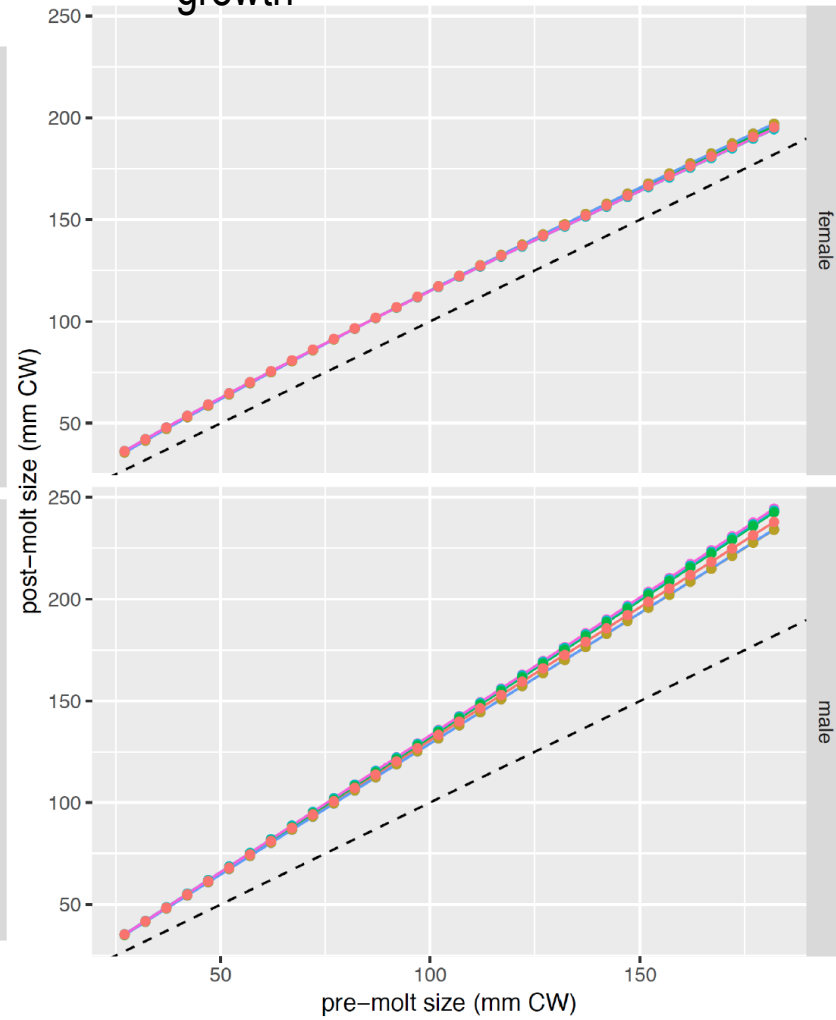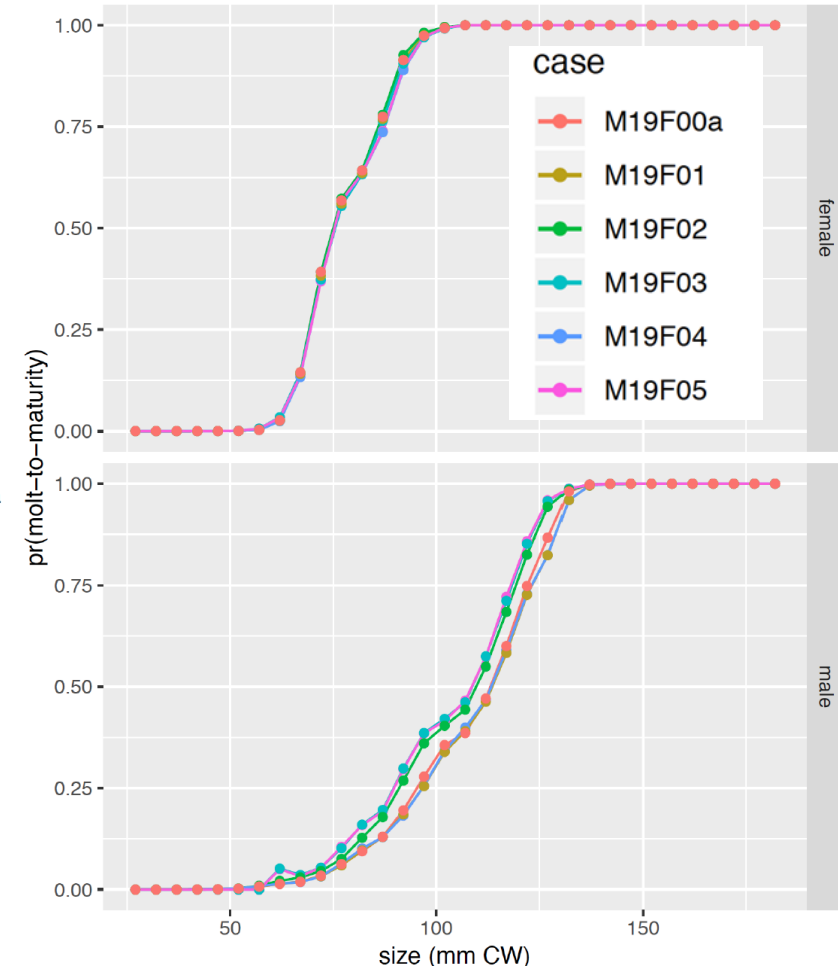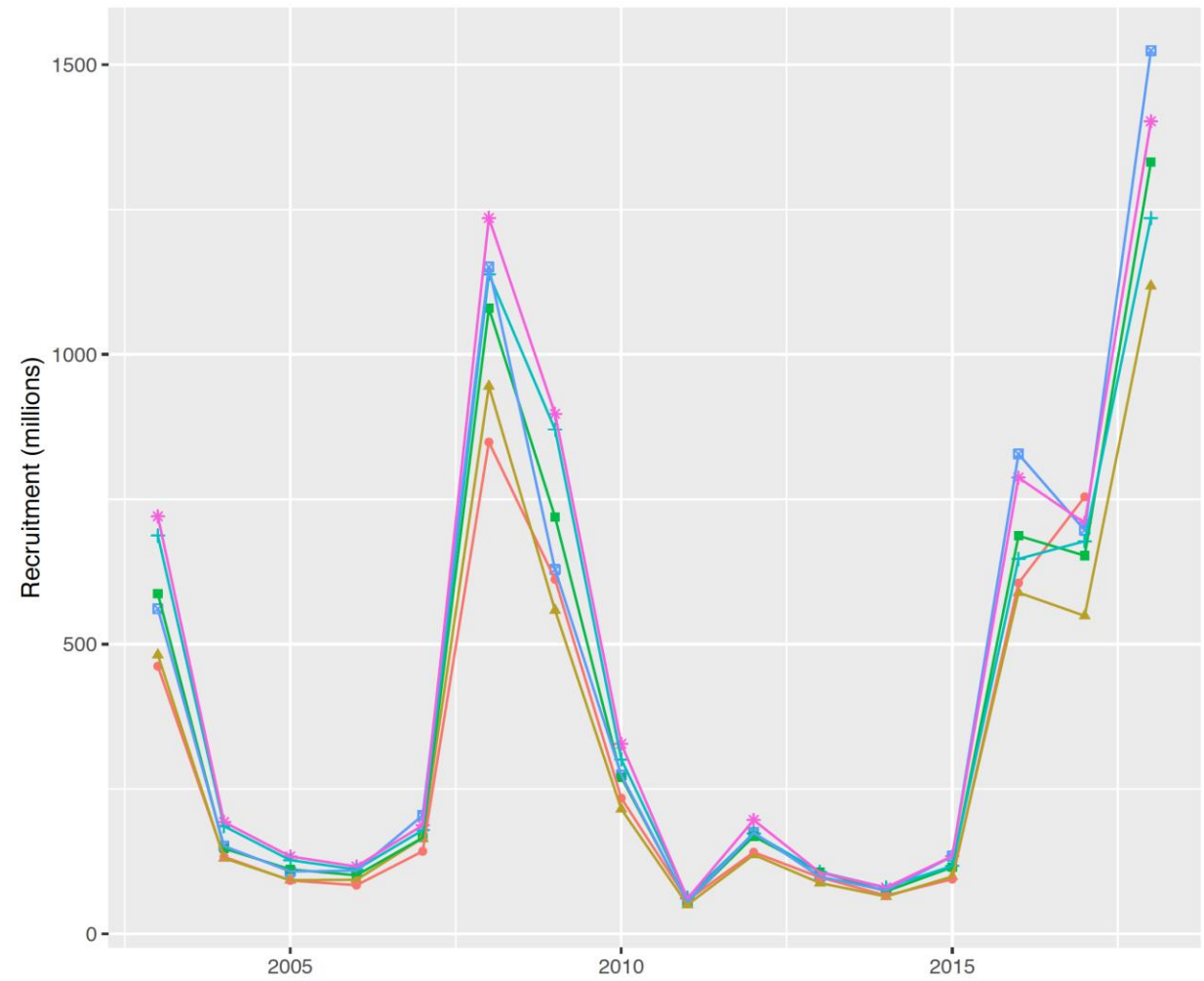
Estimated recruitment
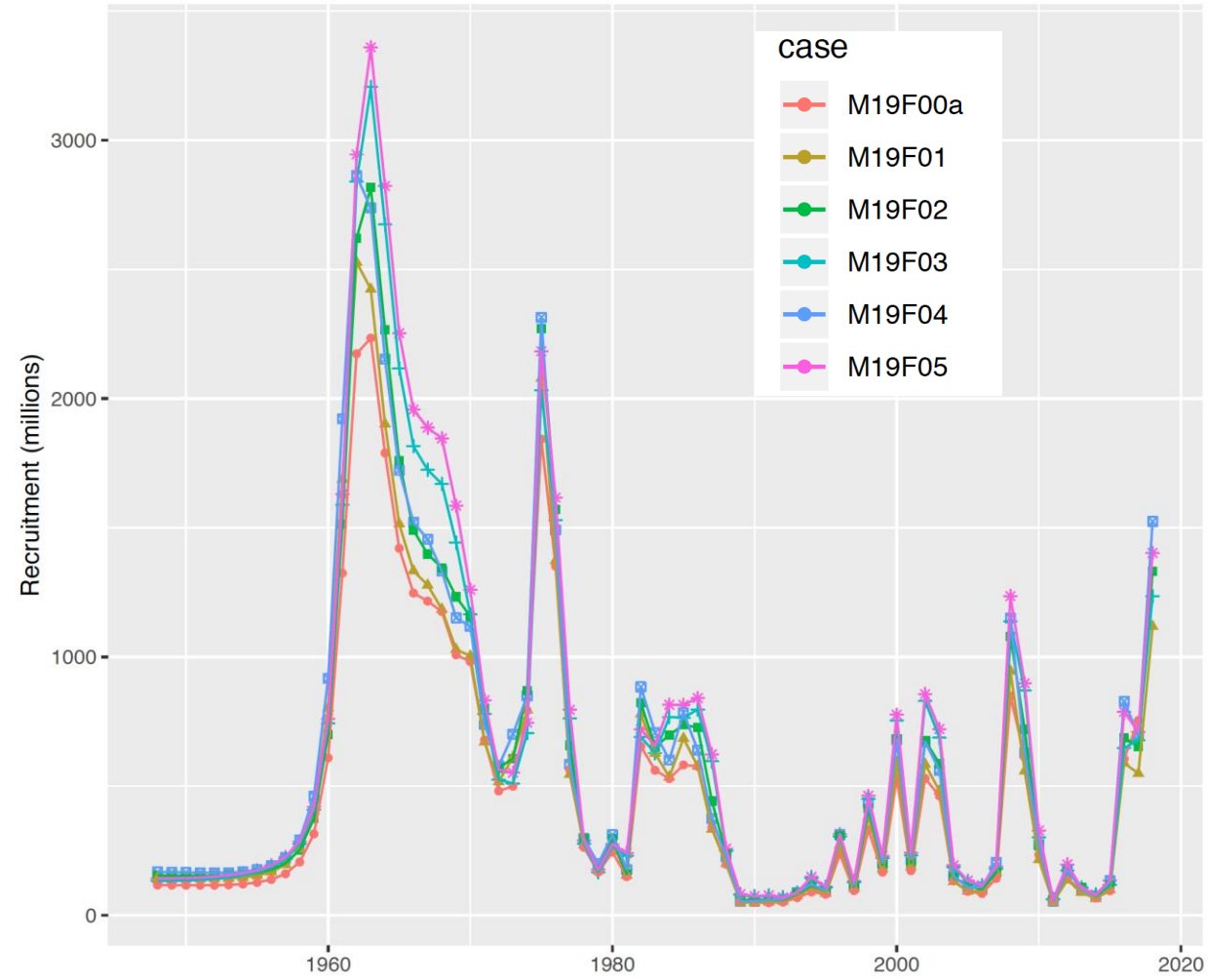
Estimated mature population biomass
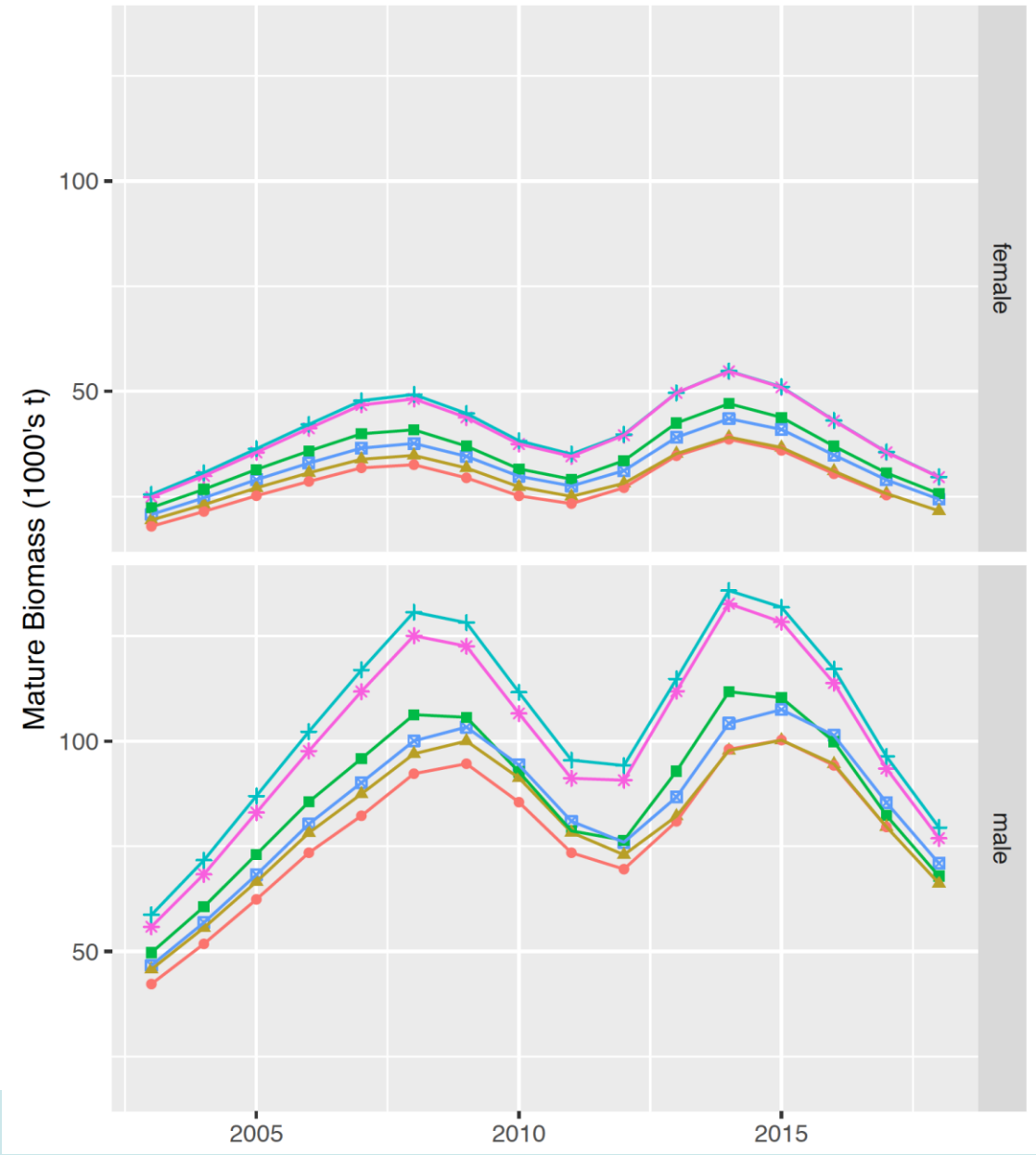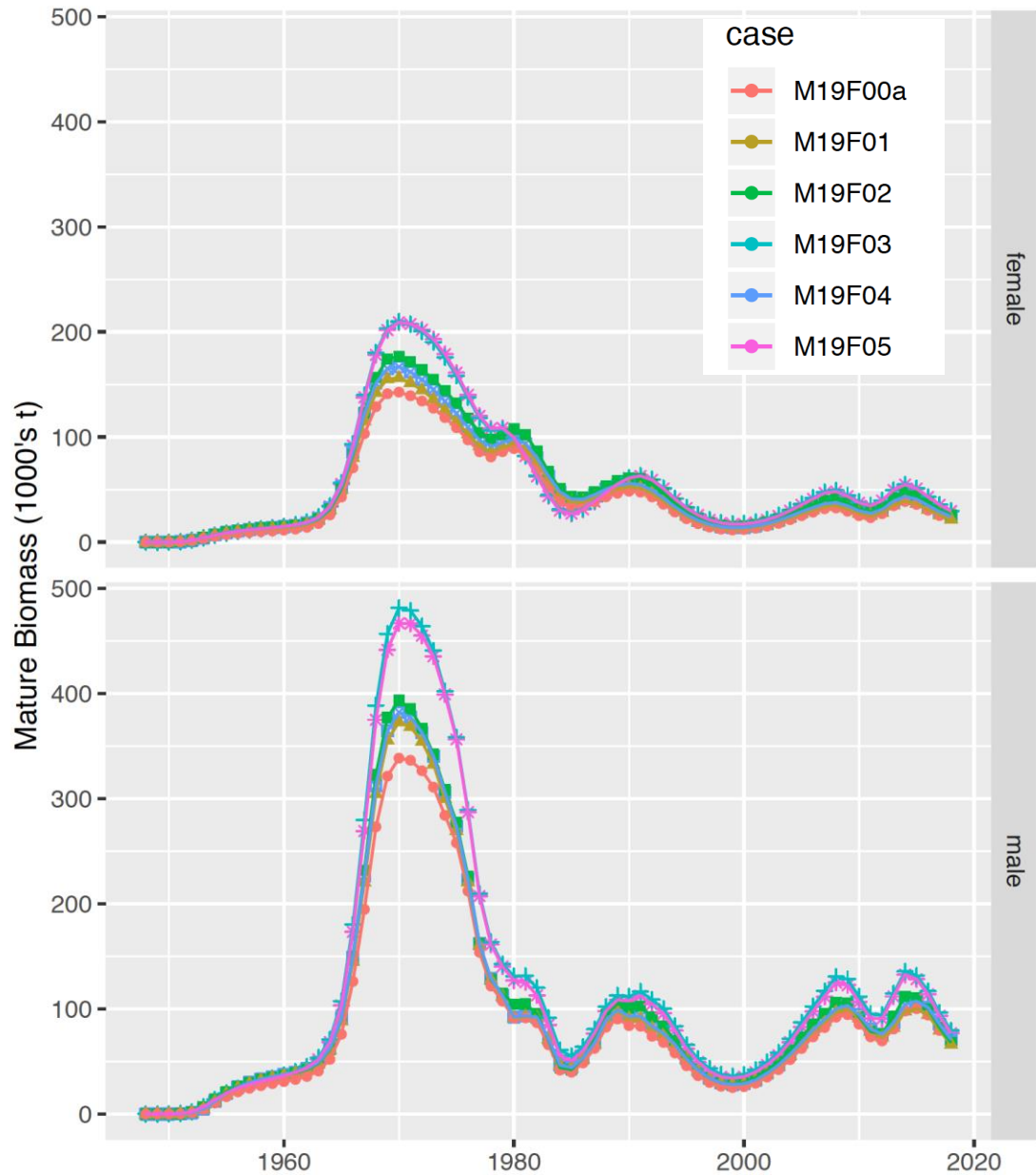
Model processes: NMFS EBS surveys
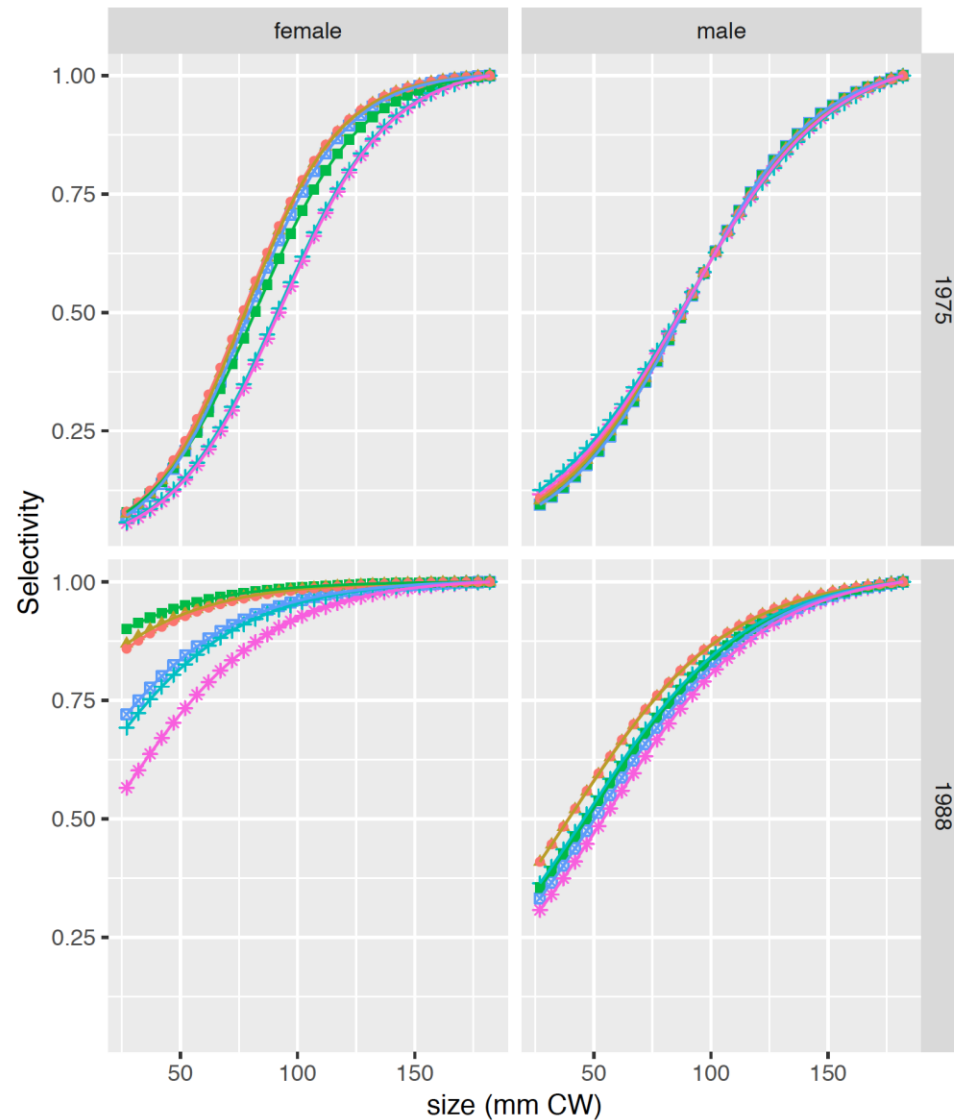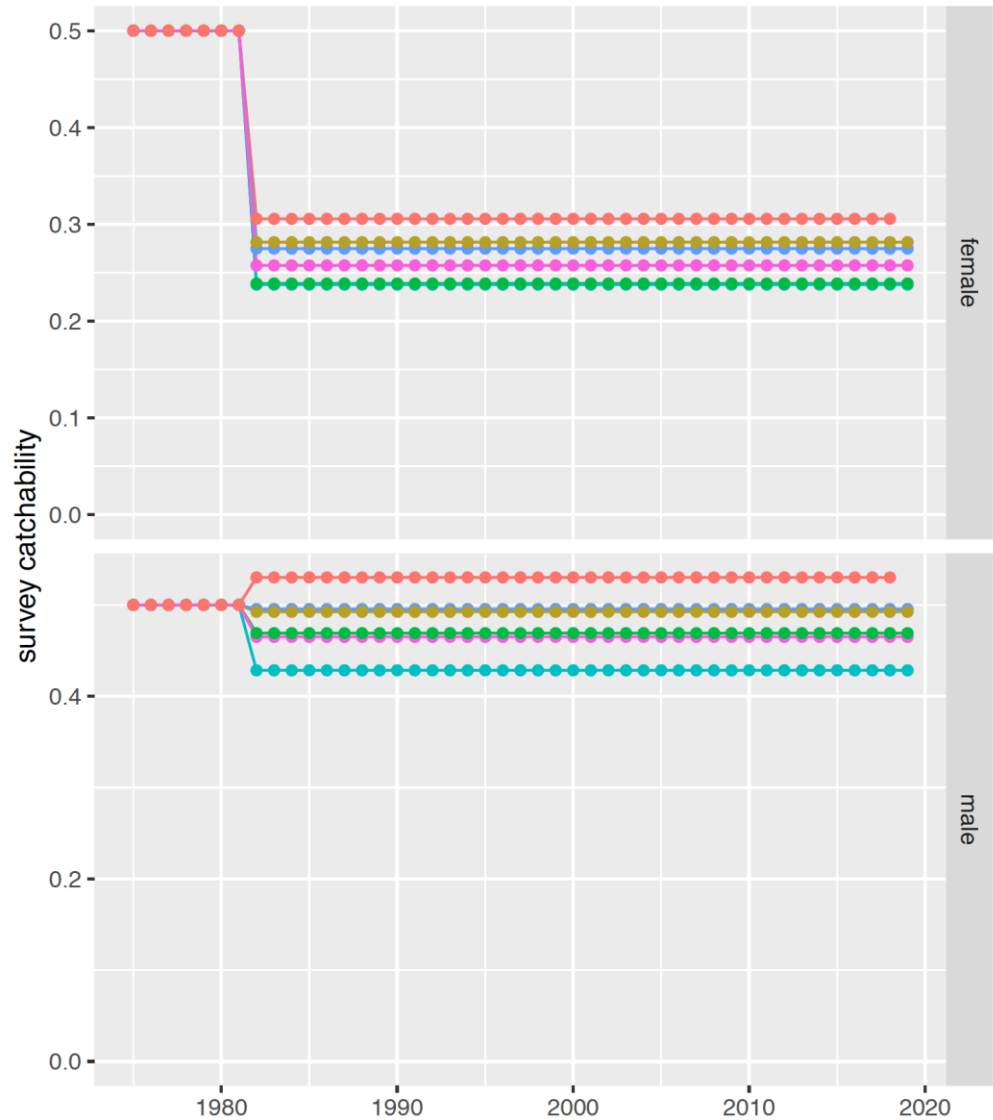
Estimated vs. Empirical Availability Functions
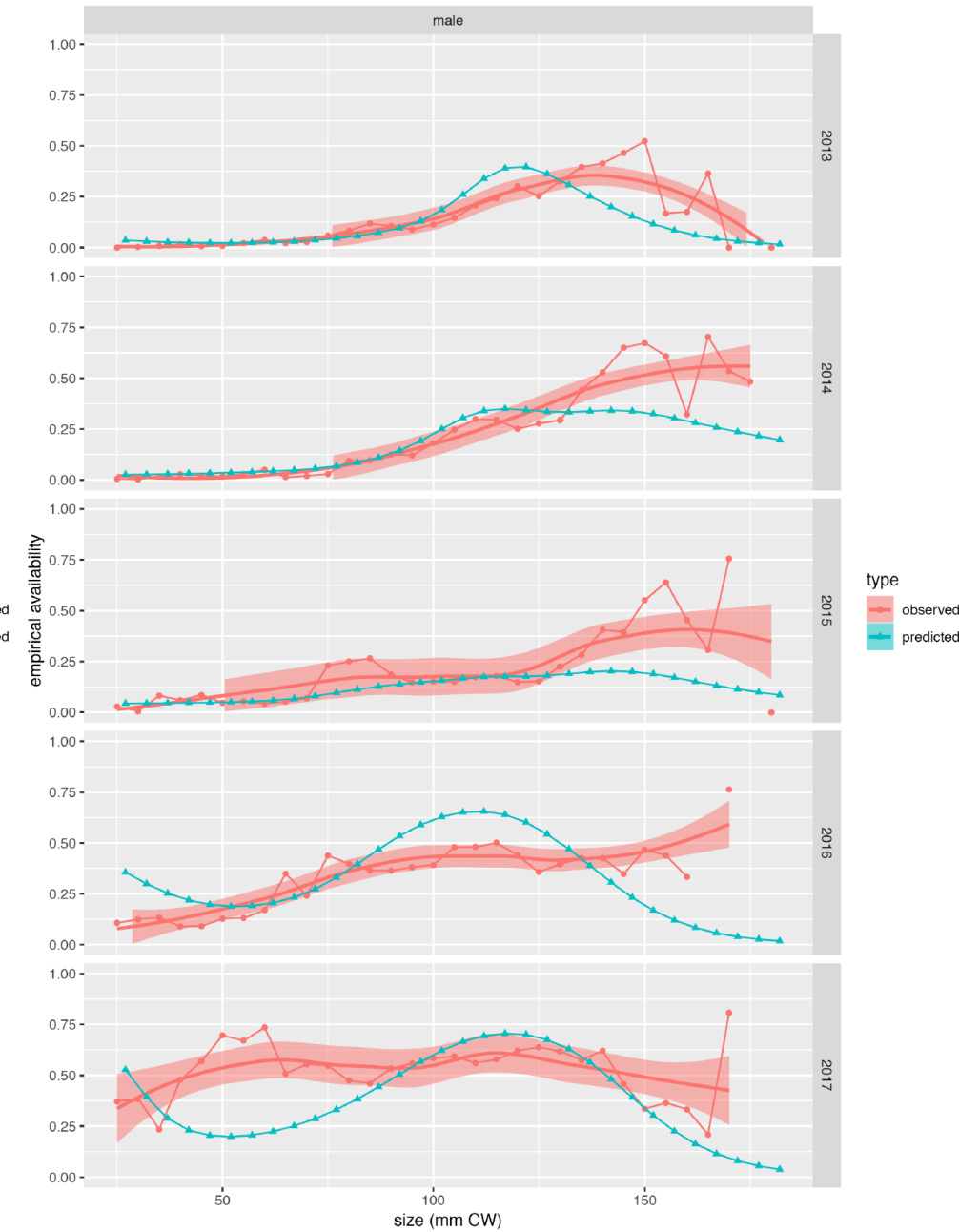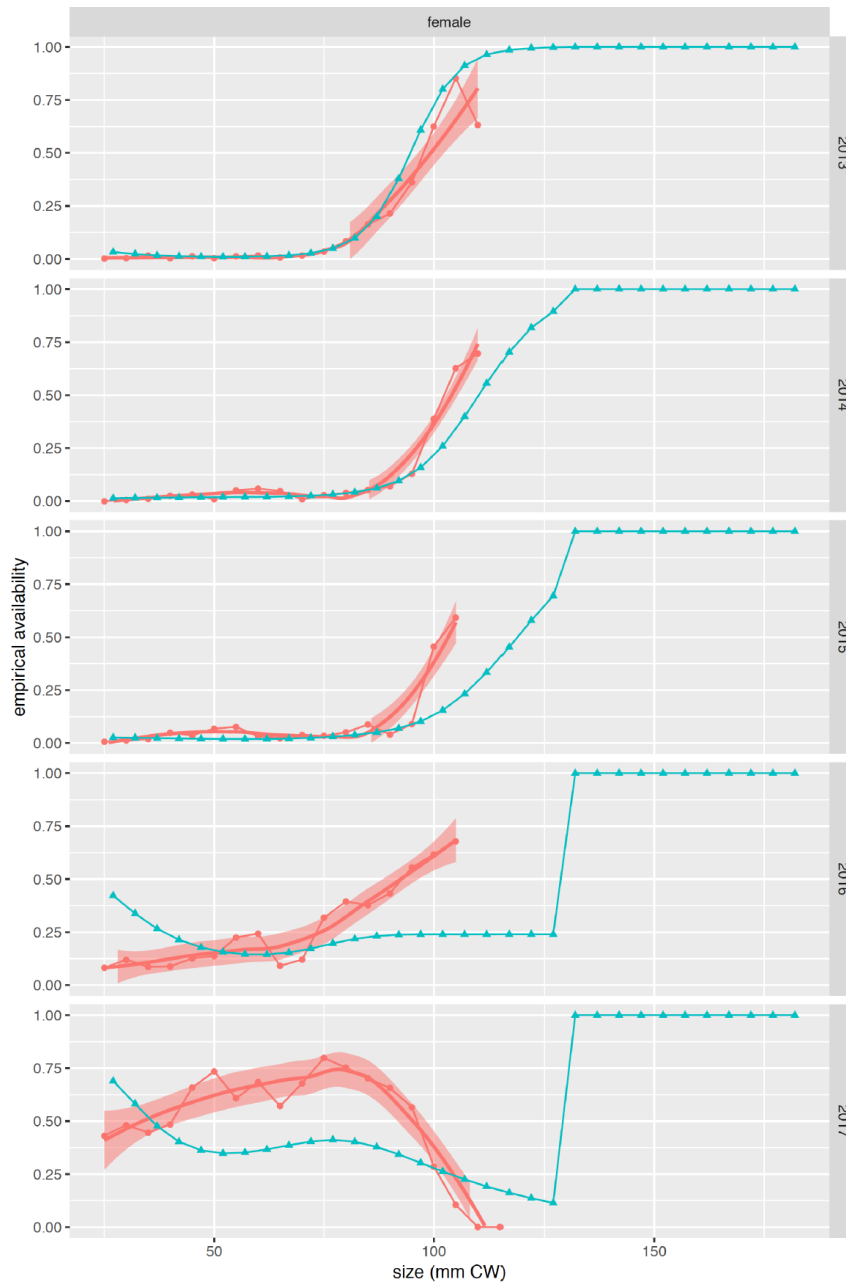
Model scenario evaluation

- All models estimate NMFS survey q's at lower bounds->population scale ~2x over M19F00
  - result principally of updated crab fishery data
  - fitting maturity ogives, SBS data secondarily
- Models with SBS data (M19F04, 05) don't seem to estimate availability very well
  - LOTS more parameters, not very stable
- M19F01 and M19F04 (& M19F00a, M19F02) fit "manufactured" male maturity data
- Author recommended model: M19F03
  - drops Rugolo-Turnock immature/mature categorization for males
  - fits 2006+ male maturity ogive data (0.1 mm CH prec.)
  - does not fit BSFRF-NMFS SBS data: better stability
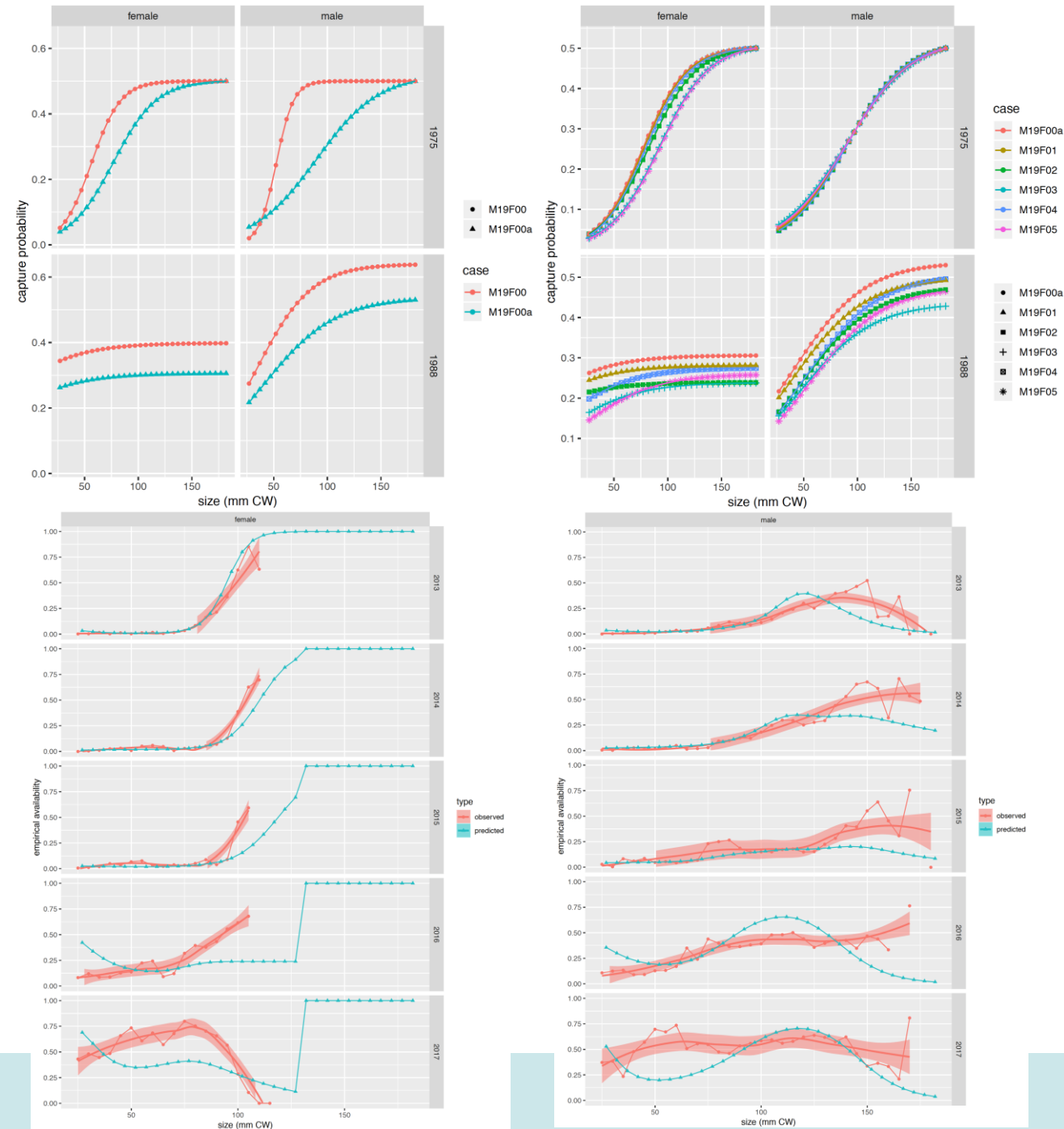
Management-related quantities

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
M19F00	223.63	66.64	86.55	30.29	0.74	12.75	0.74	20.87	35.95	1.19
M19F00a	284.28	82.05	94.24	32.99	0.89	14.58	0.89	27.90	41.52	1.26
M19F01	316.79	68.79	100.85	35.30	0.81	15.58	0.81	22.54	35.66	1.01
M19F02	367.48	71.54	105.59	36.96	1.11	17.89	1.03	24.75	34.63	0.94
M19F03	393.84	82.61	118.96	41.64	1.18	19.49	1.12	29.48	39.68	0.95
M19F04	377.28	74.03	106.76	37.37	0.87	16.87	0.87	24.87	37.50	1.00
M19F05	418.73	80.33	116.44	40.75	1.21	19.40	1.14	28.58	38.42	0.94

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2015/16	12.82	73.93	8.92	8.91	11.38	27.19	21.75
2016/17	14.58	77.96	0.00	0.00	1.14	25.61	20.49
2017/18	15.15	64.09	1.13	1.13	2.37	25.42	20.33
2018/19	20.54	82.61	1.11	1.11	1.90	20.87	16.70
2019/20		39.55				28.86	23.09

| 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})
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
2019/20	3b	41.07	39.55	0.96	1.08	1982-2019	0.23

Future work

- continue work on integrating SBS studies
  - use empirical selectivity from SBS studies as prior?
  - use empirical availabilities from SBS studies
    - instead of estimating availabilities?
    - as priors on estimated availabilities?

- consider nonparametric or re-parameterized functions for groundfish fishery selectivity

- examine pros/cons for disaggregating directed fishery into East/West 166W components

- examine size-weight relationships for crab in directed fishery

- examine more potential environmental drivers for recruitment

extra stuff

title
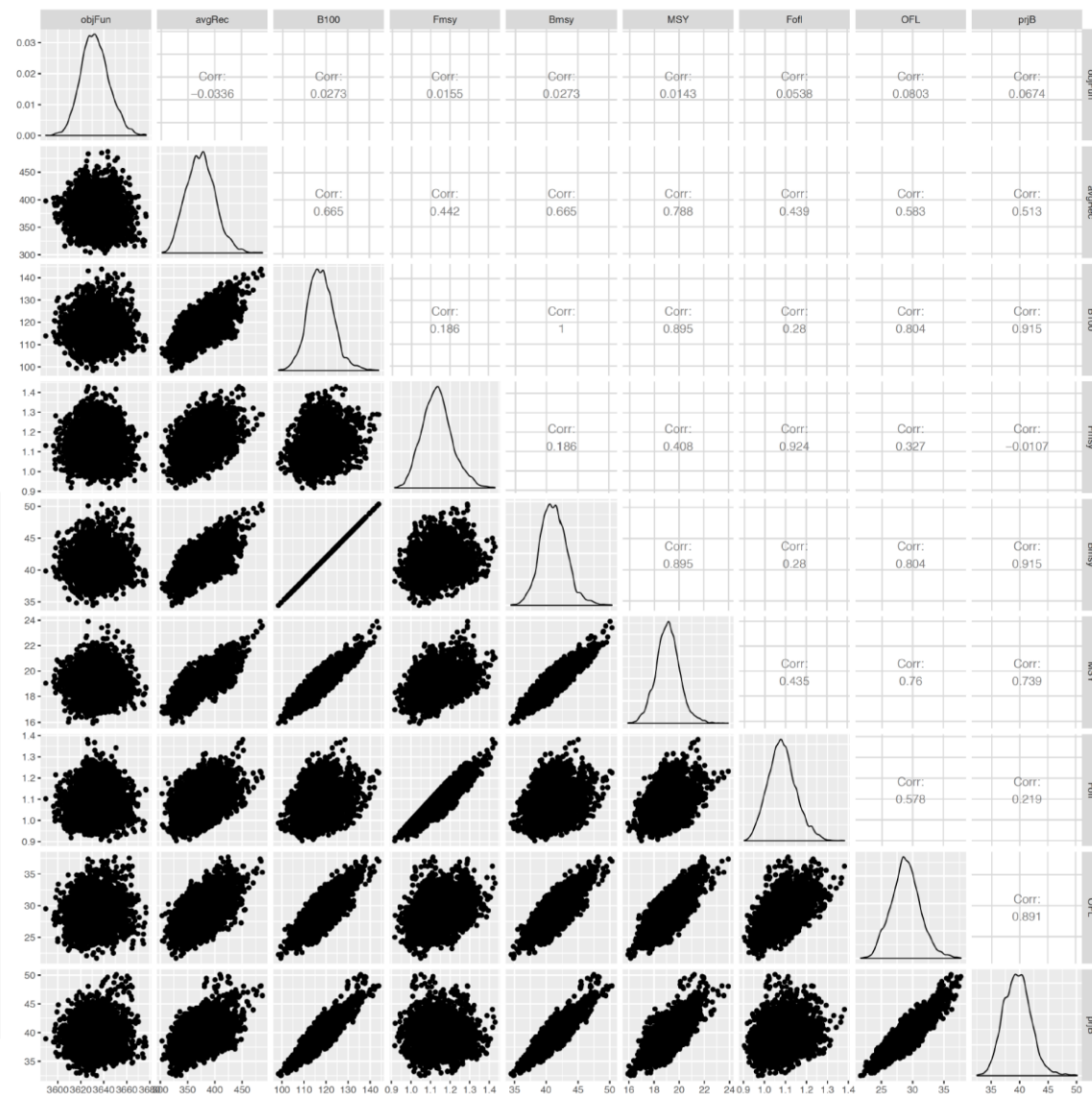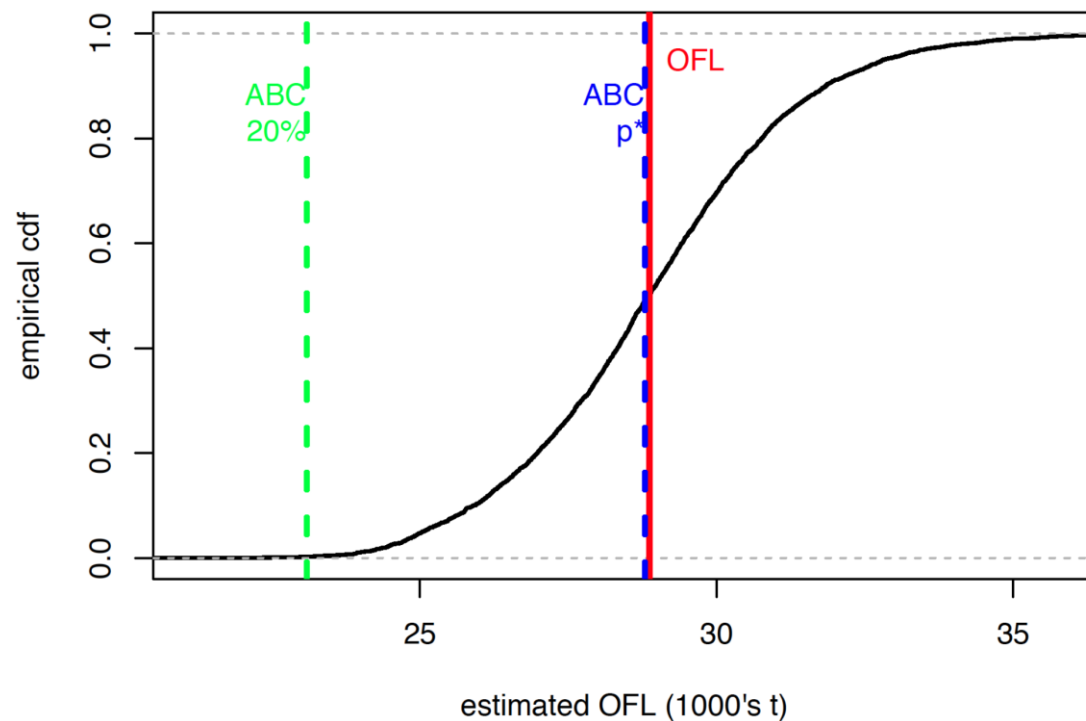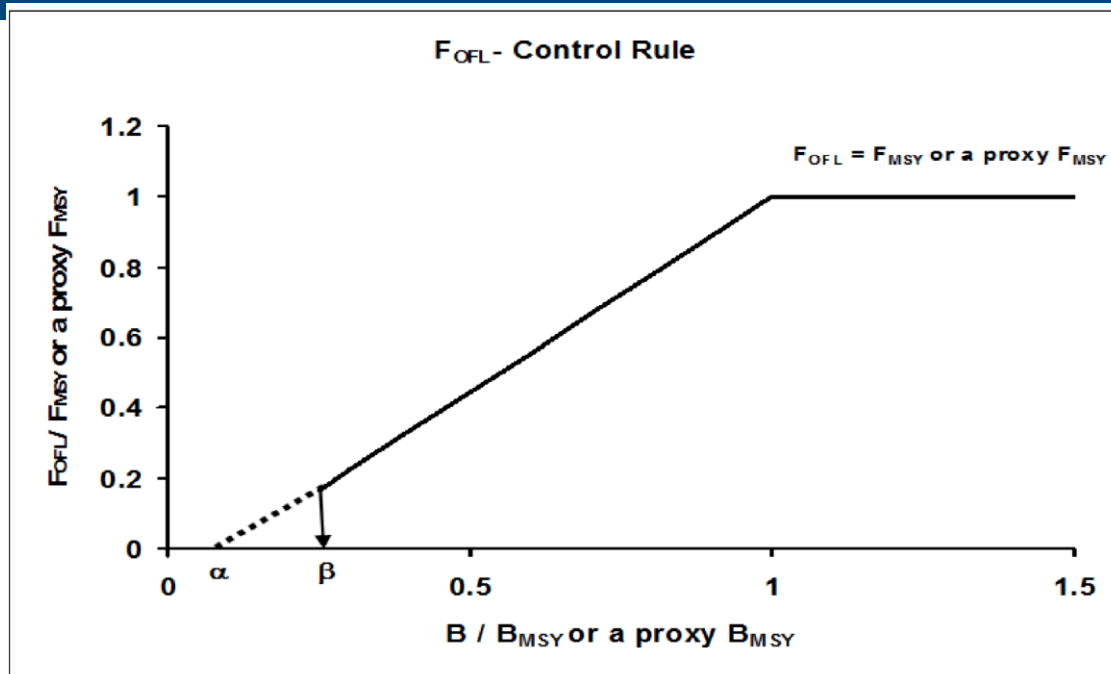
Modeling availability and selectivity

$$\tilde{n}^S_{x,z} = q^S_x \cdot S^S_{x,z} \cdot A_{x,z} \cdot n_{x,z}$$

NMFS EBS ($A_{x,z} \equiv 1$):

$$\hat{n}^{NMFS}_{x,z} = q^{NMFS}_x \cdot S^{NMFS}_{x,z} \cdot n_{x,z}$$

BSFRF ($q^{BSFRF}_x, S^{BSFRF}_{x,z} \equiv 1$):

$$\tilde{n}^{BSFRF}_{x,z} = A_{x,z} \cdot n_{x,z}$$

NMFS SBS:

$$\tilde{n}^{NMFS}_{x,z} = q^{NMFS}_x \cdot S^{NMFS}_{x,z} \cdot A_{x,z} \cdot n_{x,z}$$

Model estimation

$$A_{x,z} = \frac{1}{1+\exp{(-p_{x,z})}}$$

$$\mathcal{L}_S = \lambda \cdot \left[\nabla(\nabla p_{x,z})\right]^2$$

Empirical estimation

$$A_{x,z} = \frac{\tilde{n}^{NMFS}_{x,z}}{\hat{n}^{NMFS}_{x,z}}$$

$$S^{NMFS}_{x,z} = \frac{\tilde{n}^{NMFS}_{x,z}}{\tilde{n}^{BSFRF}_{x,z}}$$

NOAA FISHERIES

Fishery data issues: total catch revision

- Historical directed fishing effort from 1990/91+ for the Tanner crab, snow crab, and BBRKC fisheries was revised by D. Pengilly based on fish ticket data and landed catch composition to more closely match current methods assigning directed effort to crab fisheries

- Revised effort is substantially different from "historical" effort in the Tanner and snow crab fisheries, in particular

- This impacts the expansion of observed catch to total because it scales with directed effort

$$A = \frac{n_T}{n_S} \cdot a$$

n_T : directed effort (potlifts)

n_S : observer effort (pots sampled)

- Secondarily, this resulted in sampling effort (and samples) being re-assigned among fisheries

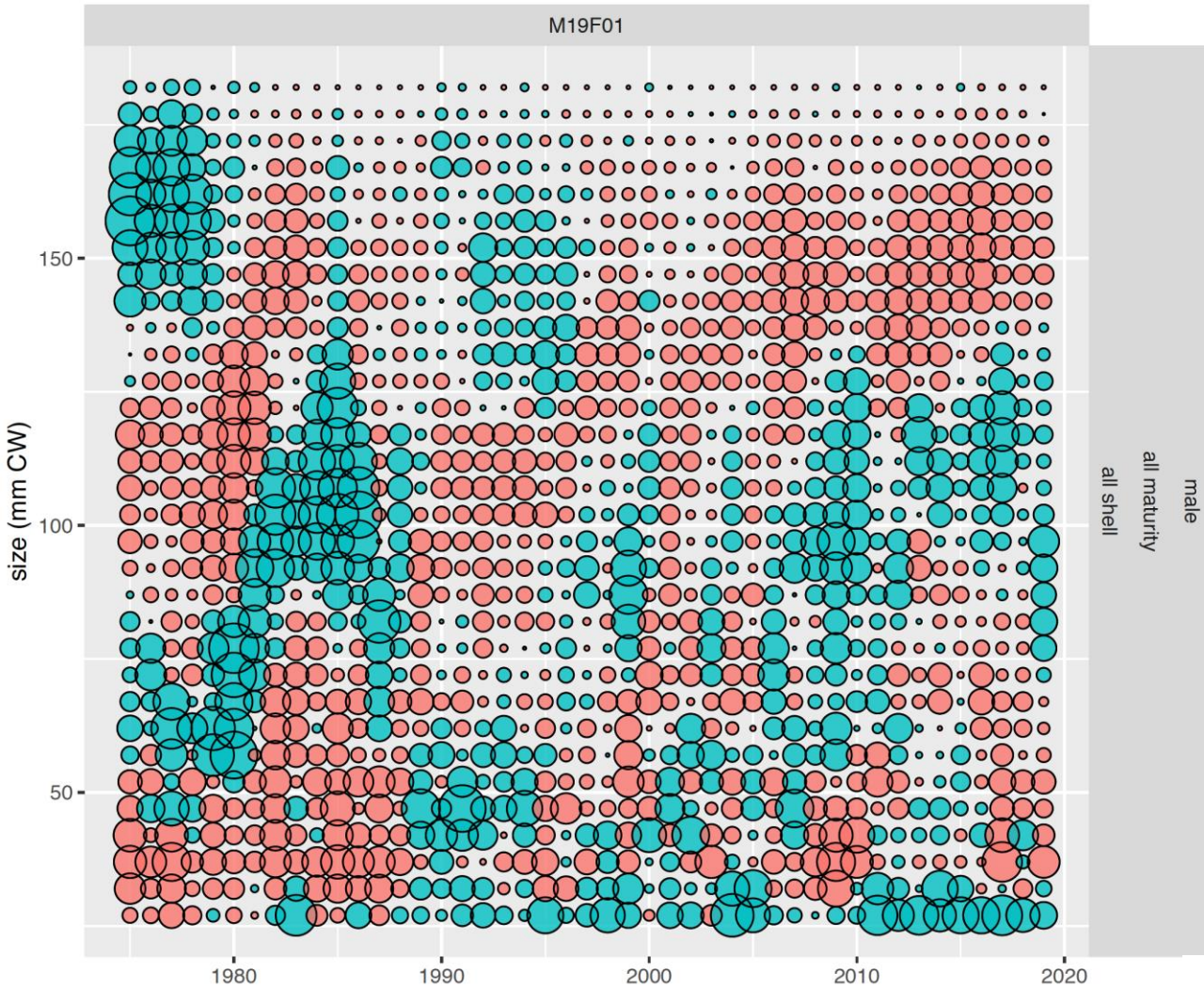# Pearson residuals for M19F01, M19F03 fits to NMFS "0"

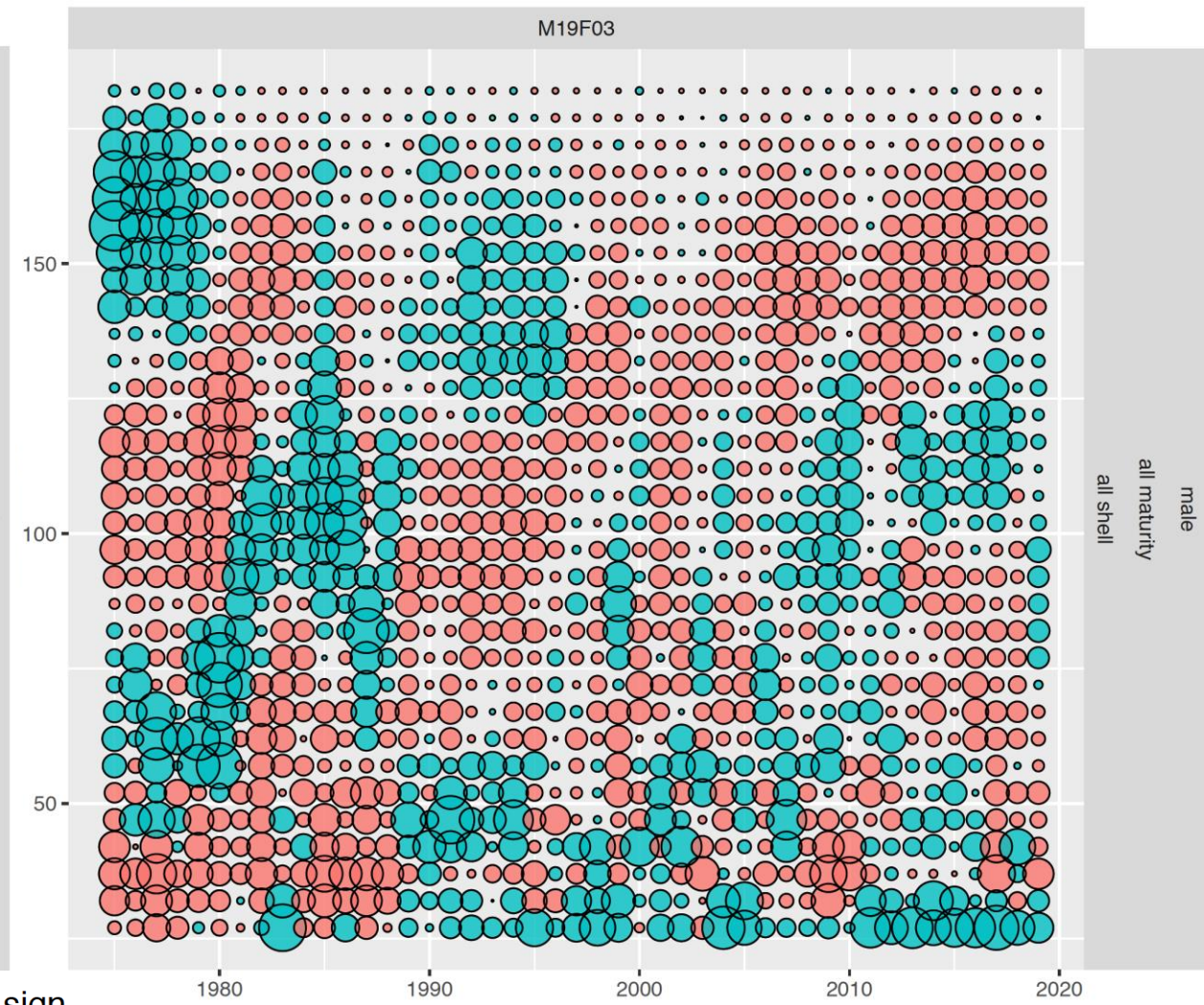# Pearson residuals for M19F01, M19F03 fits to NMFS "M"
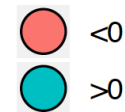
Marginal fits to SBS BSFRF size compositions
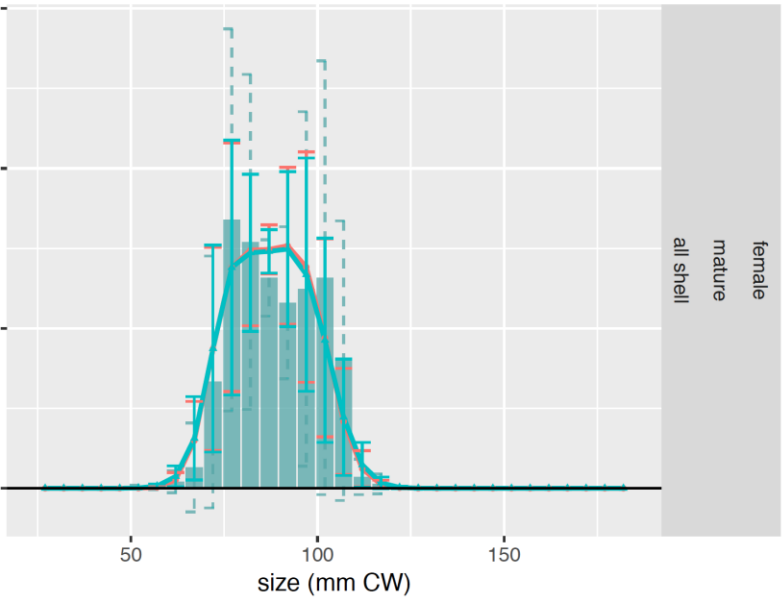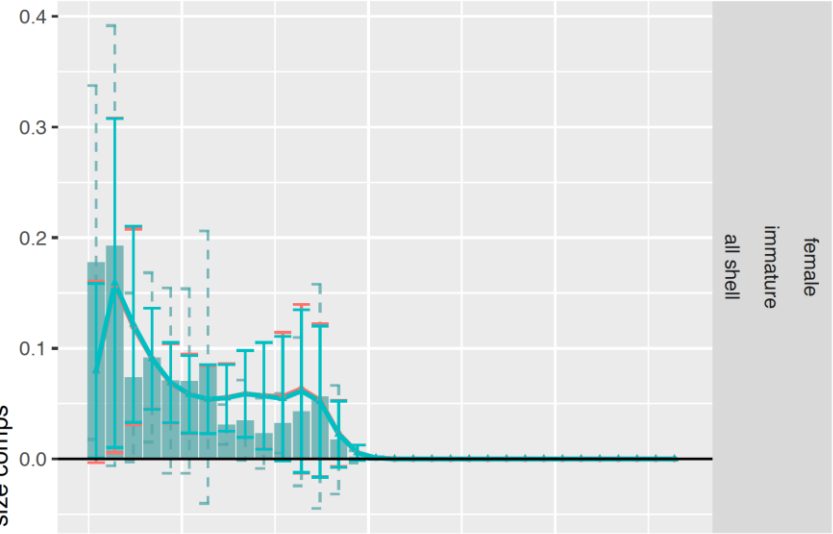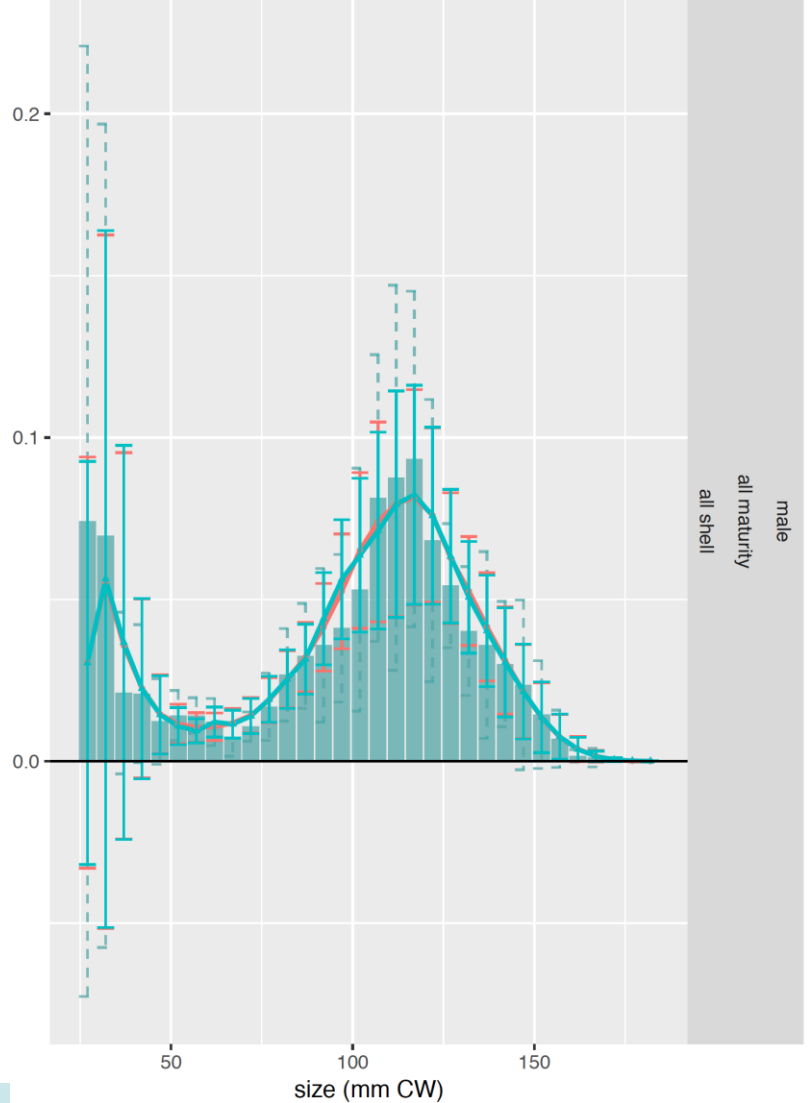
Marginal fits to SBS NMFS size compositions