2019 Tanner Crab Stock Assessment

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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%)
  - mature female biomass: 4,800 t (-2%)

immature male biomass: 8,540 t (+16%)
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 3b.
- Not overfished. Overfishing did not occur.

CPT Comments

September 2018

CPT comment: The CPT identified several concerns with new models presented in the assessment. The most important of these concerns was that all of the new models used a revised catch estimates in the directed fishery and the bycatch in snow crab fish. These estimates were nearly the same as the original estimates after 1995 but showed much larger changes in 1992-1995 (catches prior to 1992 were not revised). Inclusion of these revised catch estimates had a large impact on estimated Tanner crab biomass for the entire time series, shifting it upwards by approximately 70%. CPT was concerned that there was no opportunity to review the methodology to produce the new estimates, and it was unclear to the CPT whether observer coverage (the basis for the revised catch estimates) was adequate to support earlier estimates. Second, the revised catch time series was only used for Tanner crab and not for the other crab assessments in this cycle. The CPT would have preferred that revisions to catch estimates be done consistently for all crab stocks, rather than in a piecemeal way. Finally, it was not clear to the CPT what was driving the extreme sensitivity of the model to the revised catch estimates.
Response: The revised crab fishery catch data was reviewed at the May 2019 CPT Meeting and approved for use in this assessment. Much, but not all, of the model sensitivity to the revised data for models presented at the 2018 assessment was shown to be due the inadvertent use of raw counts, rather than counts scaled to retained catch sample sizes, as input sample sizes for the revised size composition data. The CPT requested that the accepted 2018 assessment model (18AM17) with the “old” fishery data and a “bridging” model scenario that included the revised data be presented at the Fall 2019 meeting to provide a transition to using the revised crab fishery data. This has been done (Scenarios M19F00 and M19F00a, respectively).

CPT Comments

May 2019

CPT comment: The CPT accepted the author's recommended models for presentation in September 2019.
Response: Results from all the recommended models are presented here, however the names assigned to the various scenarios differ between those used in the May meeting and those used here. The following table provides a map from the names used at the May meeting to those used here:

model scenario		scenario description
May	Sept	
19F.0	M19F00	2018 assessment model (18AM17)
19F.0a	M19F00a	M19F00 with revised ADFG data for 1990+ crab fisheries
19F.1	M19F01	M19F00a updated for 2018/19 (base model for 2019)
19F.2	M19F02	M19F01 + 2006+ observed male maturity data
19F.3	M19F03	M19F02 - male maturity characterized by Rugolo/Turnock maturity ogive
19F.4	M19F04	M19F01 + 2013-2017 BSFRF/NMFS side-by-side data
19F.5	M19F05	M19F03 + 2013-2017 BSFRF/NMFS side-by-side data

CPT Comments

May 2019

CPT comment: compare the estimated selectivity to the ratio of NMFS to BSFRF numbers at length. Is estimated and empirical catchability/availability/selectivity the same? Does the empirical selectivity look logistic?"

Response: This has been done. The empirical selectivity looks like it could be logistic (and associated q's support model estimates). The estimated availabilities are not the same as the empirical availabilities.

CPT comment: show the fits to the BSFRF length composition data by year as well as in aggregate.
Response: These fits are shown in Appendix B.

CPT comment: check the bounds of parameters when estimating the BSFRF data.
Response: Fitting the BSFRF data results in no better, or worse, performance in terms of parameters hitting their bounds.

CPT comment: indicate whether or not Hessians were produced.
Response Hessians were produced for the "best" model runs for all scenarios and .std files were obtained.

CPT comment: Suggest rationale for chosen weighting for the second difference smoothing on the availability curve.
Response: The rationale for the selected weighting is that it reflects a preference toward a smoothly-varying function, reflecting an assumption that crab of similar sizes would tend to be found together with no abrupt dichotomies (which would justify a smaller smoothing weight) in spatial distribution with size. However, this assumption has not been examined in detail.

CPT Comments

May 2019

CPT comment: Make incorporating chela height data in the assessment a priority because this might address changes in the probability of maturing over time
Response: Chela height data, in the form of male maturity ogives based on collections of chela heights since 2006, is incorporated in several model scenarios examined here, including the author-preferred scenario.

CPT comment: Compare trends in largest crab to fishing pressure and area occupied by stock.
Response: This is a good suggestion that, time permitting, will be addressed before the January 2020 CPT meeting.

CPT comment: Compare the maximum sizes seen in the fishery to the survey.
Response: Another good suggestion that, time permitting, will be addressed before the January 2020 CPT meeting.

CPT comment: Consider blocking for estimation of growth and probability of maturing.
Response: This has been on the "to do" list for a while now, but with relatively low priority. The problem is that the principal data which the model relies on for estimating both processes is, except for size compositions, only available (from a practical standpoint) since 2006 for male maturity ogives and since 2015 for (both sexes) molt increment data. The ability of the model to reliably estimate changes in these processes is thus somewhat doubtful.

CPT comment: Provide retrospective analysis and calculate Mohn's rho for MMB
Response: The current model code does not support retrospective analyses without jittering. Time was not available to evaluate jittered retrospective model runs.

SSC Comments

October 2018, June 2019

SSC Comment: The SSC reminded authors to use the model numbering protocols that allow the SSC to understand the year in which a particular version of the model was first introduced.

Response: The assessment does not follow this numbering protocol yet. Scenario M19F00 represents the model selected by the SSC/CPT last year ("18AM17", which was updated with 2018 data from the 2017 assessment model).

SSC Comment: The SSC encourages authors (using VAST estimates of survey biomass) to consider whether or not the apparent reduction in uncertainty in survey biomass is appropriately accounted for with their models/

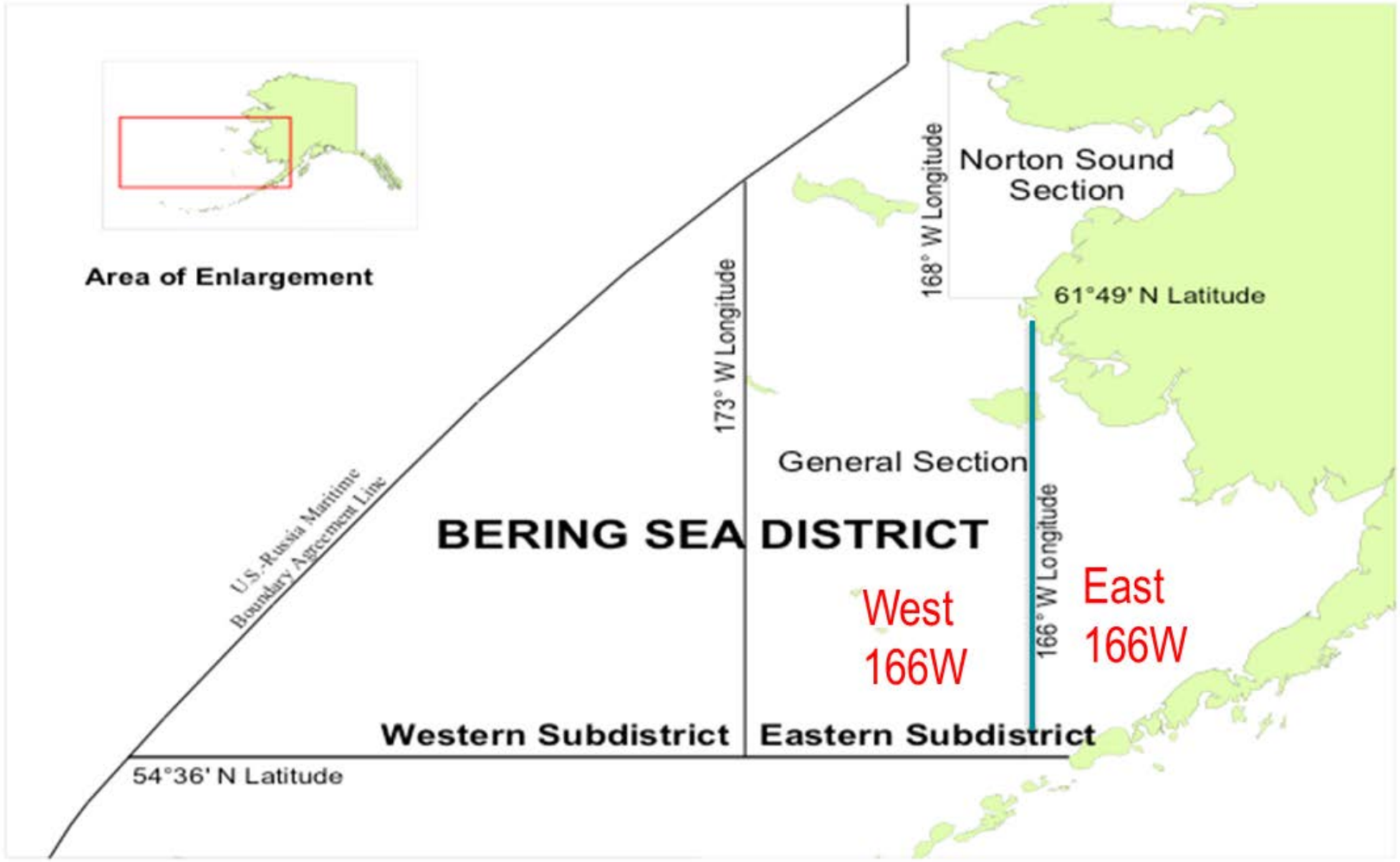
Response: The Tanner crab assessment does not yet use VAST-based estimates of survey biomass.

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).

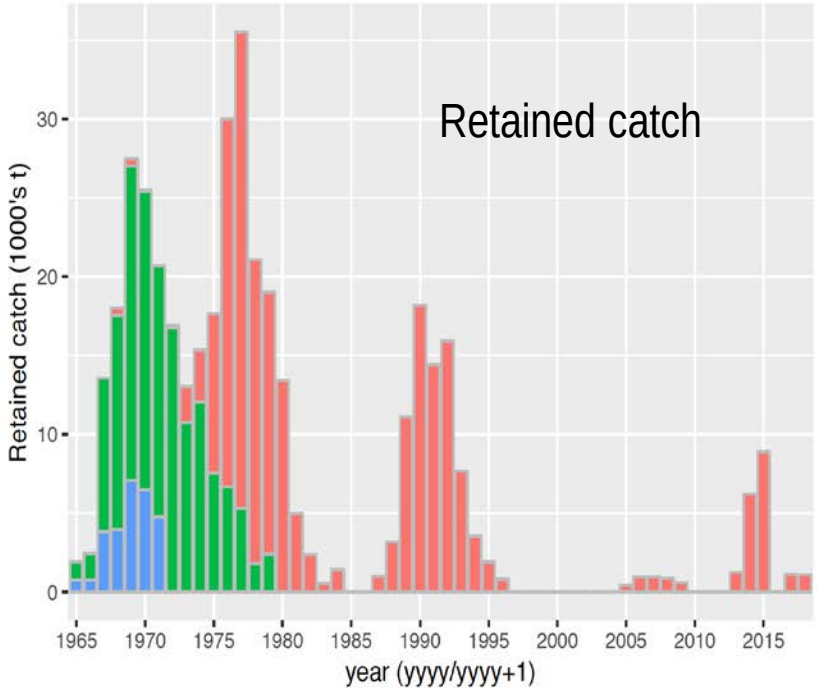
Response: The assessment includes an evaluation of all such parameters, which hit bounds in (almost) all scenarios. Several are logit-scale parameters hitting bounds of -15 or 15 (0 or 1 on arithmetic scale) as expected; these could be fixed. Two are catchability parameters for the NMFS EBS survey during 1975-1981 that hit lower bounds of 0.5, which may not be unreasonable estimates given survey gear and areal coverage during this period. The remainder are related to selectivity functions that might be re-parameterized.

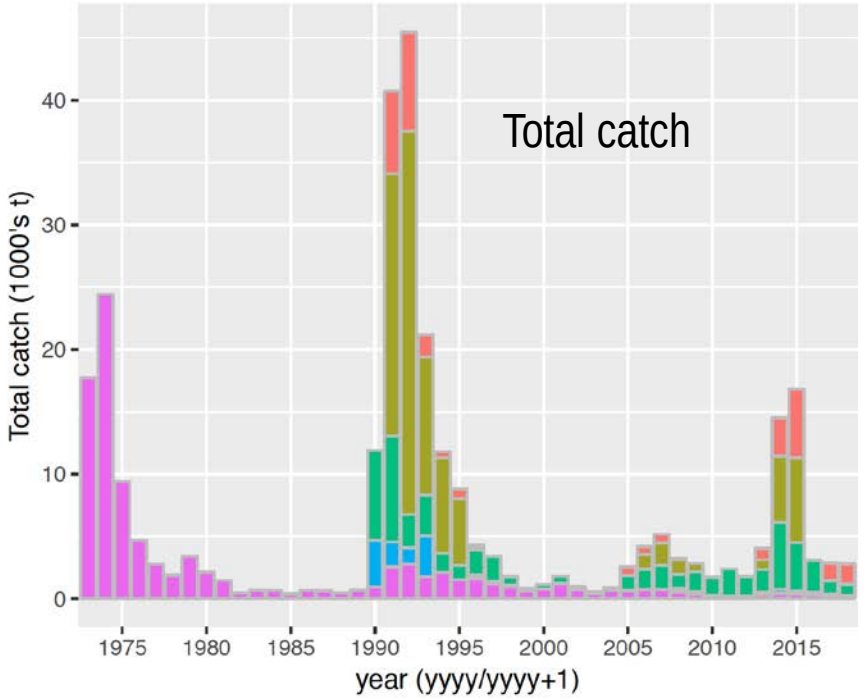
Fishery Trends

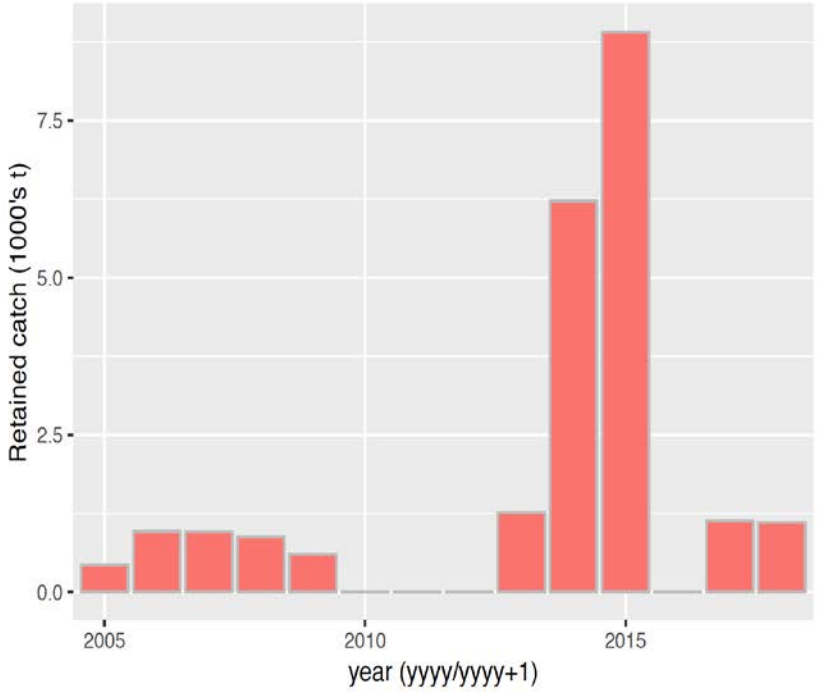
Management Regions

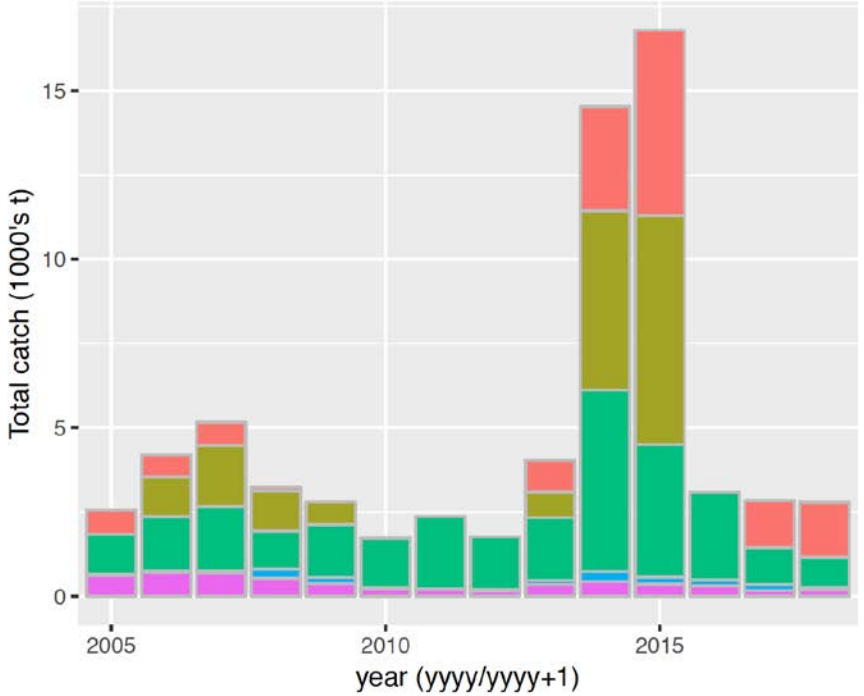


Fishery trends

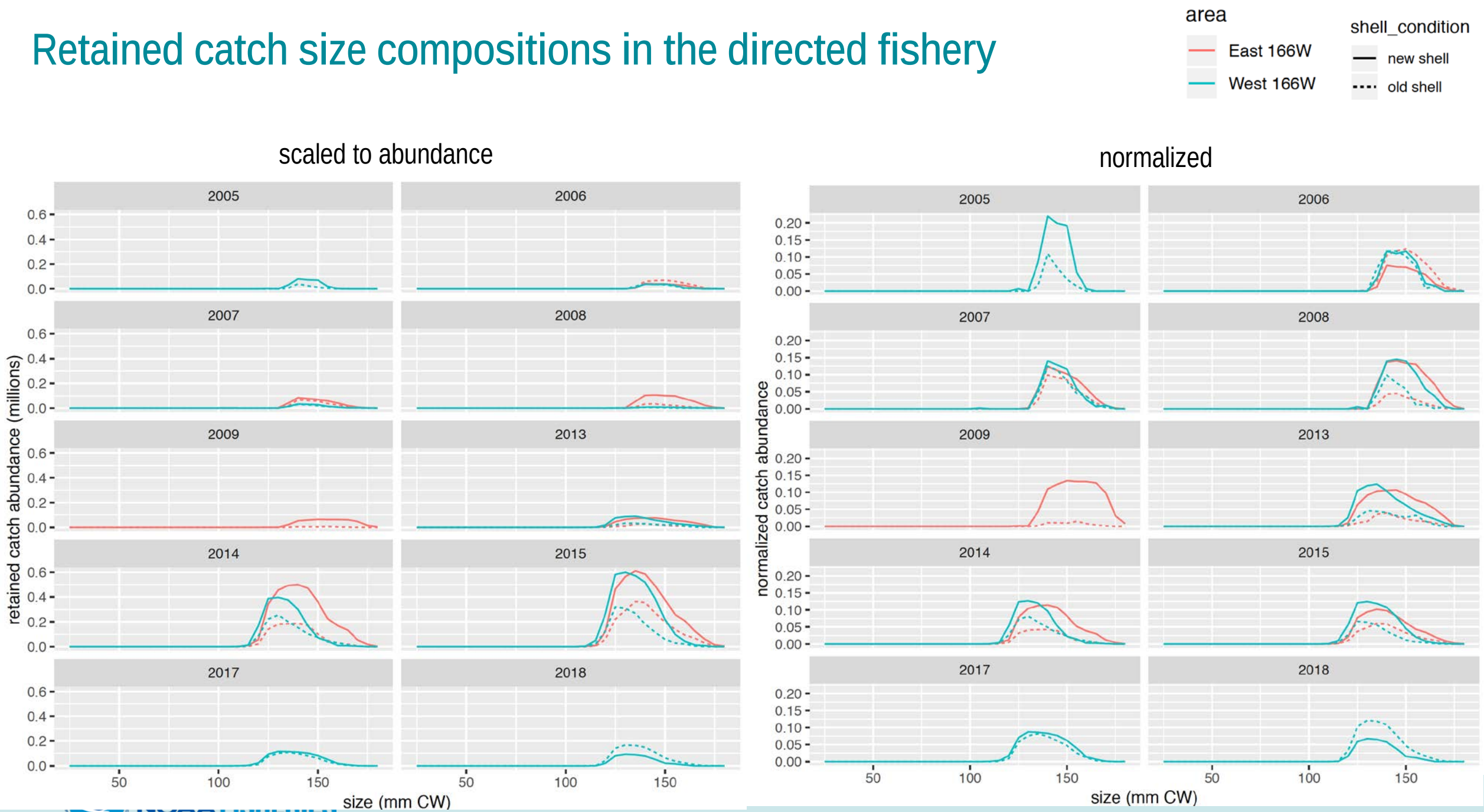




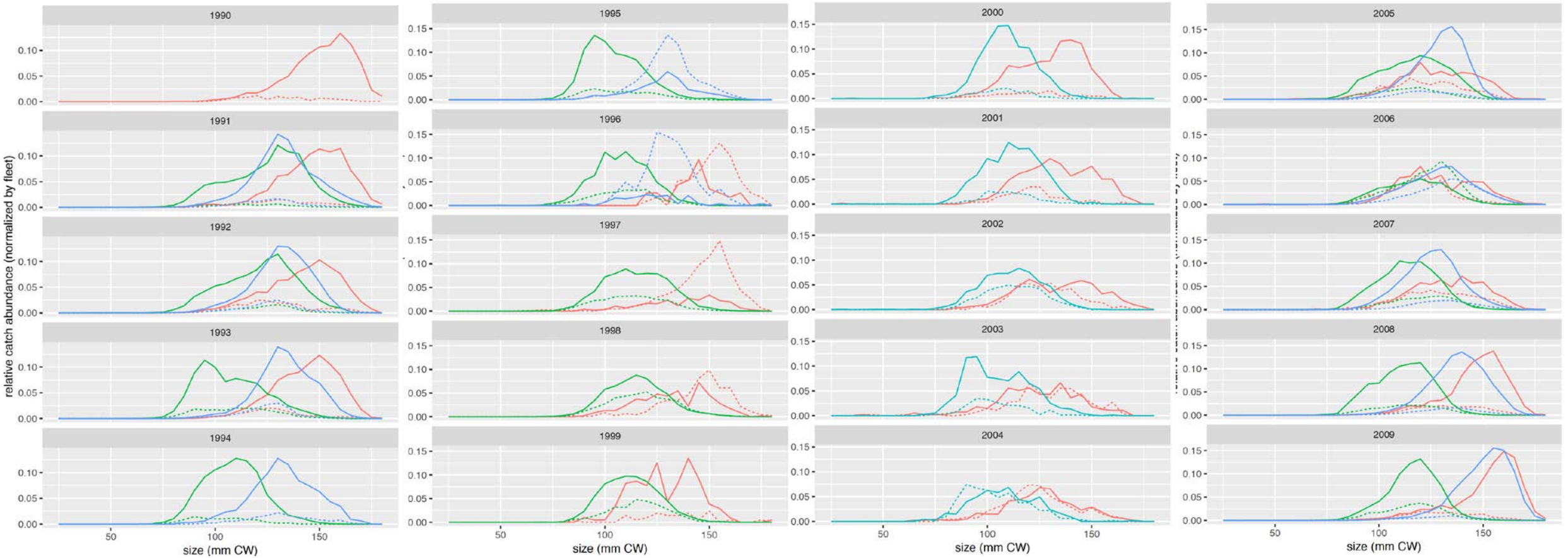




Retained catch size compositions in the directed fishery



Total catch size compositions for males in the crab fisheries



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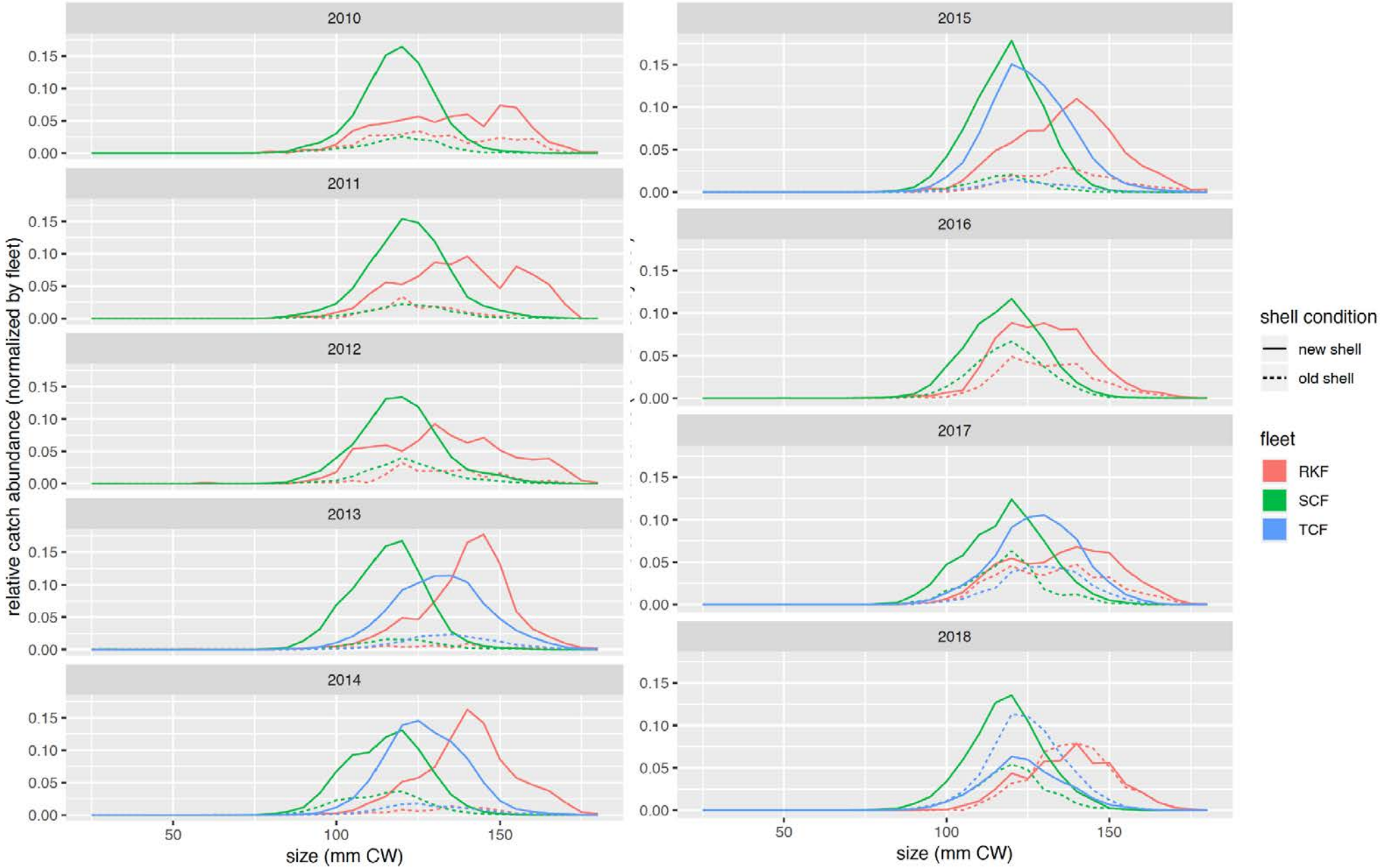
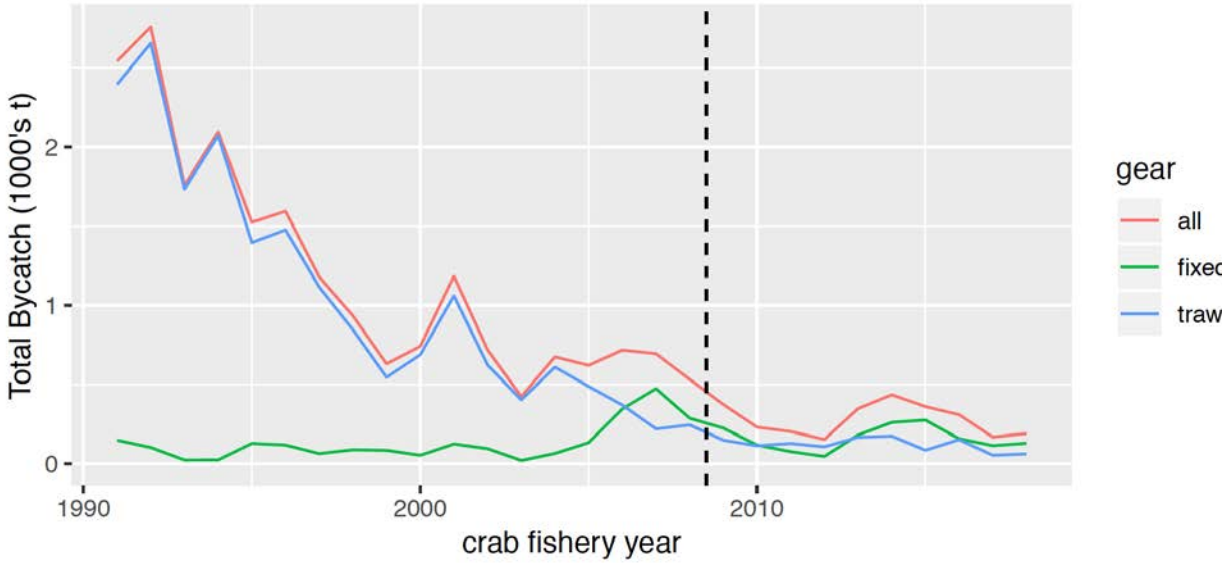
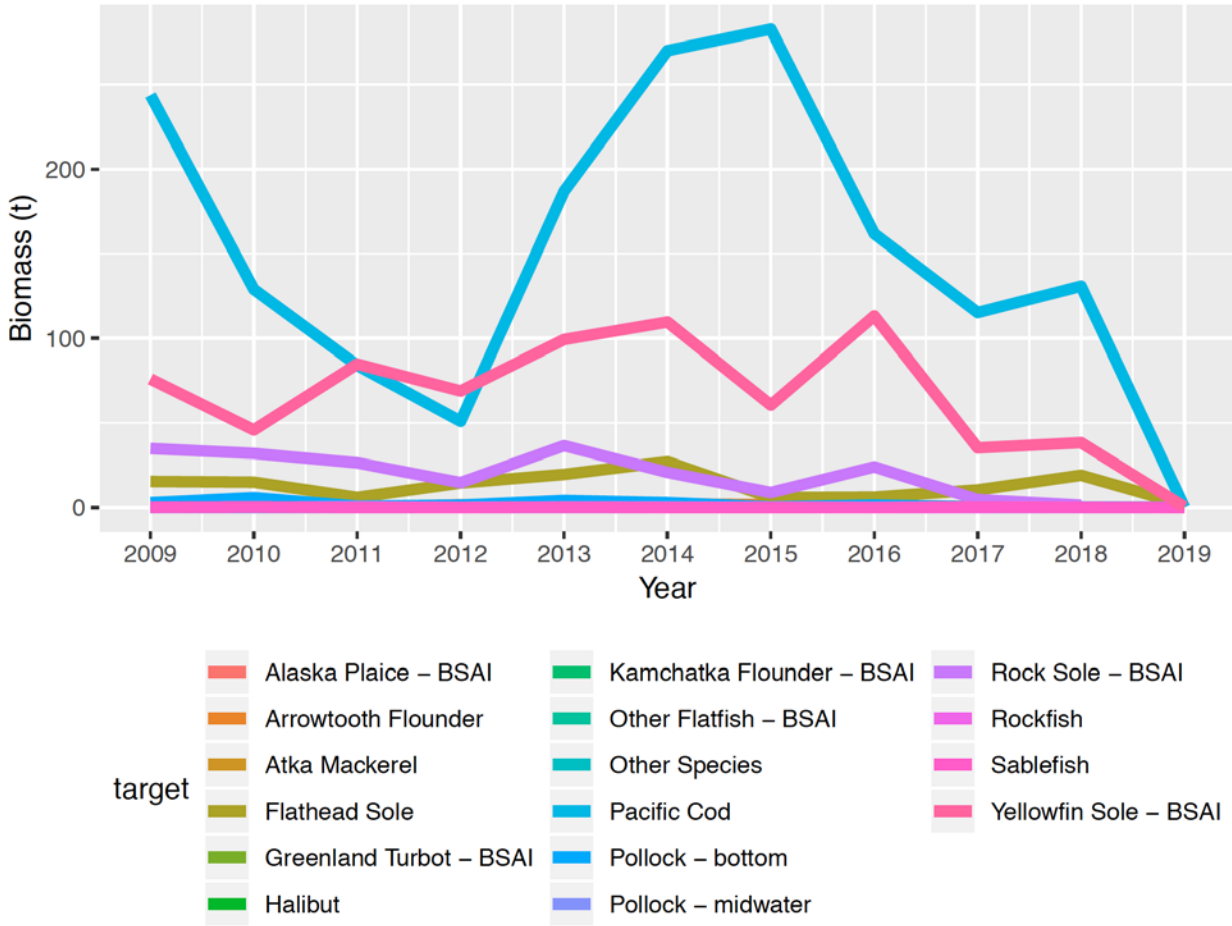


Bycatch in the groundfish fisheries





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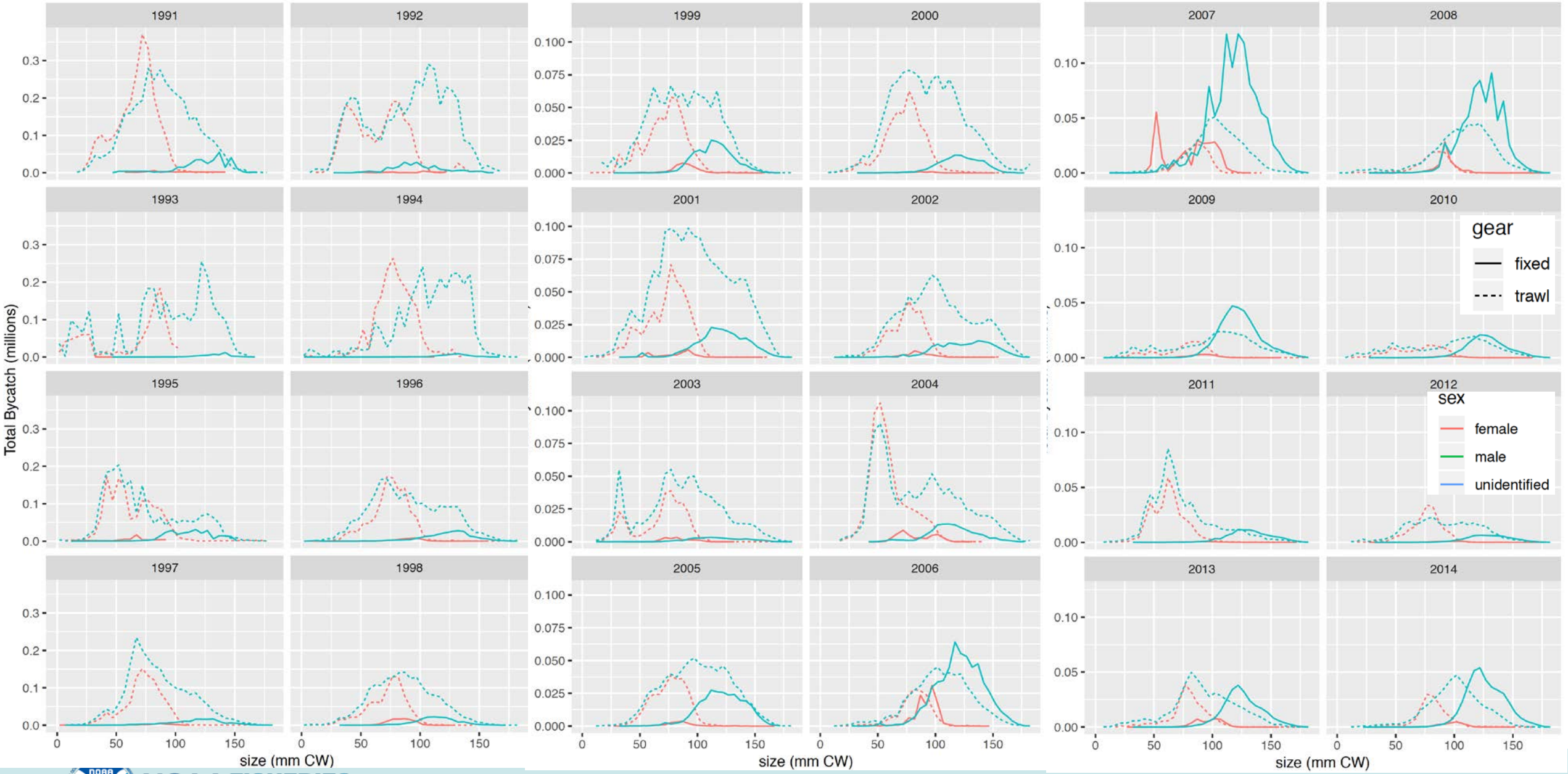
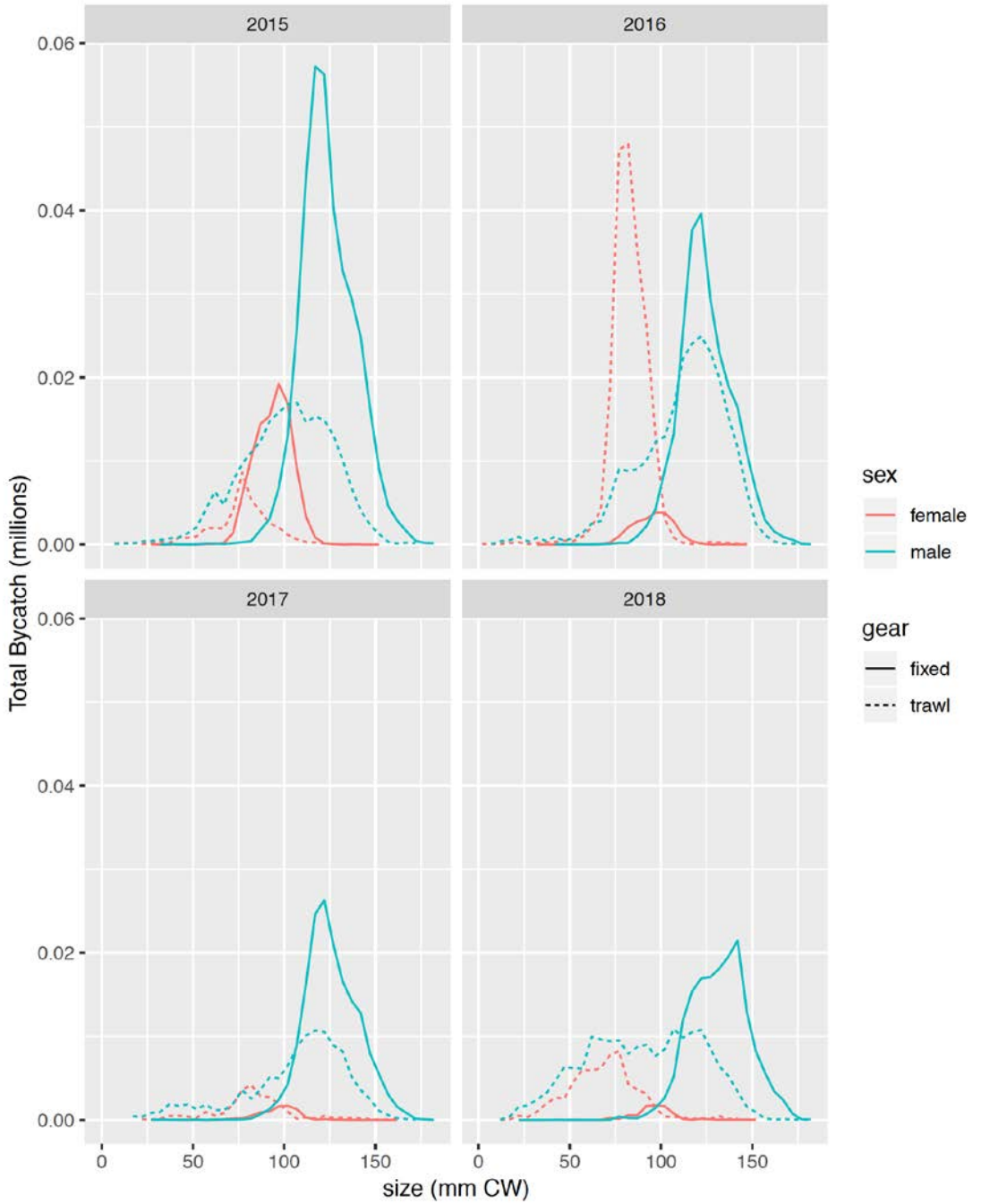
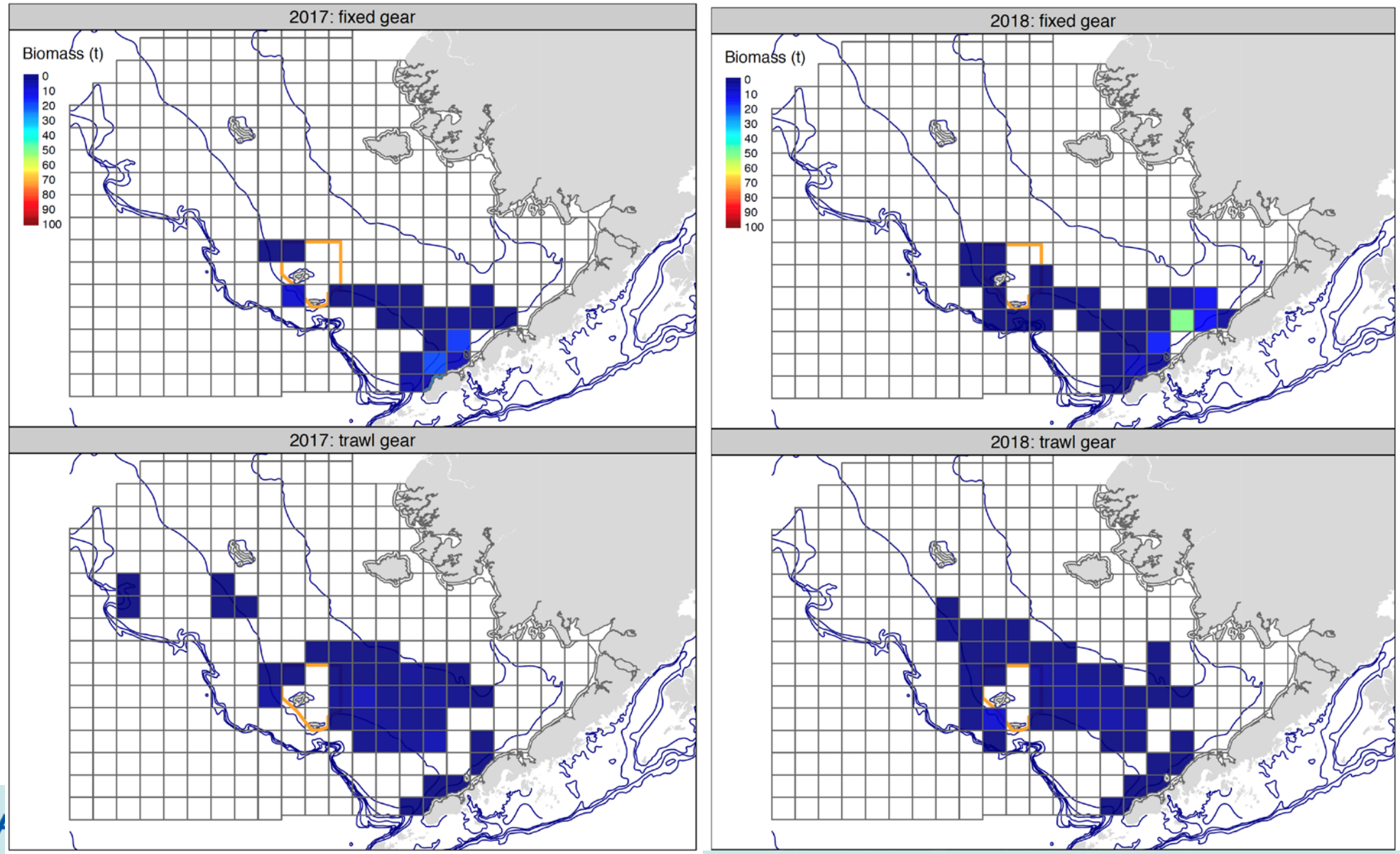


Bycatch in the groundfish fisheries

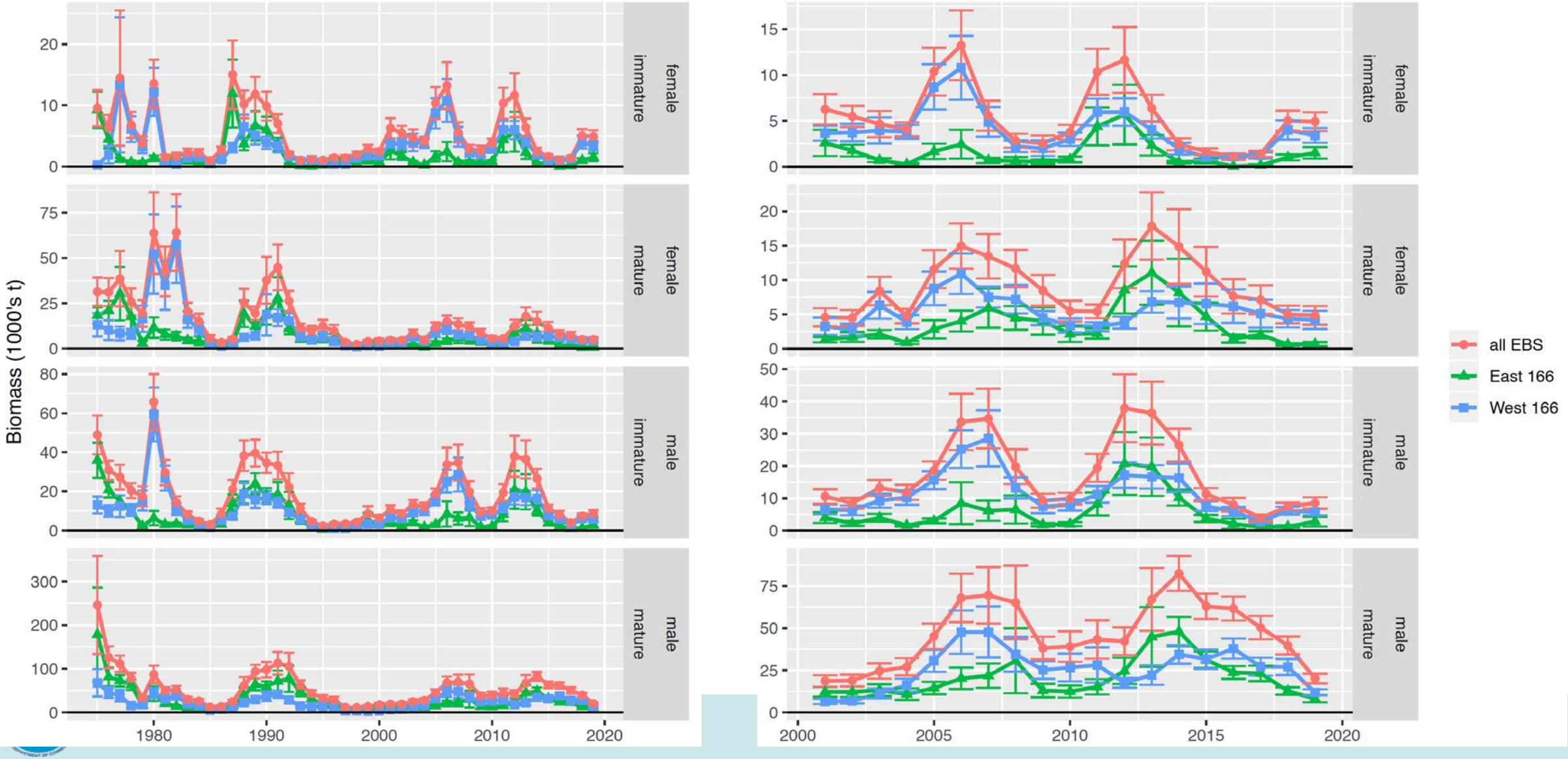


Bycatch in the groundfish fisheries

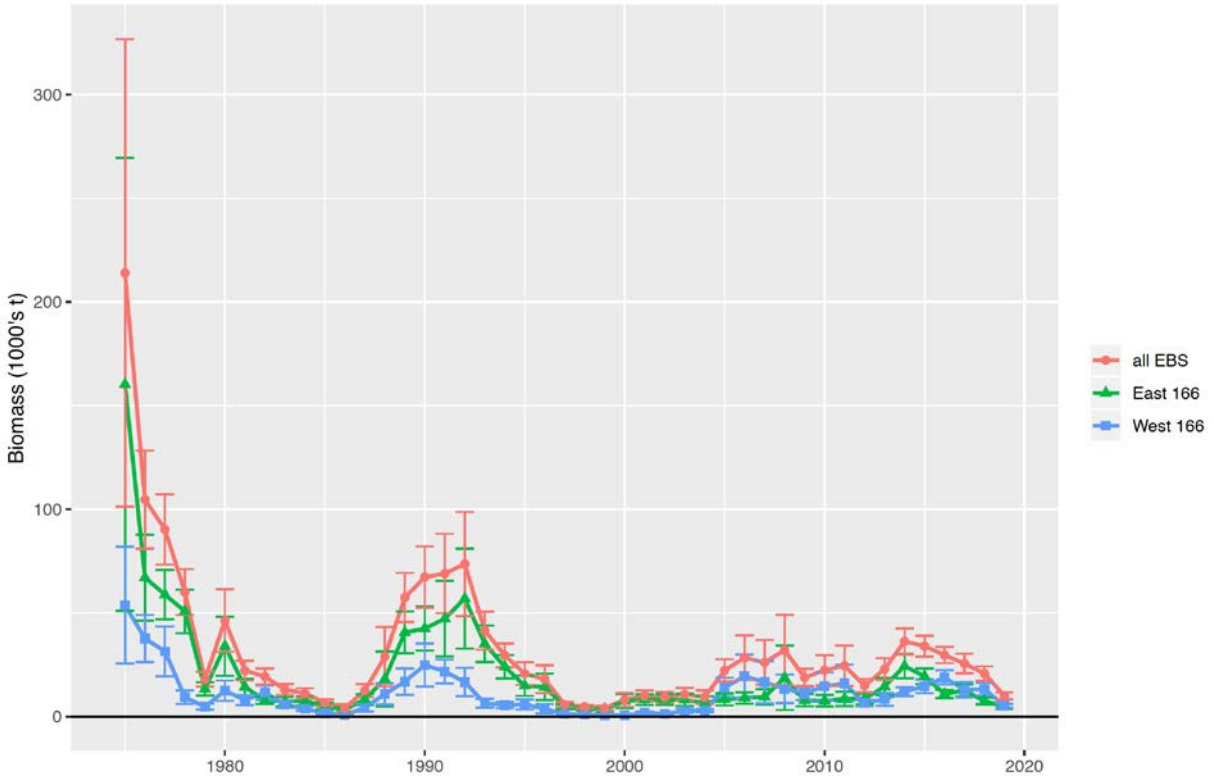


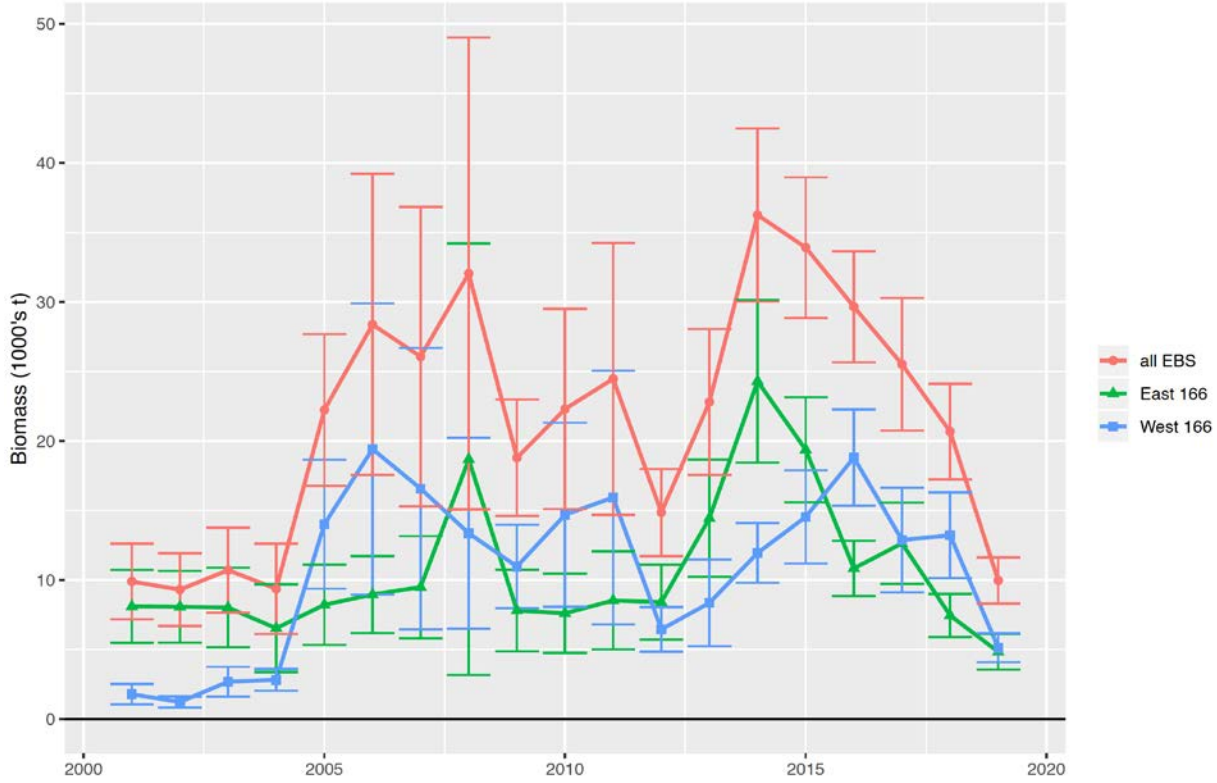
Survey Trends

NMFS EBS Survey Trends

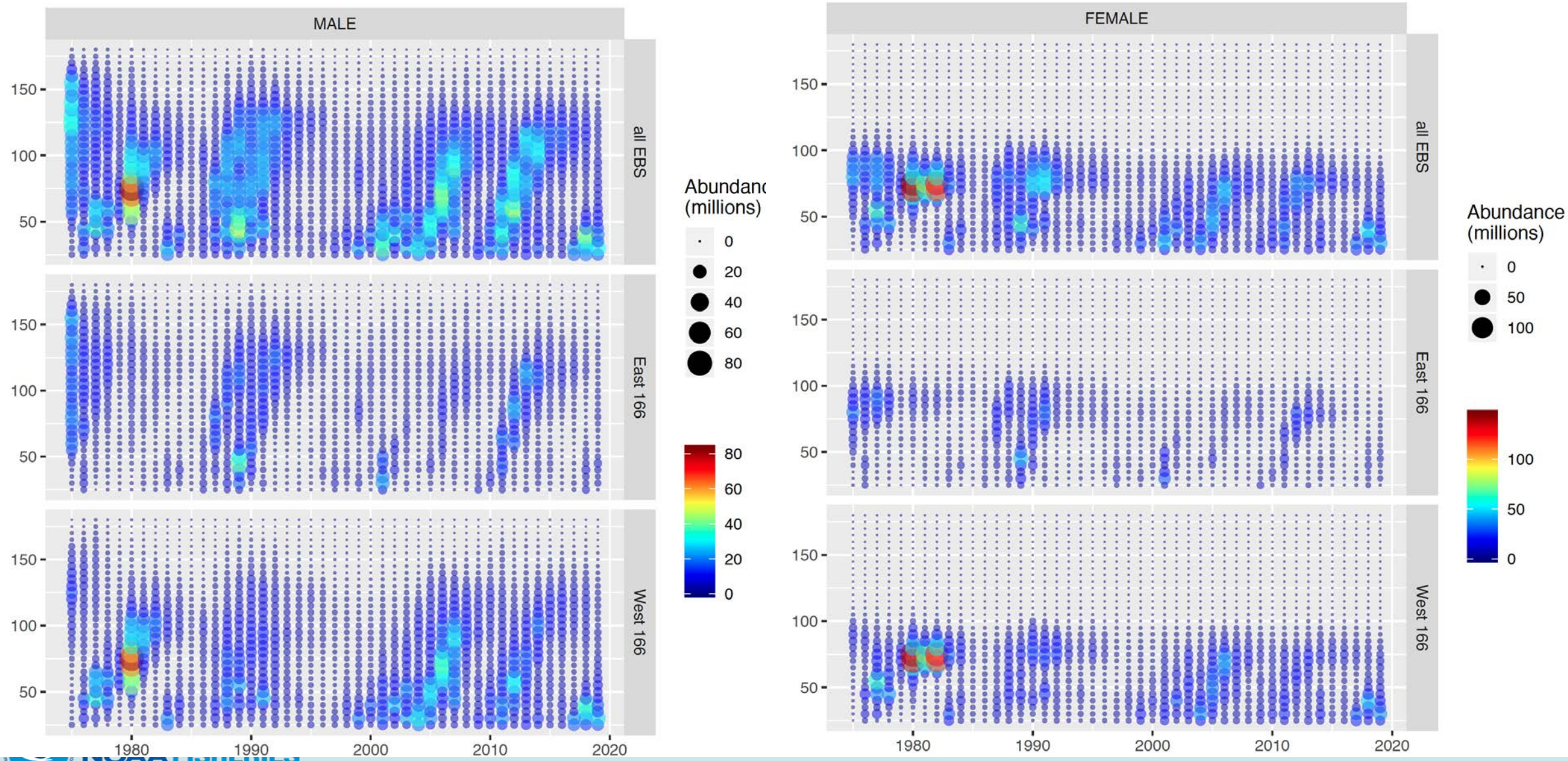


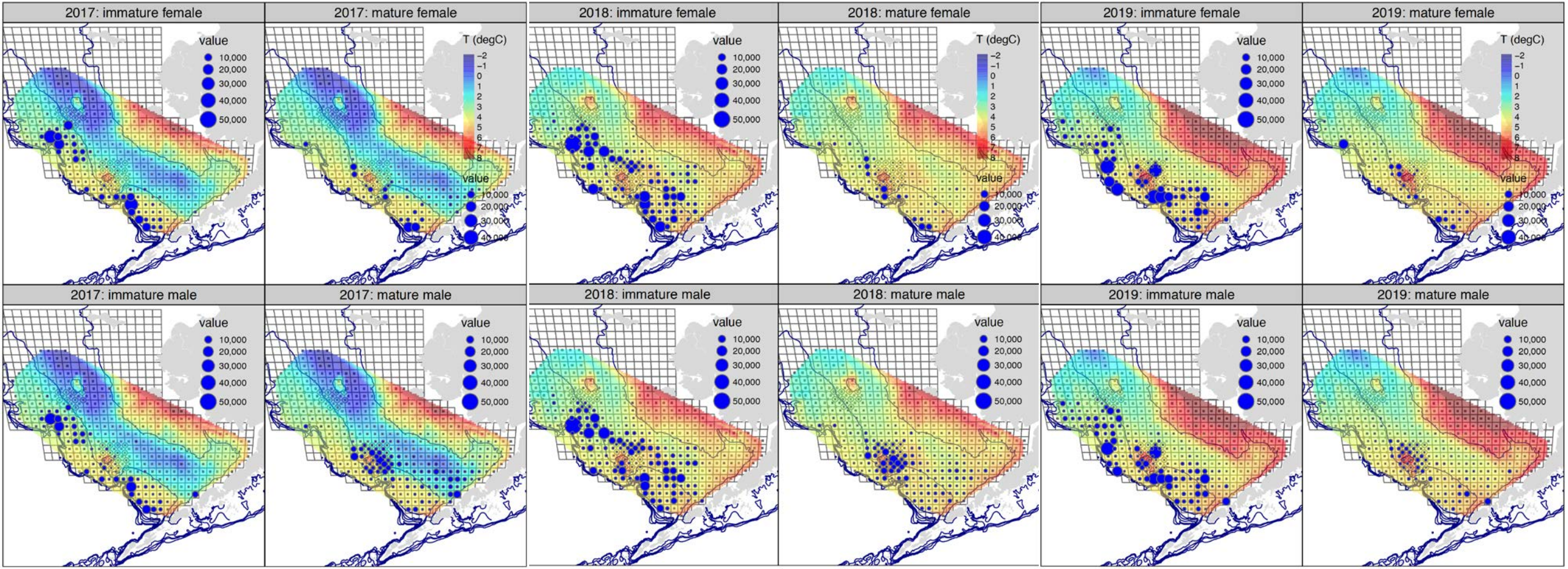
Legal Male Trends in the NMFS EBS Survey





NMFS EBS Survey Size Compositions




2017: immature female
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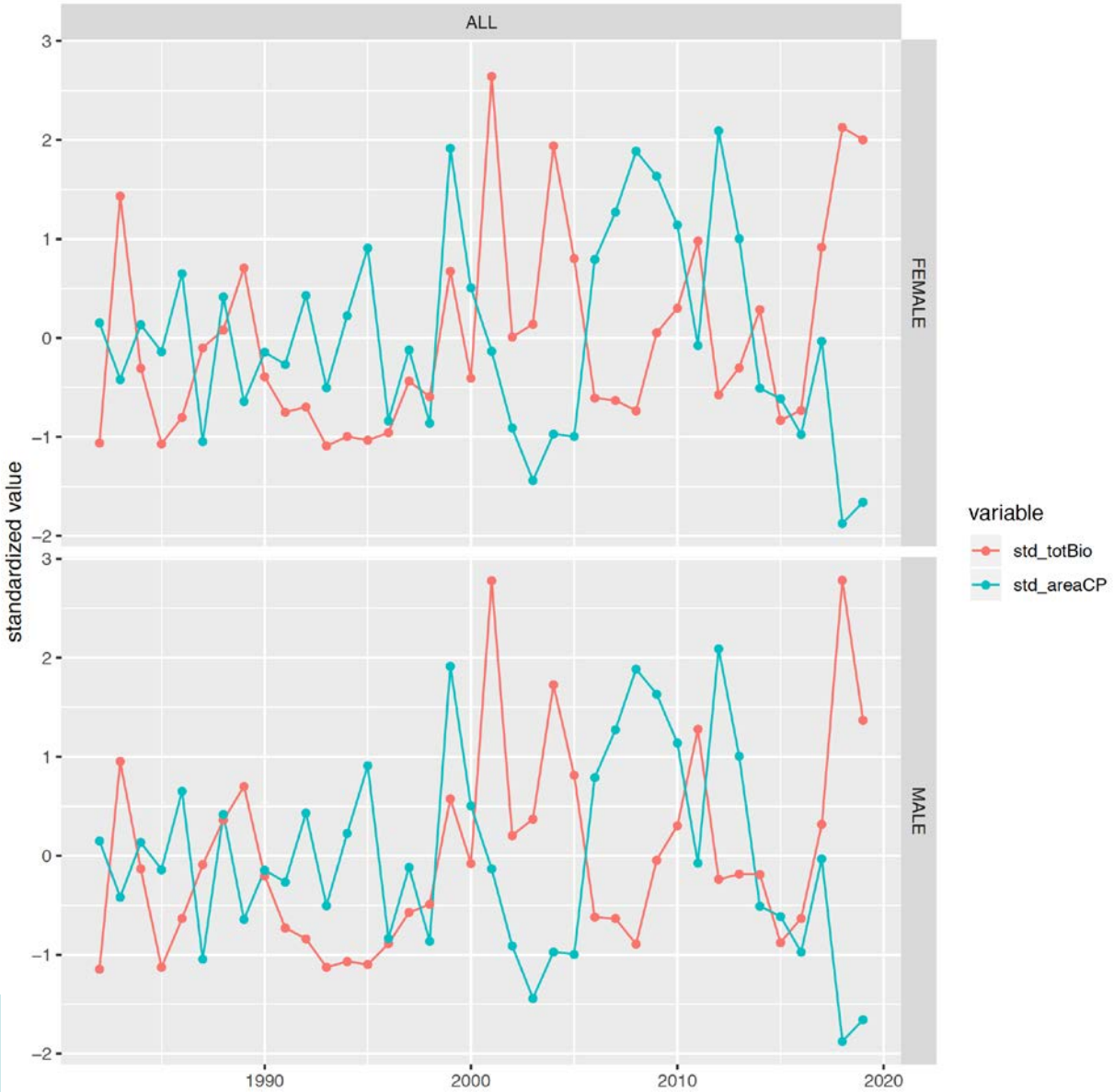
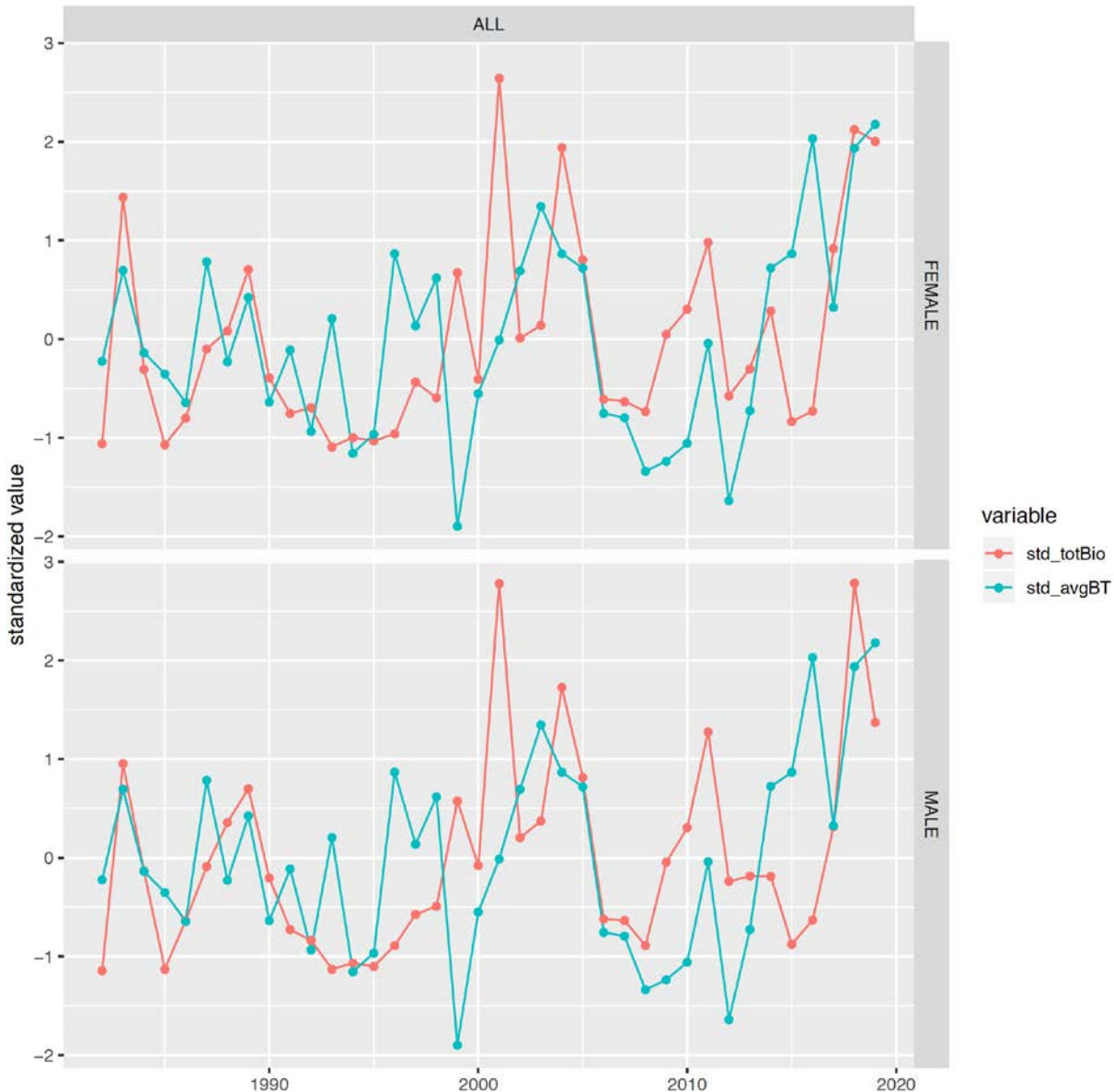
Survey biomass of small (< 40 mm CW) crab vs. environmental variables

Cold Pool Area



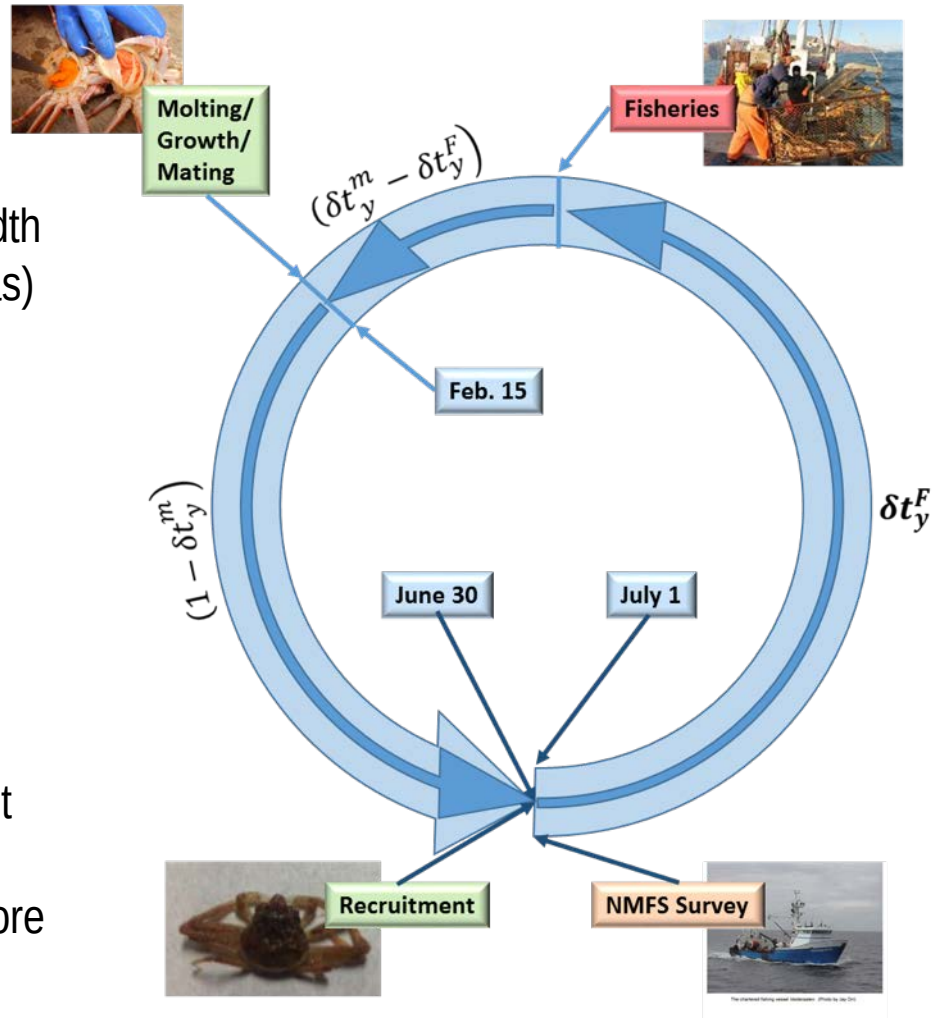
Average Bottom Temperature



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

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

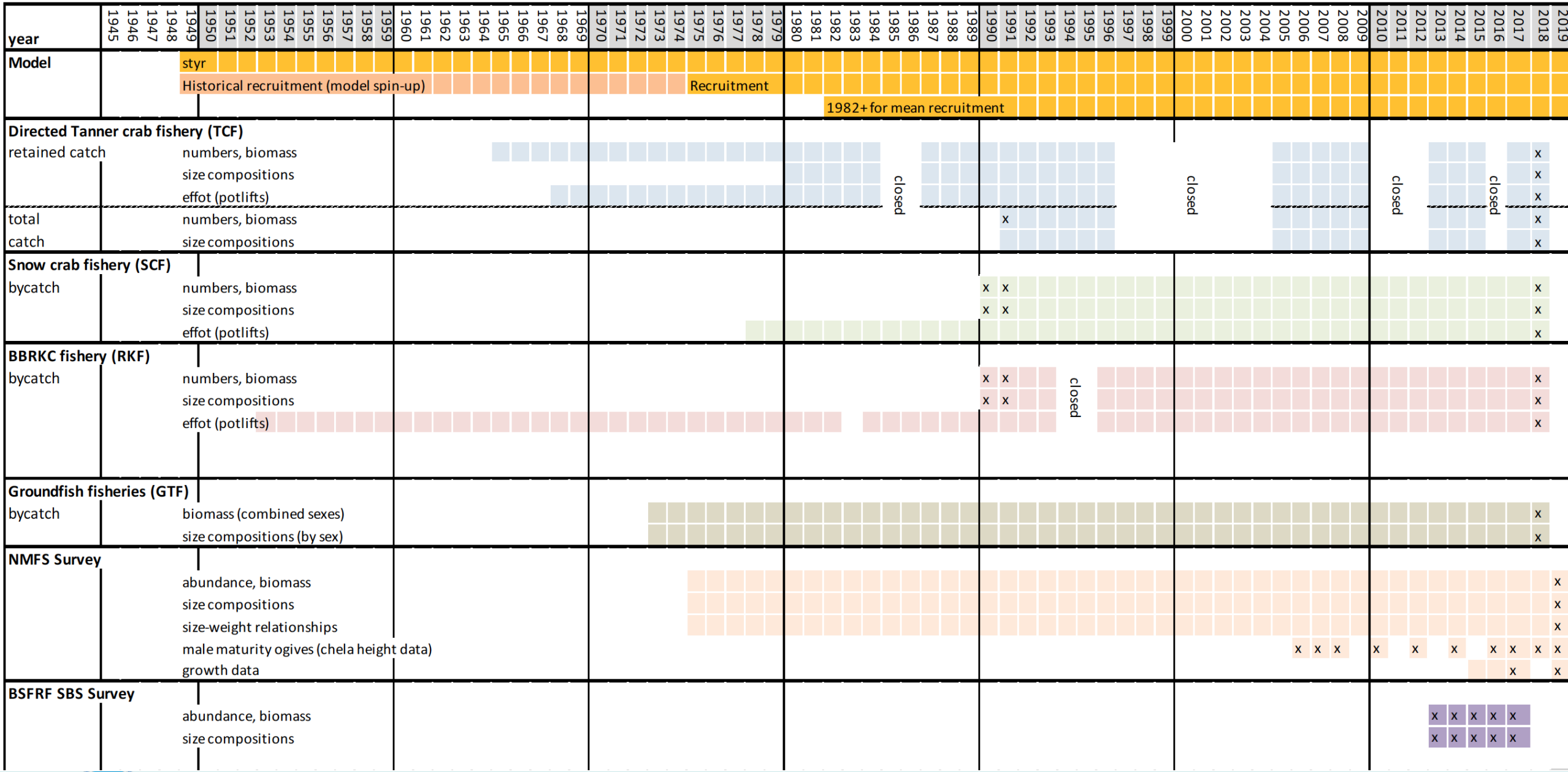
process	time blocks	description
Surveys		
NMFS EBS trawl survey		
male survey q	1975-1981	ln-scale
	1982+	ln-scale w/ prior based on Somerton's underbag experiment
female survey q	1975-1981	ln-scale
	1982+	ln-scale w/ prior based on Somerton's underbag experiment
male selectivity	1975-1981	ascending logistic
	1982+	ascending logistic
female selectivity	1975-1981	ascending logistic
	1982+	ascending logistic

Base model: likelihood components

Component	Type	included in optimization	Distribution	Likelihood
TCF: retained catch	abundance	no	lognormal	males only
	biomass	yes	norm2	males only
	size comp.s	yes	multinomial	males only
TCF: total catch	abundance	no	lognormal	by sex
	biomass	yes	norm2	by sex
	size comp.s	yes	multinomial	by sex
SCF: total catch	abundance	no	lognormal	by sex
	biomass	yes	norm2	by sex
	size comp.s	yes	multinomial	by sex
RKF: total catch	abundance	no	lognormal	by sex
	biomass	yes	norm2	by sex
	size comp.s	yes	multinomial	by sex
GTF: total catch	abundance	no	lognormal	by sex
	biomass	yes	norm2	by sex
	size comp.s	yes	multinomial	by sex
NMFS "0" survey	abundance	no	lognormal	by sex
	biomass	yes	lognormal	by sex, for mature crab only
	size comp.s	yes	multinomial	by sex/maturity
	chela height data	no	--	--
NMFS "M" survey (males only, no maturity)	abundance	no	lognormal	all males
	biomass	no	lognormal	all males
	size comp.s	no	multinomial	all males
NMFS "F" survey (females only, w/ maturity)	abundance	no	lognormal	by maturity classification
	biomass	no	lognormal	by maturity classification
	size comp.s	no	multinomial	by maturity classification
growth data	EBS only	yes	gamma	by sex

Model Datasets

Model/data timelines



Updated data

Description	Data types	Time frame	Notes	Source
NMFS EBS Bottom Trawl Survey	area-swept abundance, biomass	1975-2019	recalculated, new	NMFS
	size compositions	1975-2019	recalculated, new	
	male maturity data	2006+	new	
NMFS/BSFRF	molt-increment data	2015-17, 2019	uodated	NMFS, BSFRF
BSFRF SBS Bottom Trawl Survey	area-swept abundance, biomass	2013-17	new	BSFRF
	size compositions	2013-17	new	
Directed fishery	historical retained catch (numbers, biomass)	1965/66-1996/97	not updated	2018 assessment
	historical retained catch size compositions	1980/81-2009/10	not updated	2018 assessment
	retained catch (numbers, biomass)	2005/06-2018/19	updated, new	ADFG
	retained catch size compositions	2013/14-2018/19	updated, new	ADFG
	total catch (abundance, biomass)	1991/92-2017/18	revised, new	ADFG
	total catch size compositions	1991/92-2017/18	revised, new	ADFG
Snow Crab Fishery	historical effort	1978/79/1989/90	not updated	2018 assessment
	effort	1990/91-2018/19	revised, new	ADFG
	total bycatch (abundance, biomass)	1990/91-2018/19	revised, new	ADFG
	total bycatch size compositions	1990/91-2018/19	revised, new	ADFG
Bristol Bay Red King Crab Fishery	historical effort	1953/54-1989/90	not updated	2018 assessment
	effort	1990/91-2018/19	revised, new	ADFG
	total bycatch (abundance, biomass)	1990/91-2018/19	revised, new	ADFG
	total bycatch size compositions	1990/91-2018/19	revised, new	ADFG
Groundfish Fisheries (all gear types)	historical total bycatch (abundance, biomass)	1973/74-1990/91	not updated	2018 assessment
	hostorical total bycatch size compositions	1973/74-1990/91	not updated	
	total bycatch (abundance, biomass)	1991/92-2017/18	revised, new	NMFS/AKFIN
	total bycatch size compositions	1991/92-2017/18	updated, new	

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

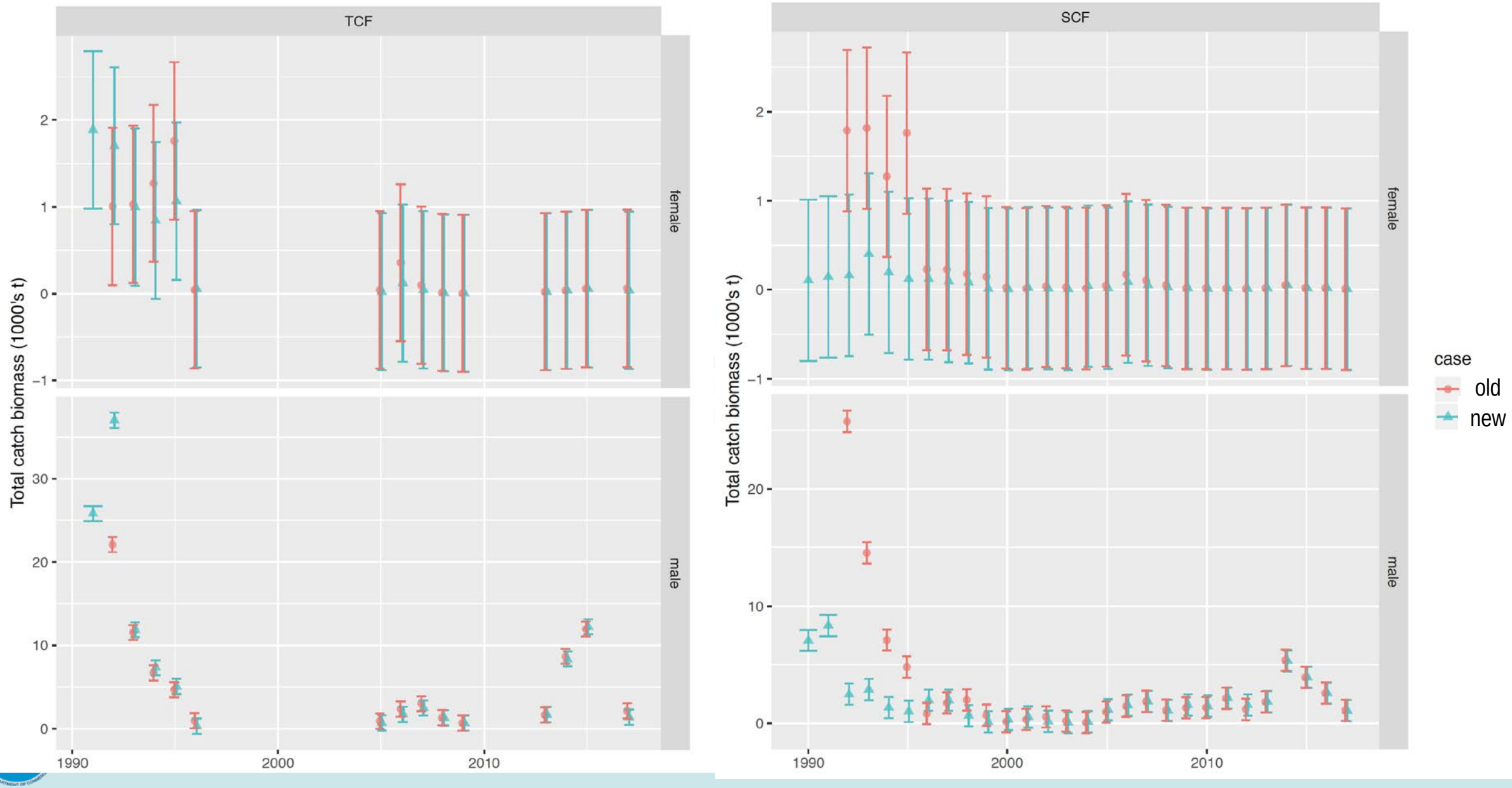
$$A = \frac{n_T}{n_s} \cdot a$$

n_T : directed effort (potlifts)

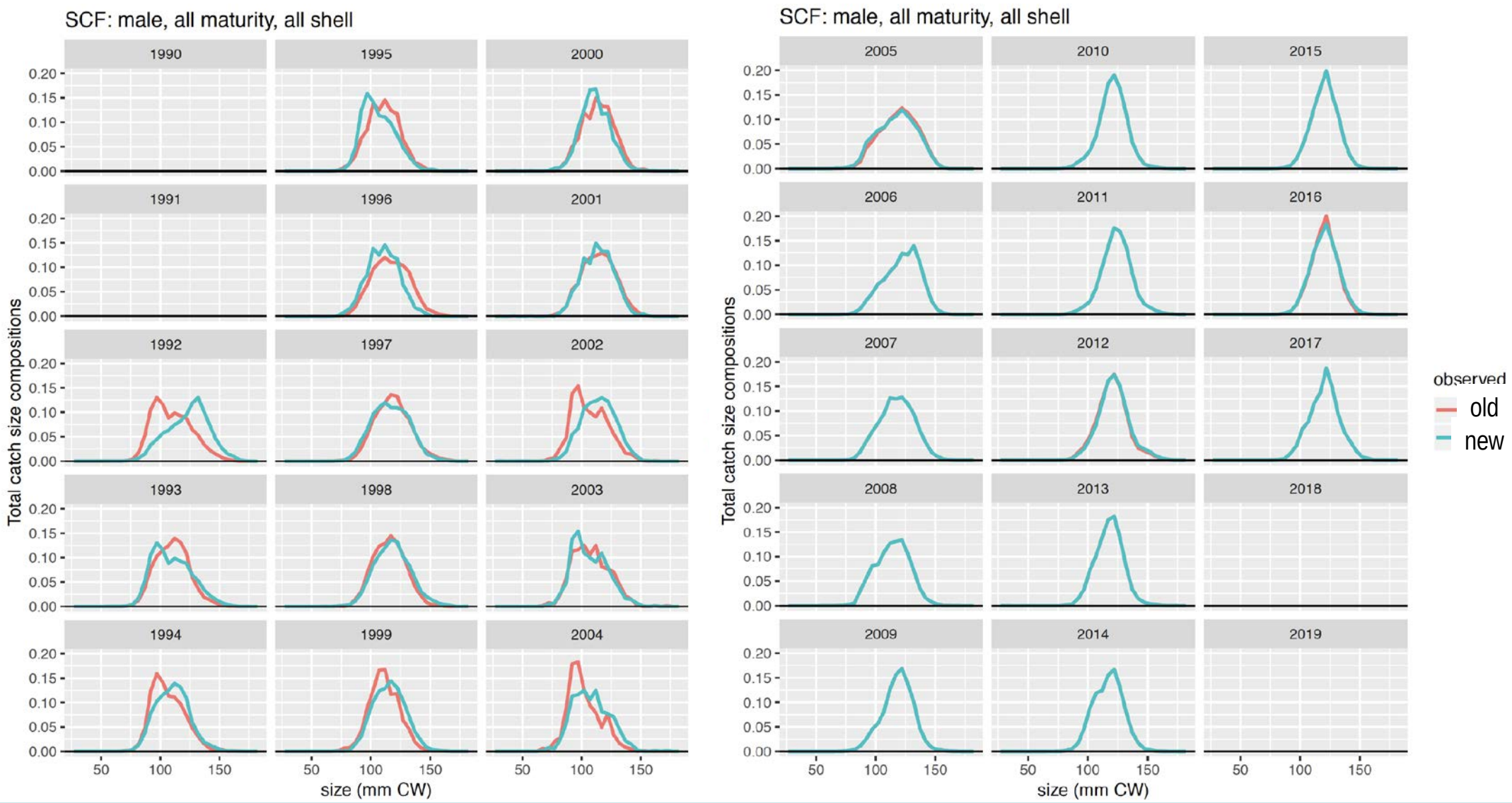
n_s : observer effort (pots sampled)

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

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

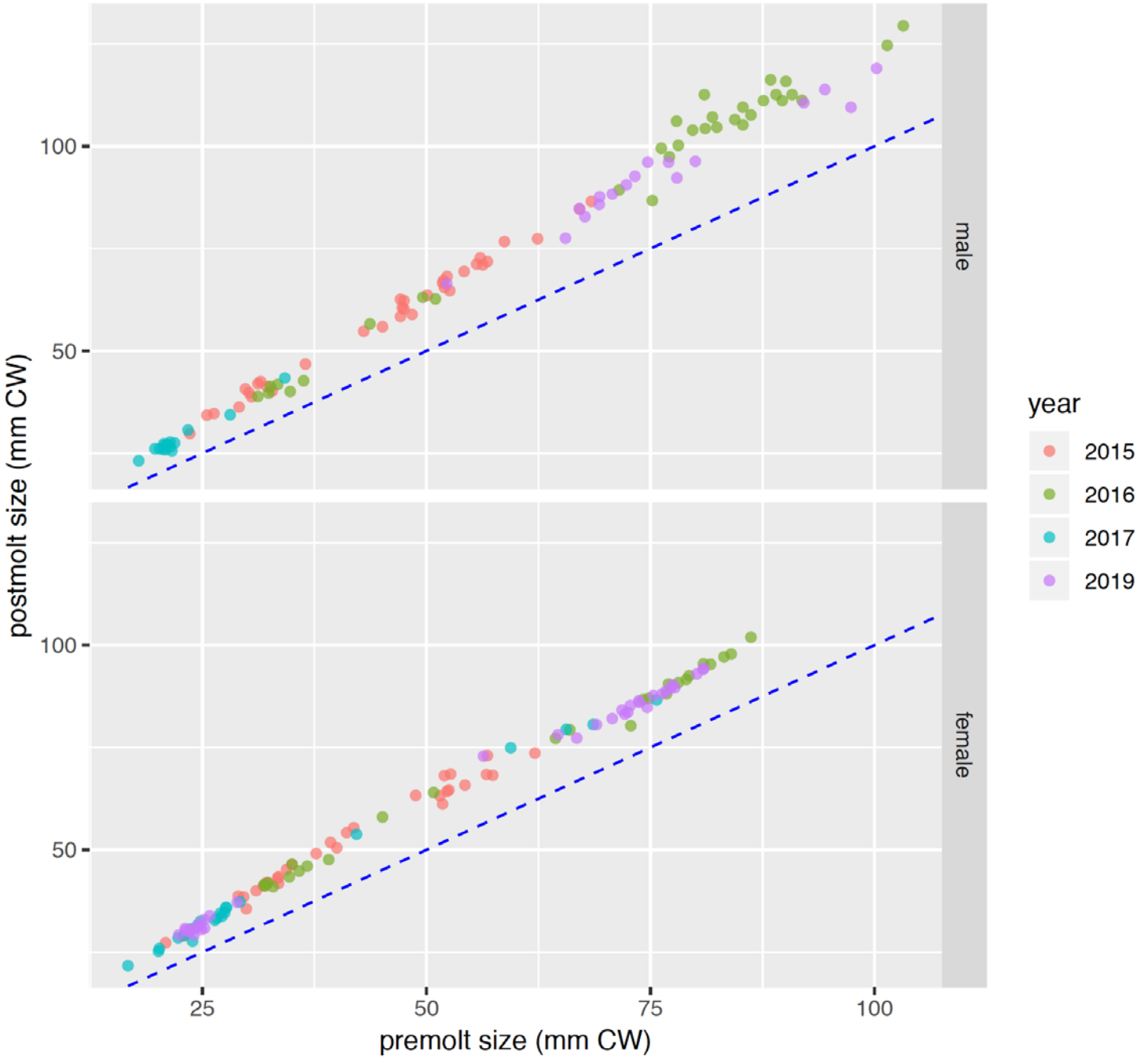


Bycatch size compositions in the snow crab fishery



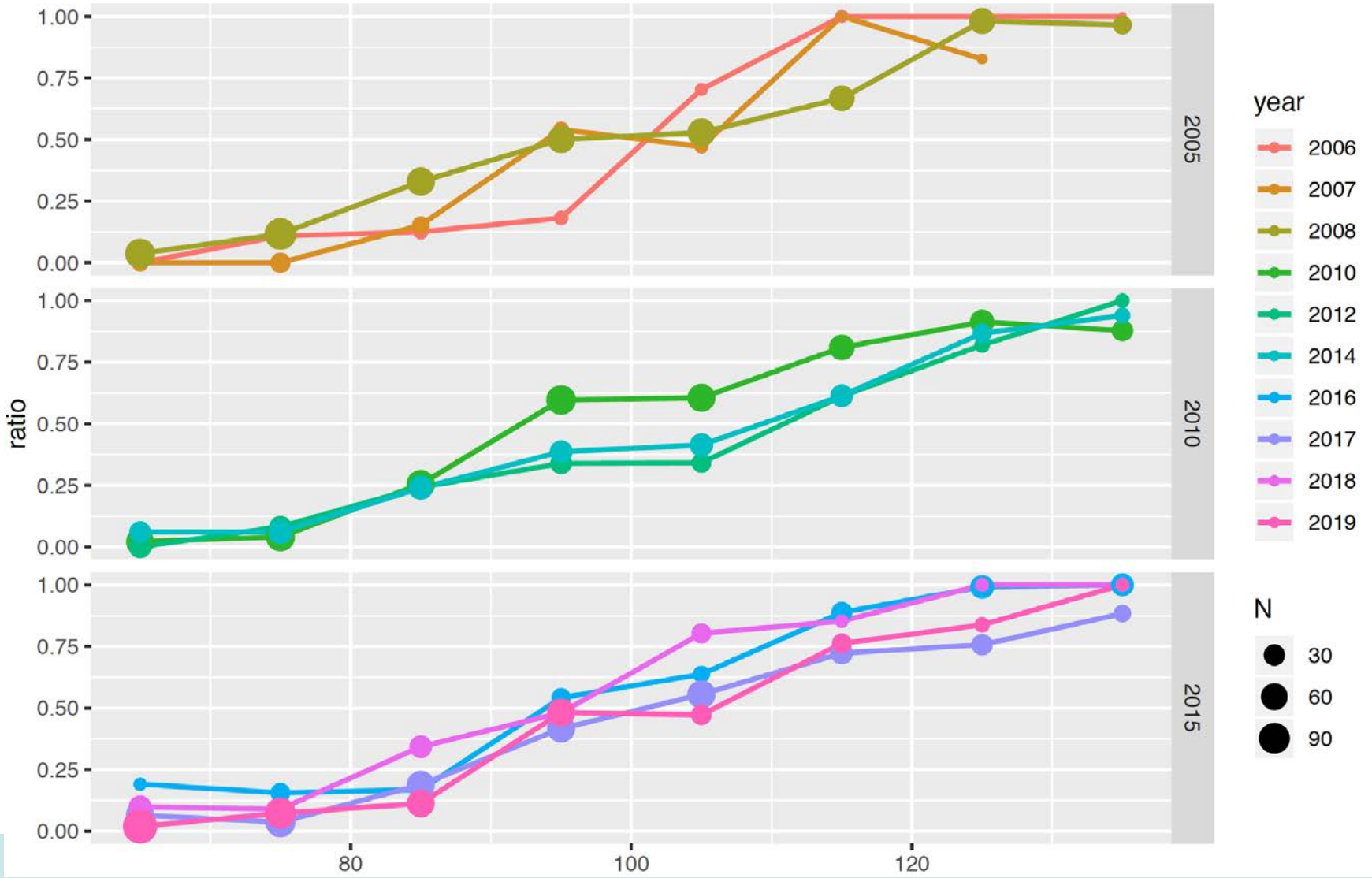
Molt Increment Data

- 16 new male observations
- 34 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



Fitting male maturity data

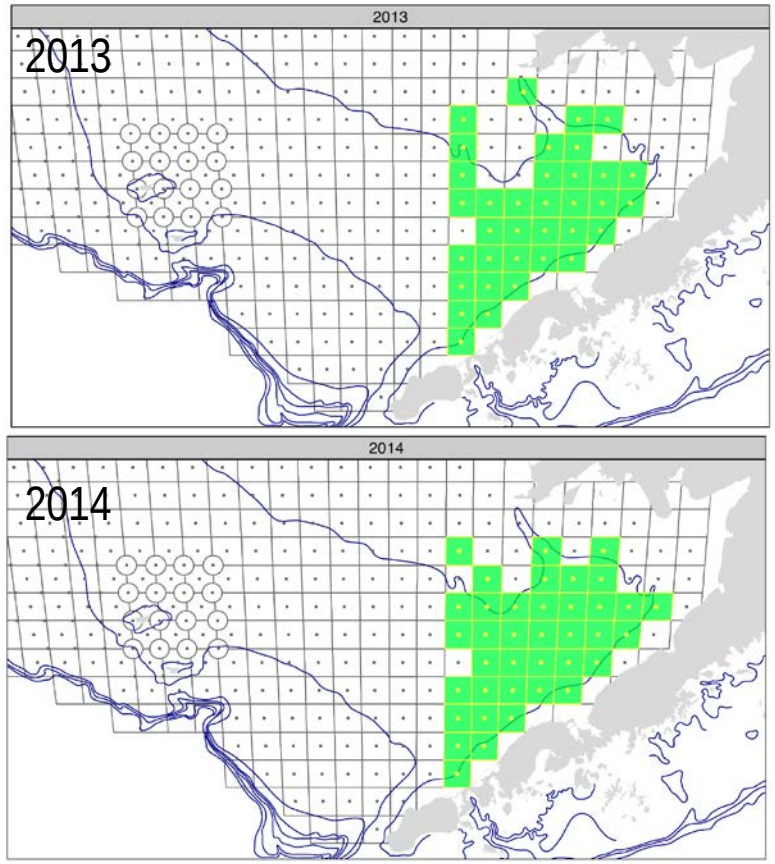
- Observed size-specific ratio (new shell mature males/all new shell males) assumed binomial-distributed
- Likelihood given by:

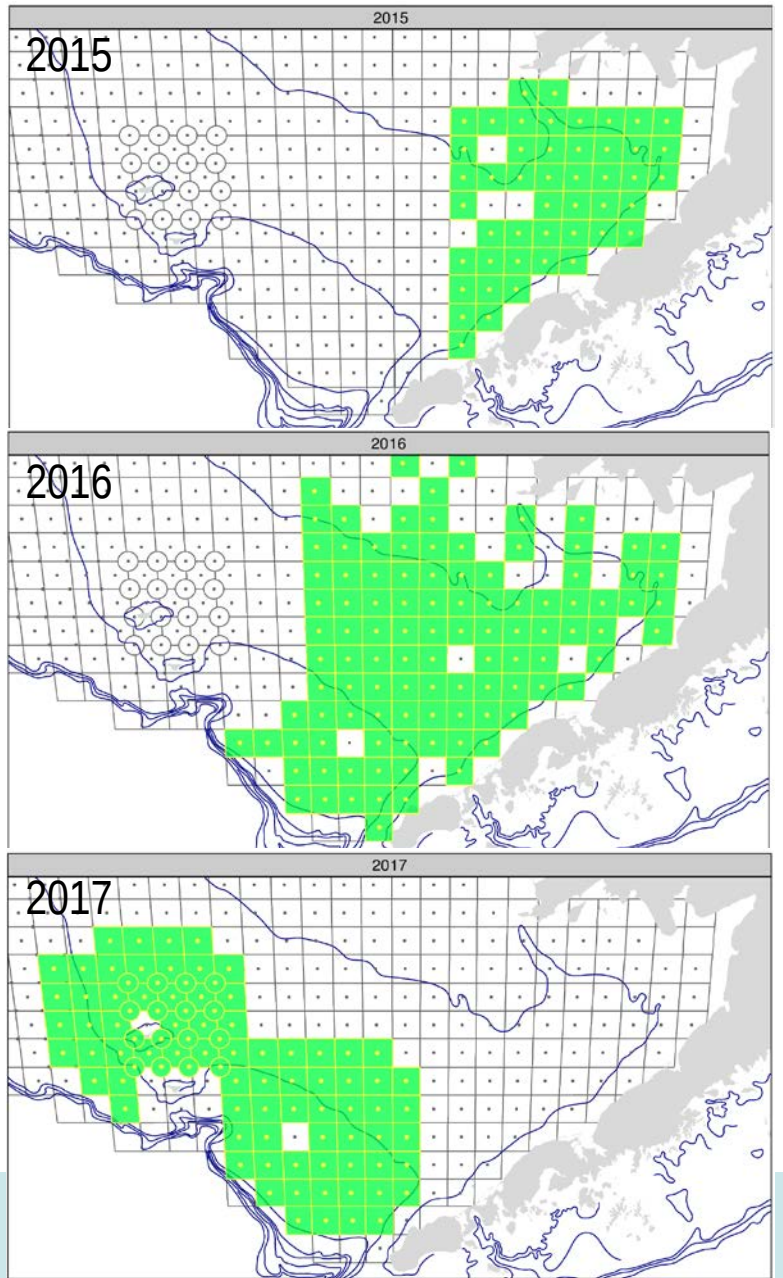
$$\mathrm{L}_m = \sum_{y,z} n_{y,z} \cdot \left\{ p_{y,z}^{obs} \cdot \ln\left(p_{y,z}^{mod} + \delta\right) + \left(1 - p_{y,z}^{obs}\right) \cdot \ln\left(1 - p_{y,z}^{mod} + \delta\right) \right\}$$

- $n_{y,z}$: number of observations

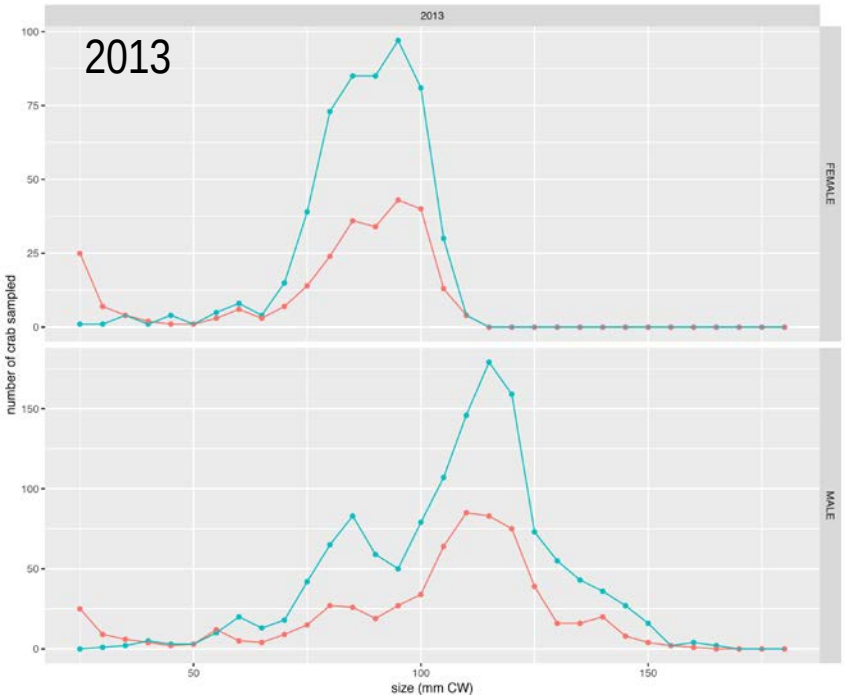
BSFRF/NMFS side-by-side (SBS) catchability studies

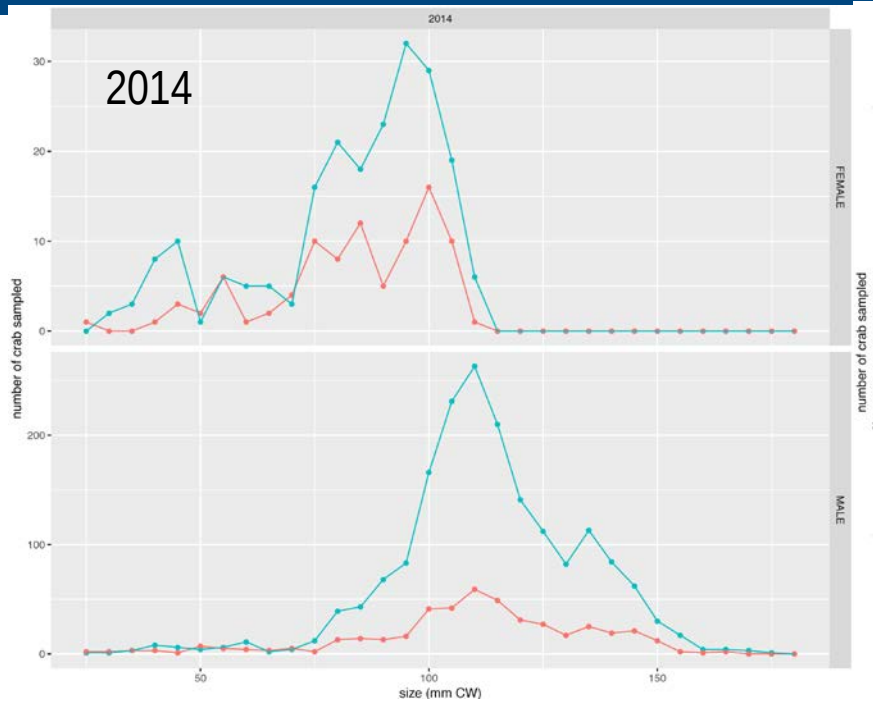
- BSFRF and NMFS conducted side-by-side haul studies to better characterize catchability for Tanner crab
  - 2013-2017
  - 2018 (not yet available)
- NMFS hauls
  - 83-112 trawl gear
  - 30 min. tow
- BSFRF hauls
  - modified nephrops trawl gear
  - 5 min. tow

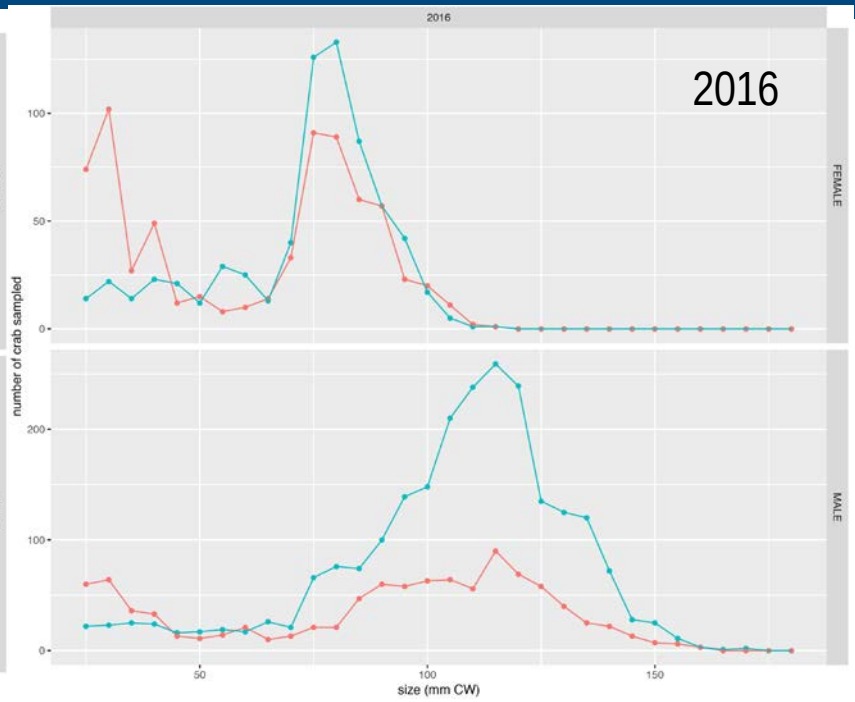


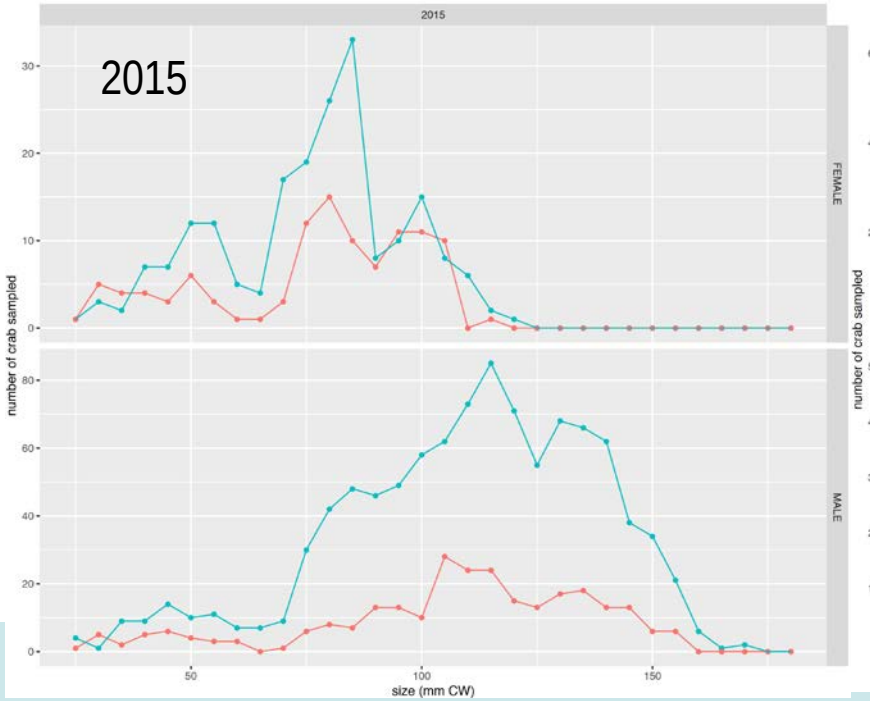


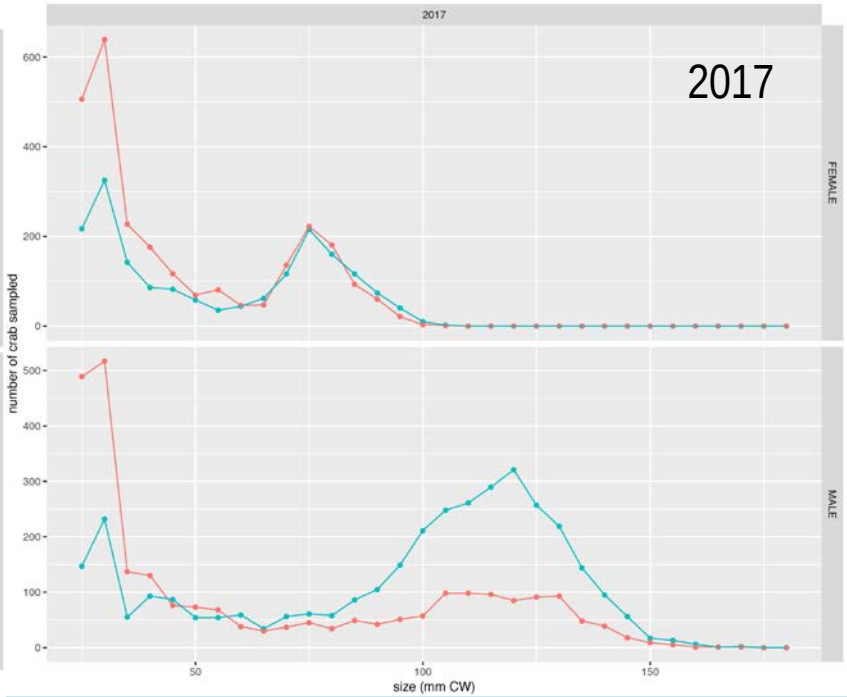
SBS catchability studies: sampled crab











survey

- BSFRF
- NMFS

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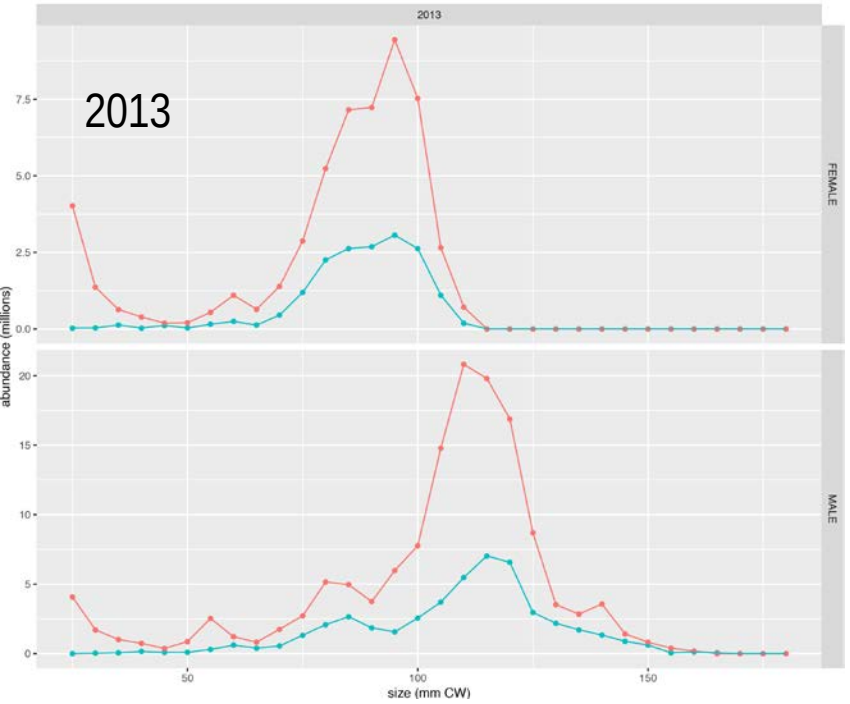
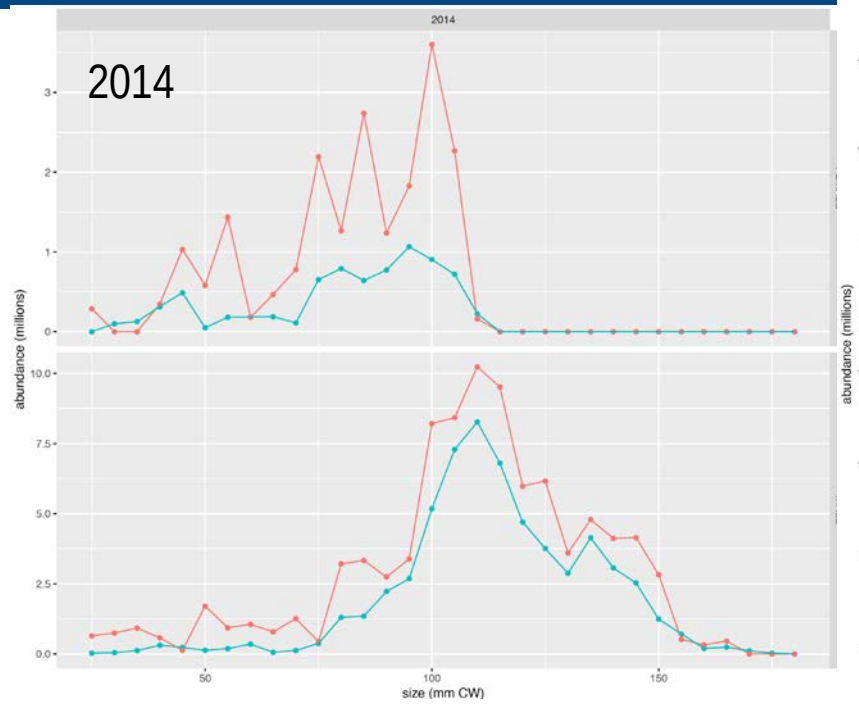
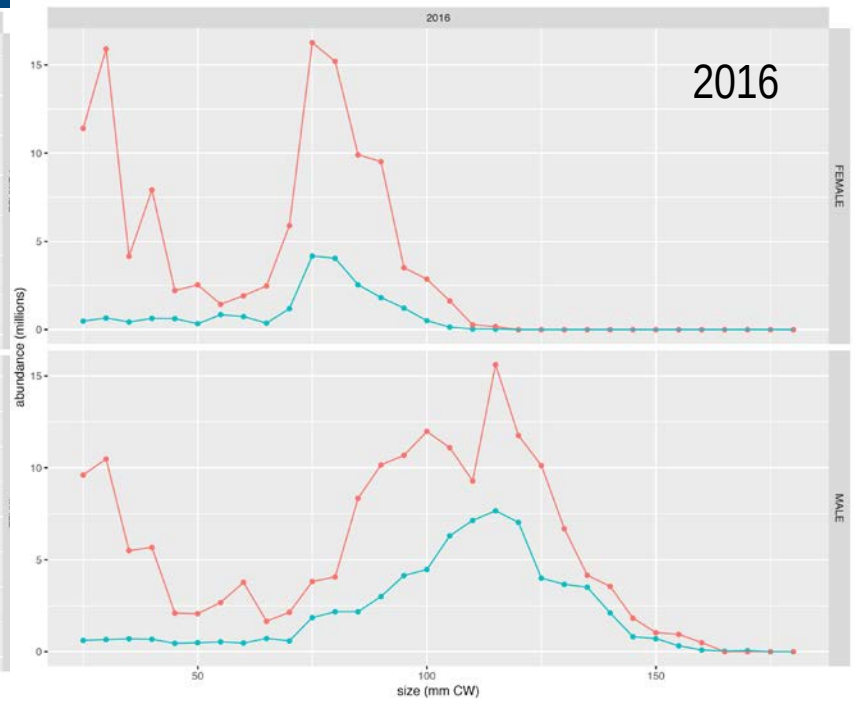
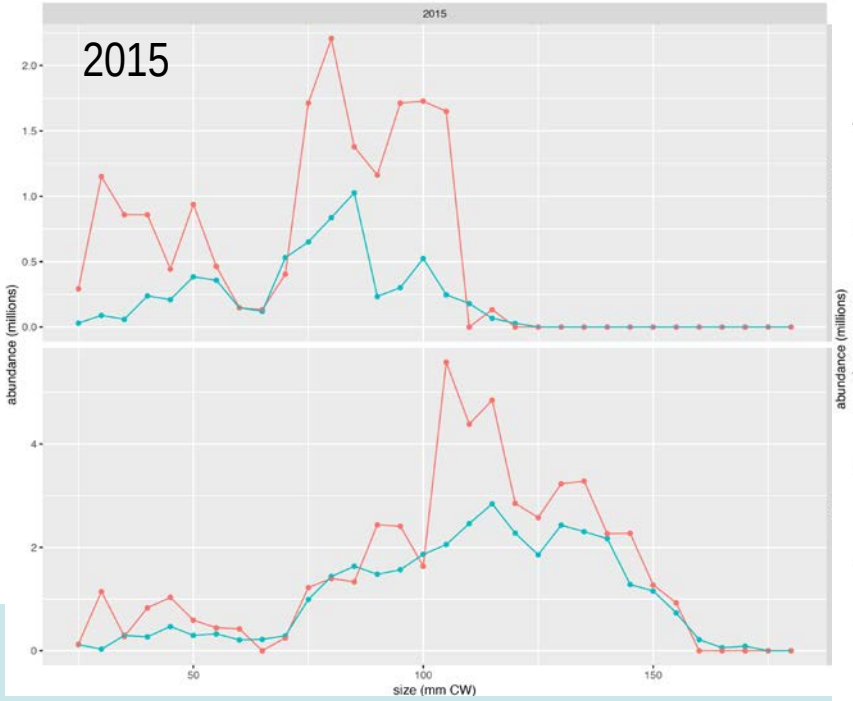
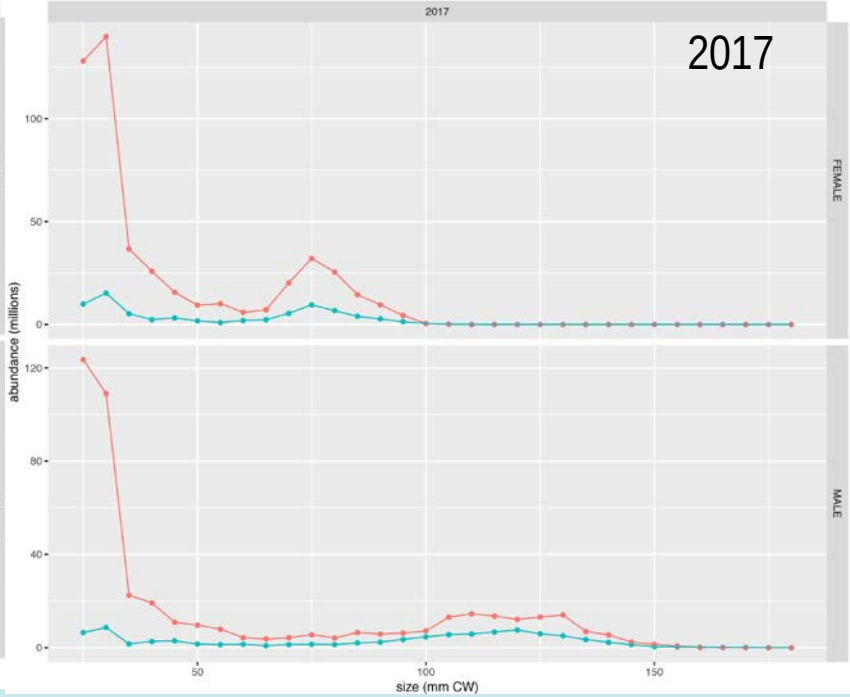
SBS catchability studies: area-swept abundance











survey

- BSFRF
- NMFS

NOAA FISHERIES

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

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

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

Empirical estimation

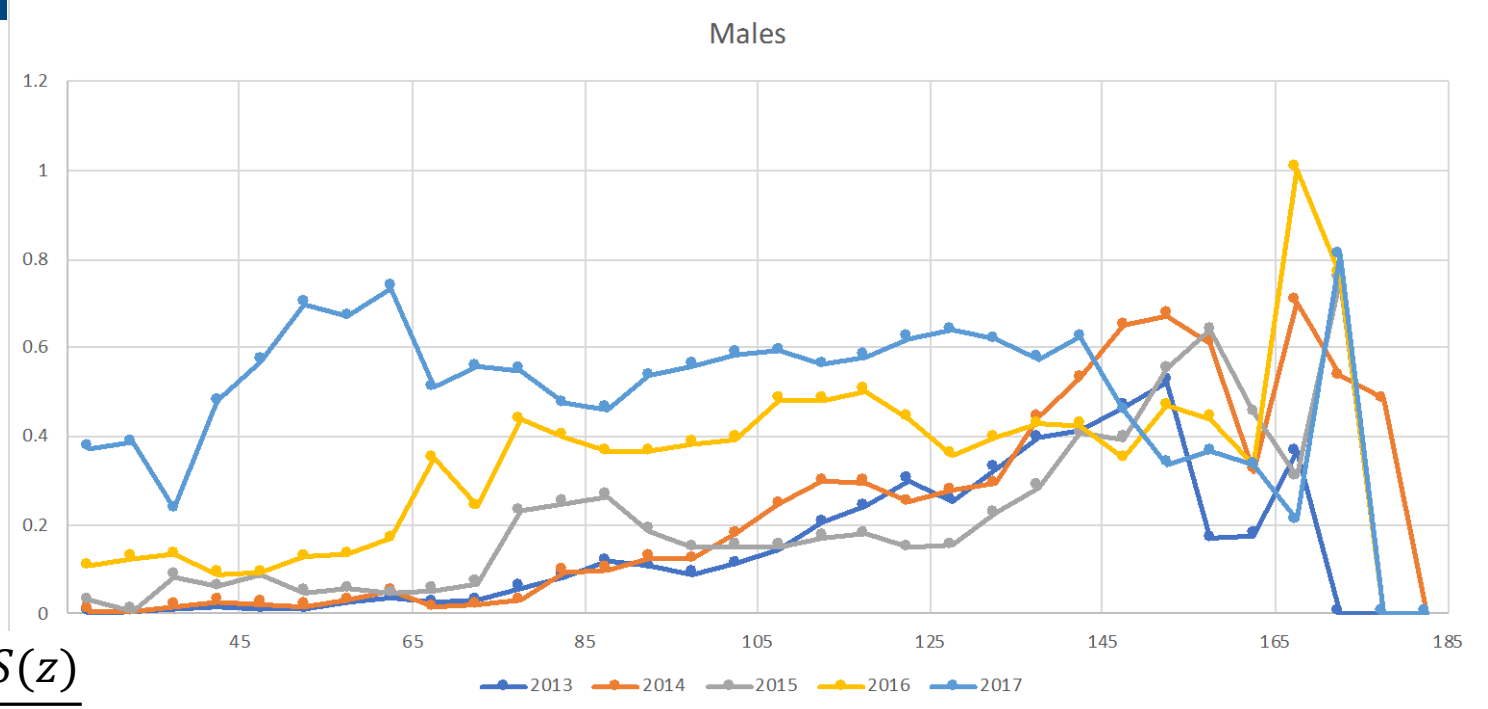
$$A_{x,z} = \frac{\tilde{n}^{NMFS}_{x,z}}{\hat{n}^{NMFS}_{x,z}} \qquad S^{NMFS}_{x,z} = \frac{\tilde{n}^{NMFS}_{x,z}}{\tilde{n}^{BSFRF}_{x,z}}$$

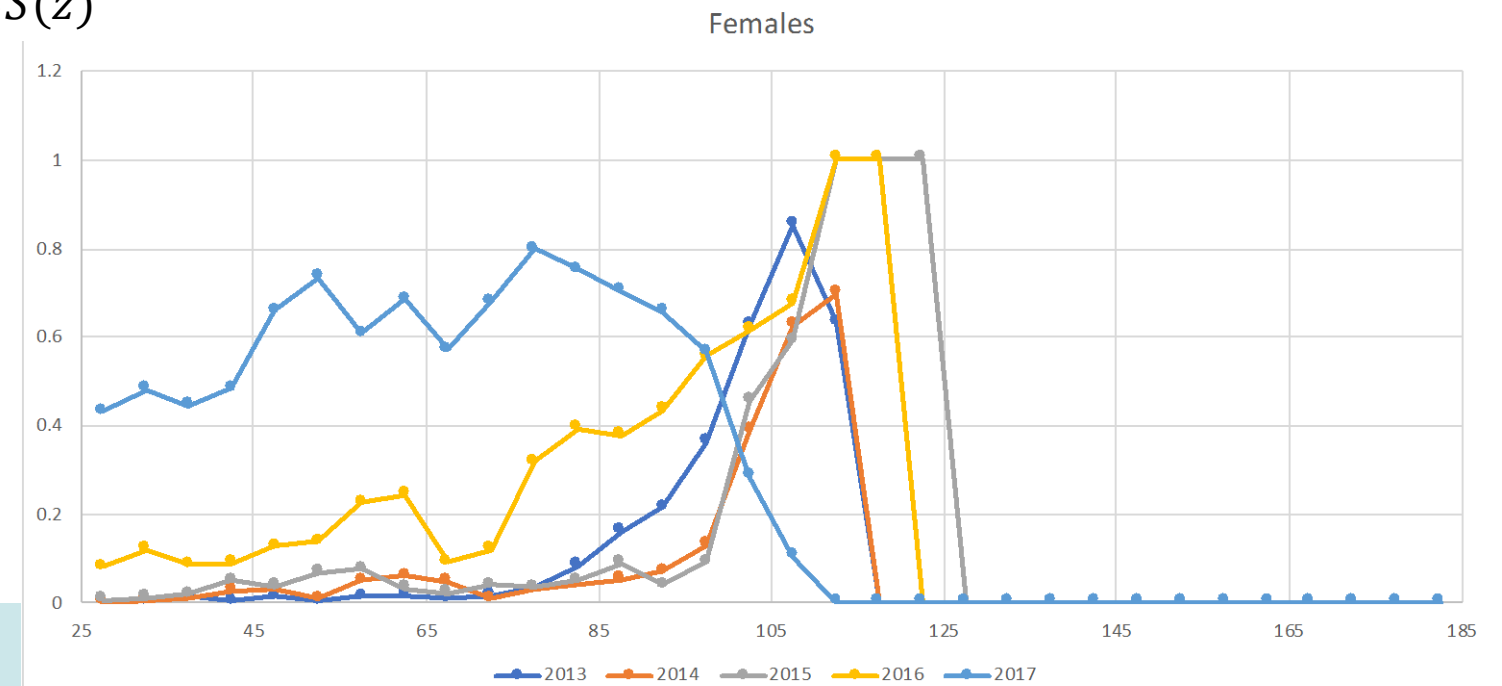
SBS catchability studies: empirical availability

empirical estimate for availability:

- not logistic

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



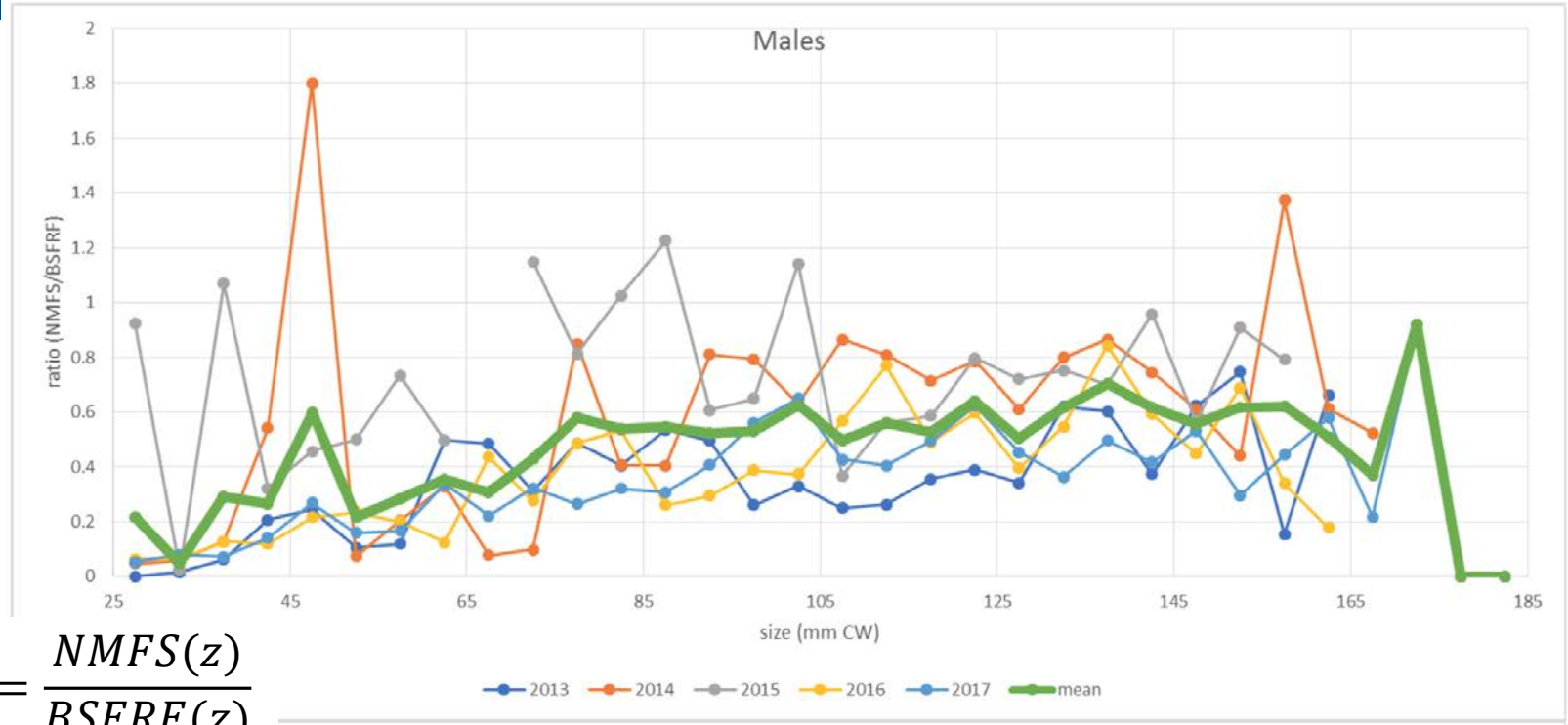


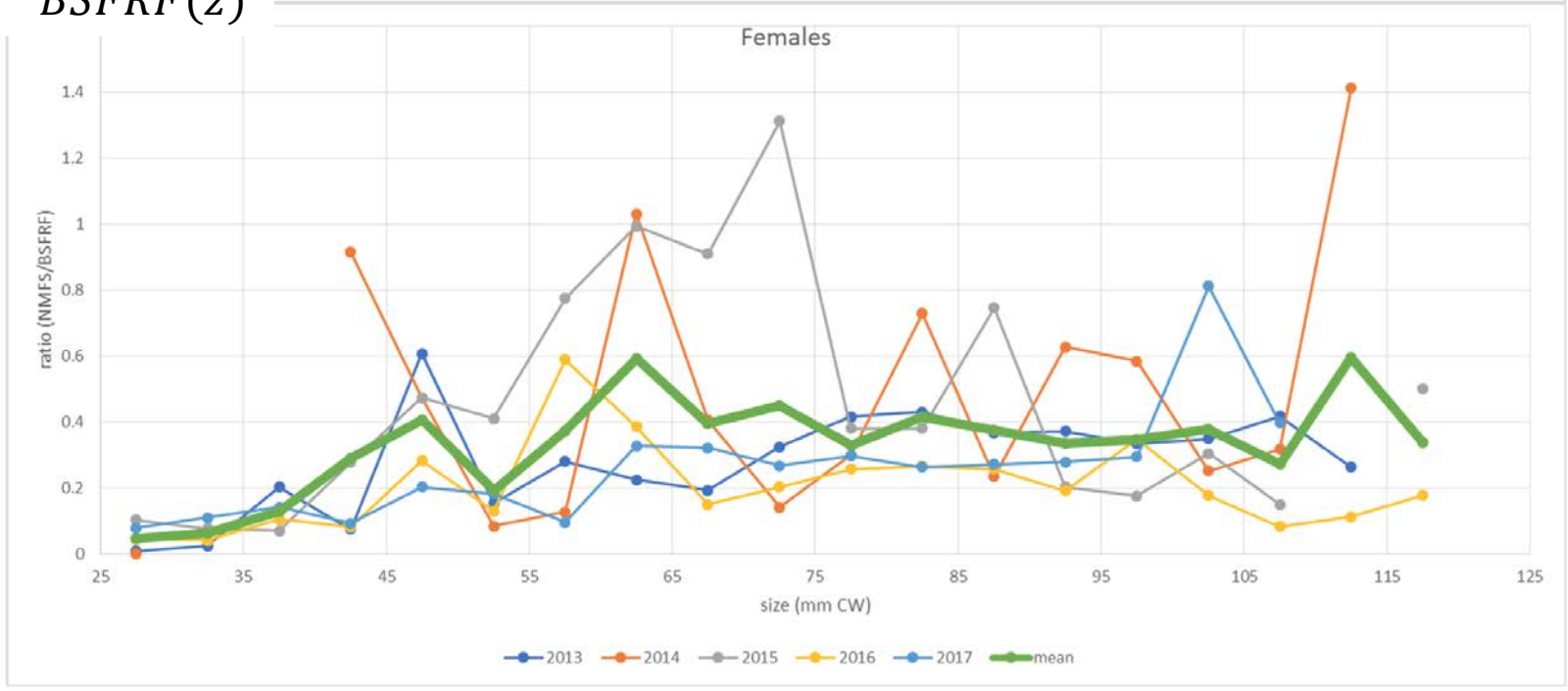
SBS catchability studies: empirical catchability

empirical estimate for q:

- males: ~0.6
- females: ~0.4

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





Model Performance

Model scenario highlights

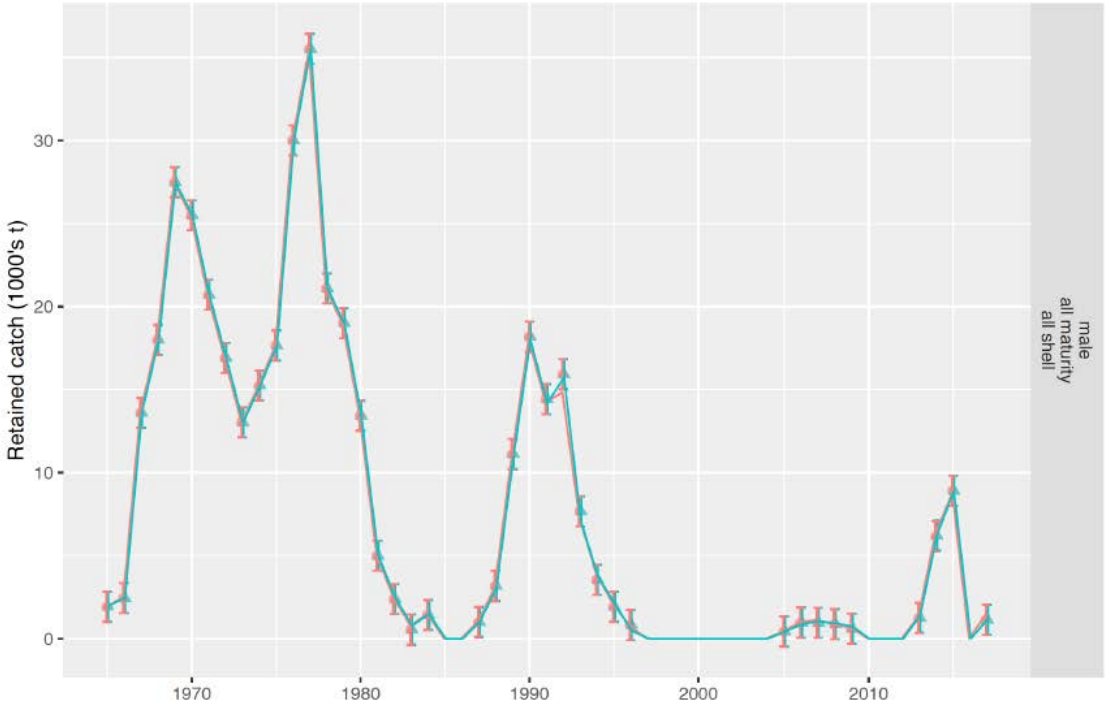
- 5 scenarios evaluated for 2019
  - Crab fishery data updated 1990-2019
  - All fit new molt increment data
  - Some fit maturity ogive data
  - Some fit BSFRF-NMFS SBS data
- All scenarios fit fishery very well
- All scenarios fit survey data reasonably well
- Lower estimates for NMFS survey catchability,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

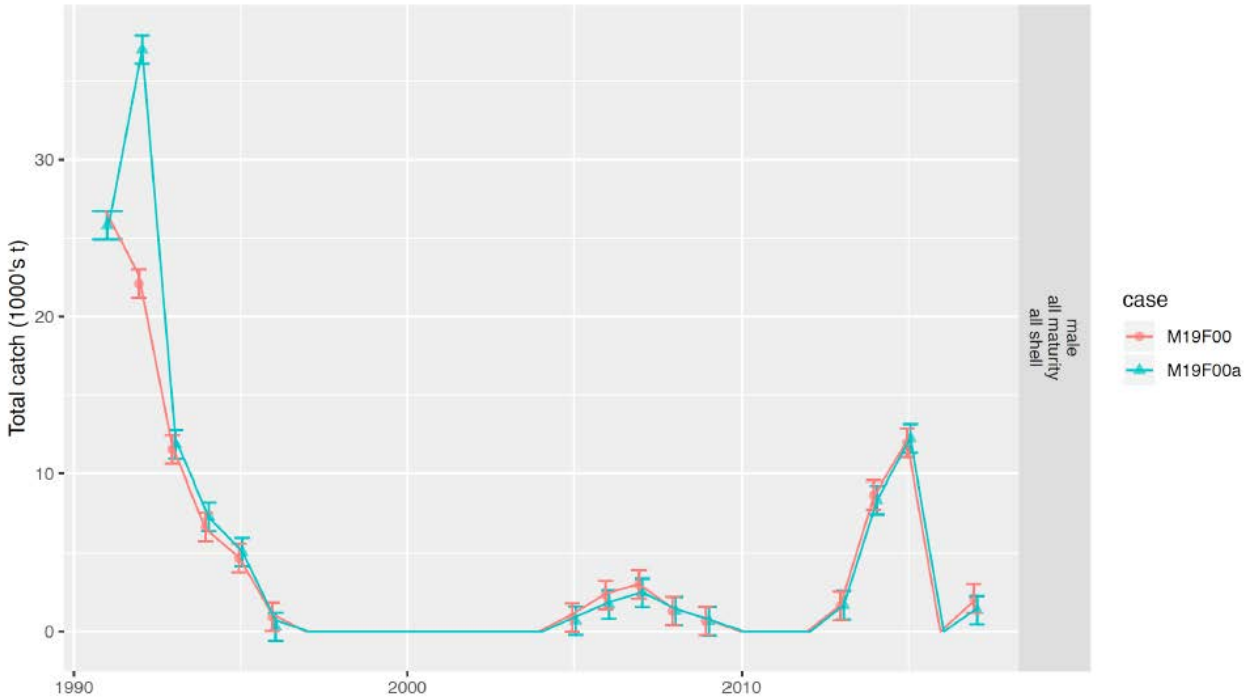
Model performance

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

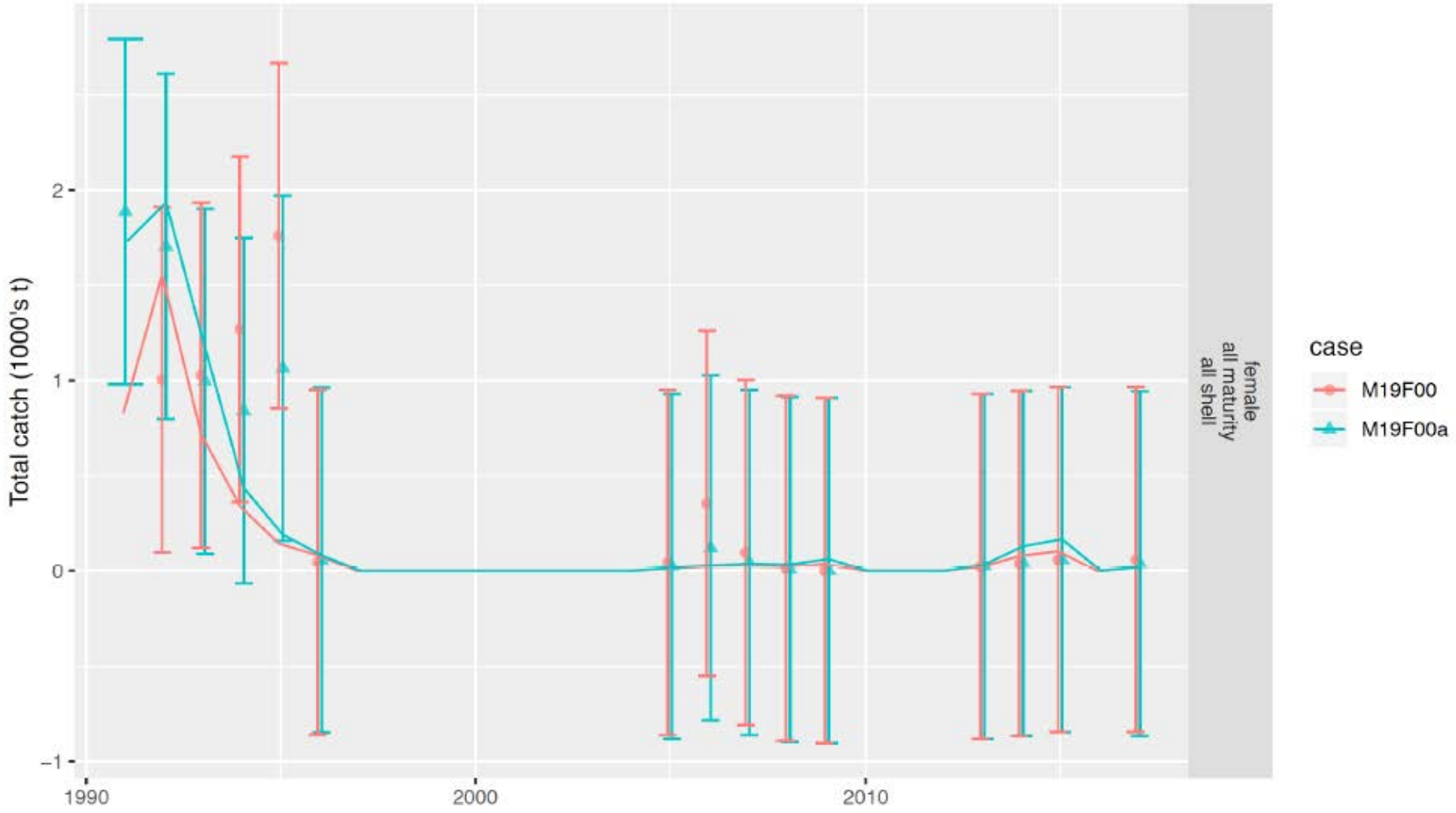
M19F00 vs. M19F00a: Effects of revised fishery data

Directed fishery: fits to male catch data

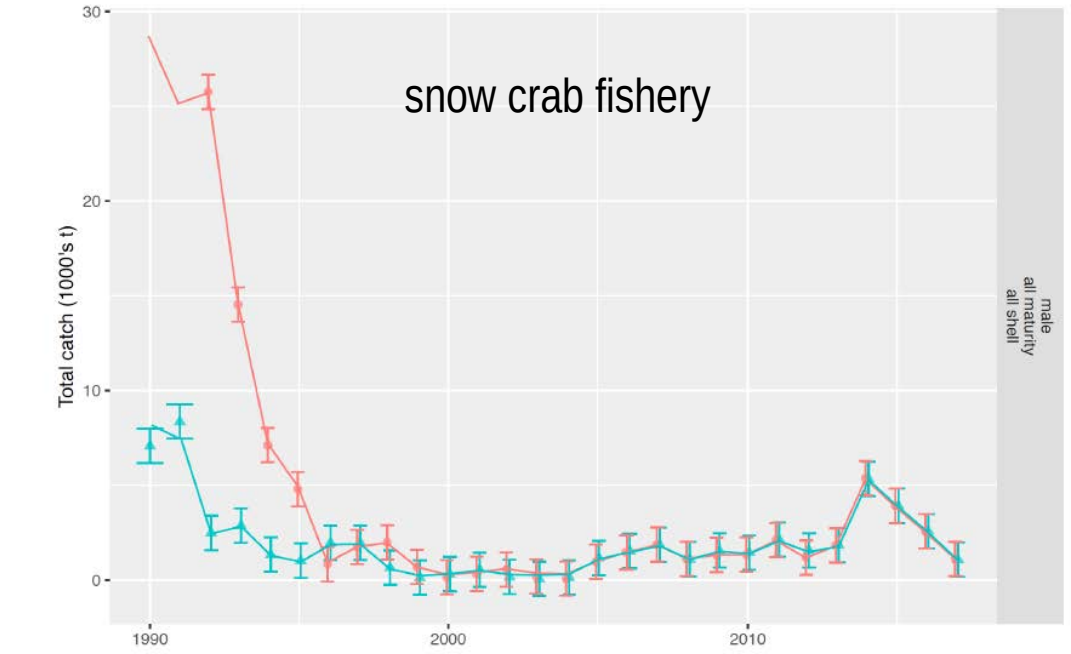


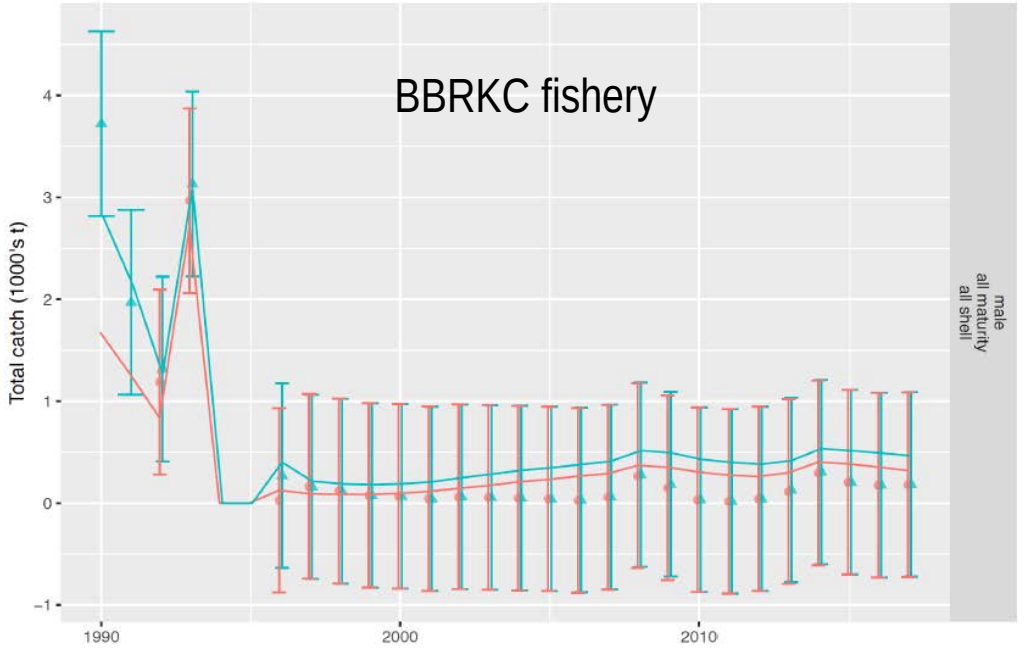


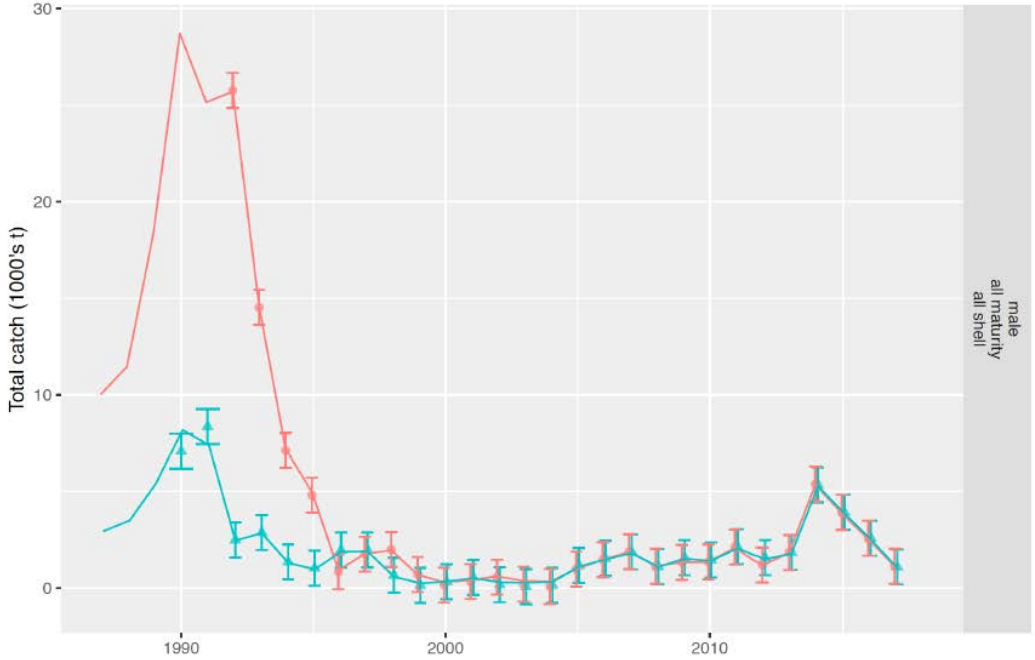
Directed fishery: fits to female bycatch data

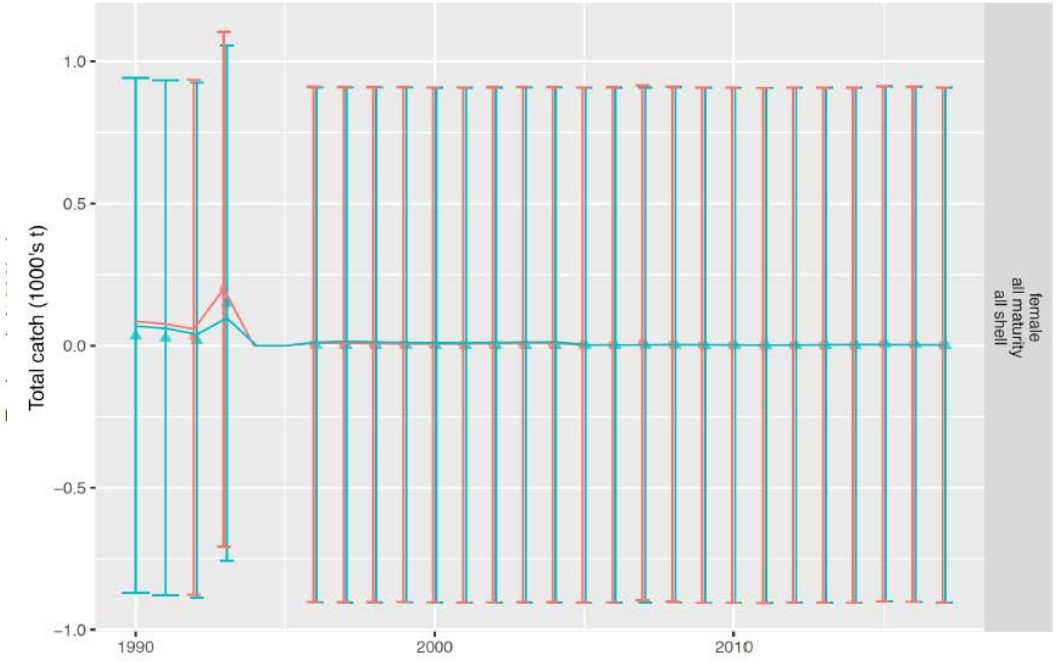


More fits to bycatch data

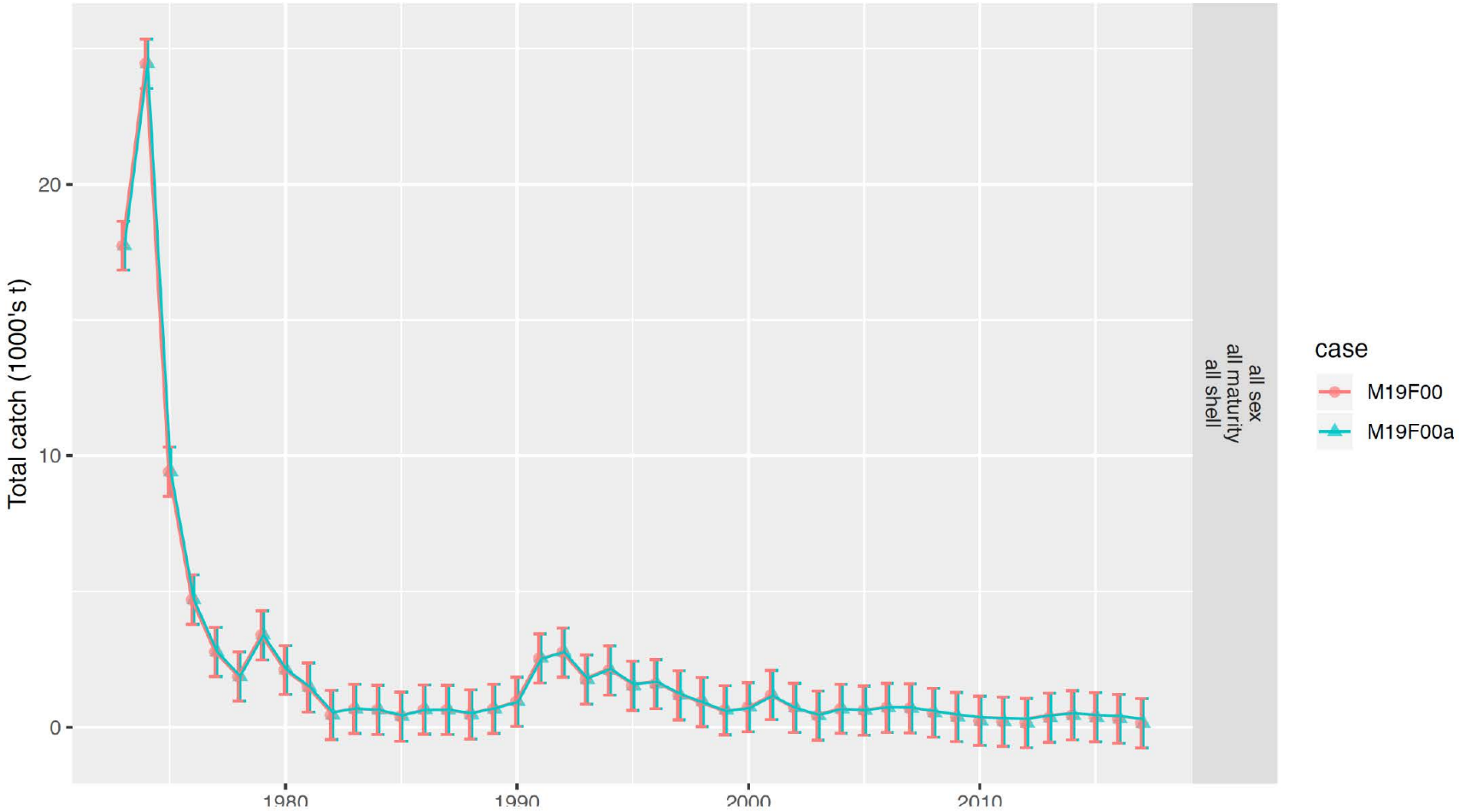




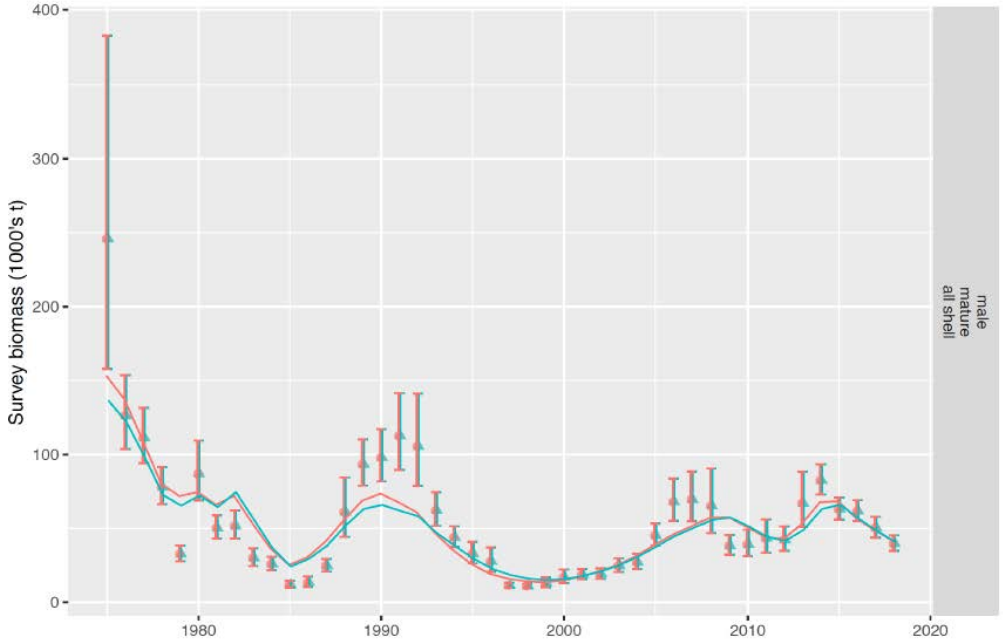




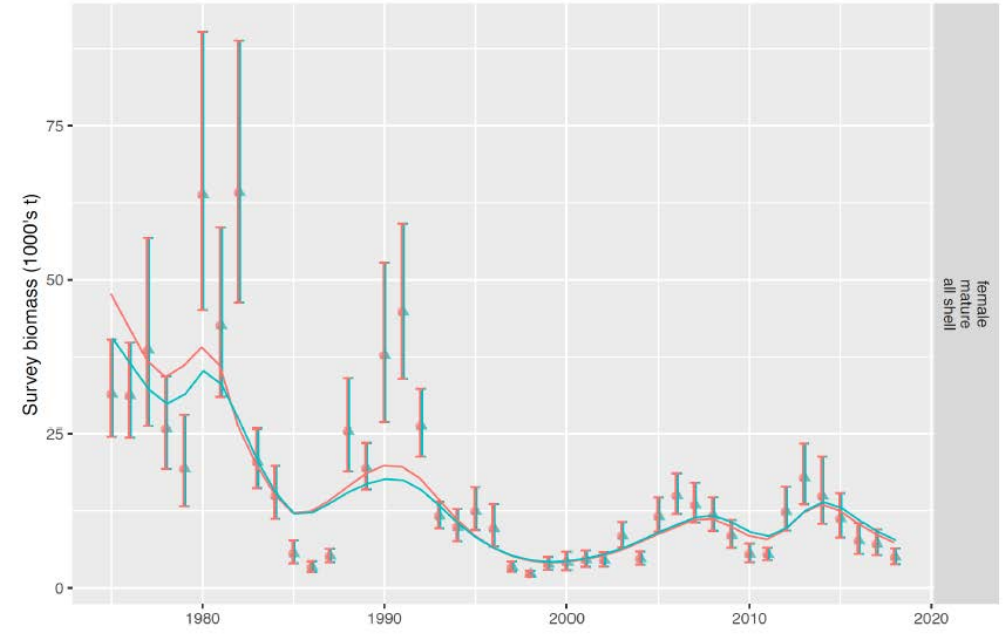
Fits to bycatch data from the groundfish fisheries



Fits to NMFS EBS mature survey biomass

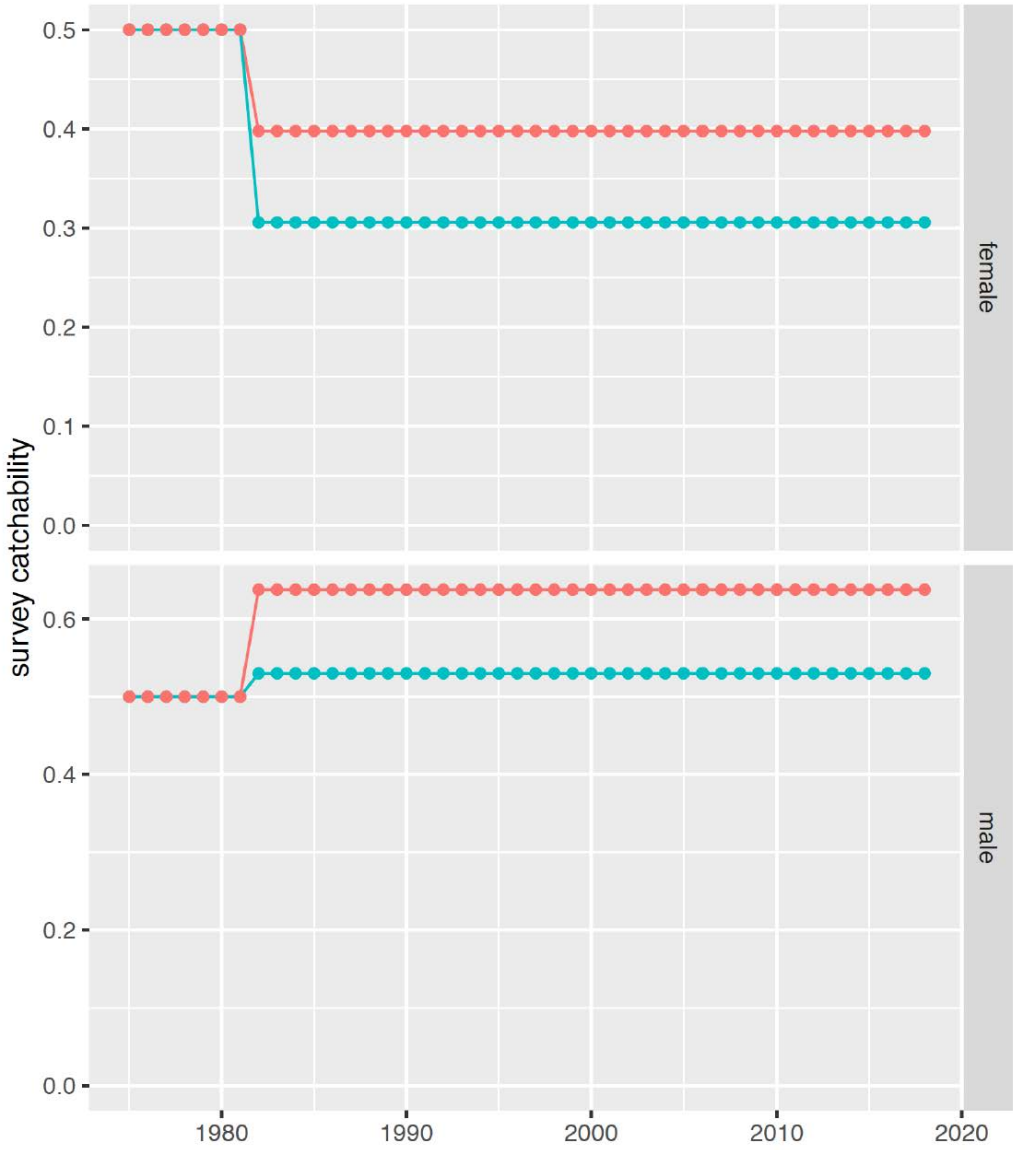


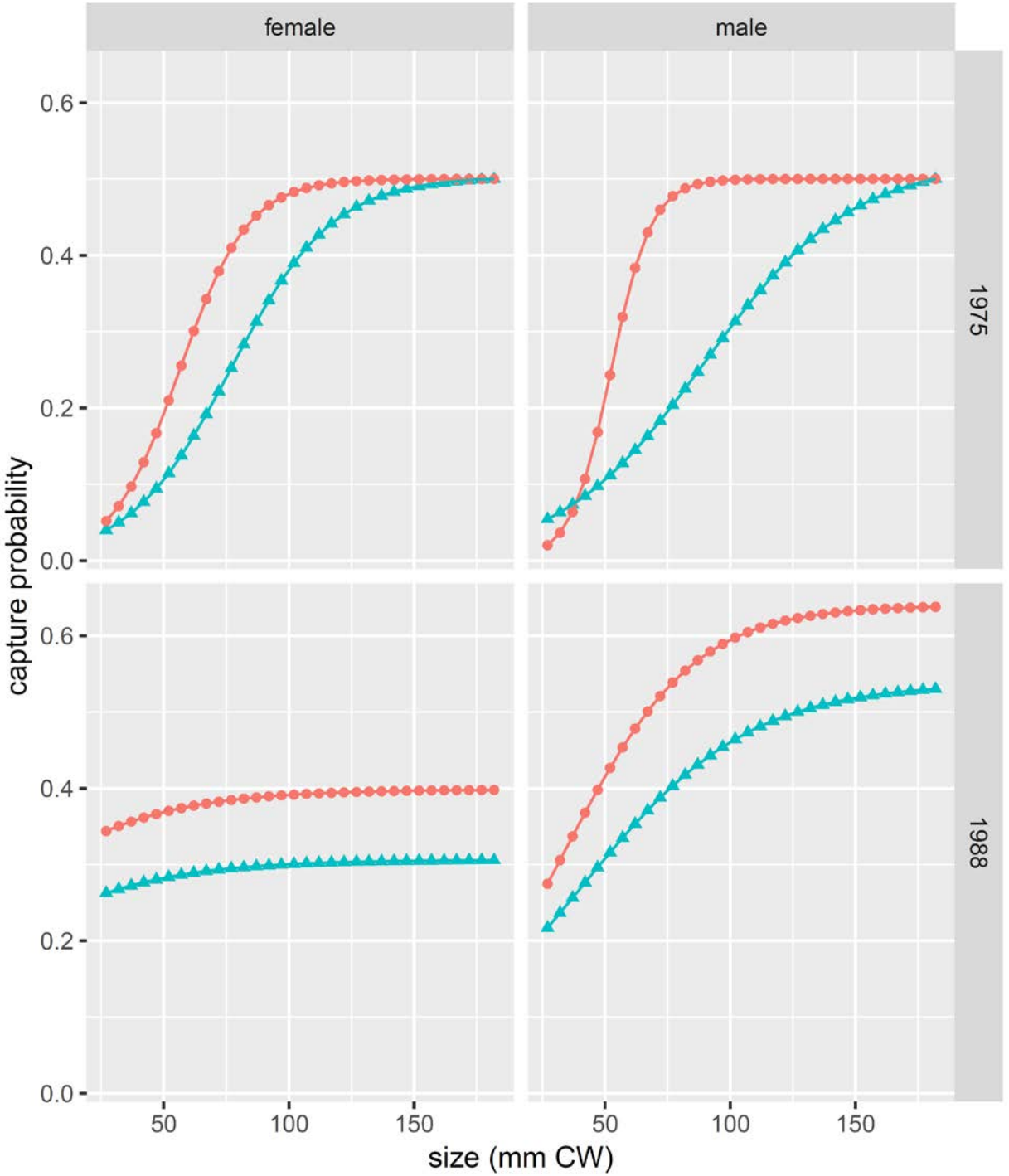
Males



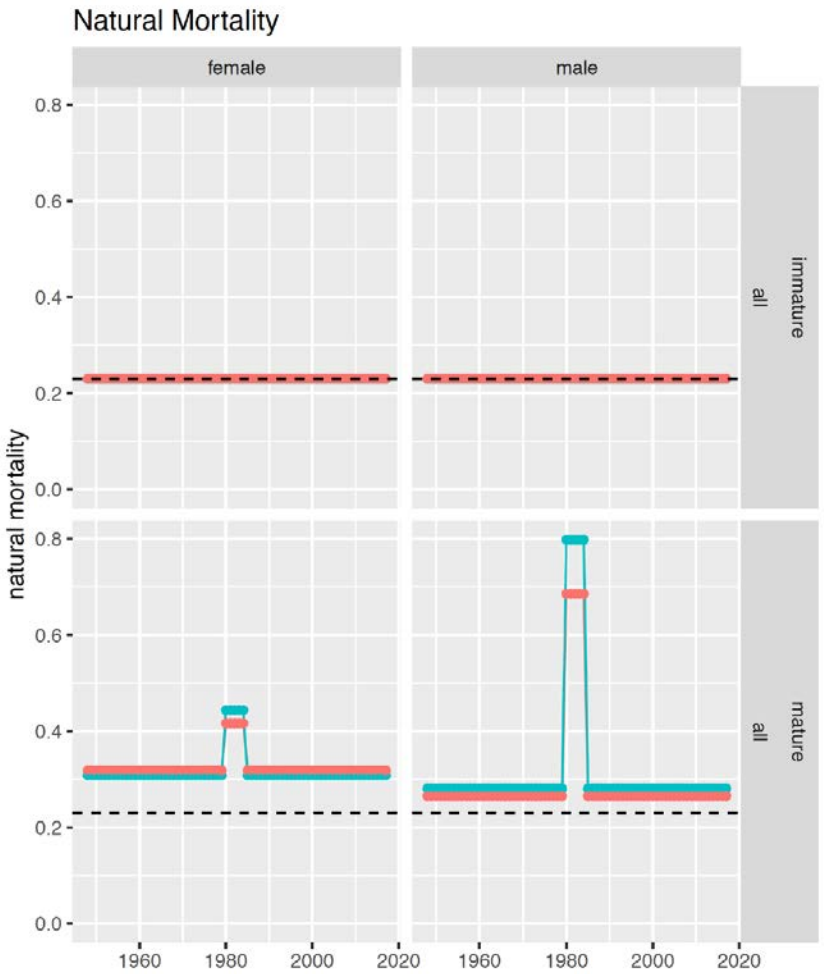
Females

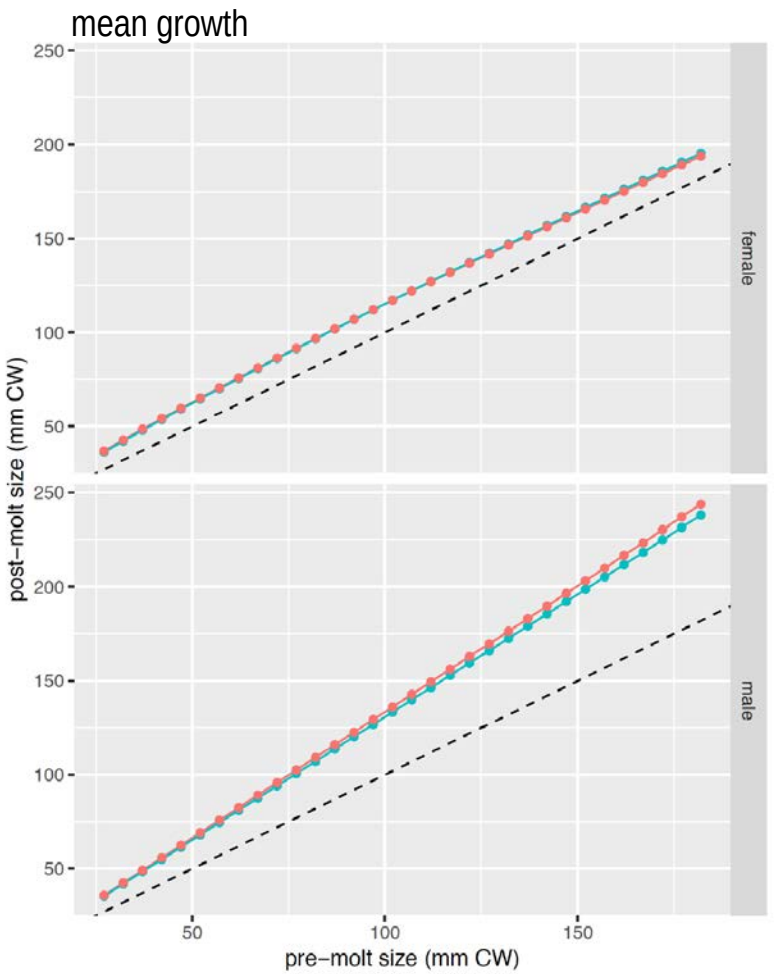
Model processes: NMFS survey

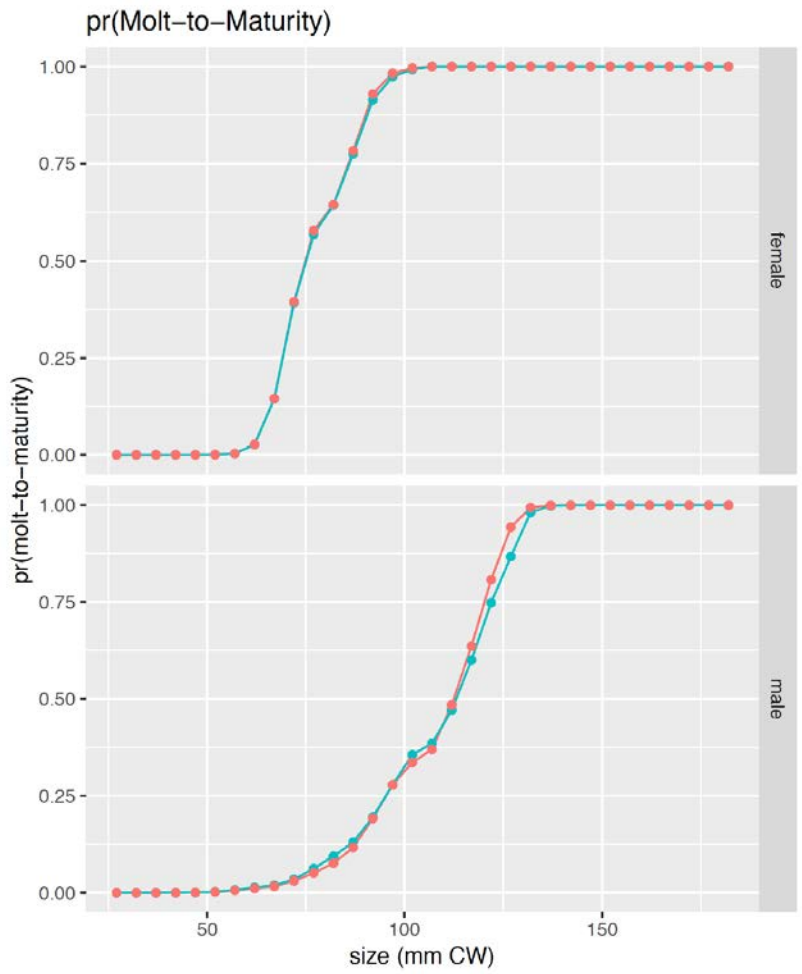




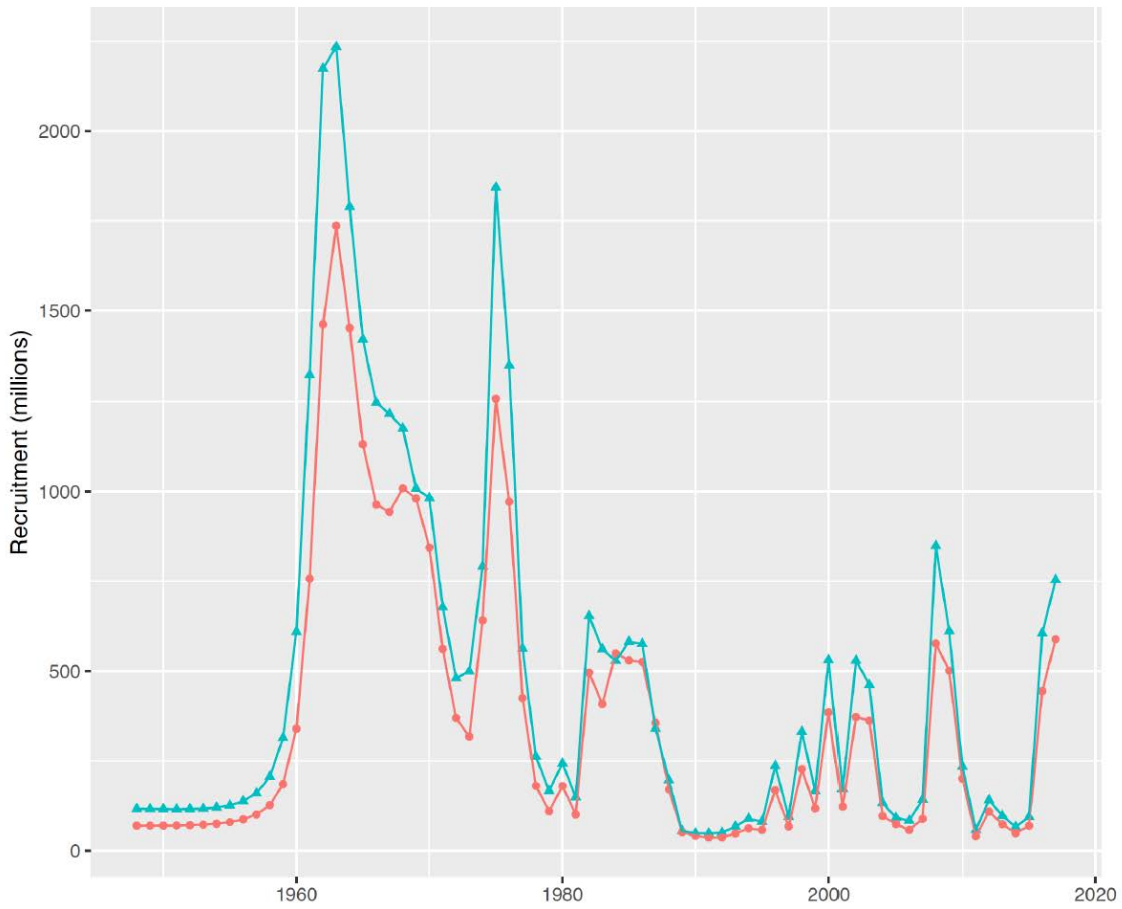
Model processes

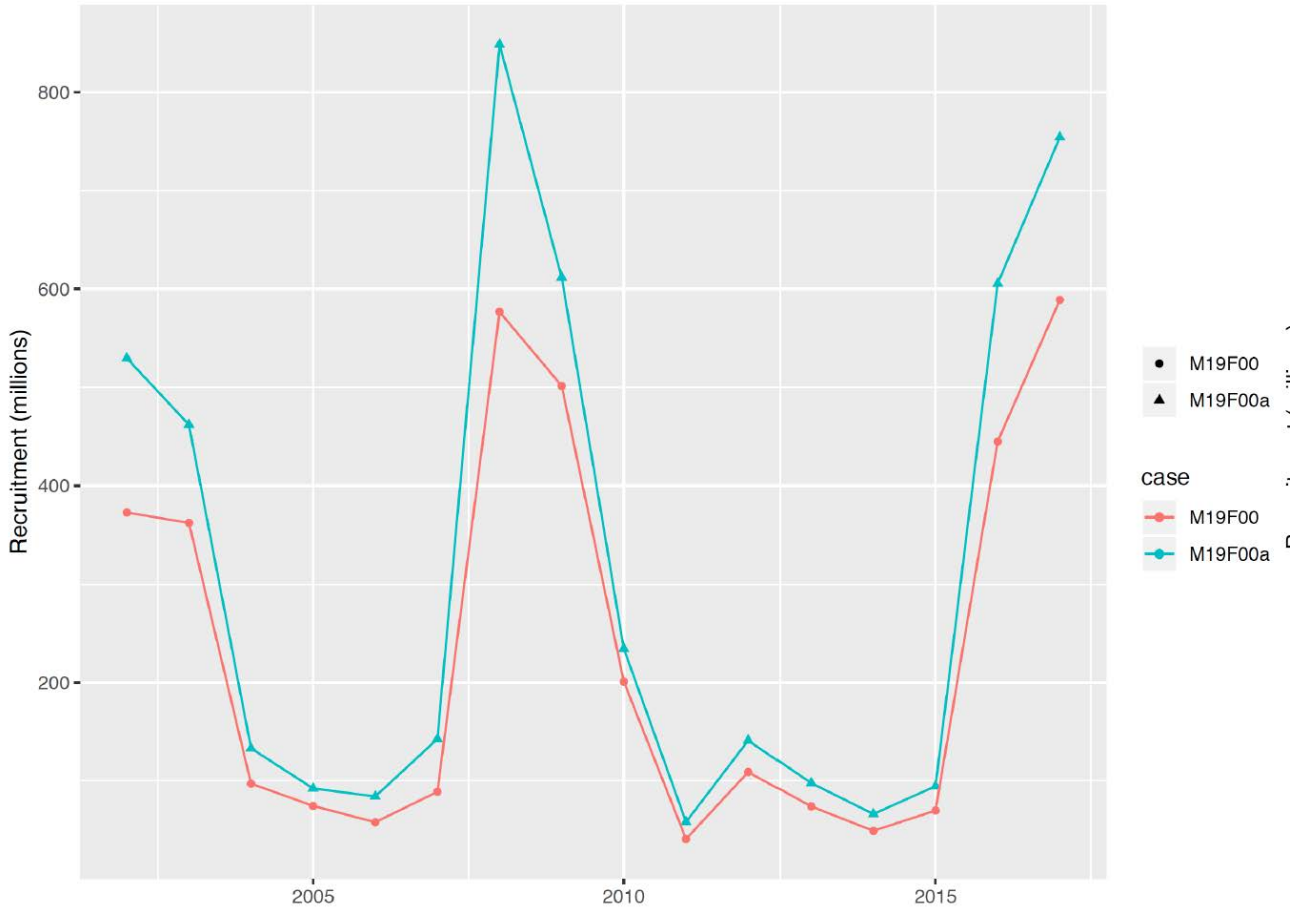




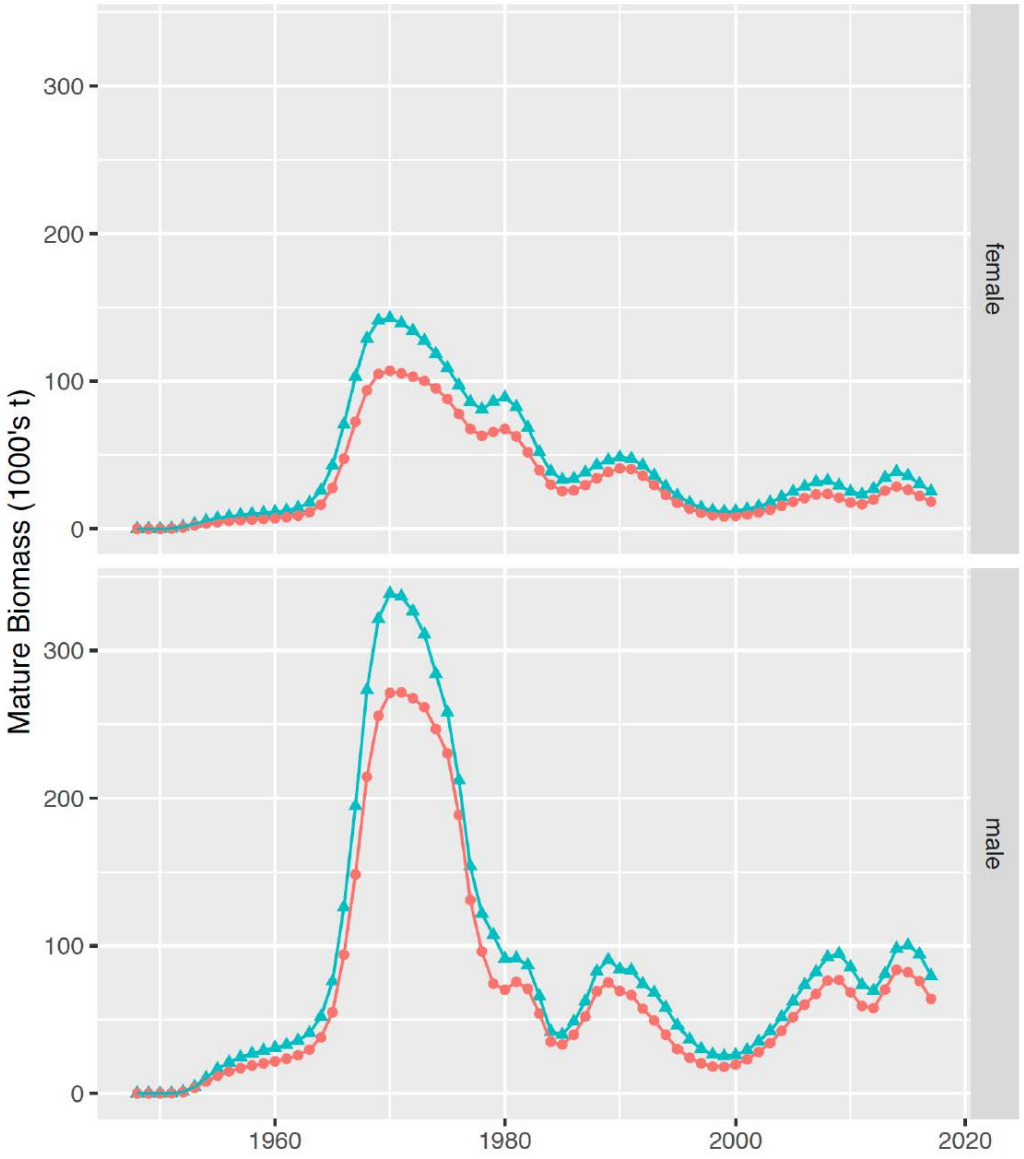


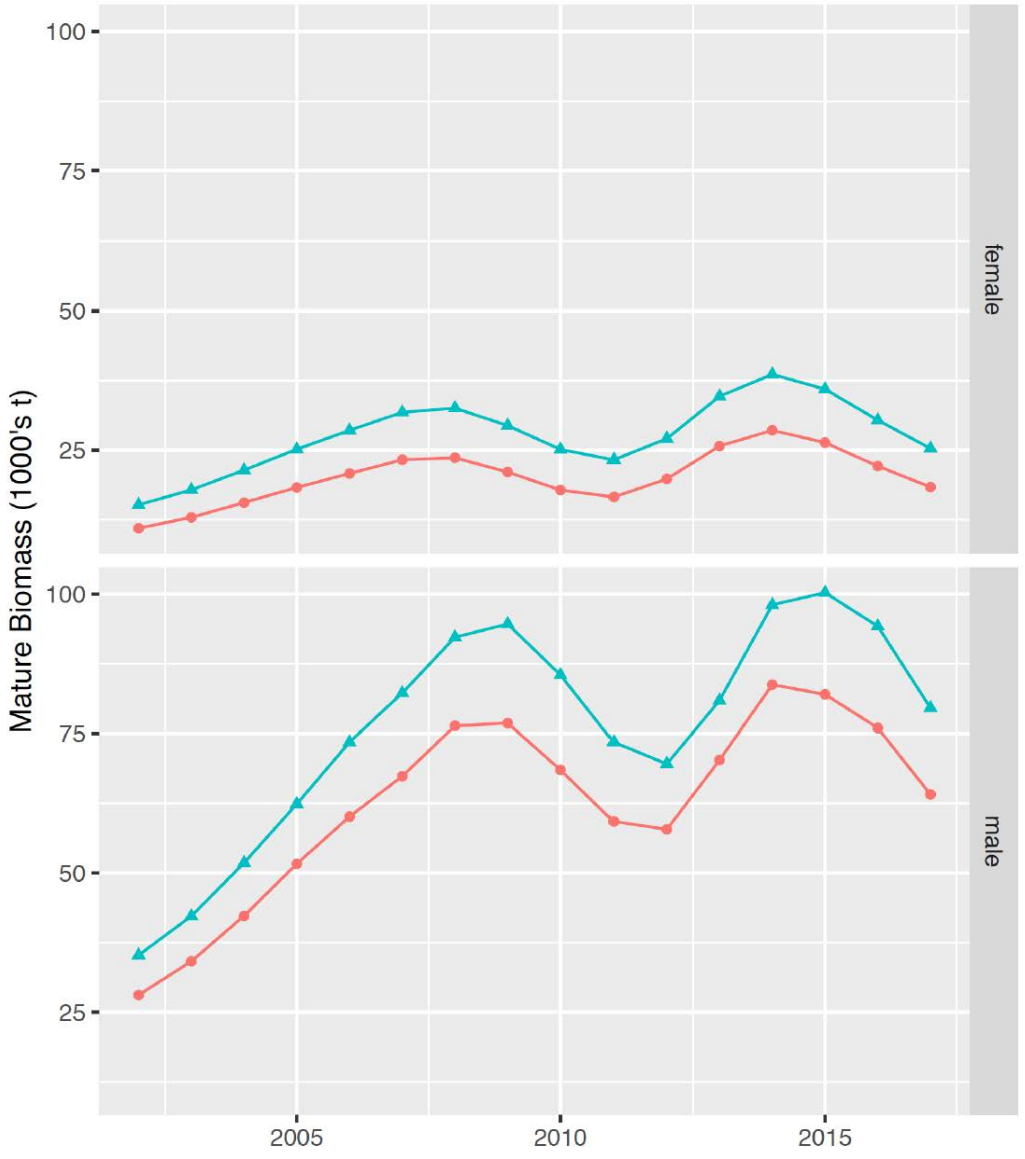
Model recruitment estimates



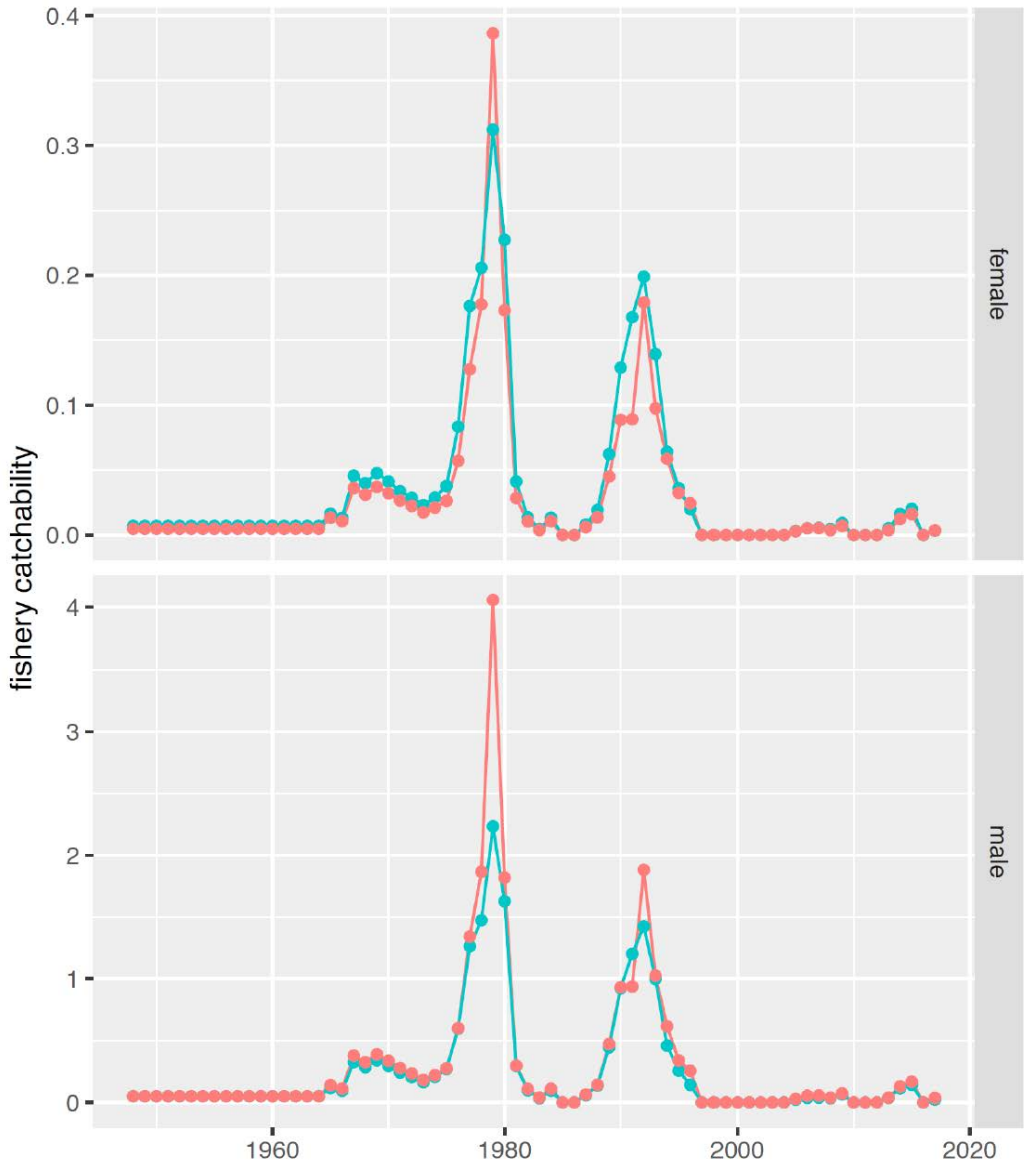


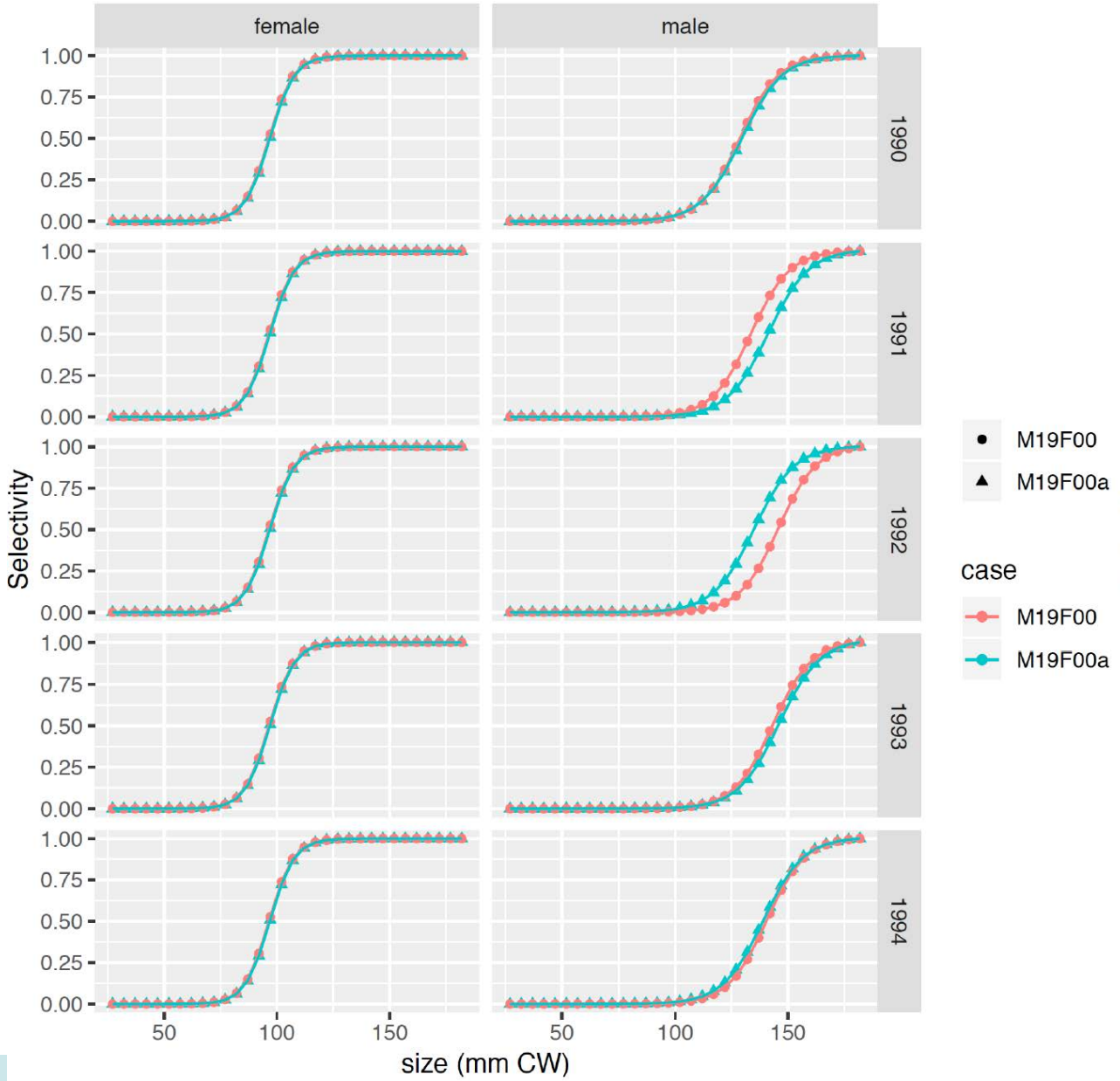
Model population estimates



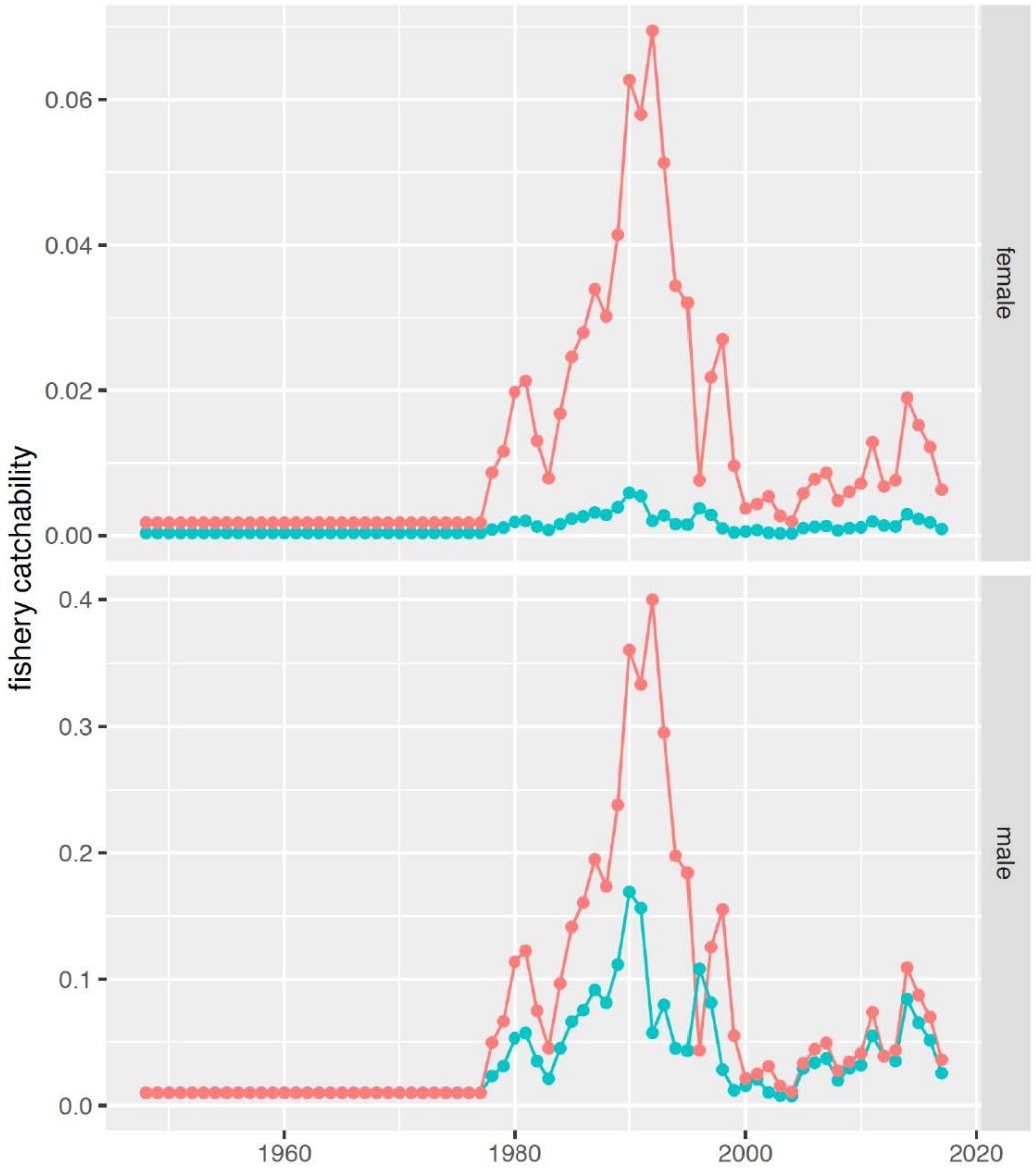


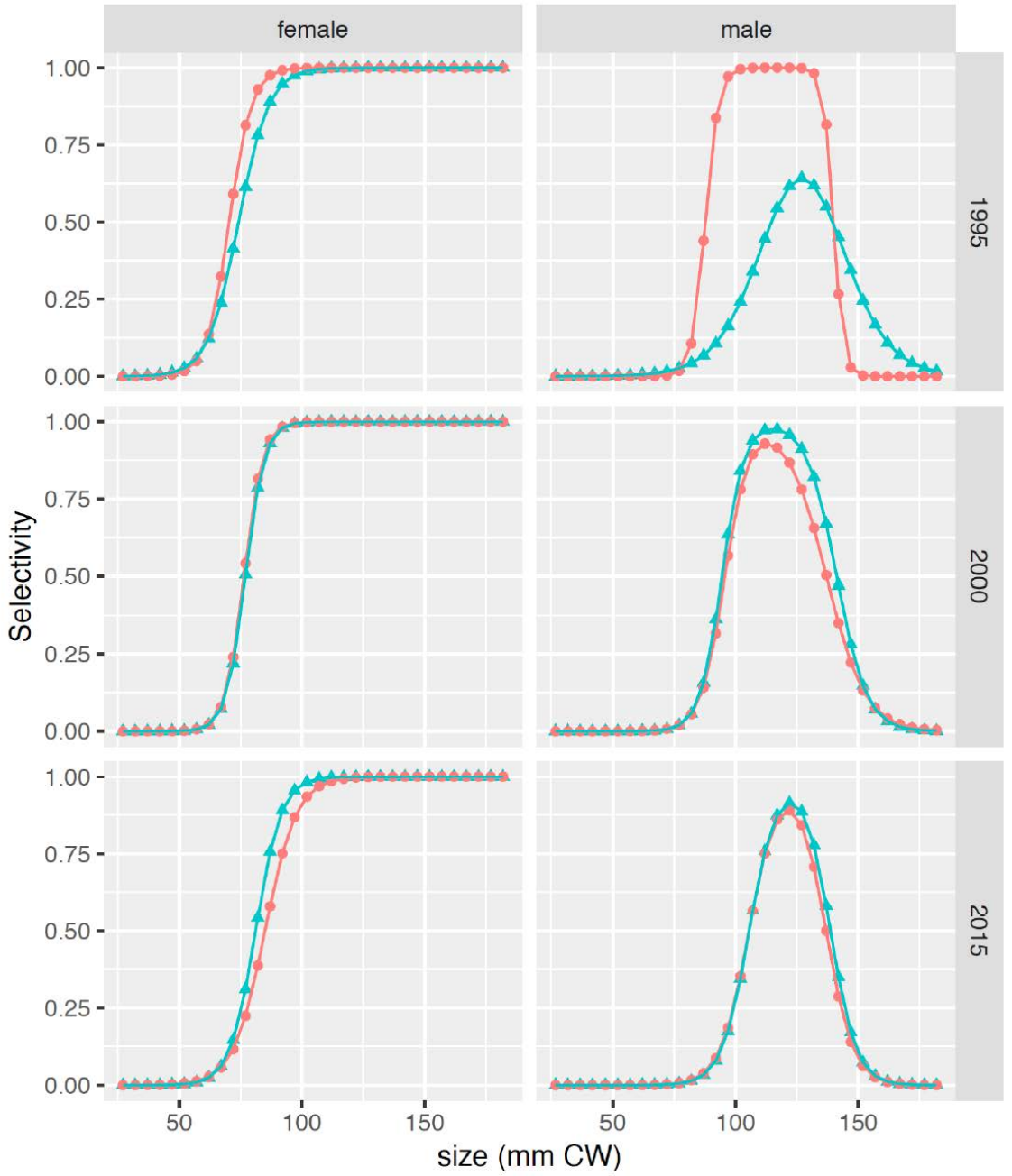
Model processes: directed fishery



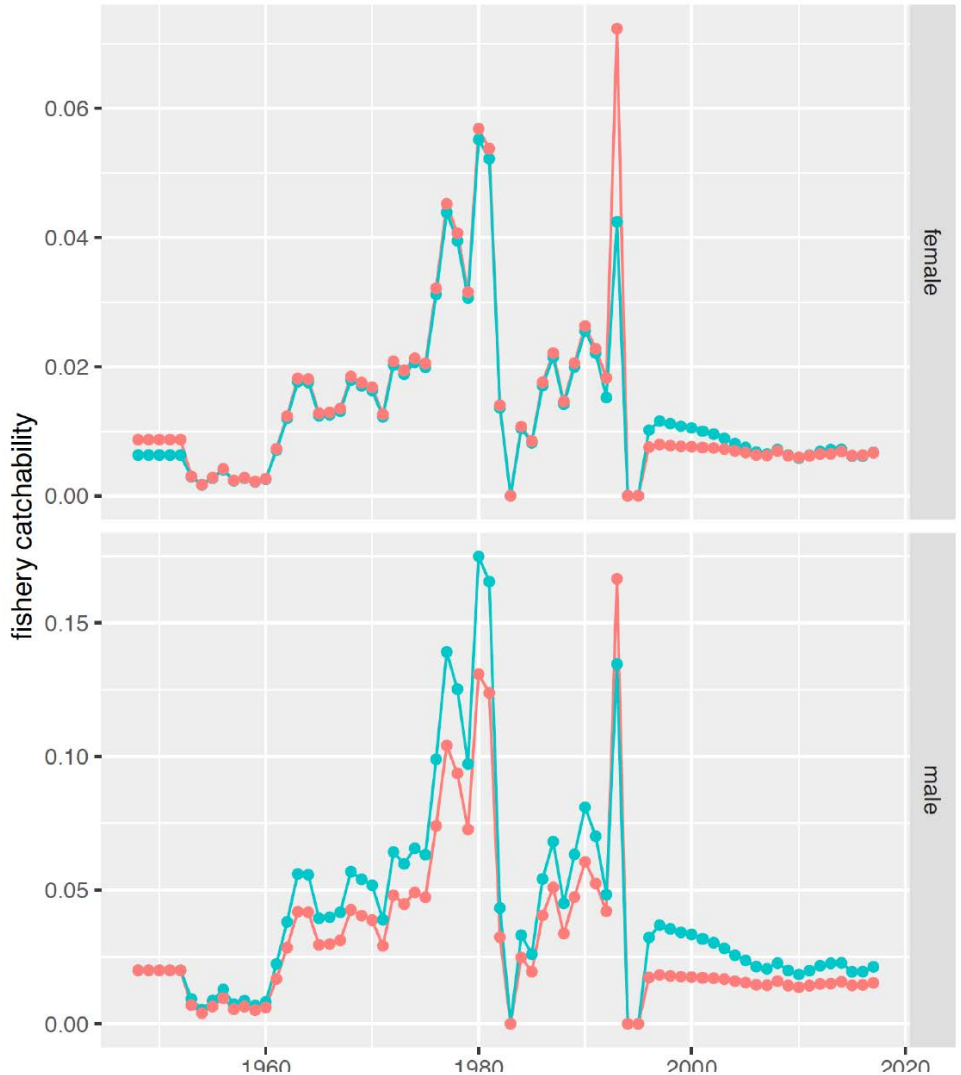


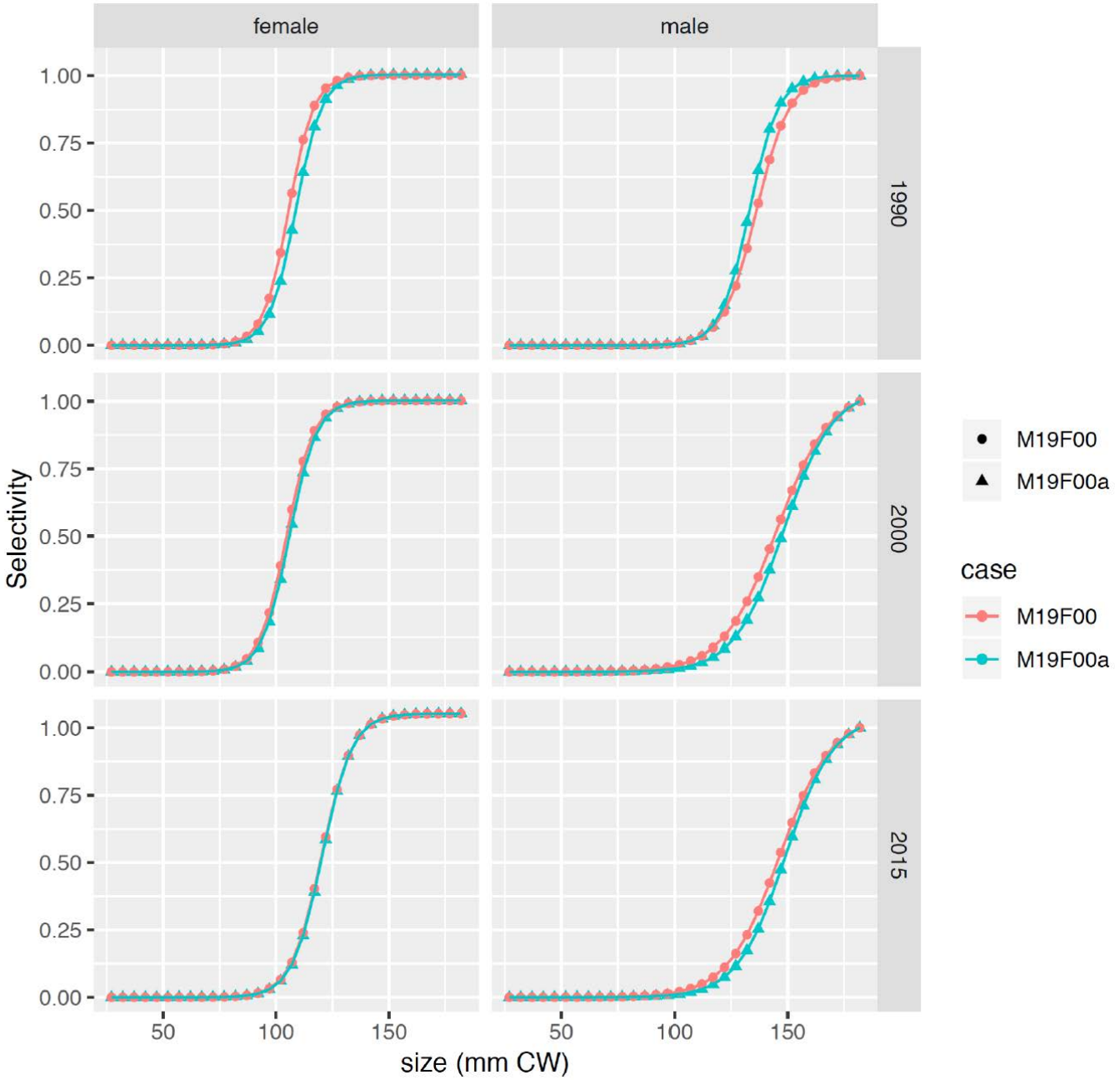
Model processes: snow crab fishery



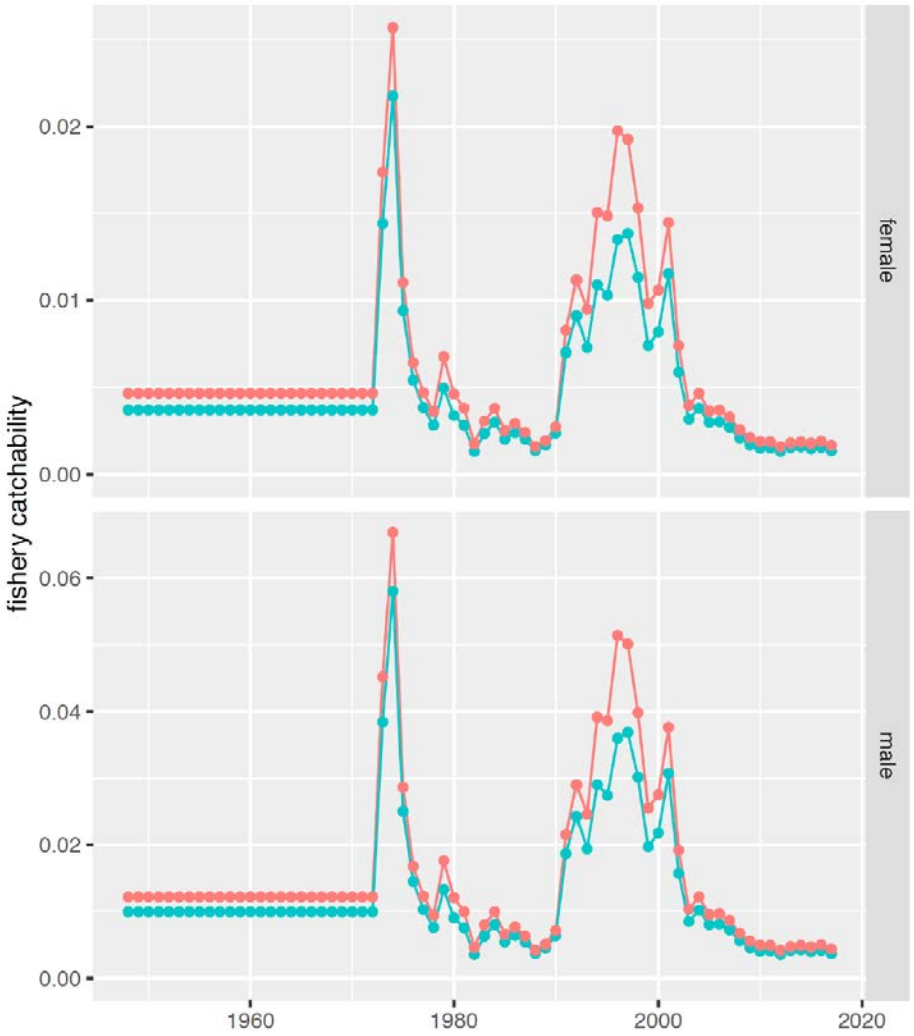


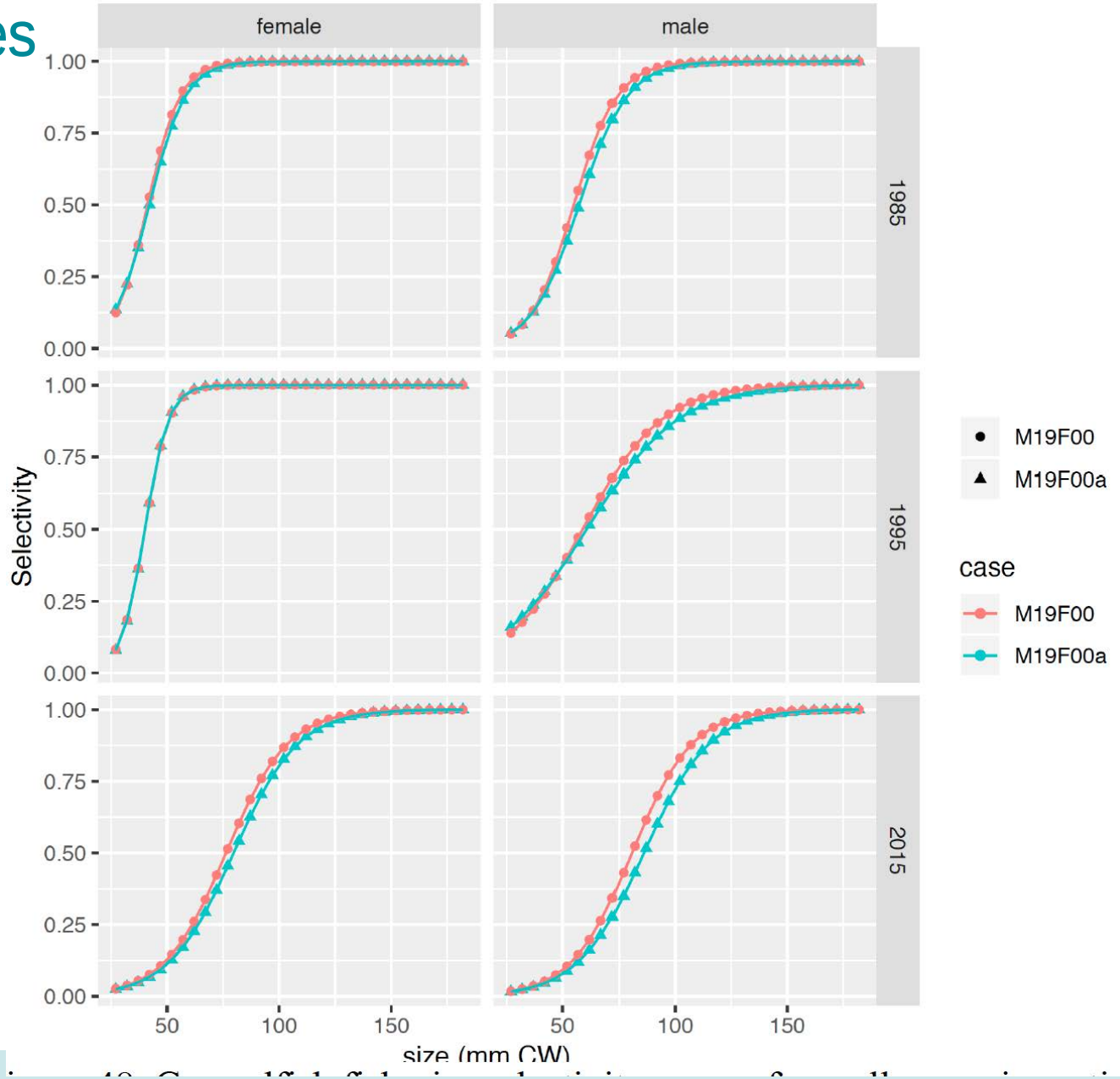
Model processes: BBRKC fishery





Model processes: groundfish fisheries



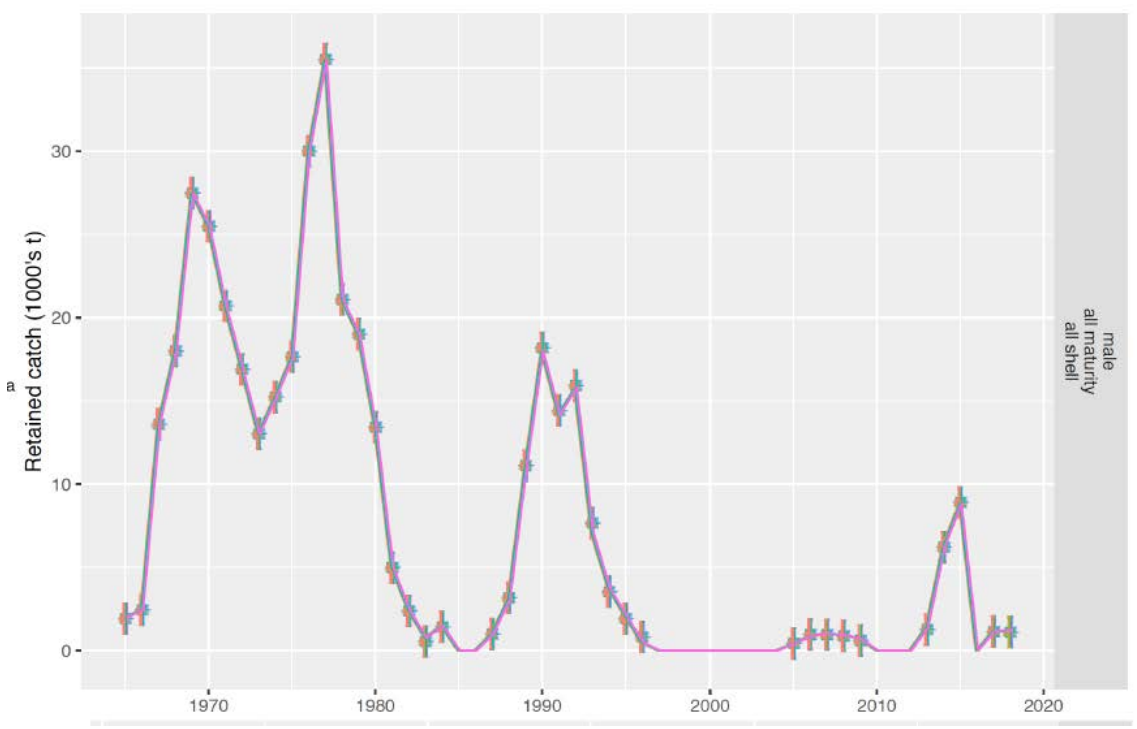


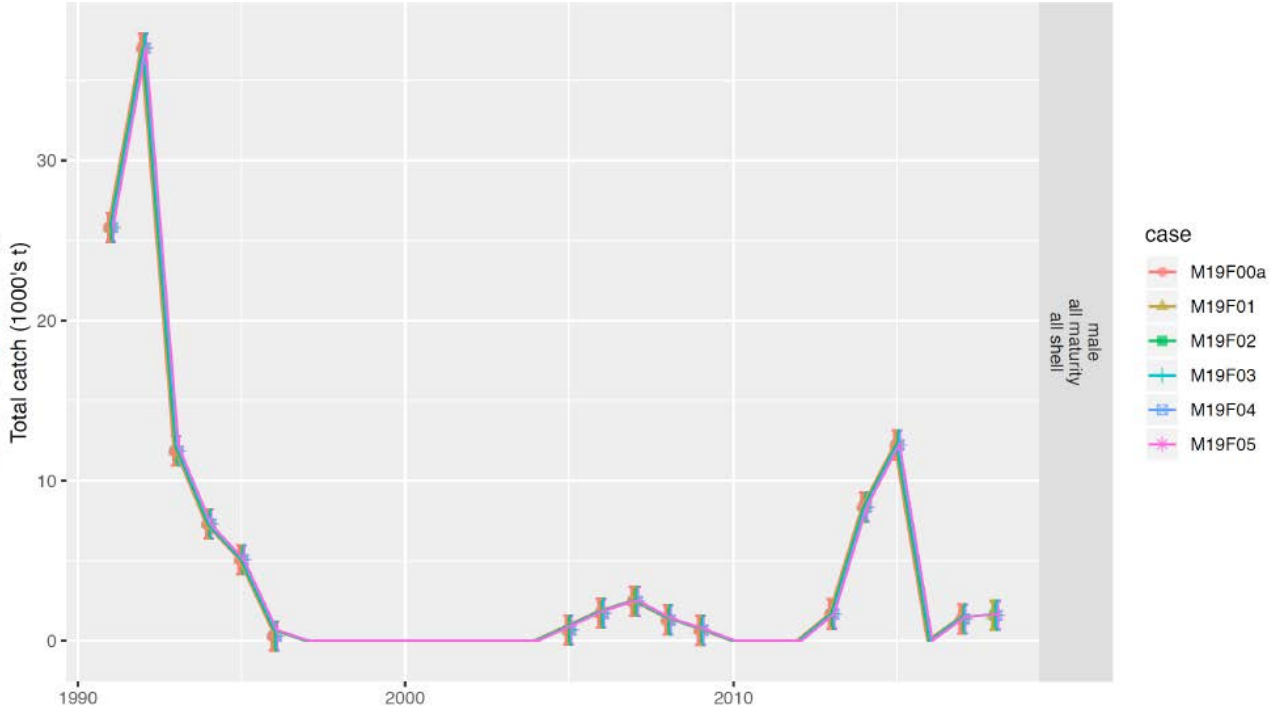
Changes in management quantities

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

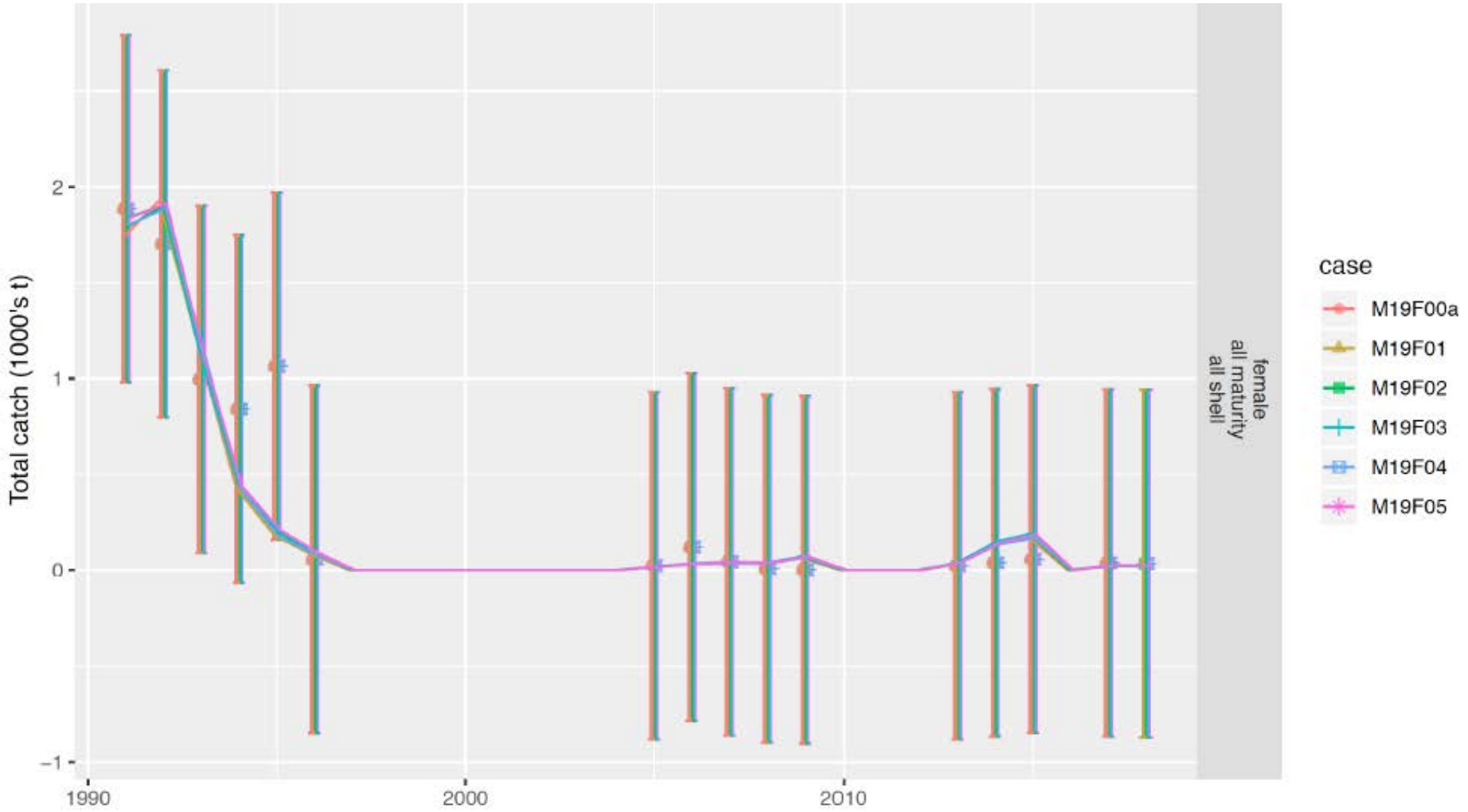
Results from M19F0X Scenarios

Directed fishery: fits to male catch data

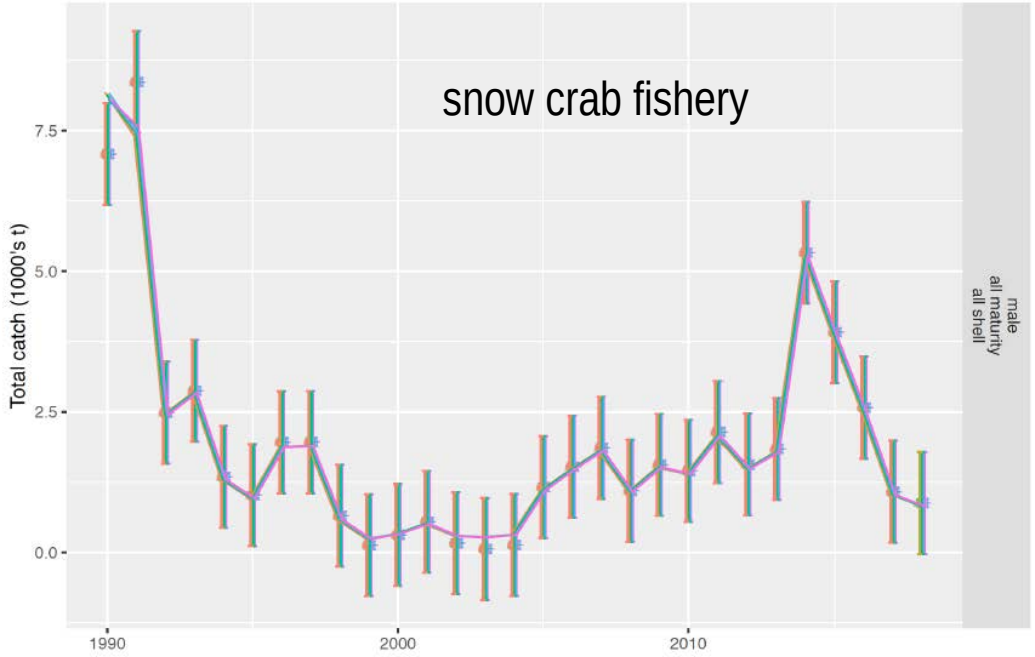


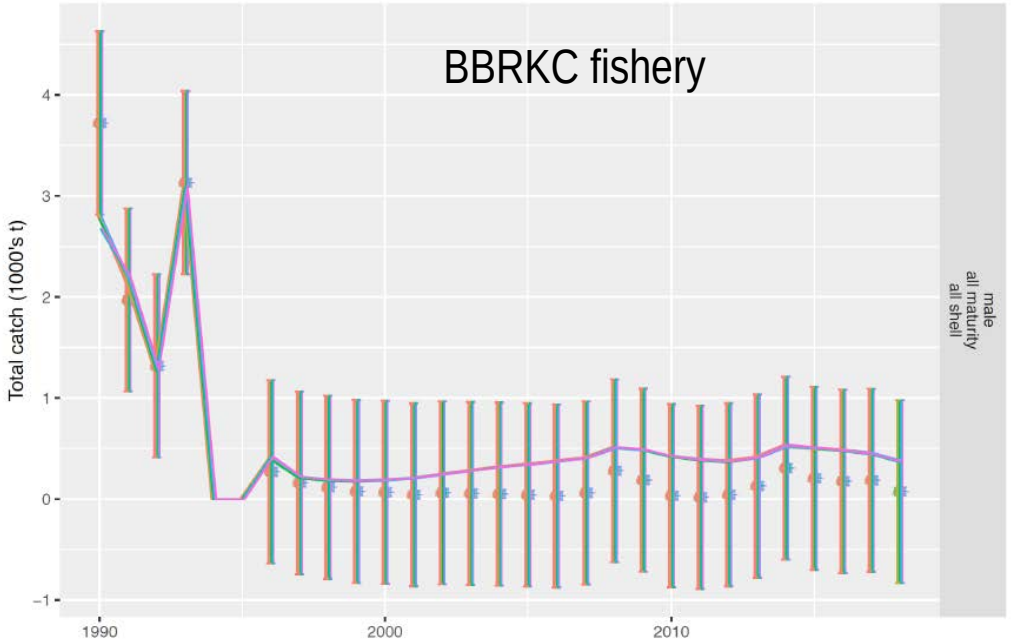


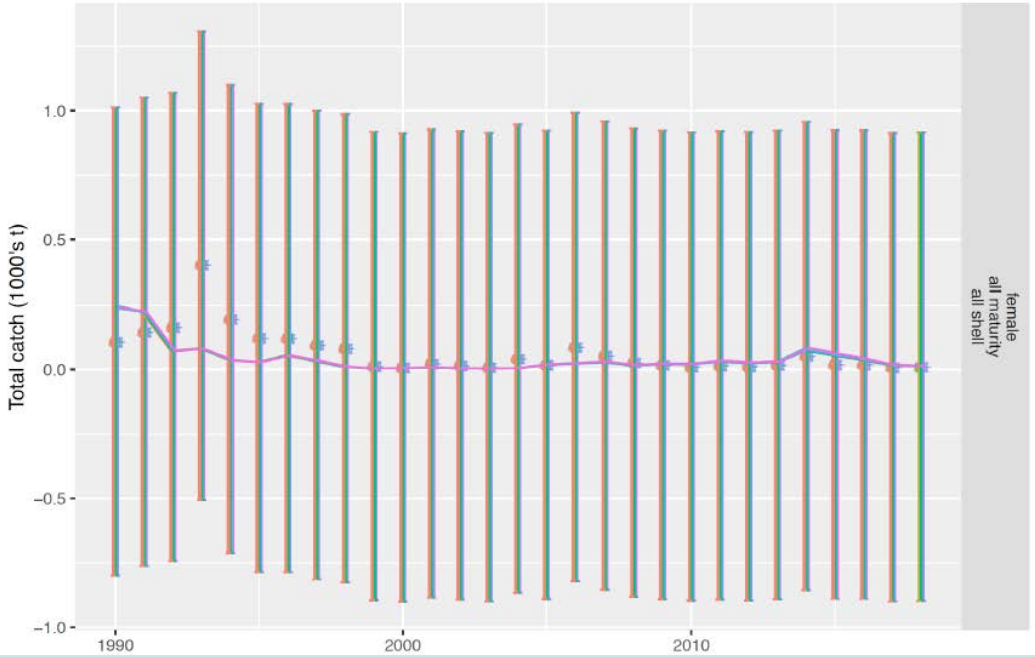
Directed fishery: fits to female bycatch data

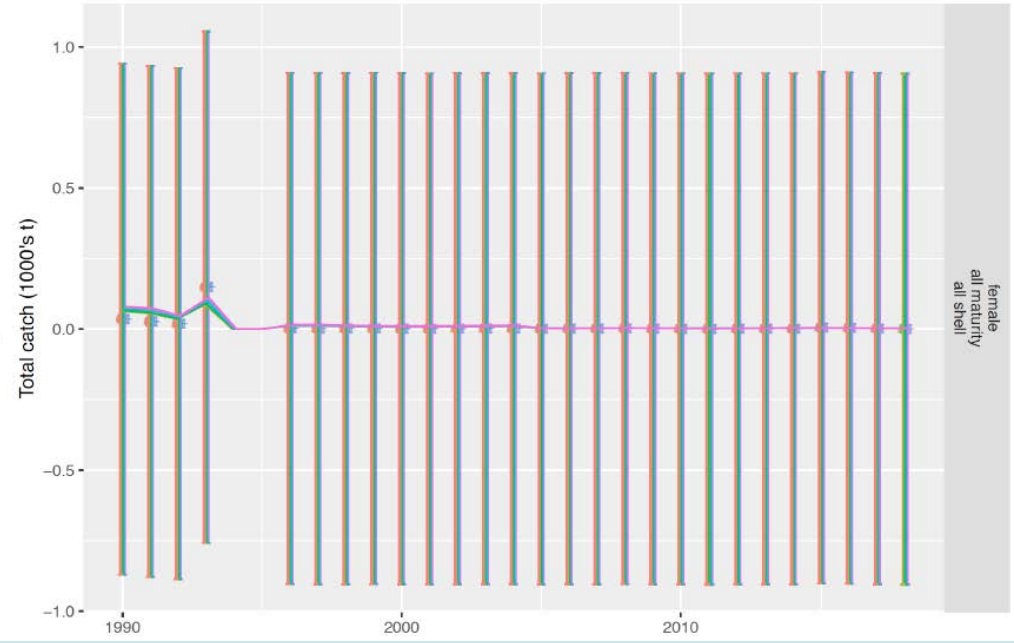


More fits to bycatch data

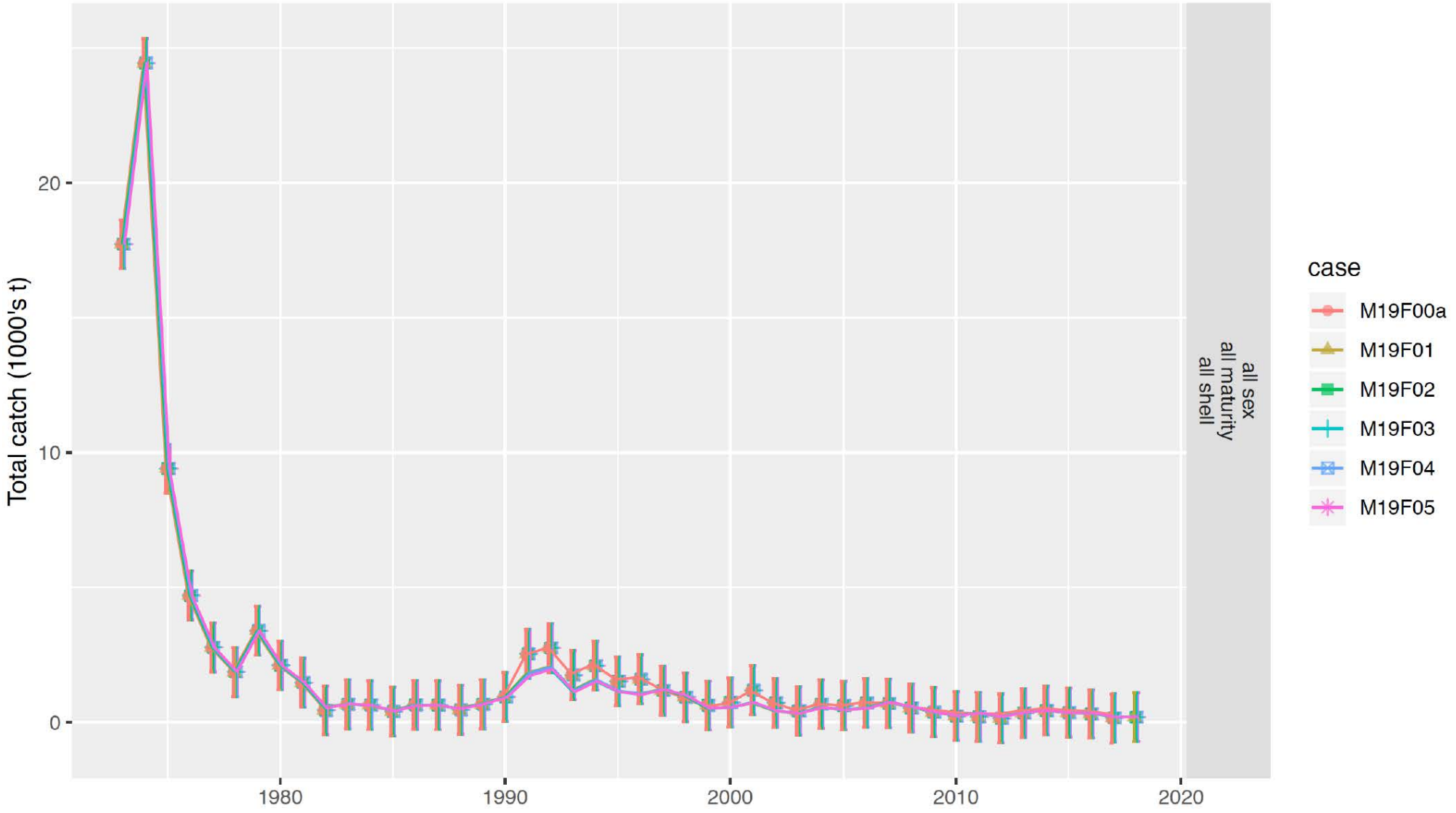




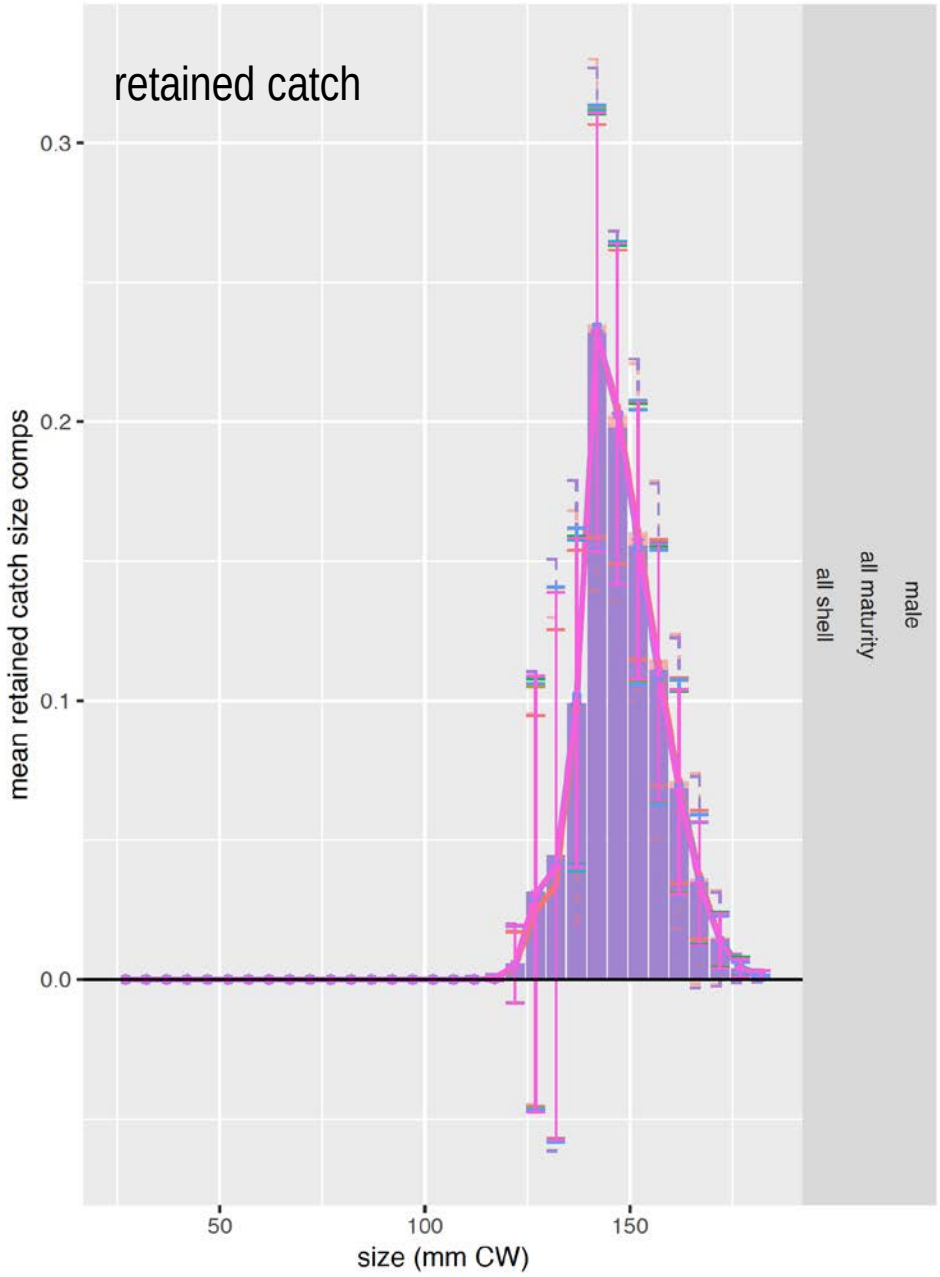


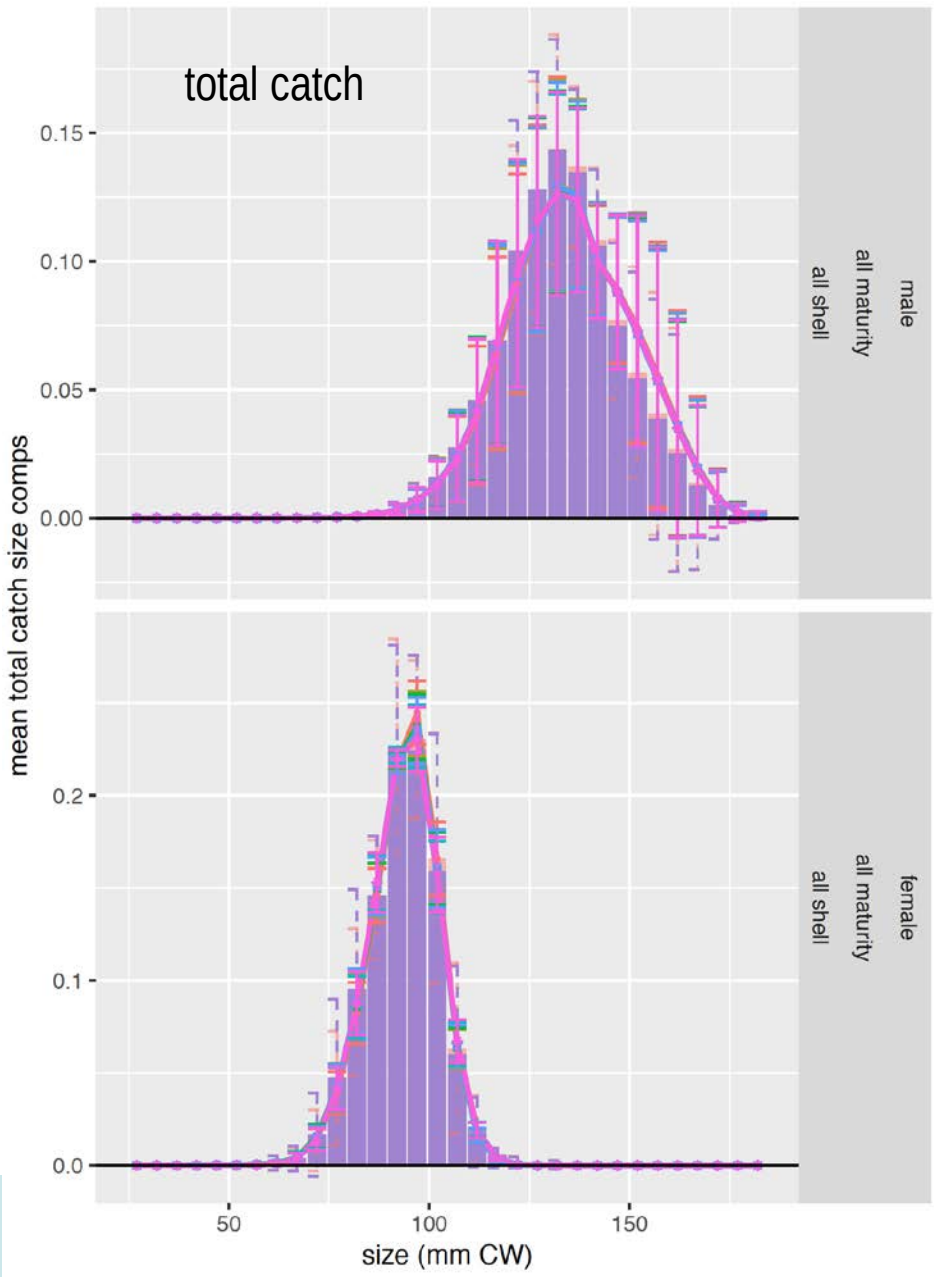


Fits to bycatch data from the groundfish fisheries

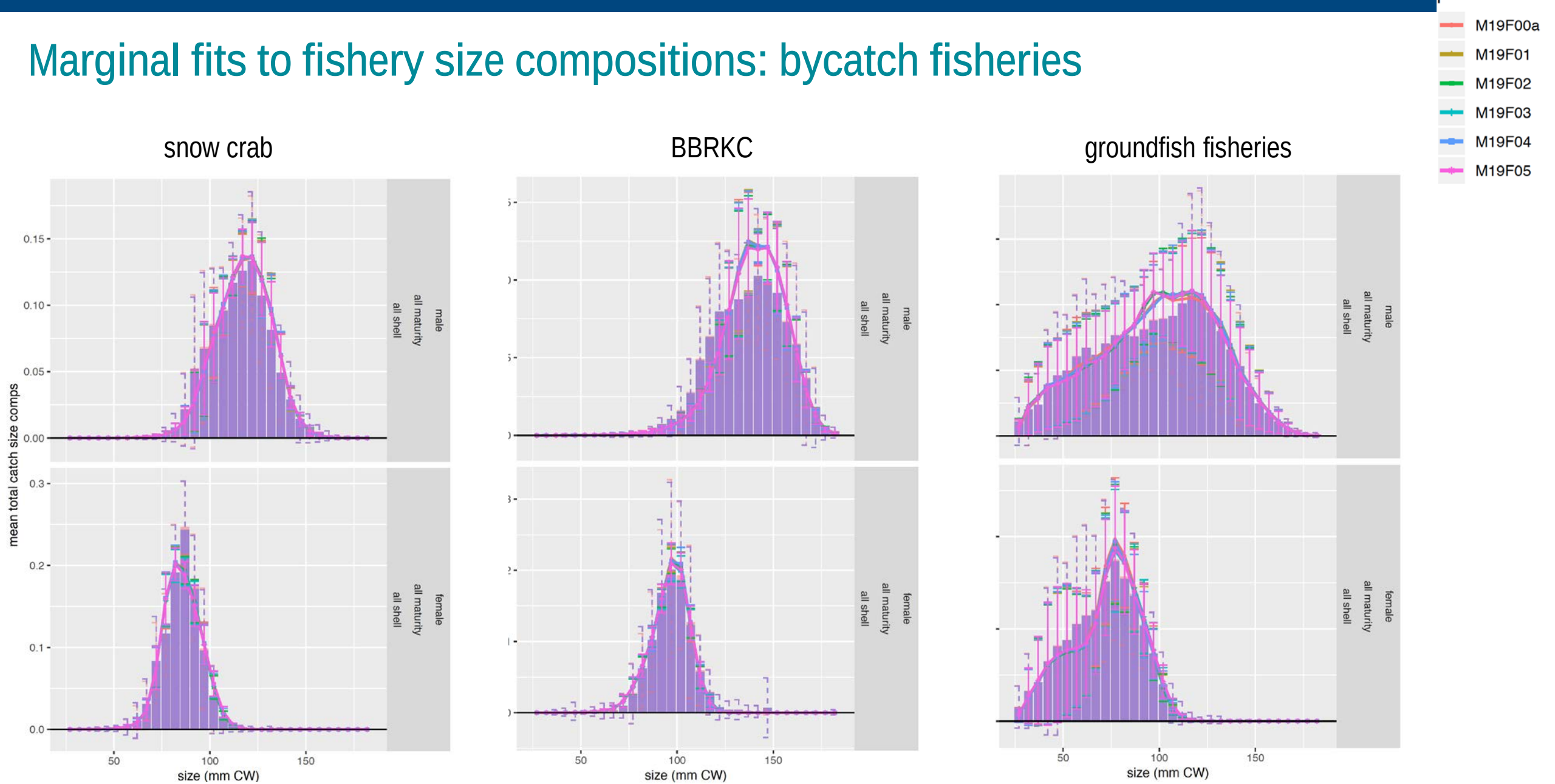


Marginal fits to fishery size compositions: directed fishery

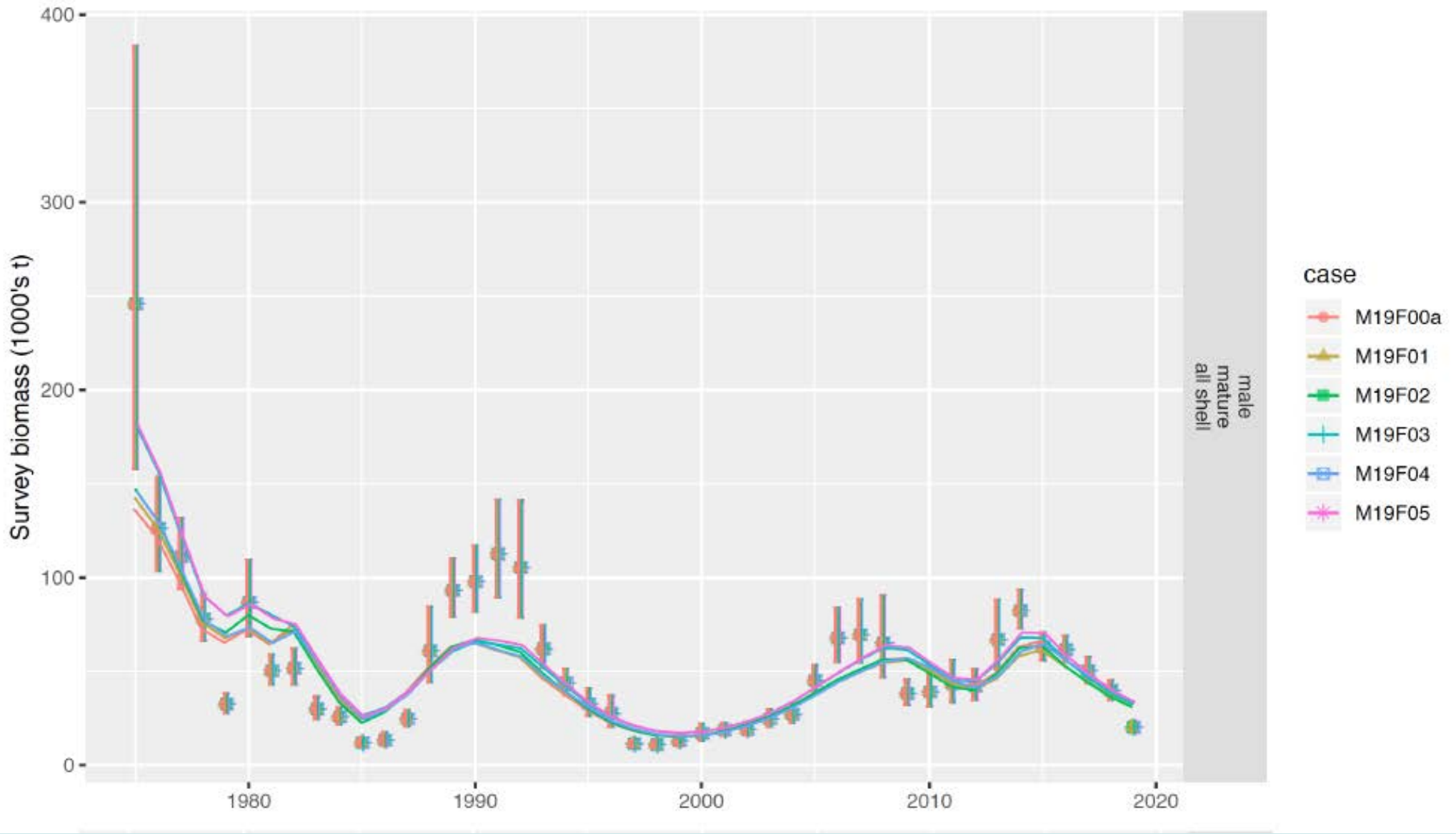




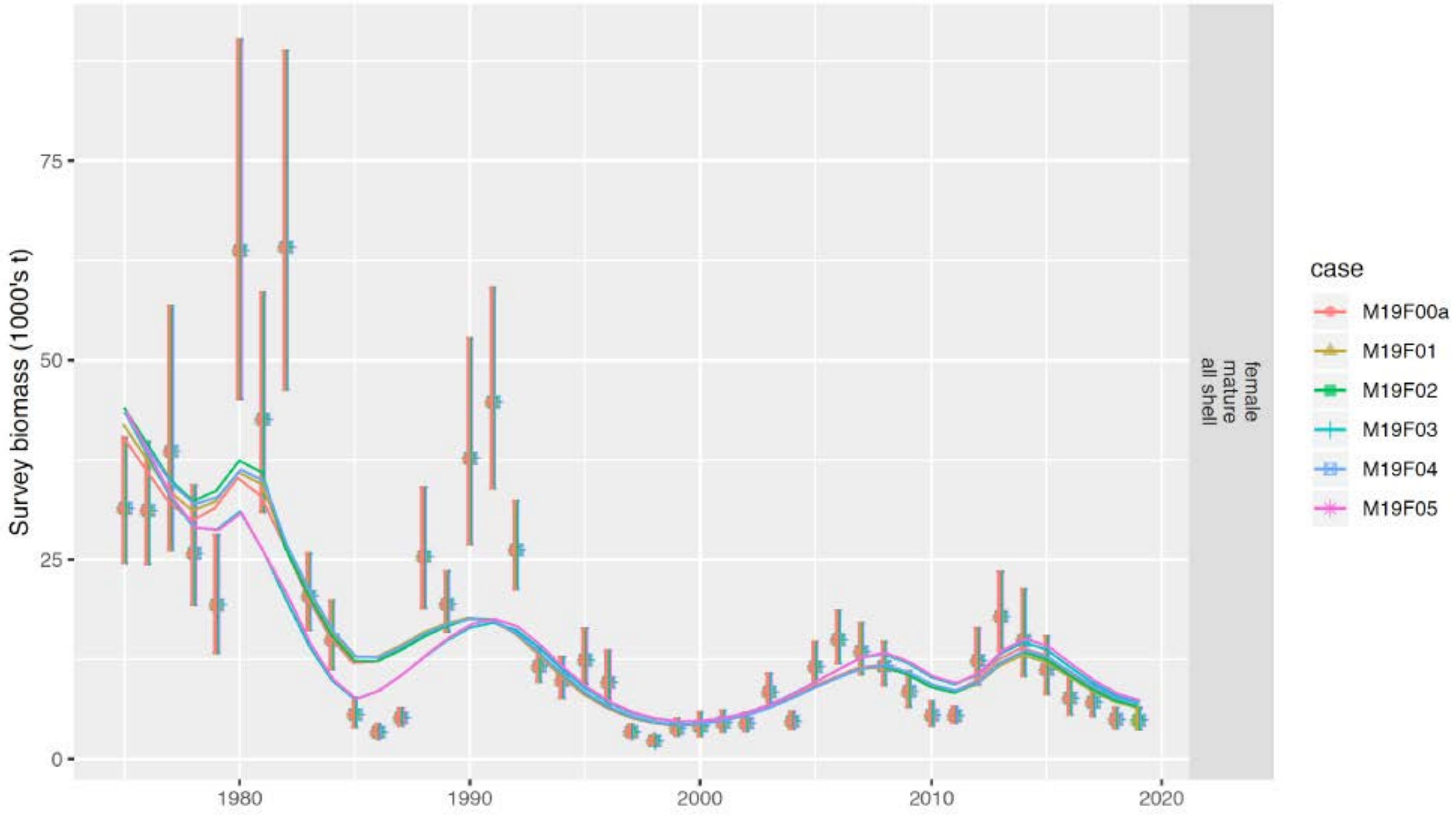
Marginal fits to fishery size compositions: bycatch fisheries



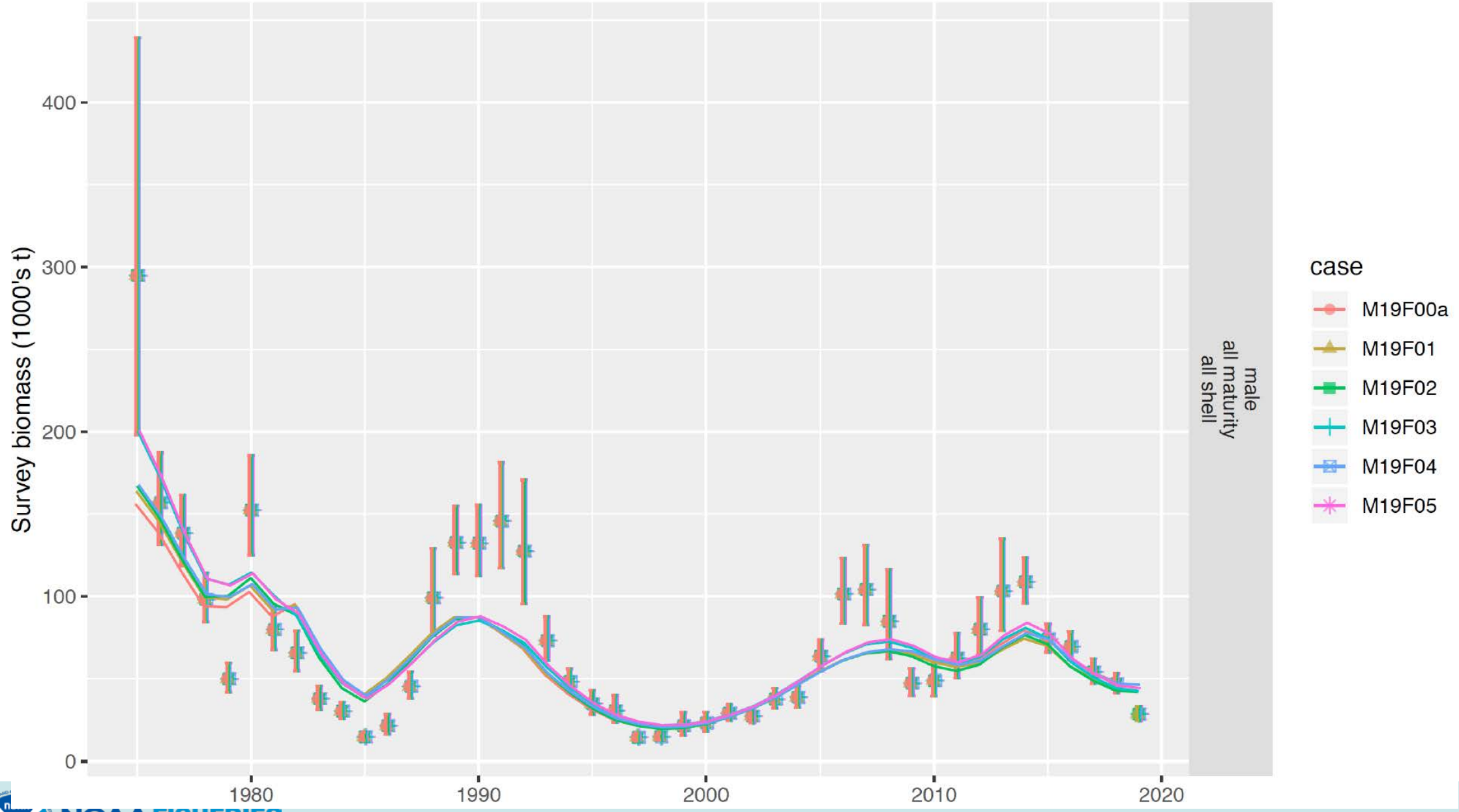
Fits to NMFS EBS mature male survey biomass



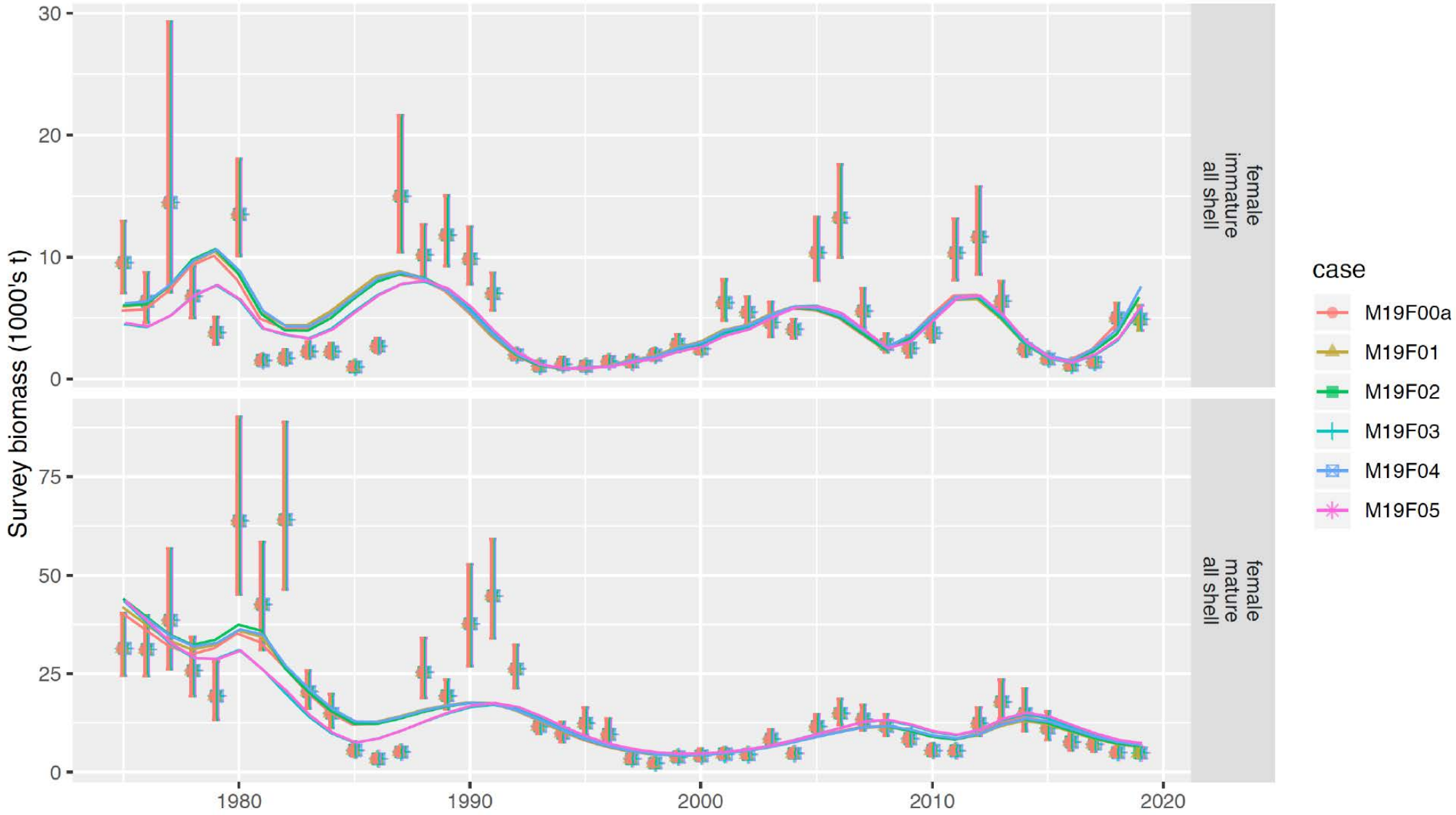
Fits to NMFS EBS mature female survey biomass



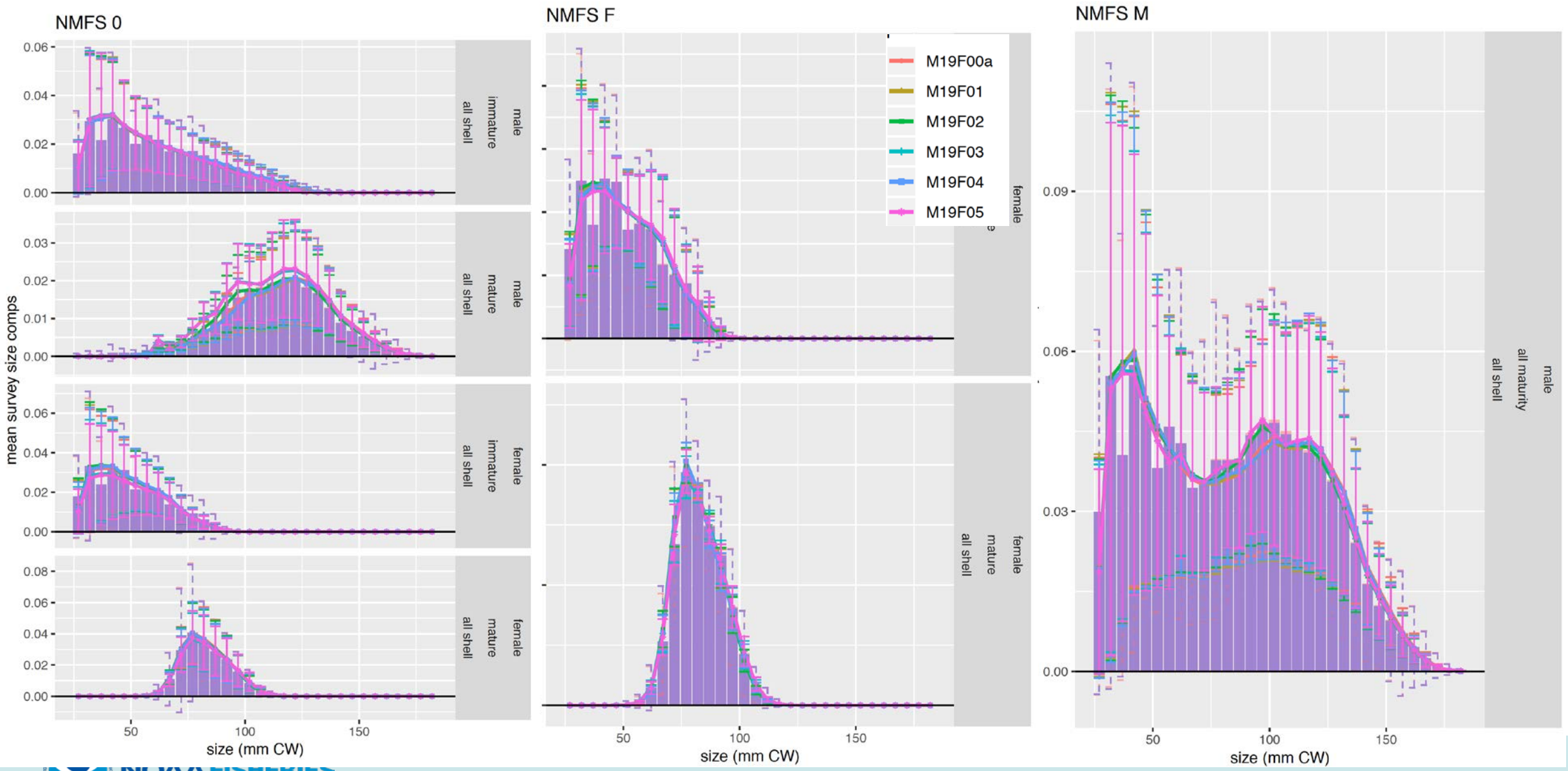
Fits to NMFS EBS (all) male survey biomass



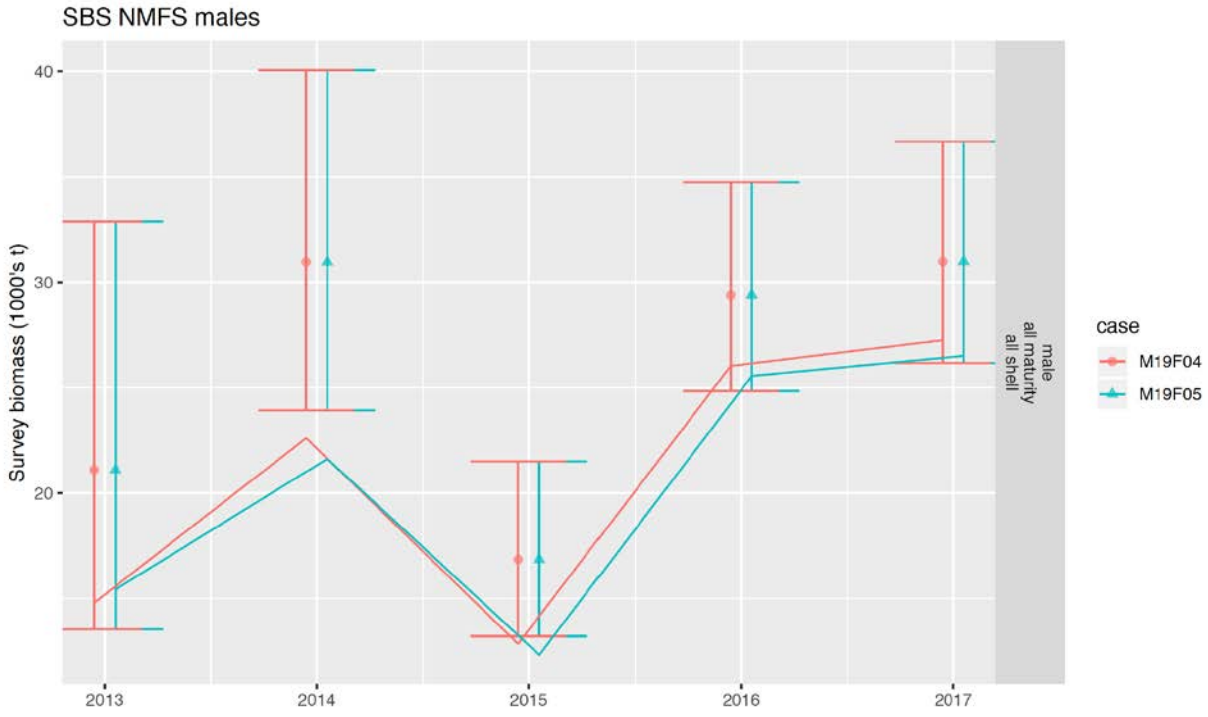
Fits to NMFS EBS female survey biomass

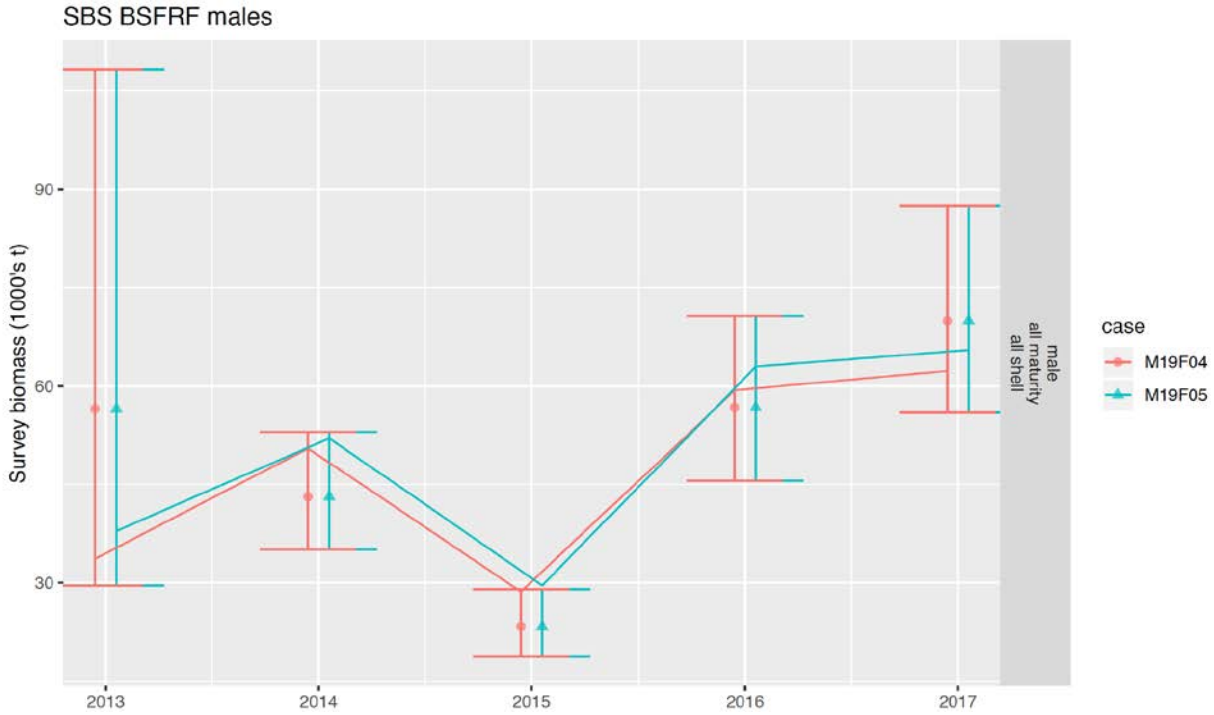


Marginal fits to NMFS survey size compositions

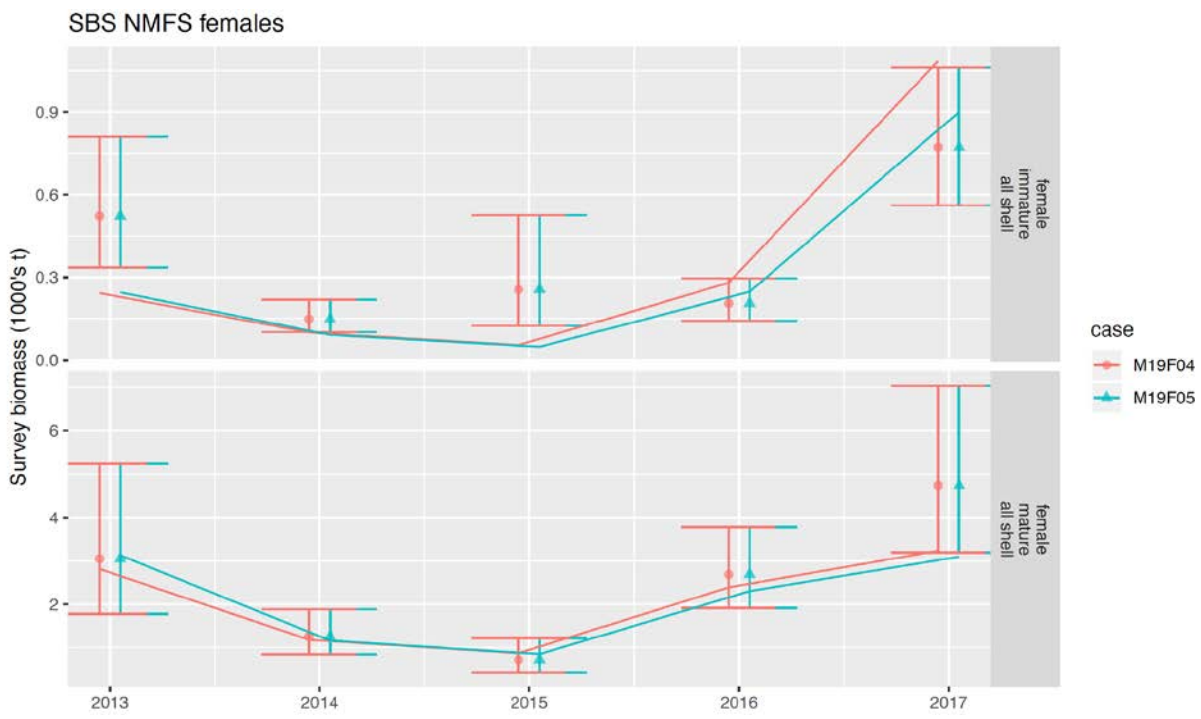


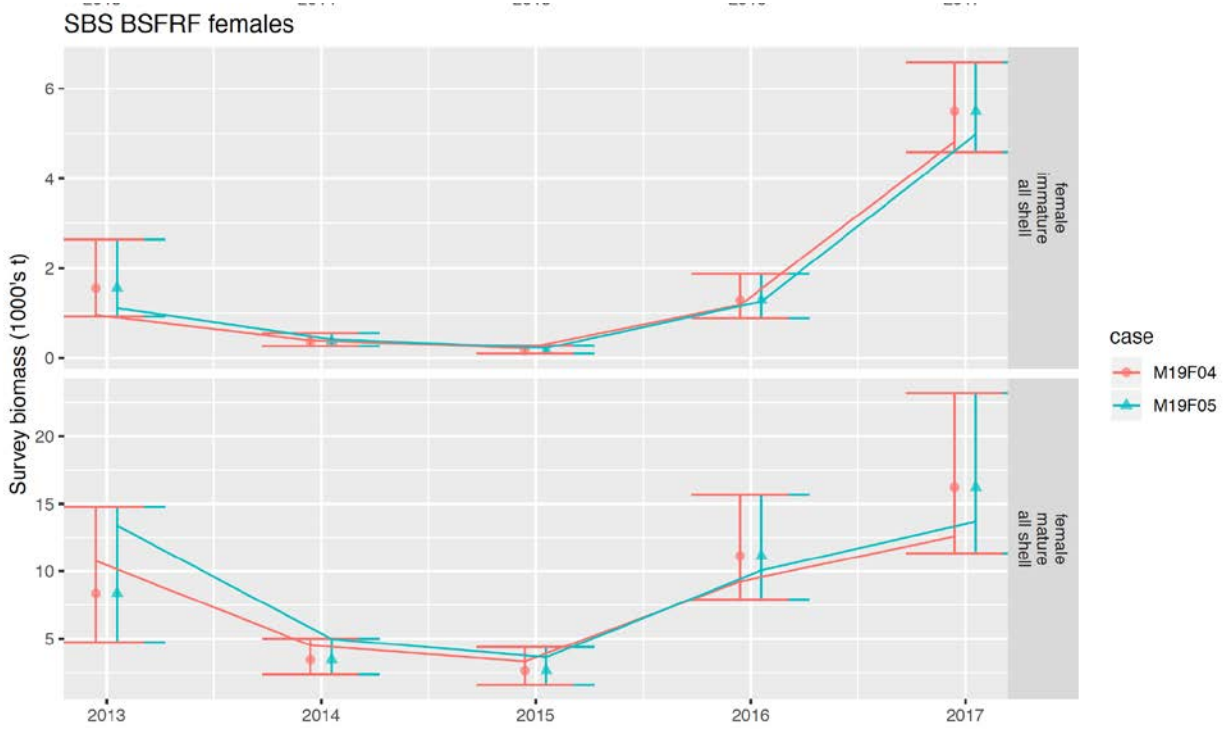
Fits to SBS male survey biomass



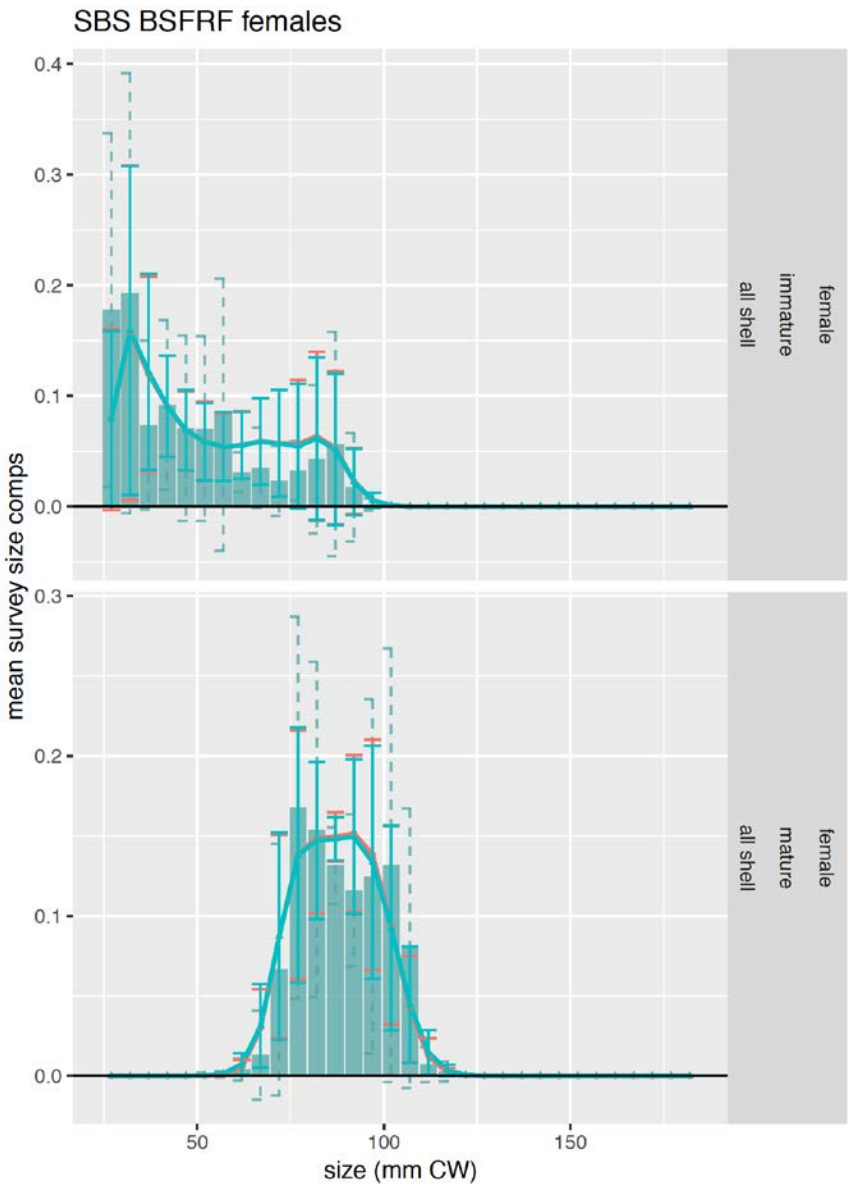


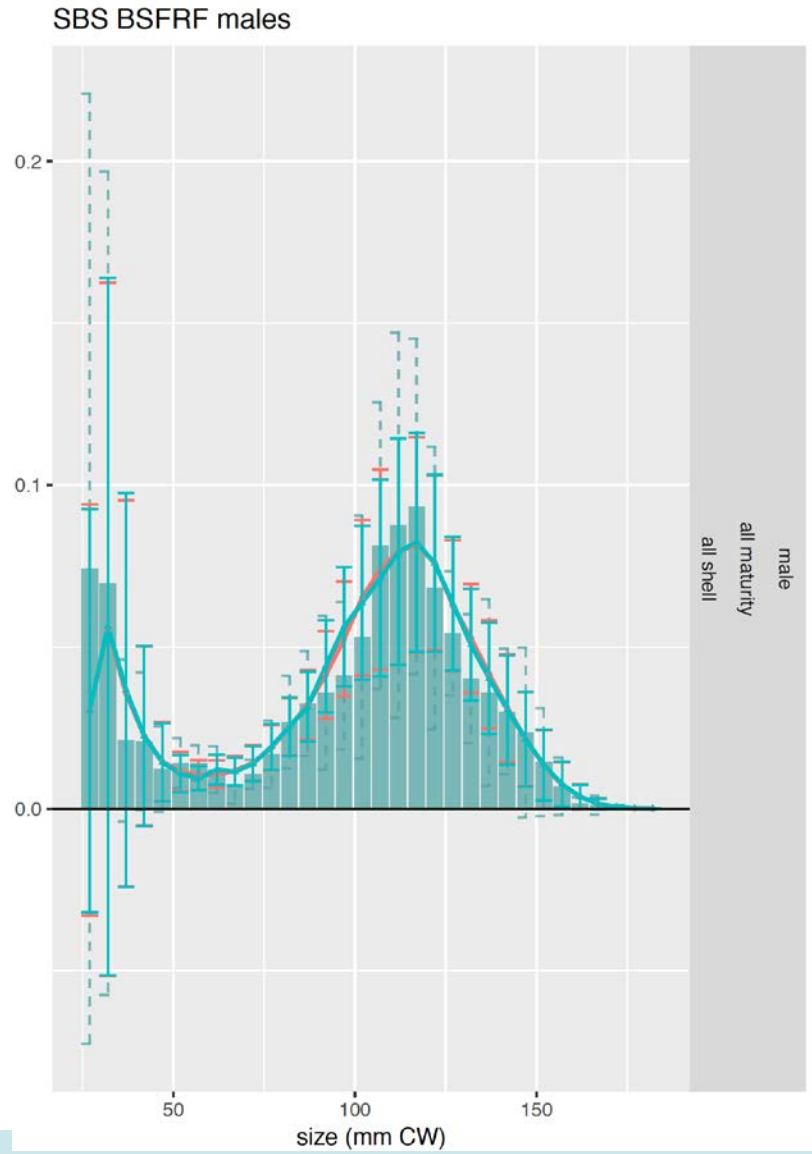
Fits to SBS female survey biomass





Marginal fits to SBS BSFRF size compositions

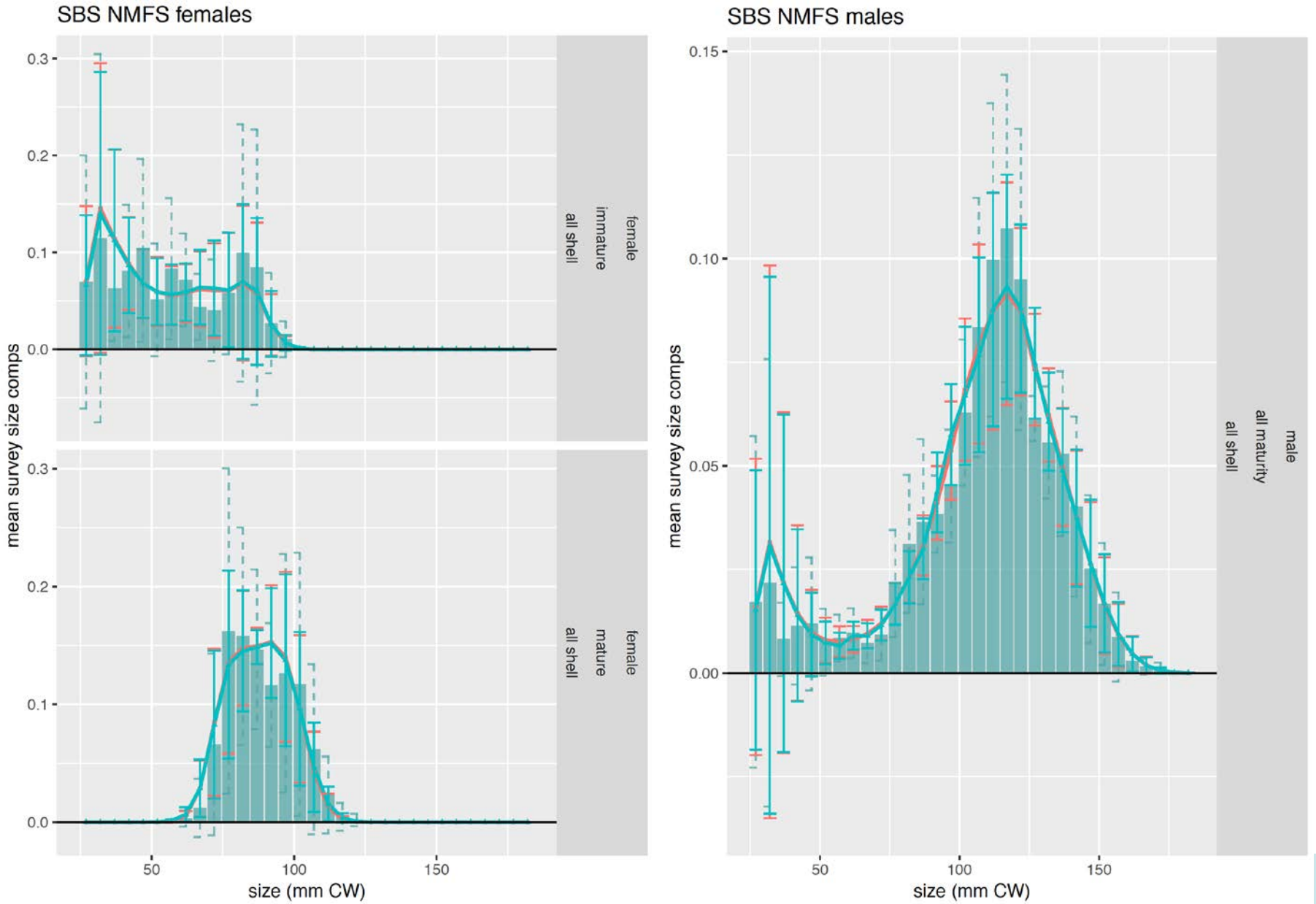




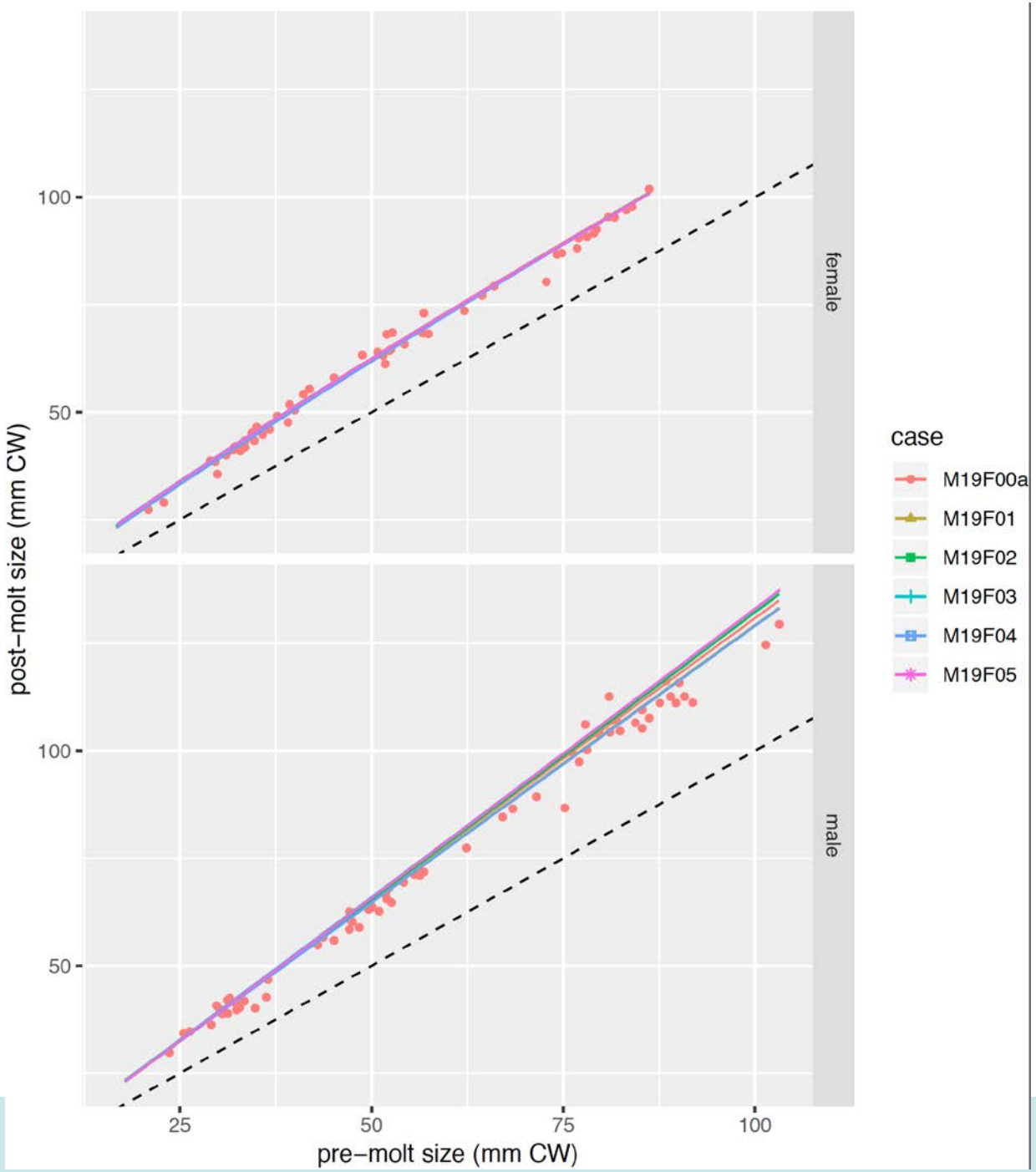
M19F04

M19F05

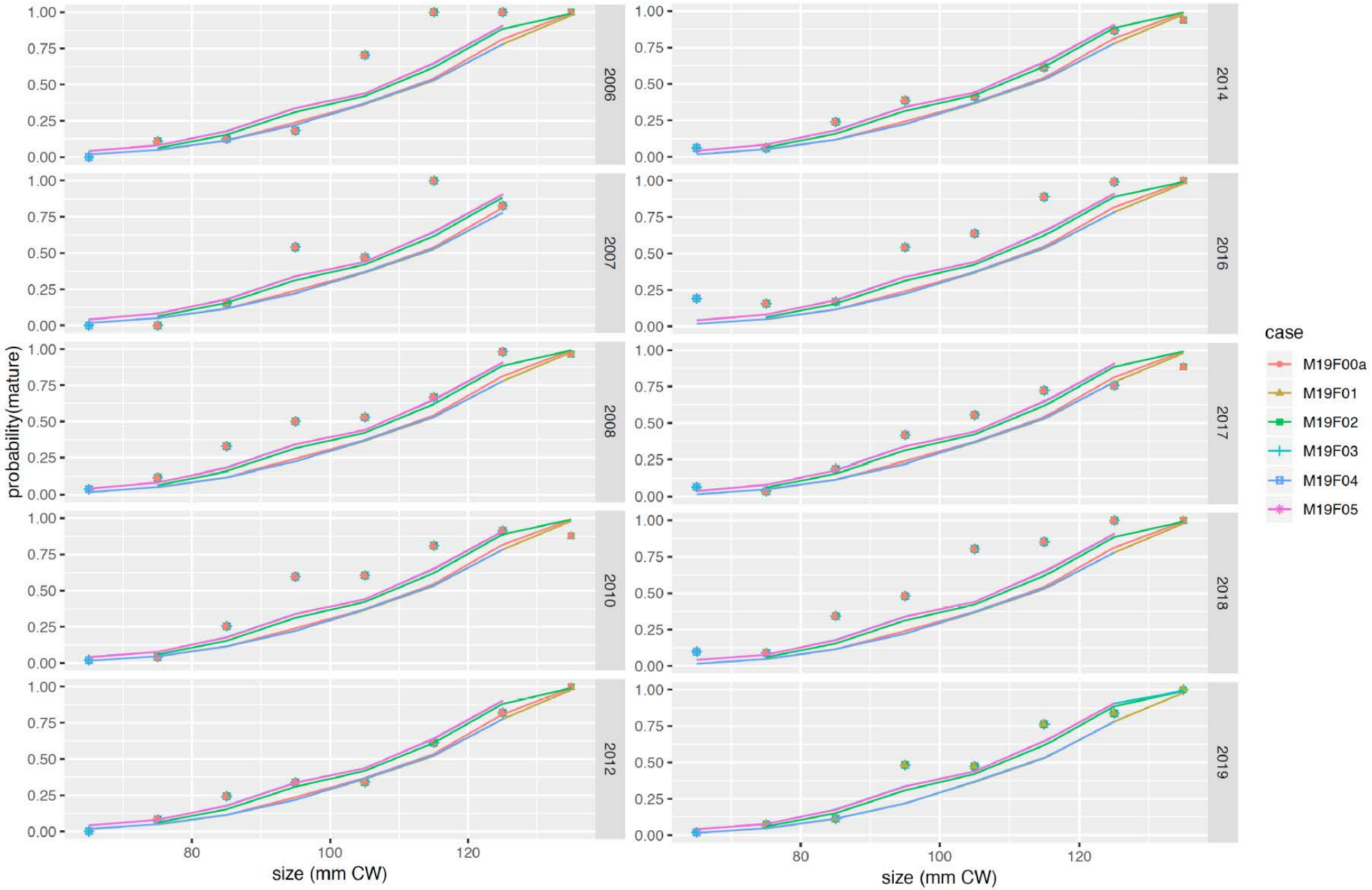
Marginal fits to SBS NMFS size compositions



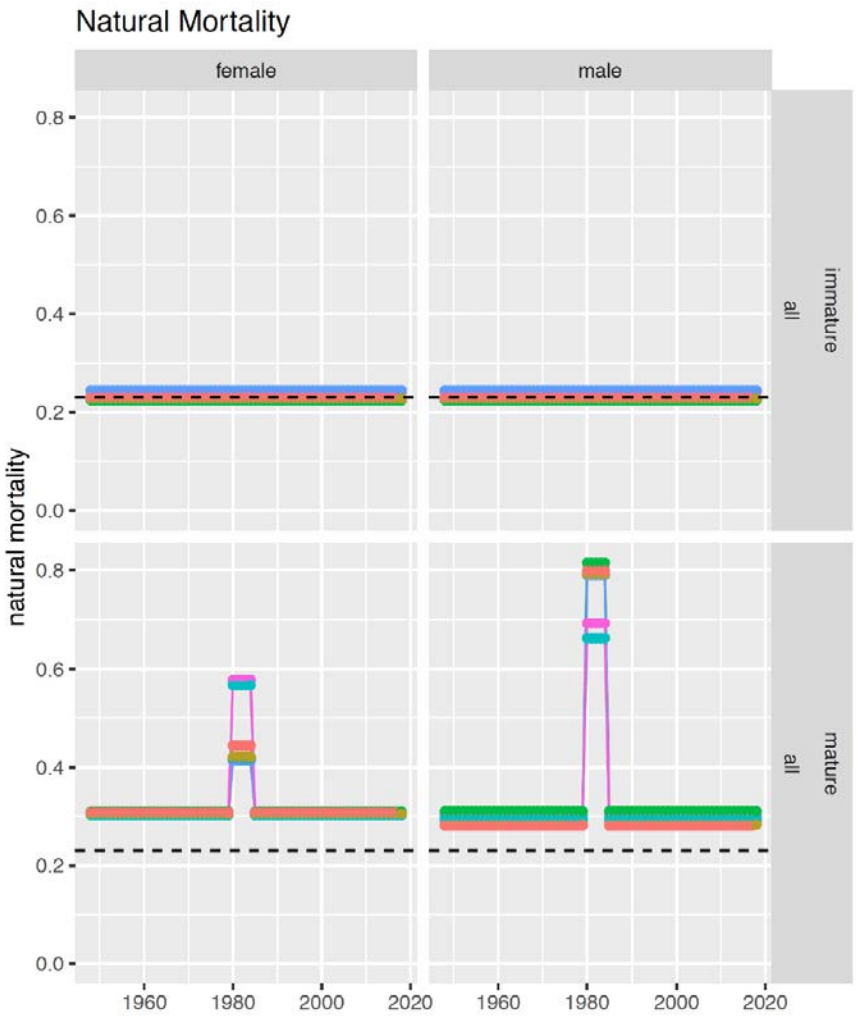
Fits to molt increment data

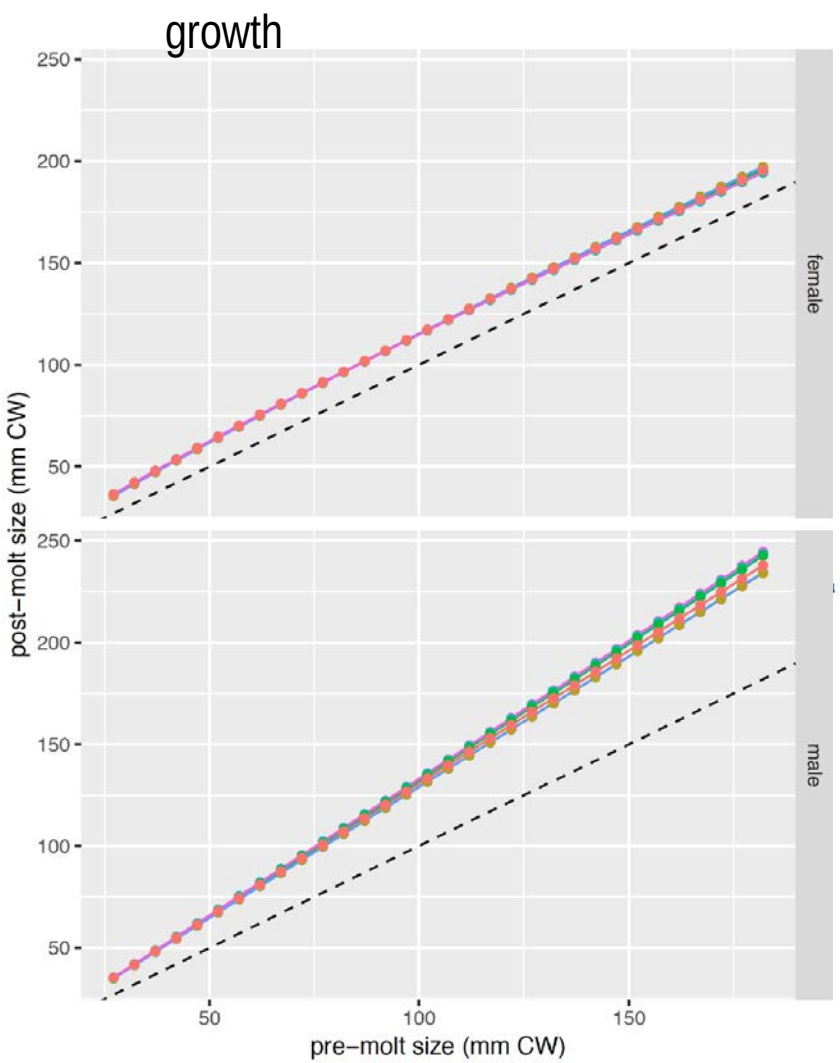


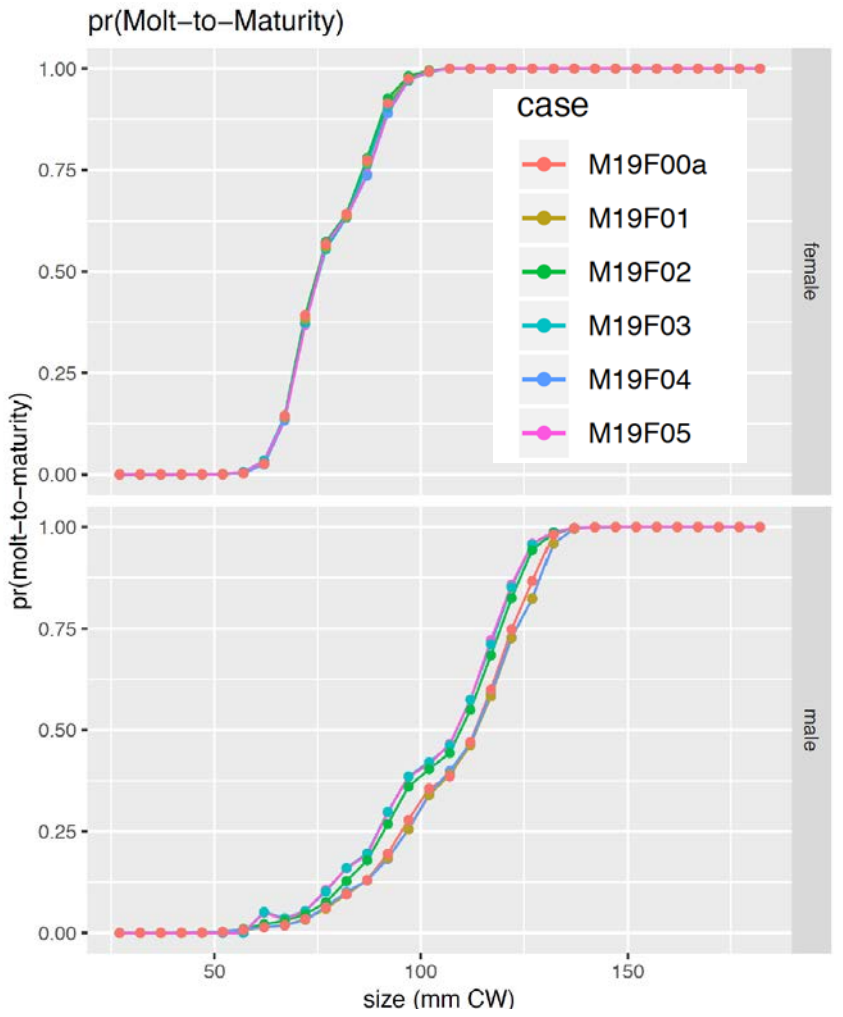
Fits to maturity ogive data



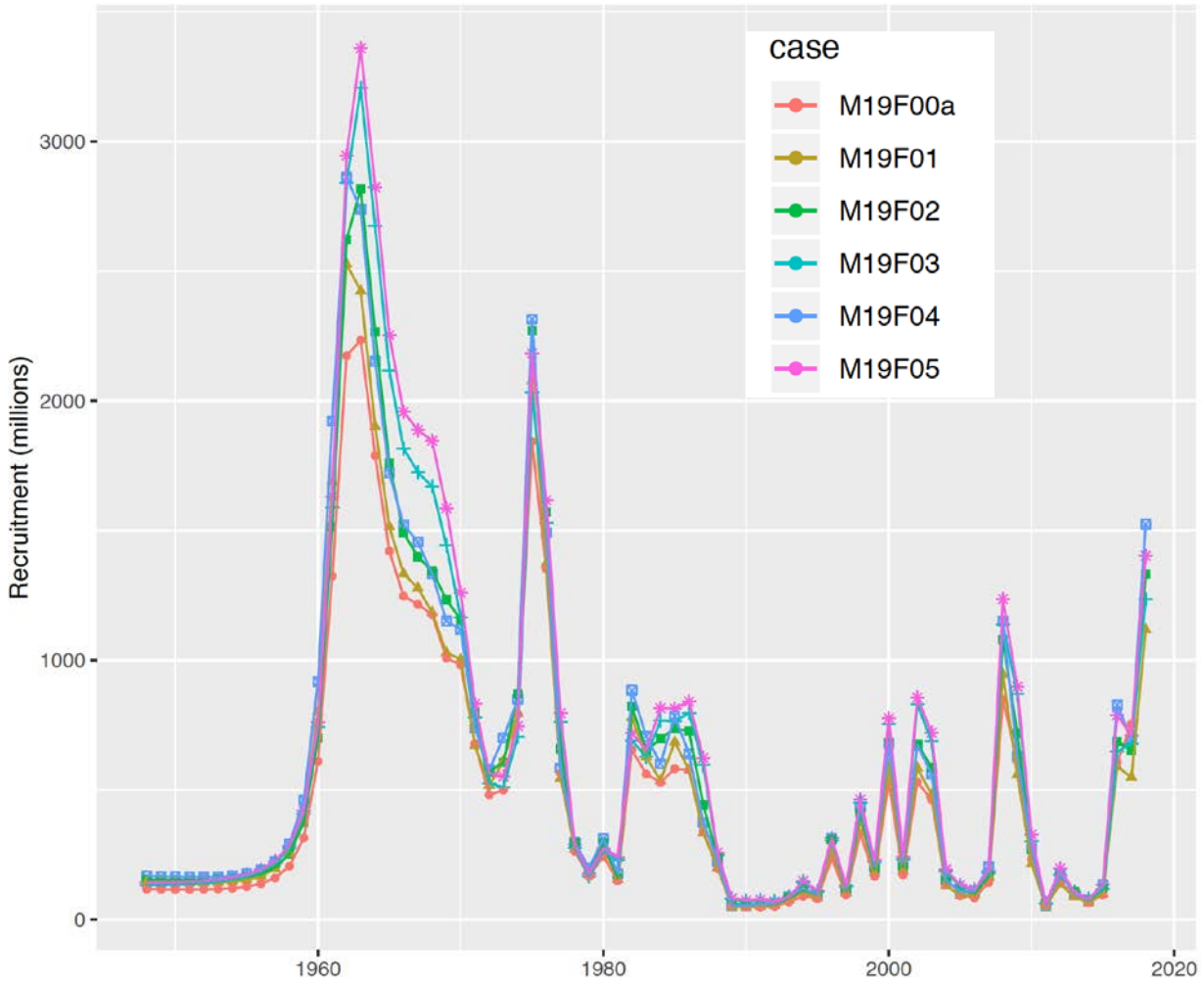
Estimated model processes

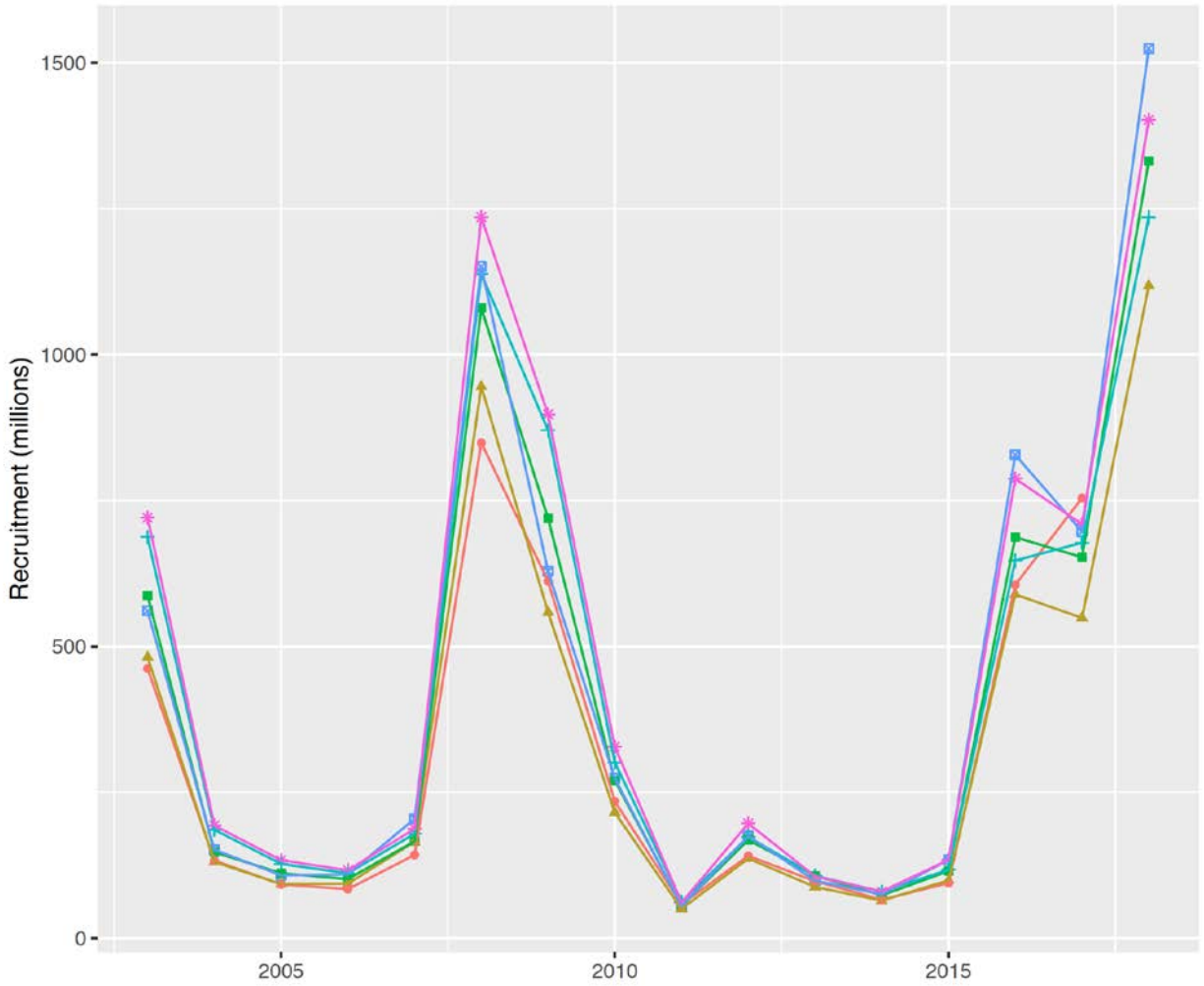




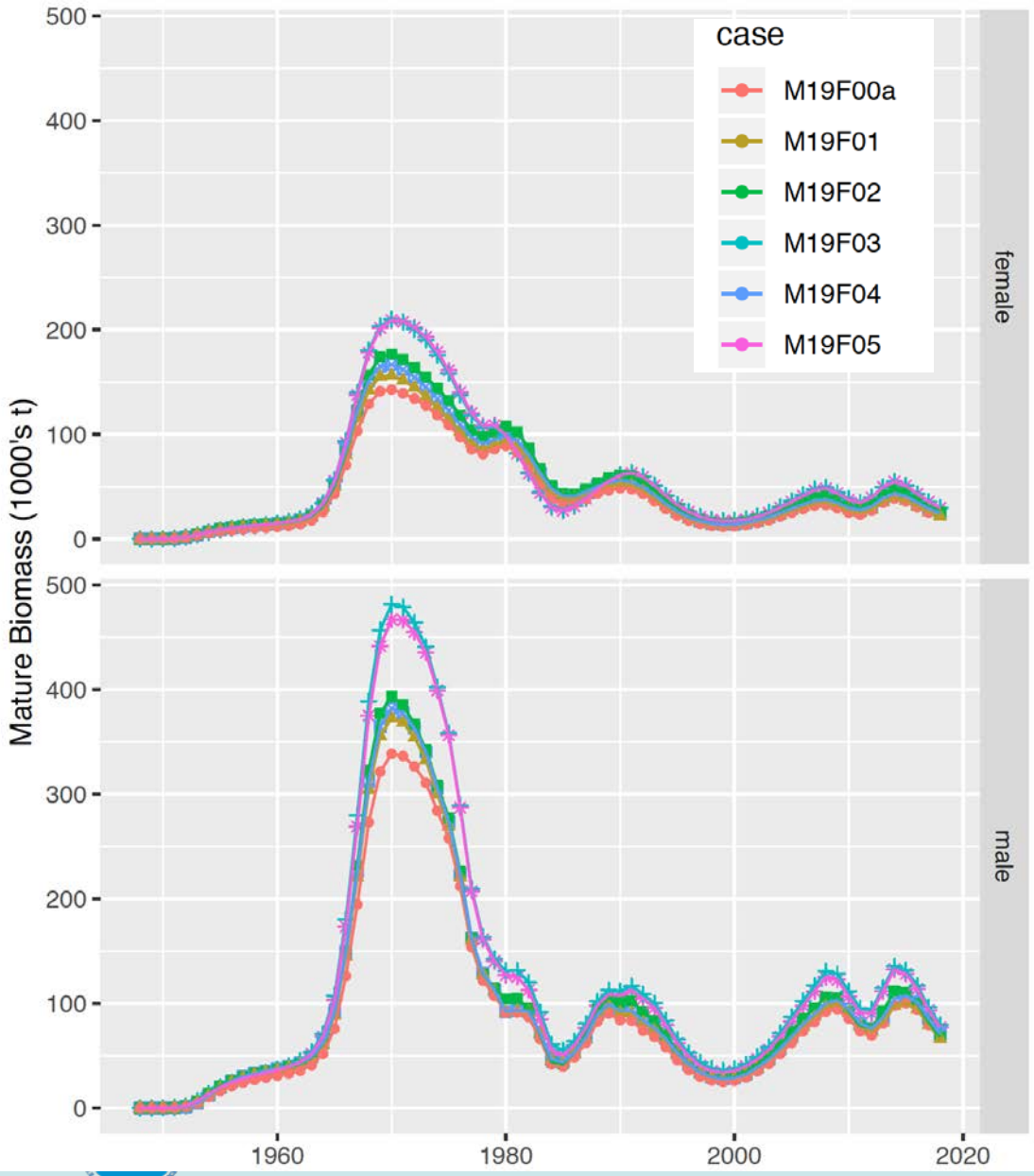


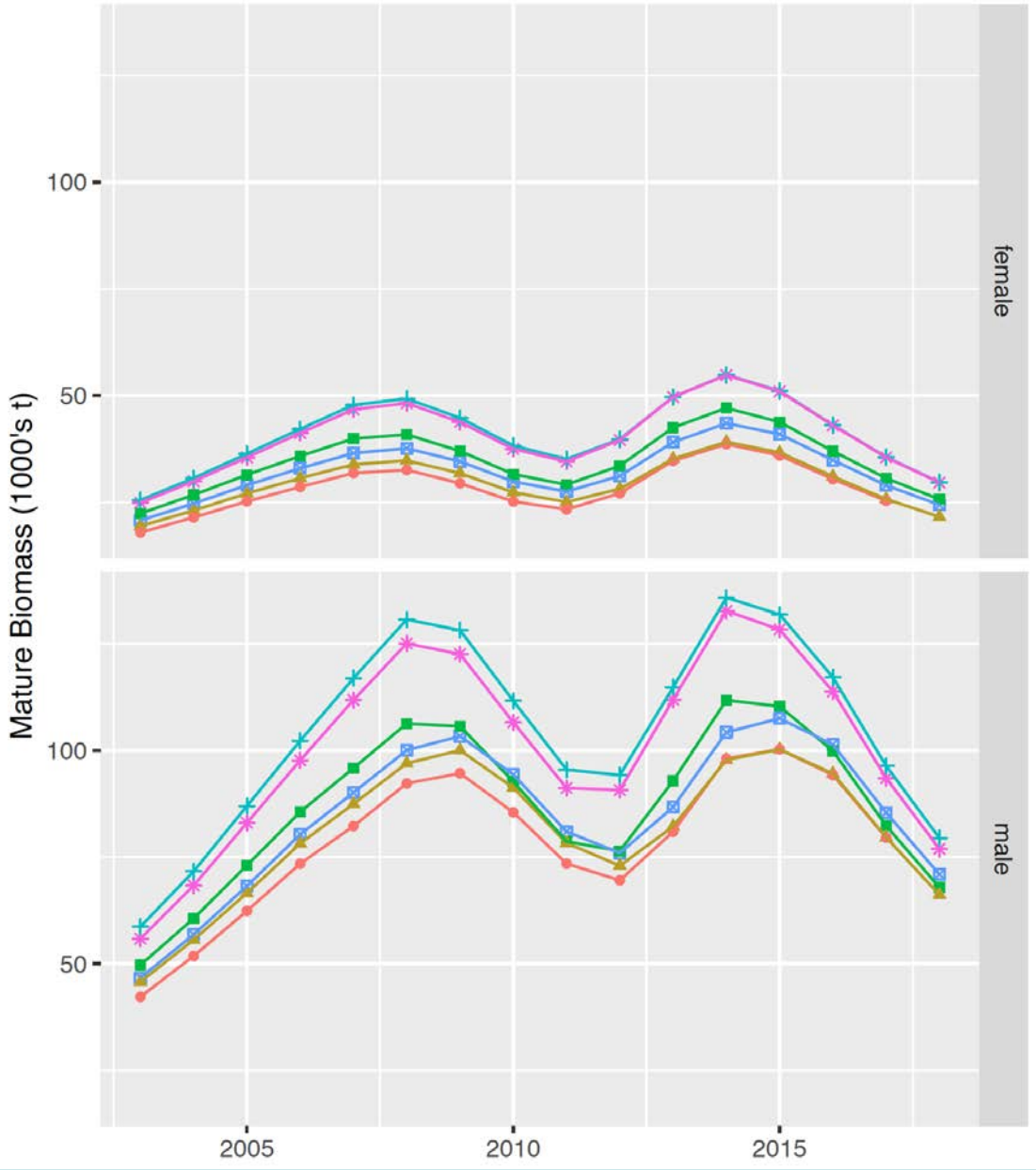
Estimated recruitment



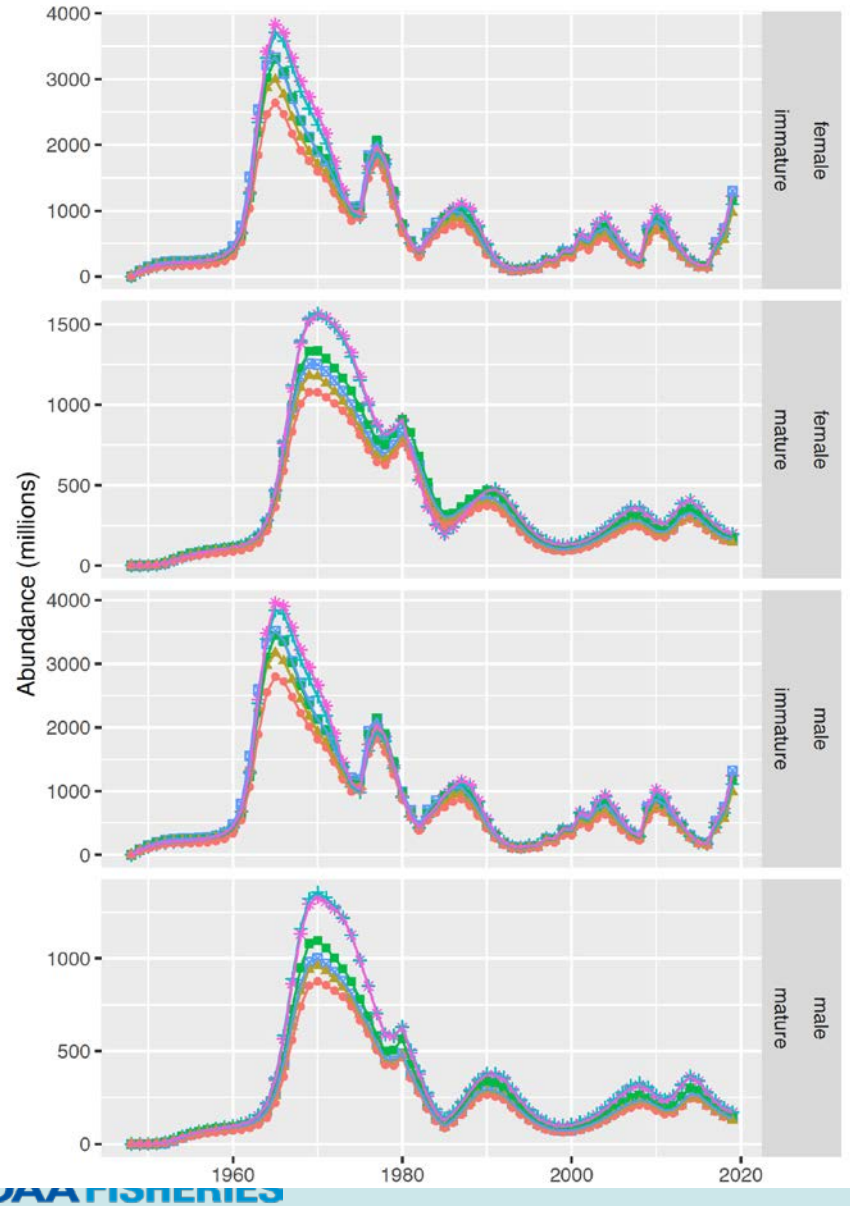


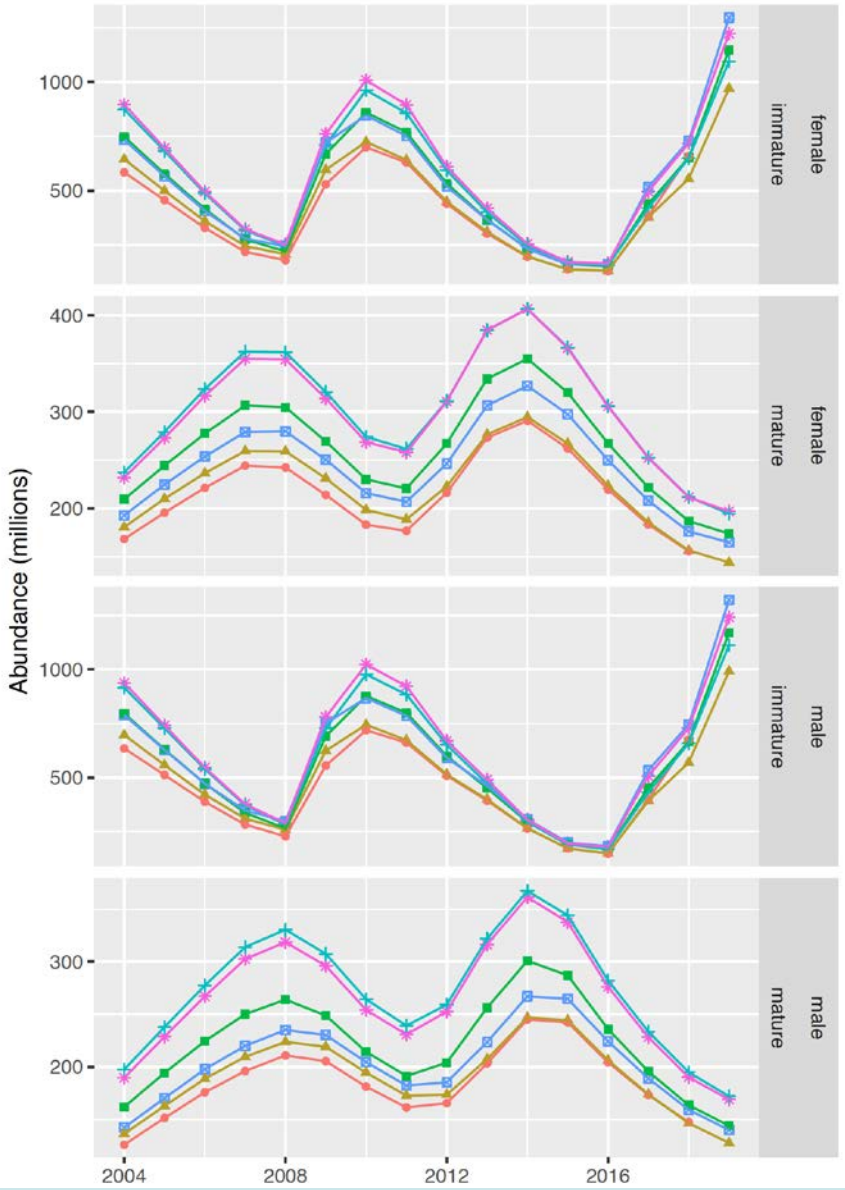
Estimated mature population biomass

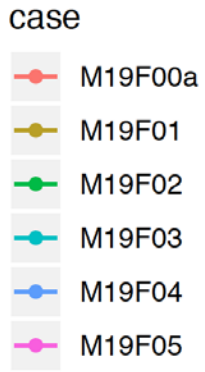




Population abundance trends

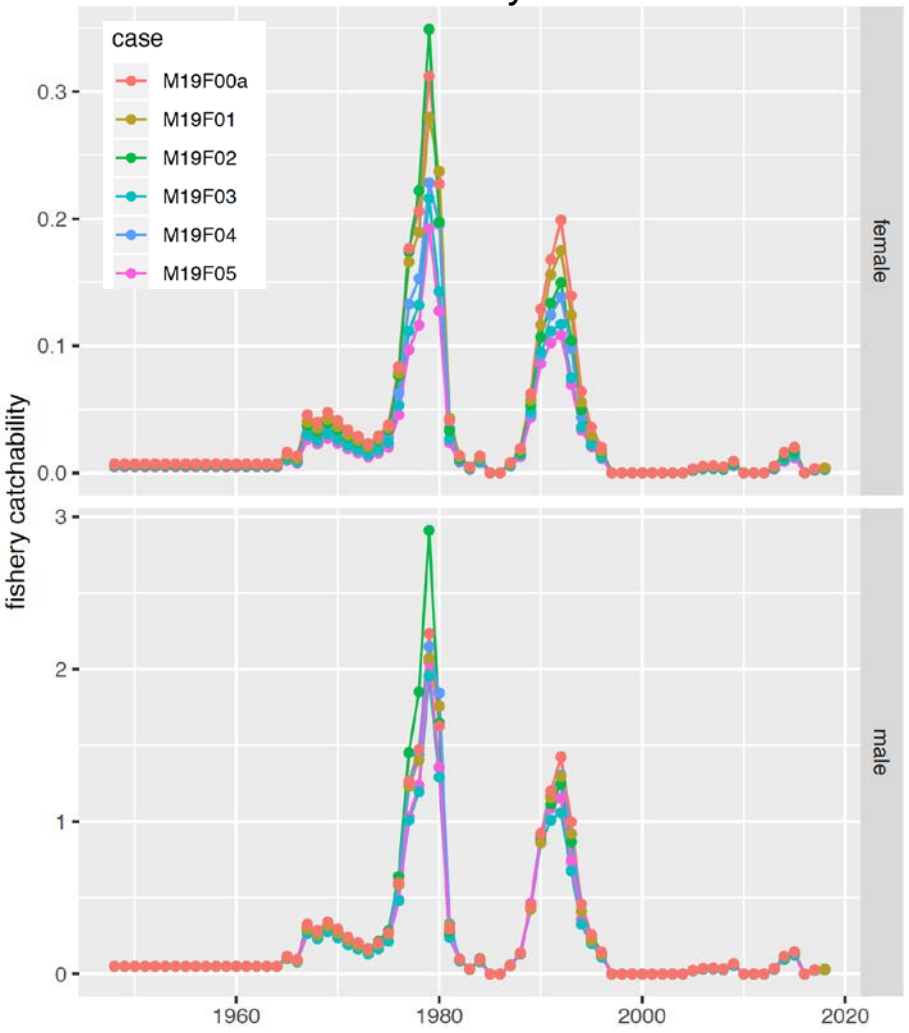




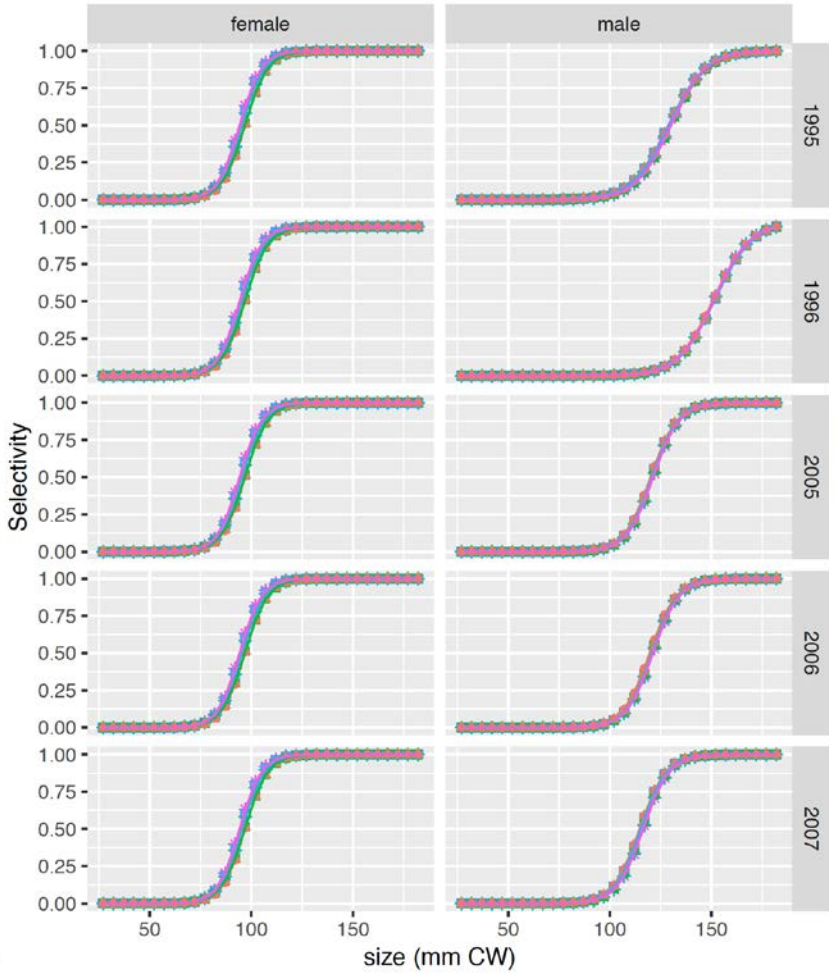


Model processes: directed fishery

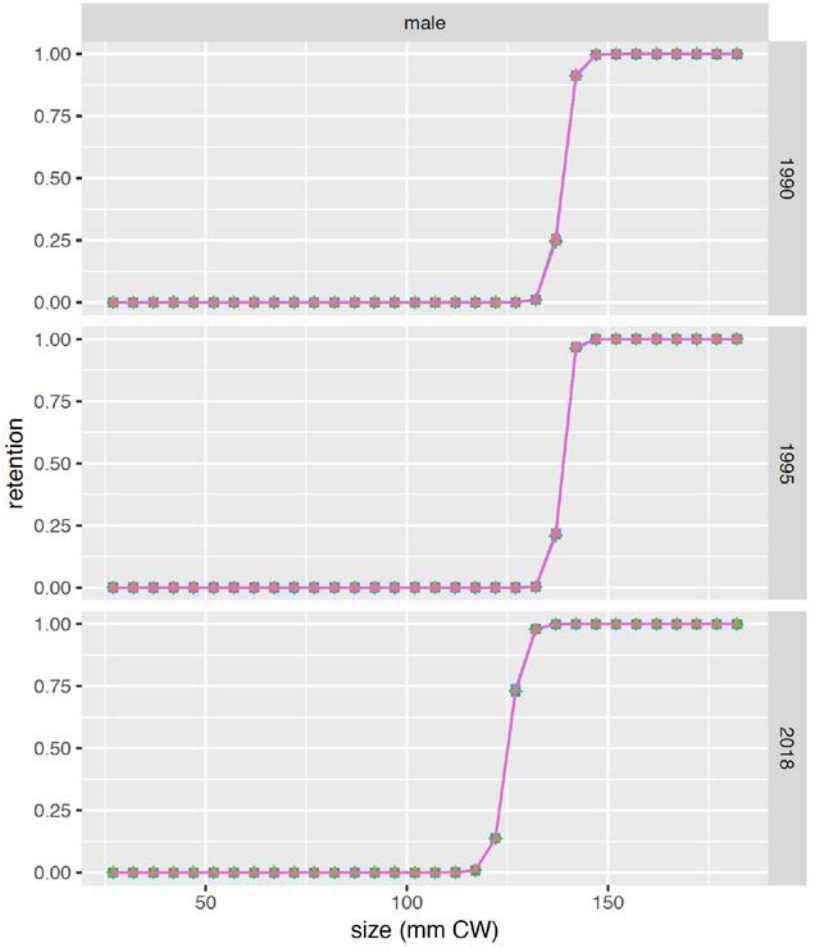
catchability



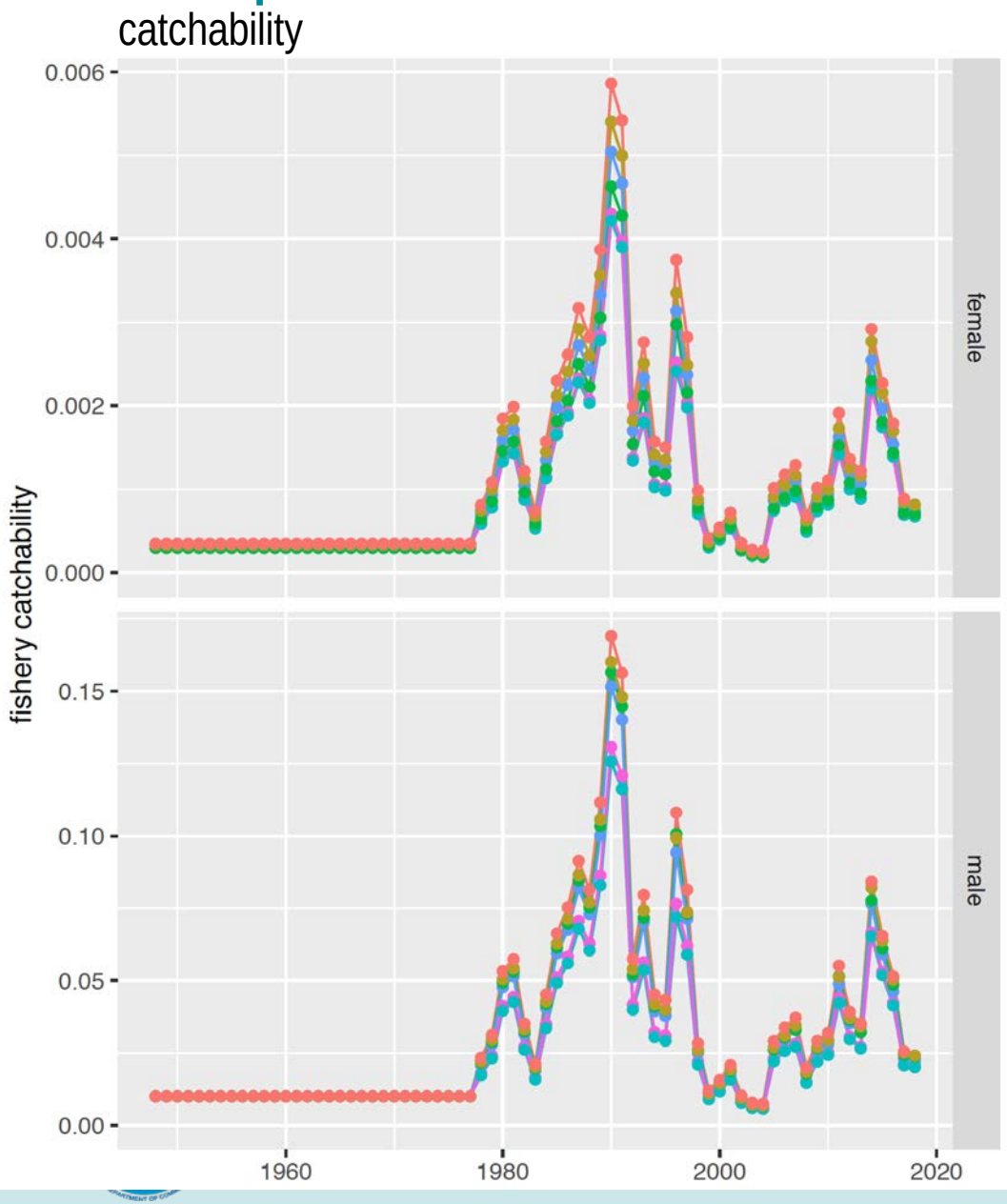
capture selectivity

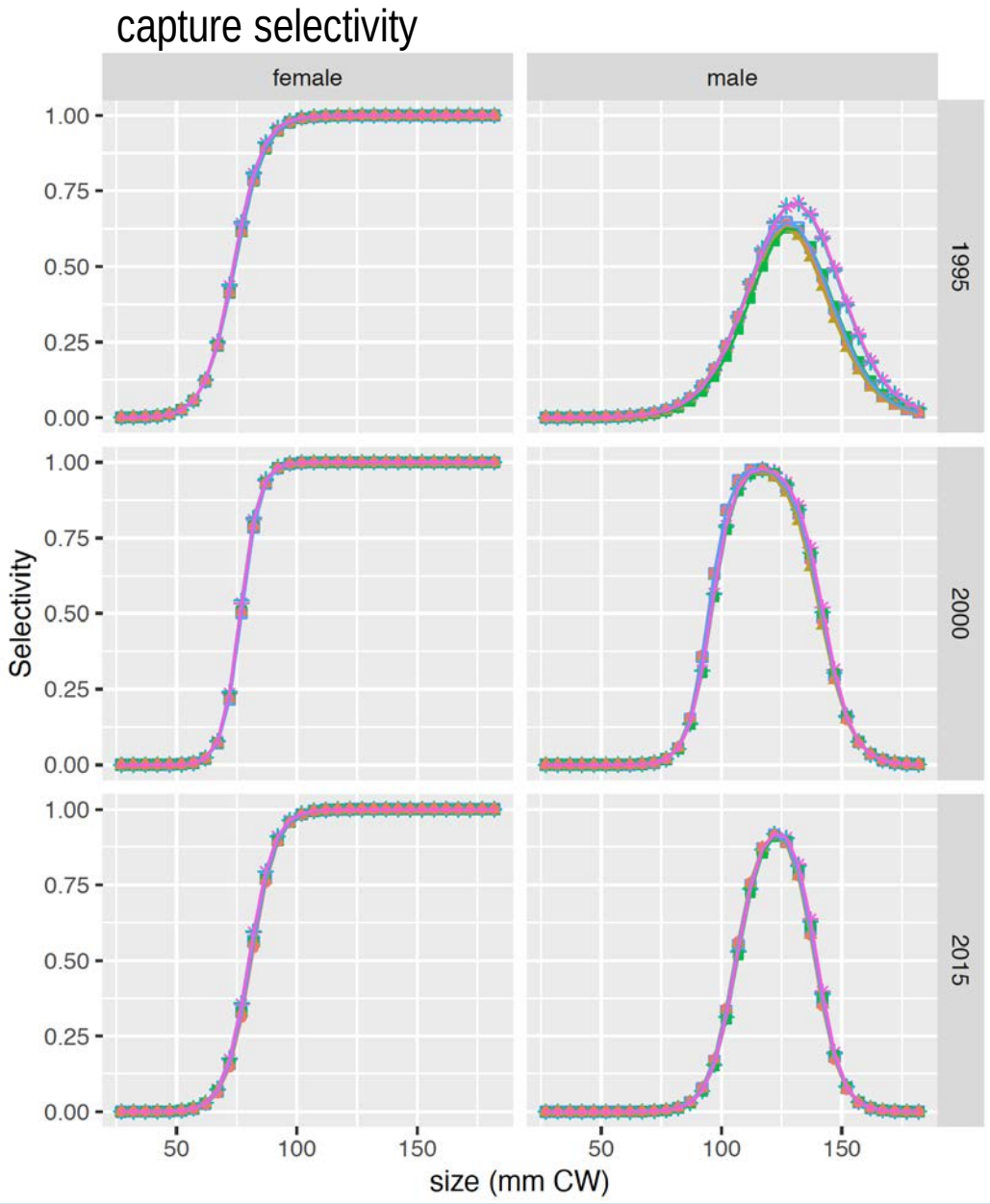


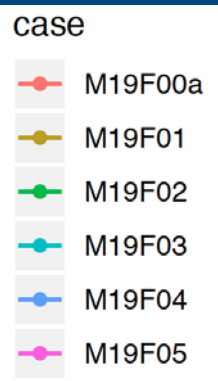
retention



Model processes: snow crab fishery

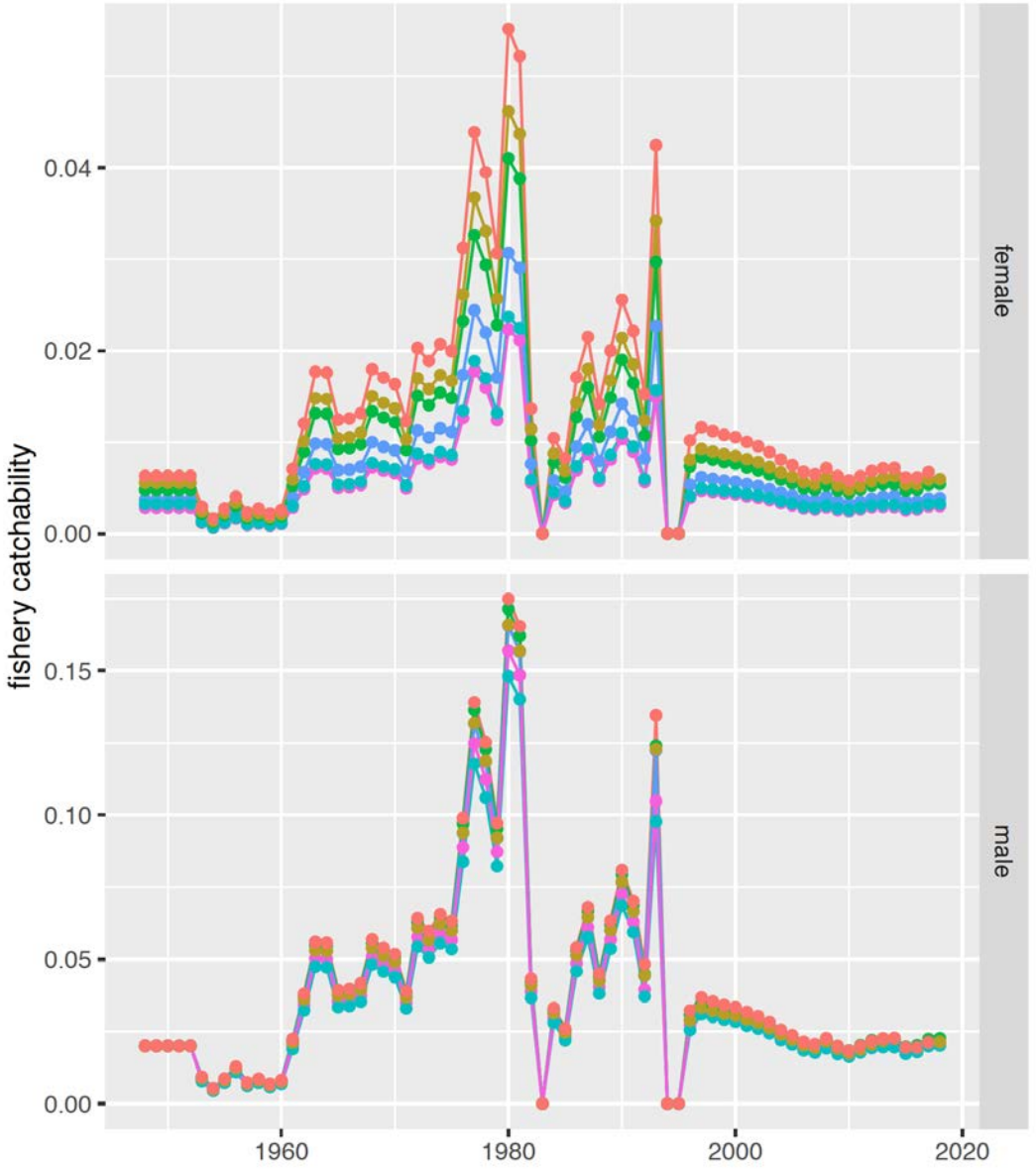




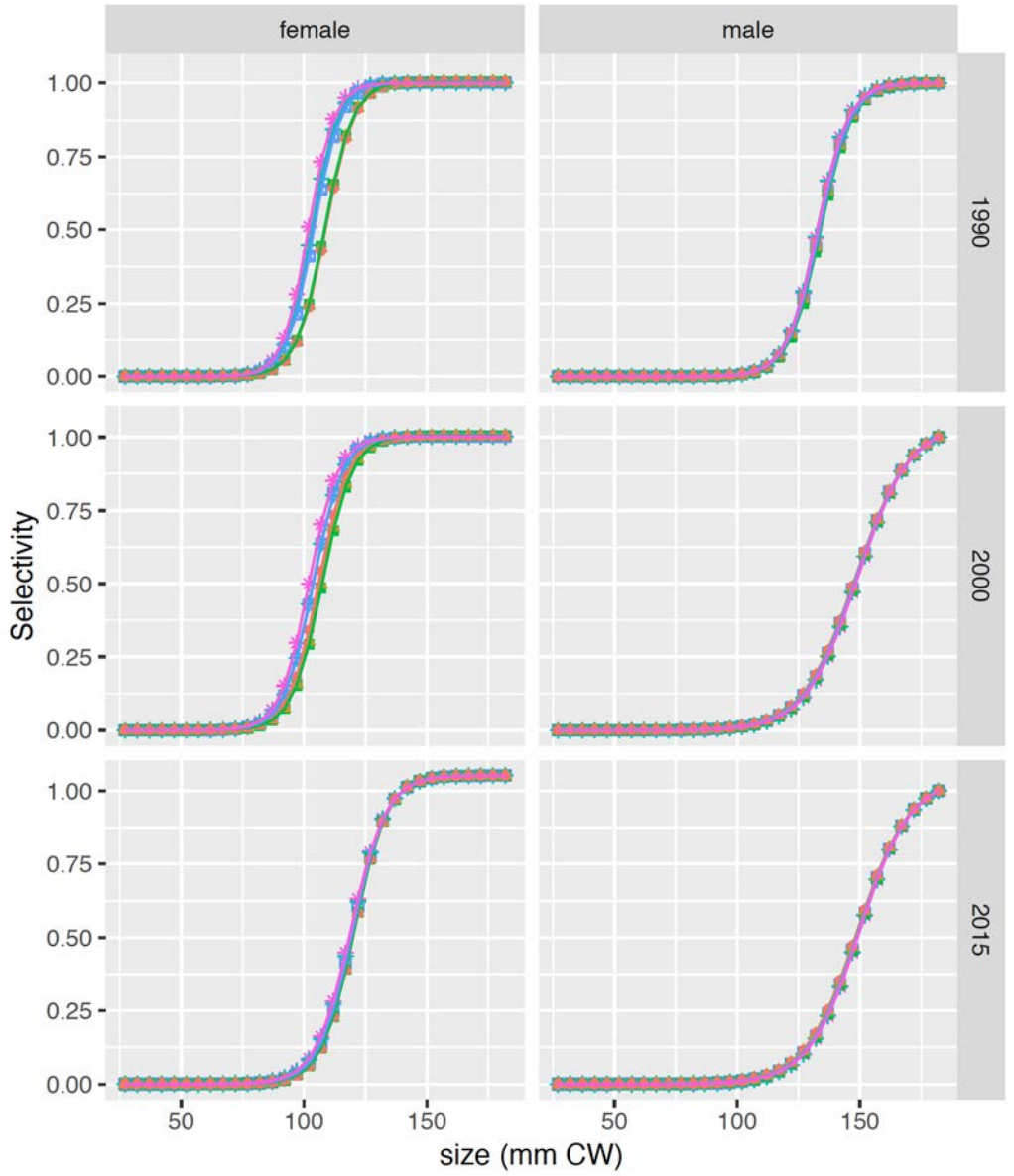


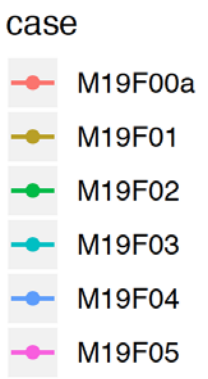
Model processes: BBRKC fishery

catchability



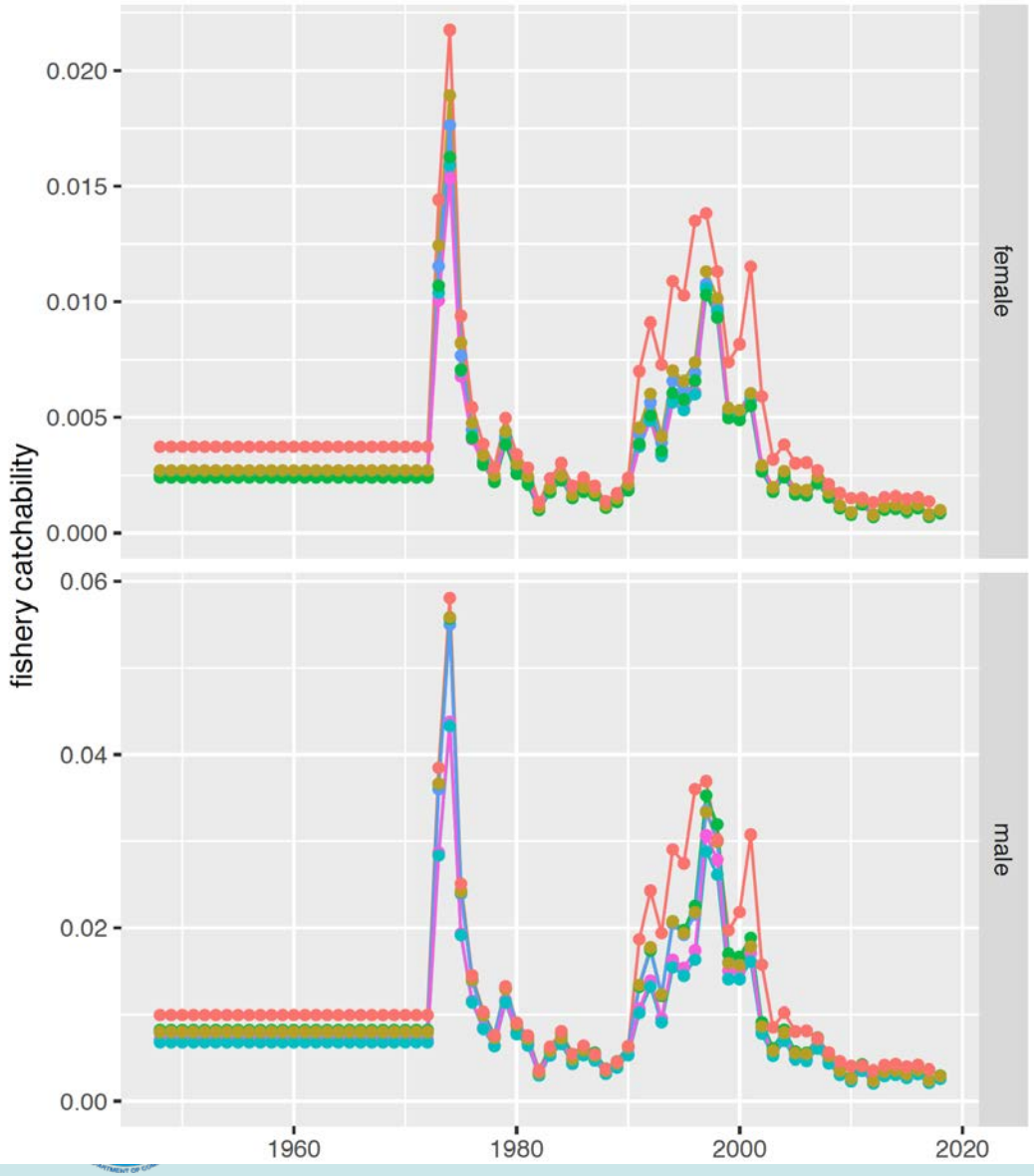
capture selectivity



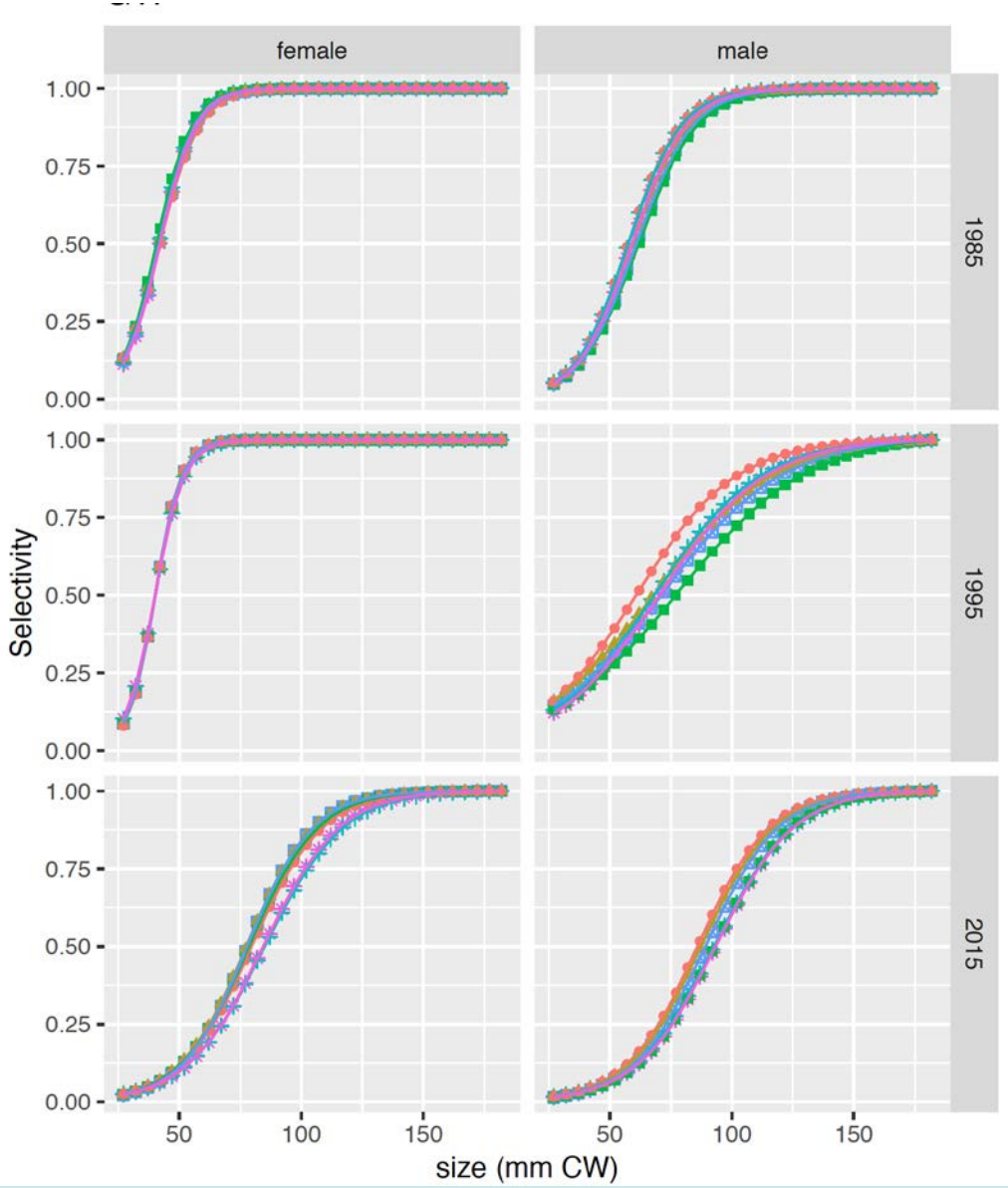


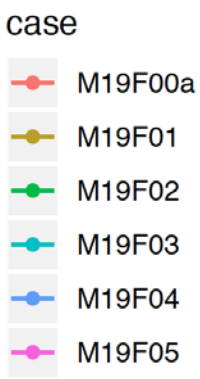
Model processes: groundfish fisheries

catchability

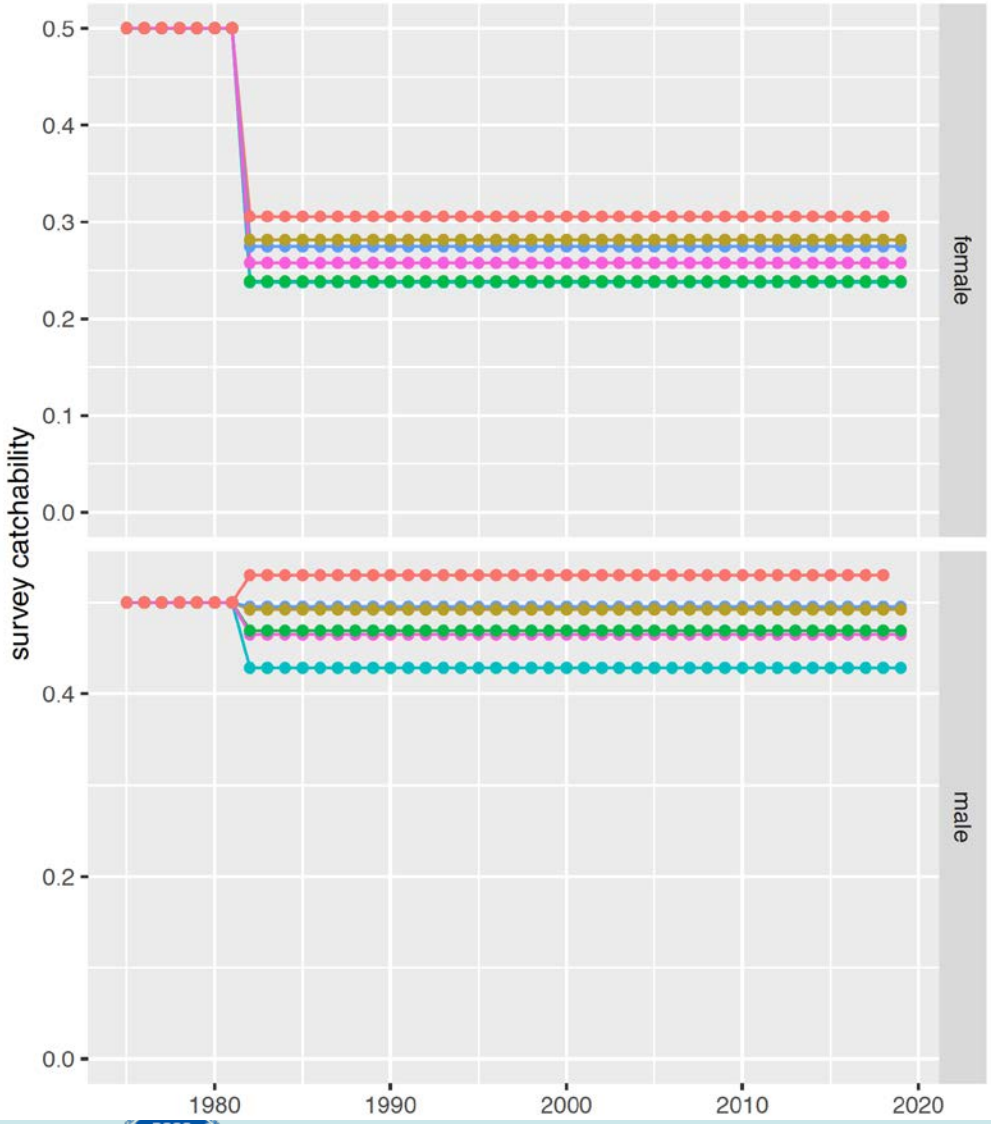


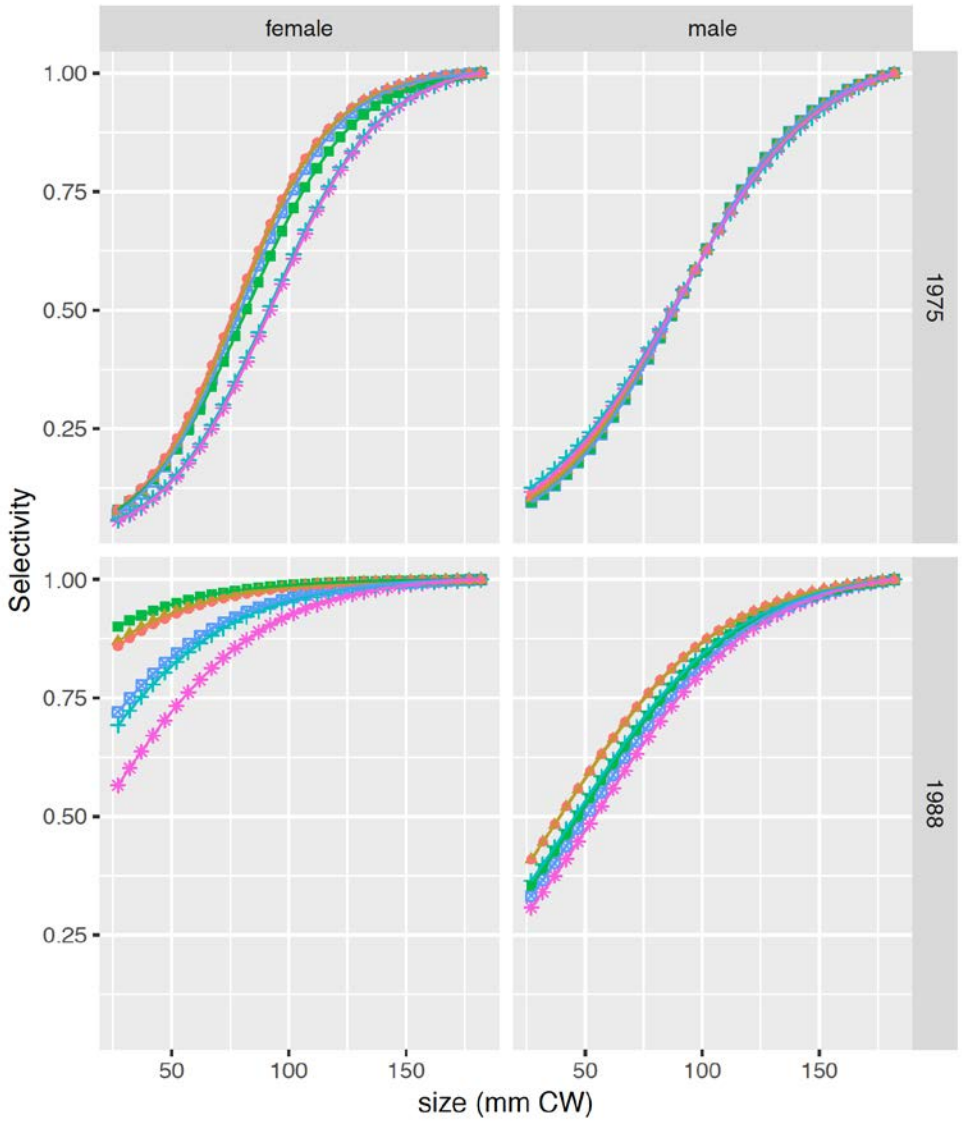
capture selectivity

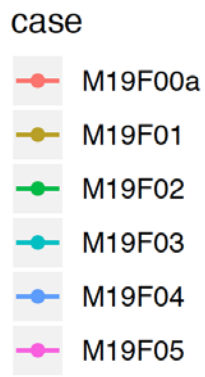




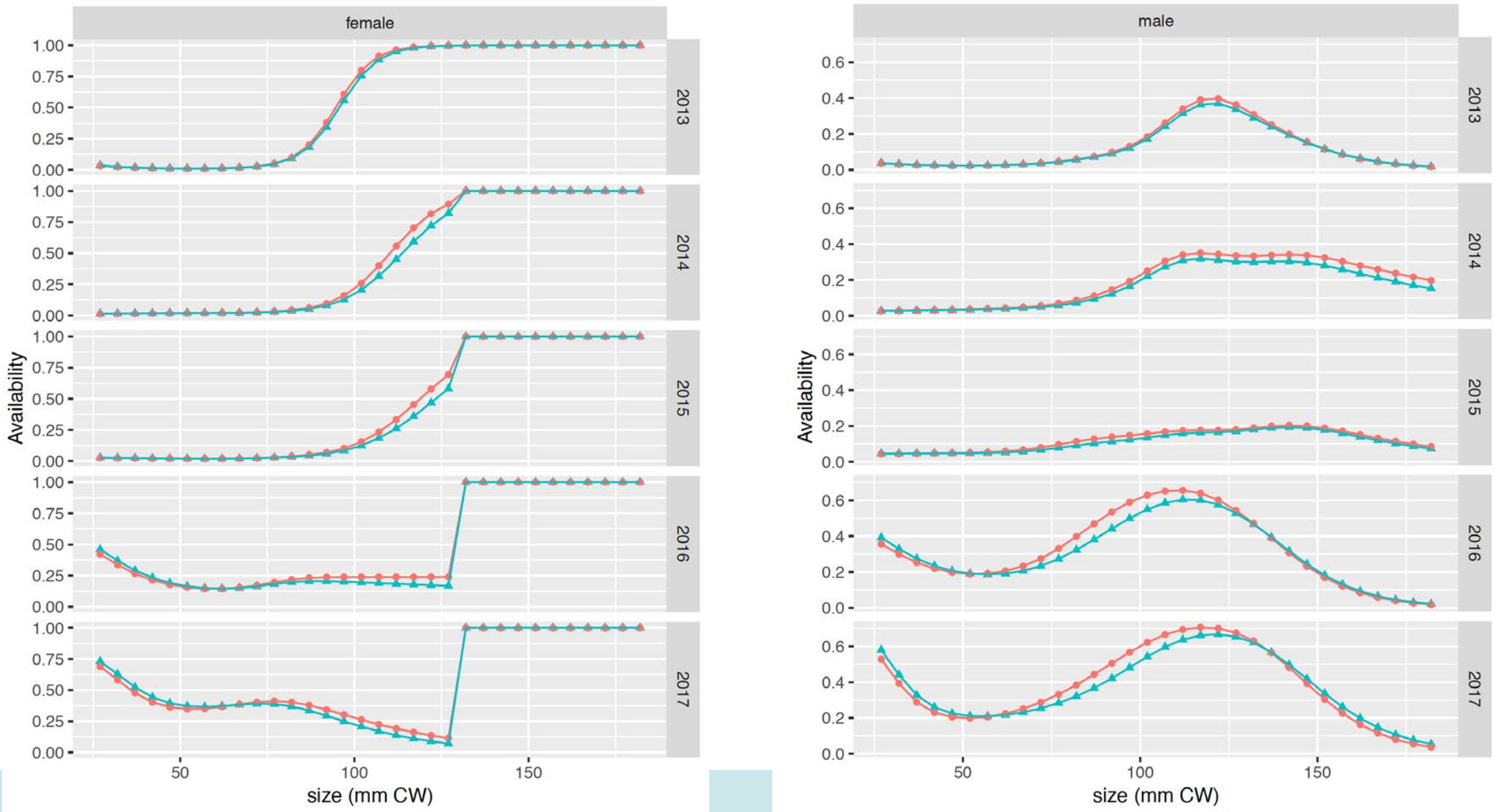
Model processes: NMFS EBS surveys



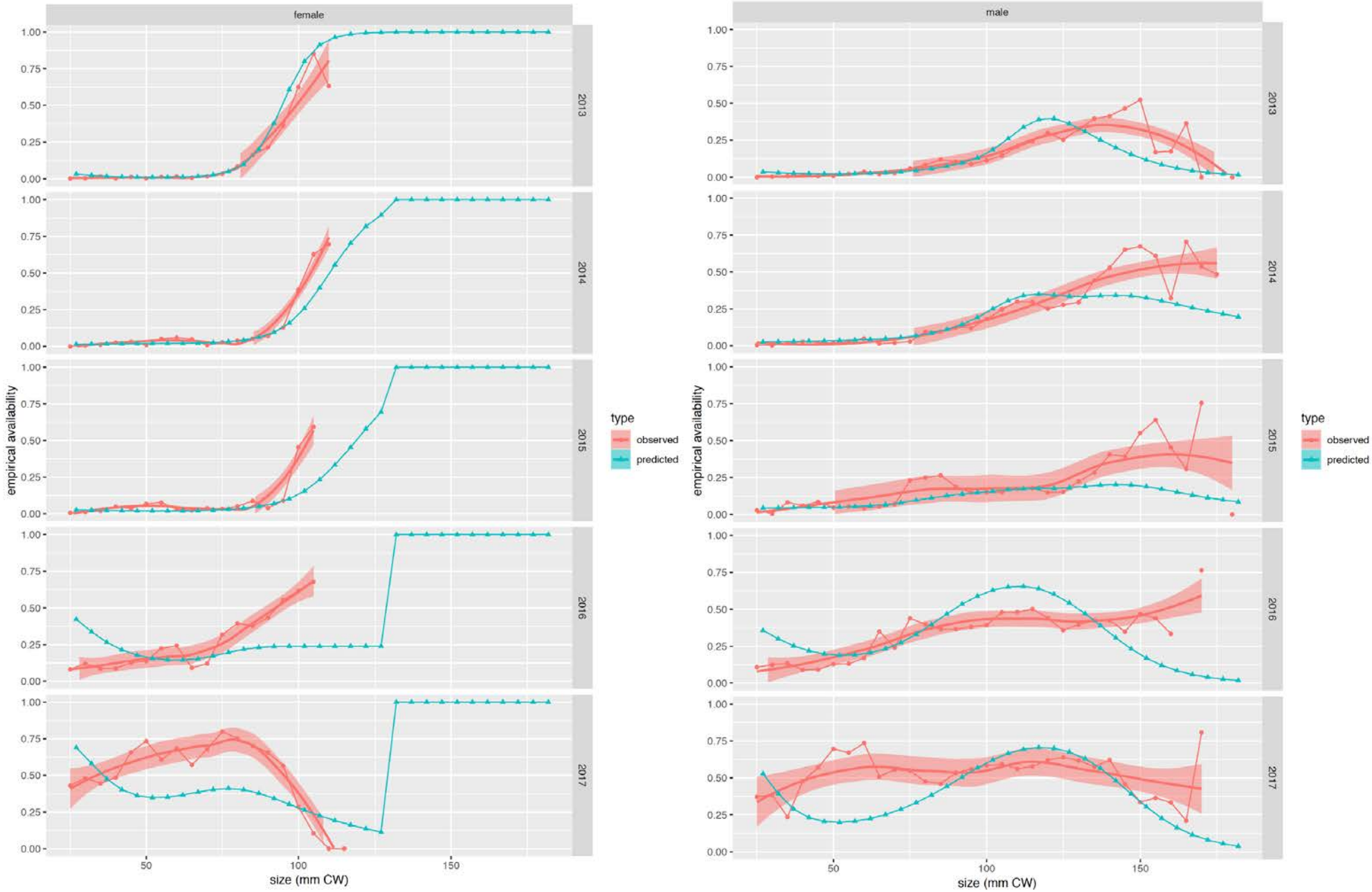




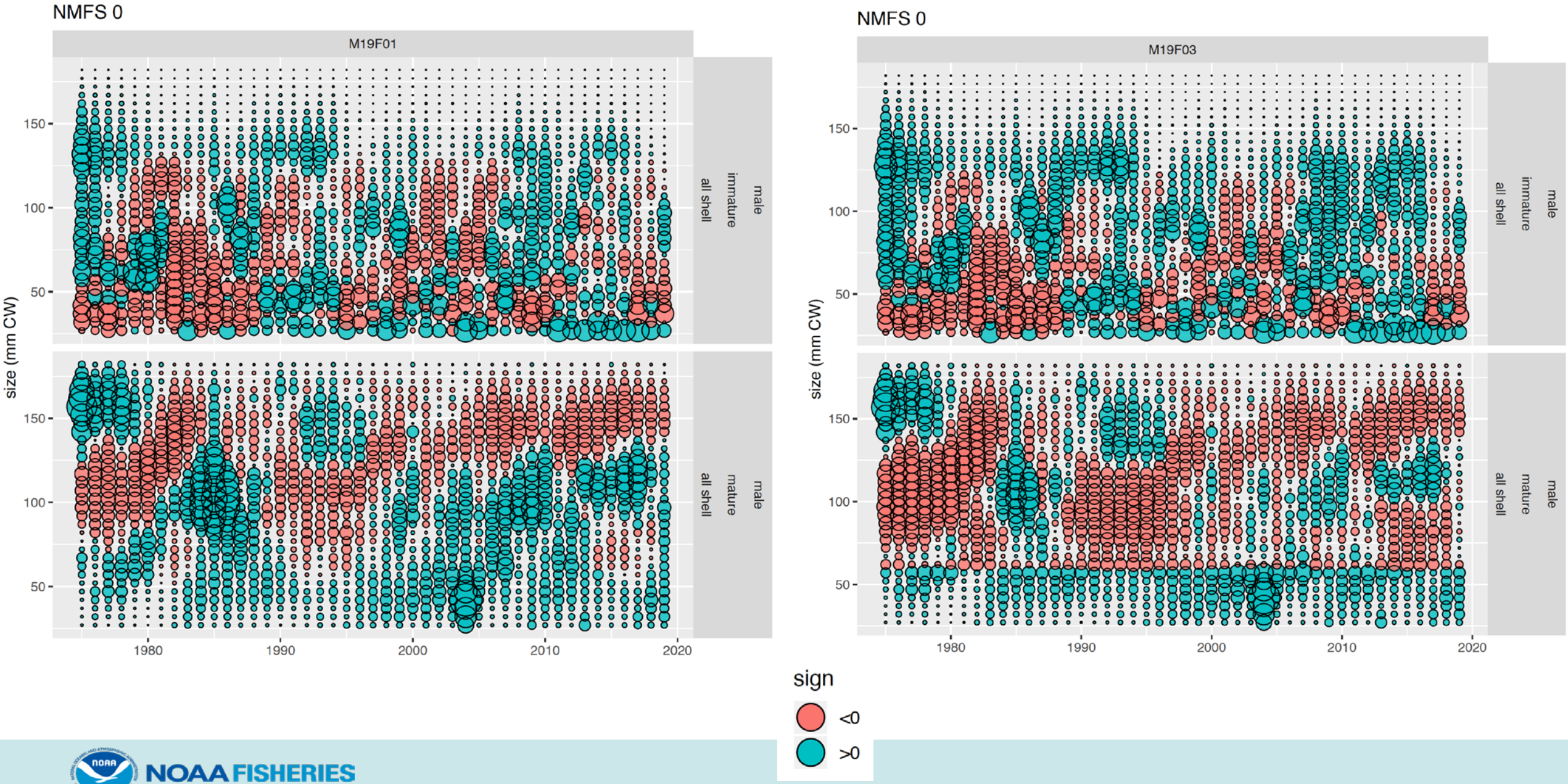
Model processes: SBS availability functions



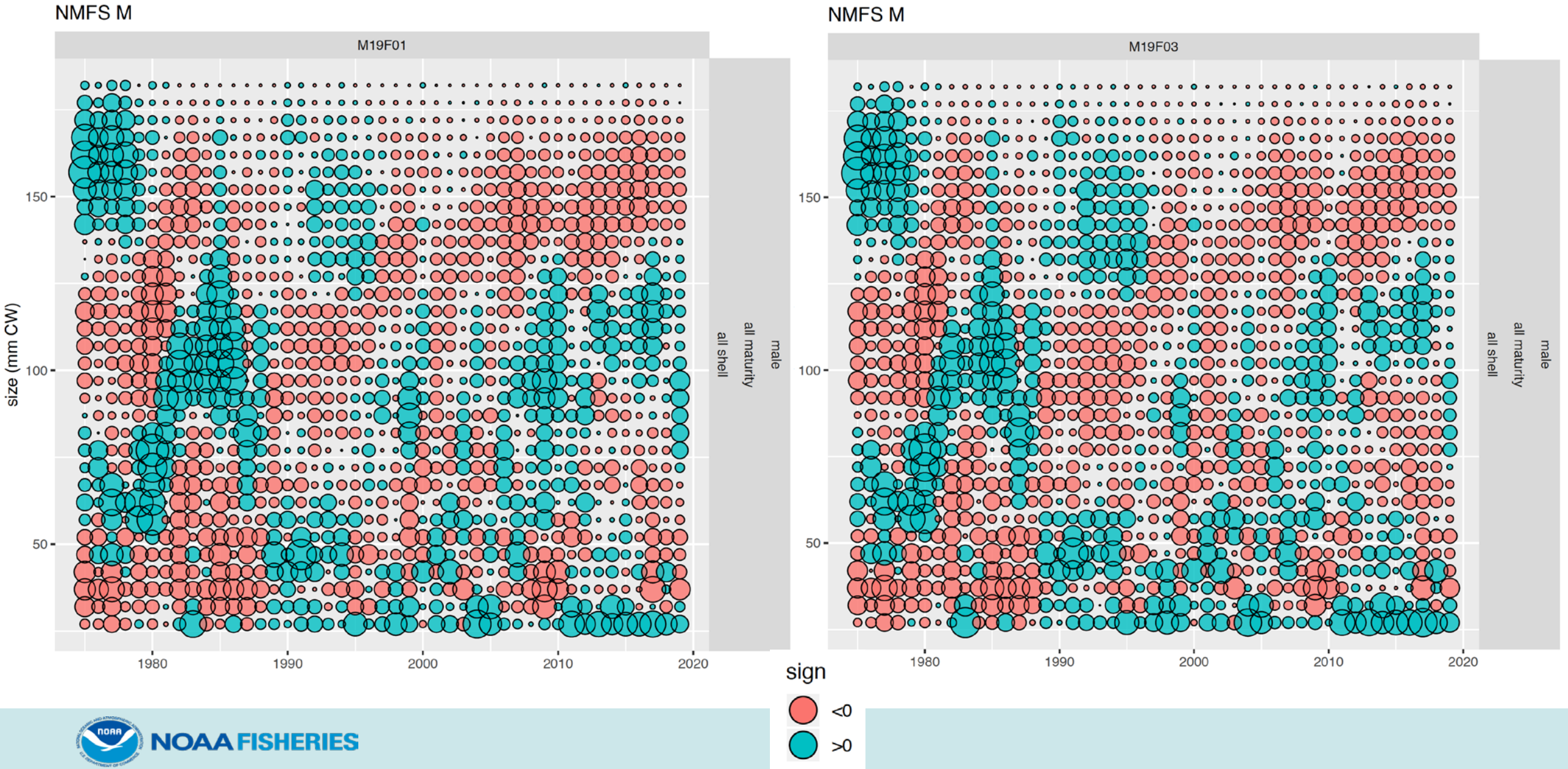
Estimated vs. Empirical Availability Functions



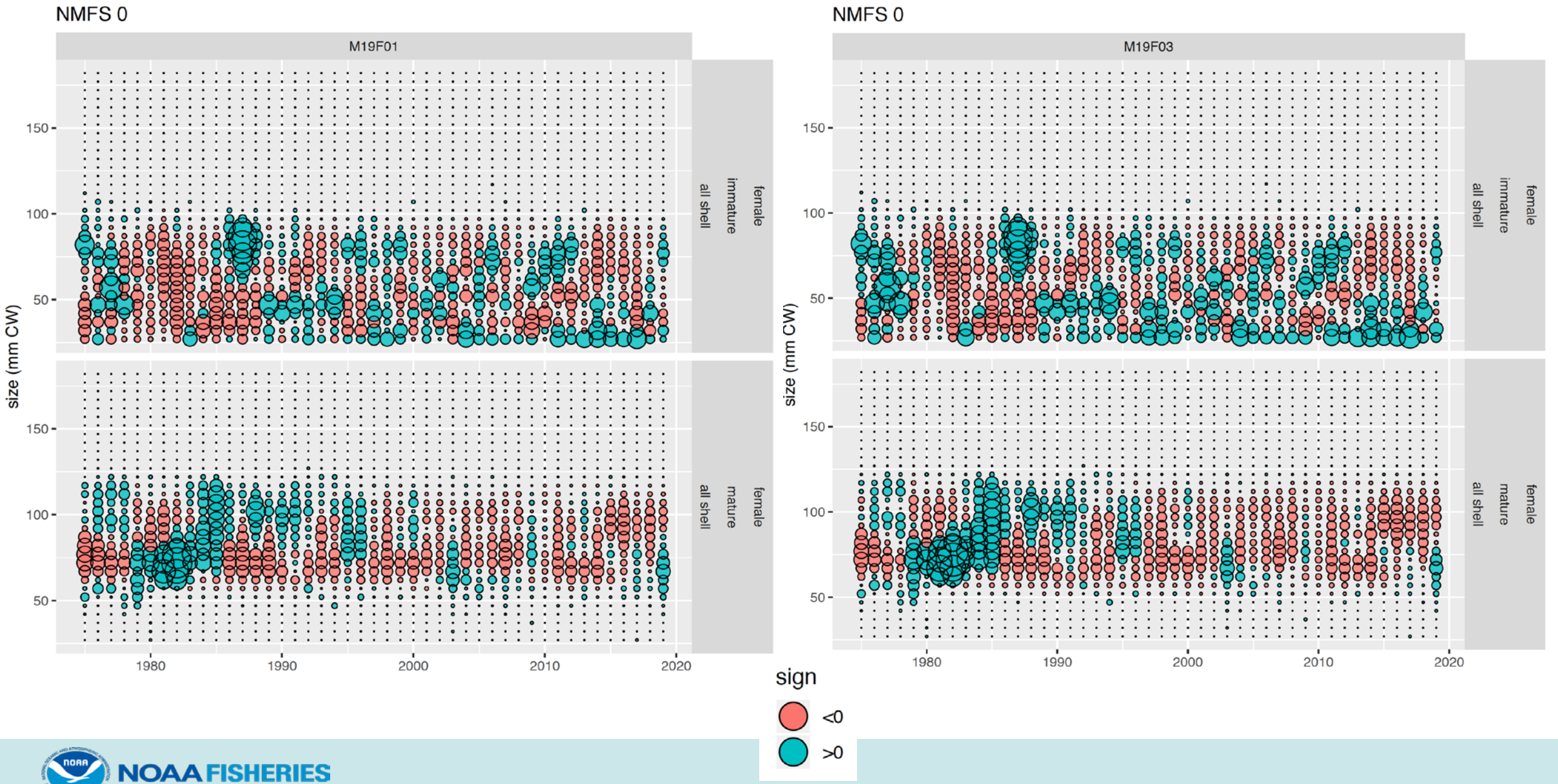
Pearson residuals for M19F01, M19F03 fits to NMFS “0”



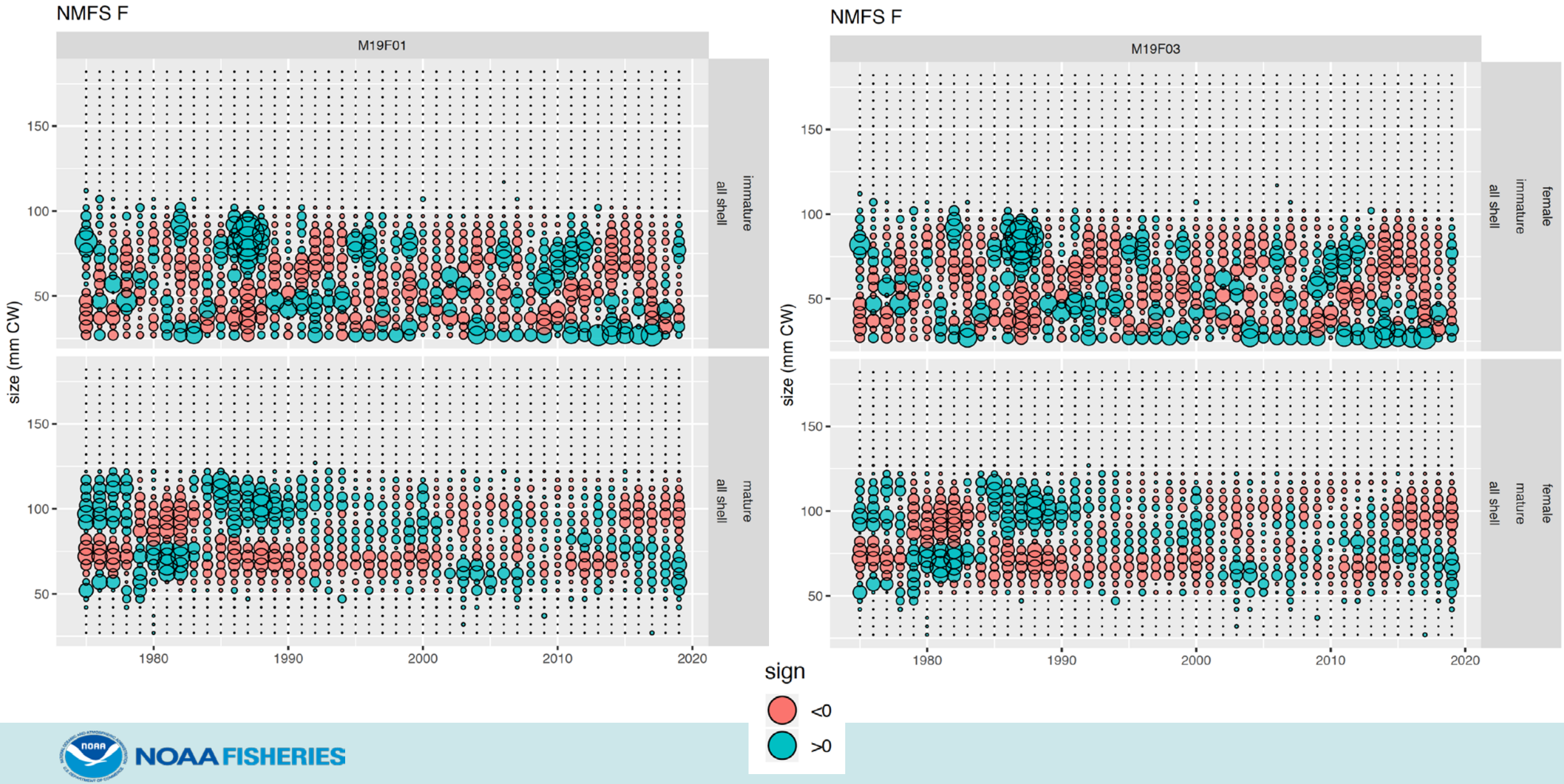
Pearson residuals for M19F01, M19F03 fits to NMFS “M”



Pearson residuals for M19F01, M19F03 fits to NMFS “0”

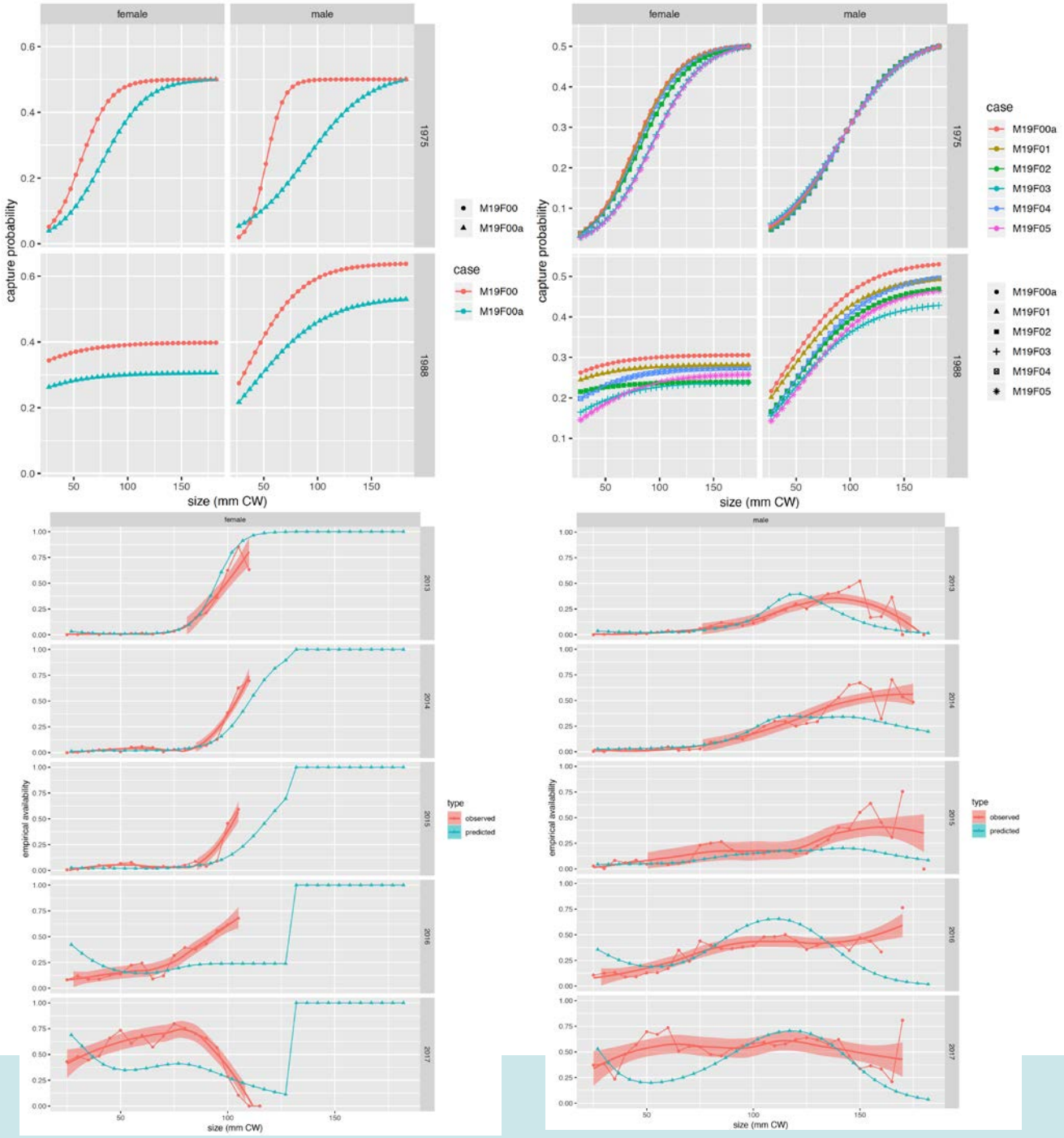


Pearson residuals for M19F01, M19F03 fits to NMFS “0”



Model scenario evaluation

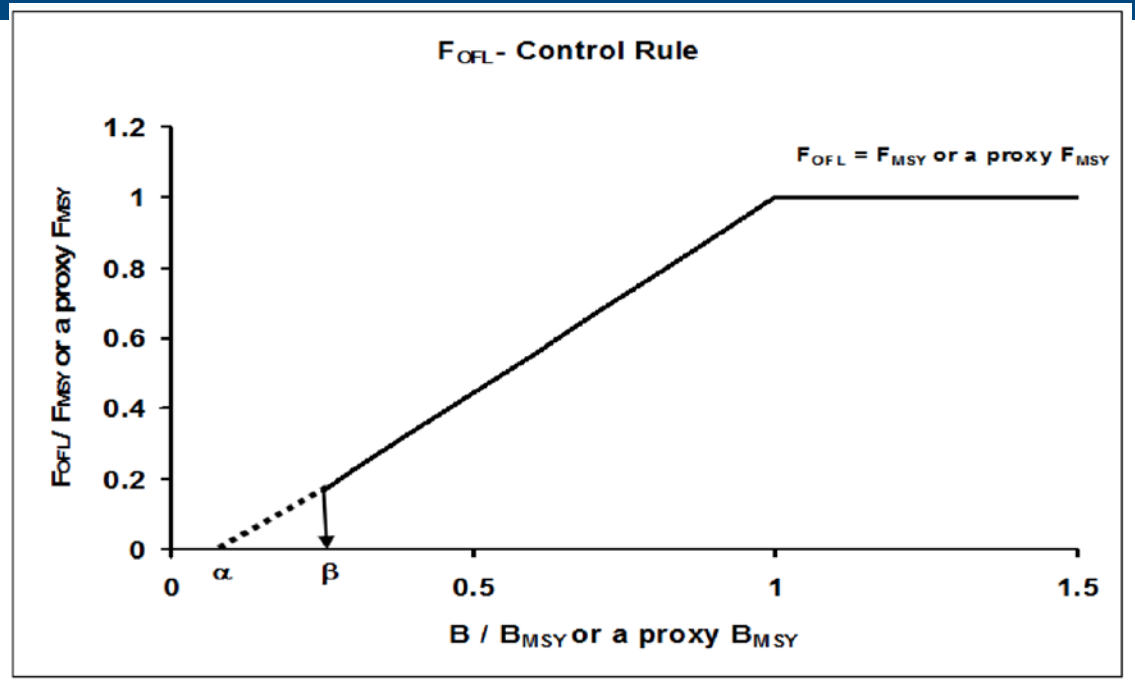
- All models estimate NMFS survey q's at lower bounds->population scale ~2x over M19F00
  - result principally of updated crab fishery data
  - fitting maturity ogives, SBS data secondarily
- Models with SBS data (M19F04, 05) don't seem to estimate availability very well
  - LOTS more parameters, not 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

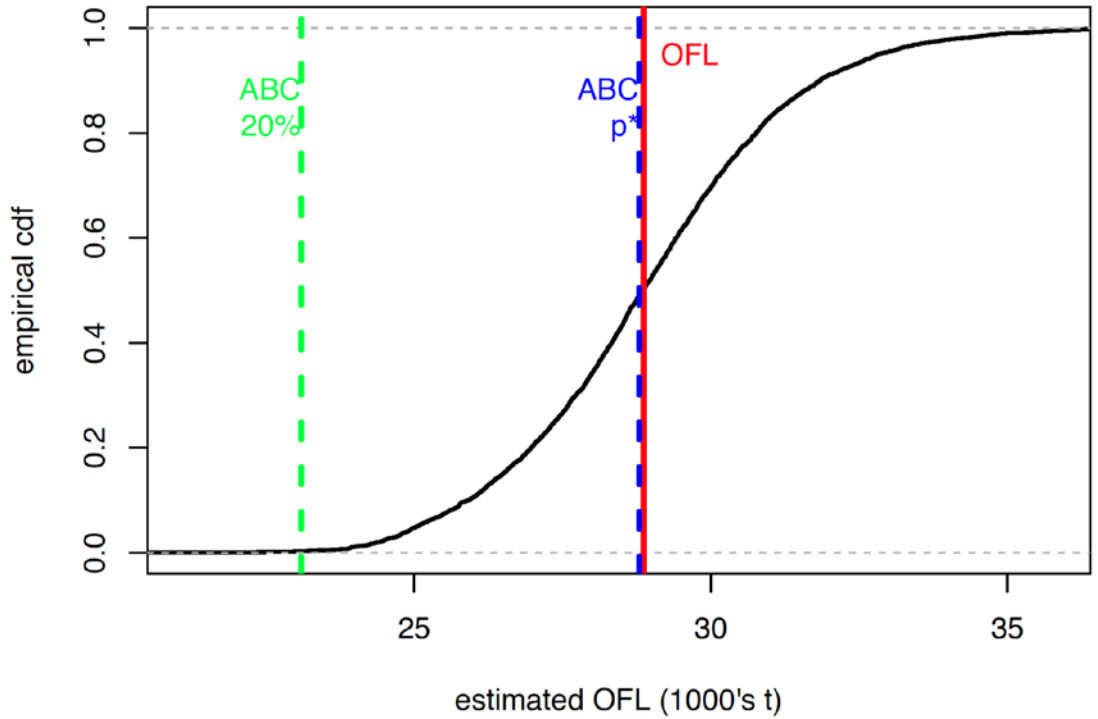


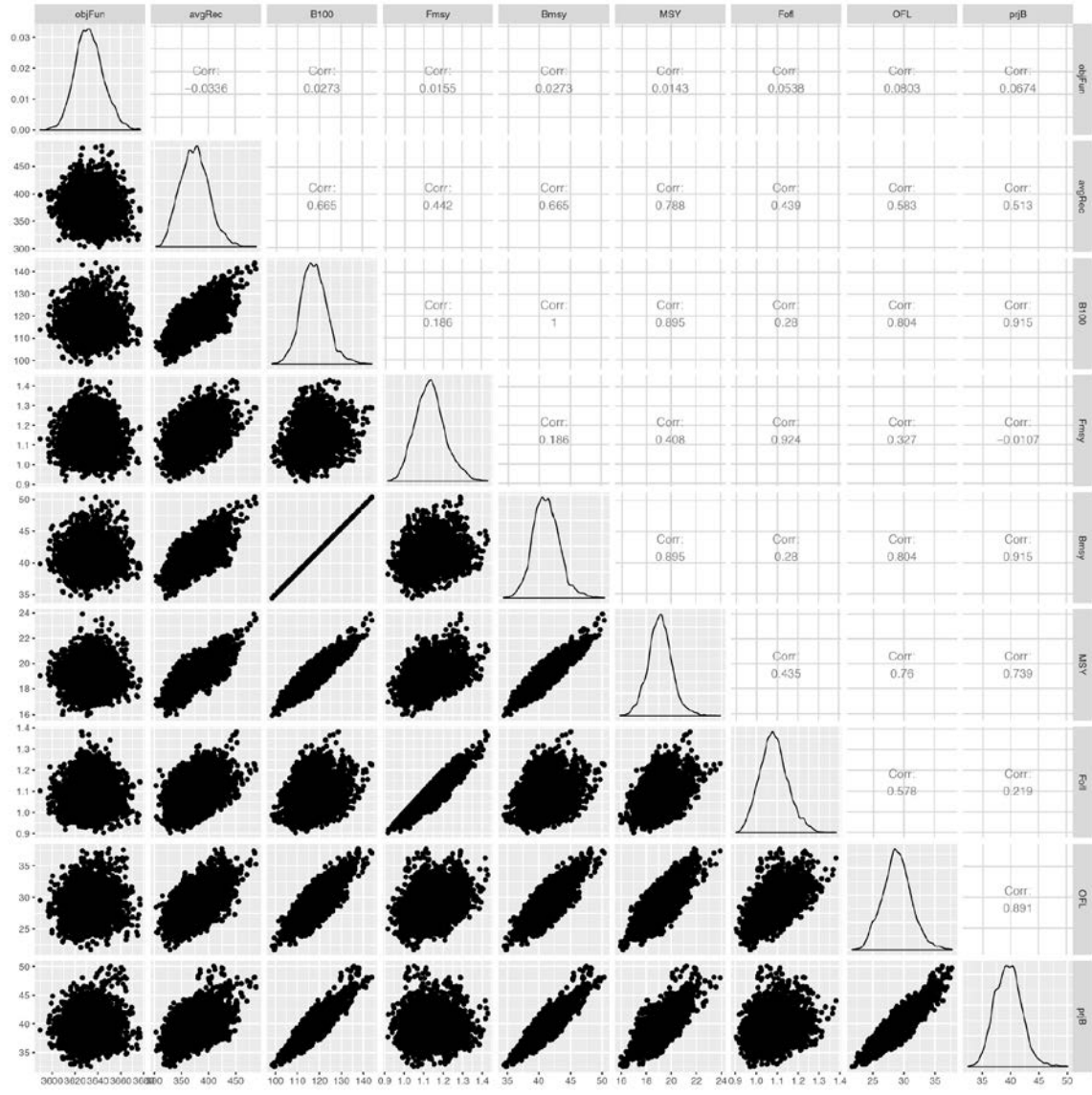
Management-related quantities

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

title


FOFL - Control Rule
FOFL = FMSY or a proxy FMSY
FOFL/ FMSY or a proxy FMSY
B / BMSY or a proxy BMSY
α
β
0
0.2
0.4
0.6
0.8
1
1.2
0.5
1.5


ABC
20%
ABC
p*
OFL
empirical cdf
estimated OFL (1000's t)
0.0
0.2
0.4
0.6
0.8
1.0
25
30
35


objFun
avgRec
B100
Fmsy
Bmsy
MSY
Foll
OFL
pjB

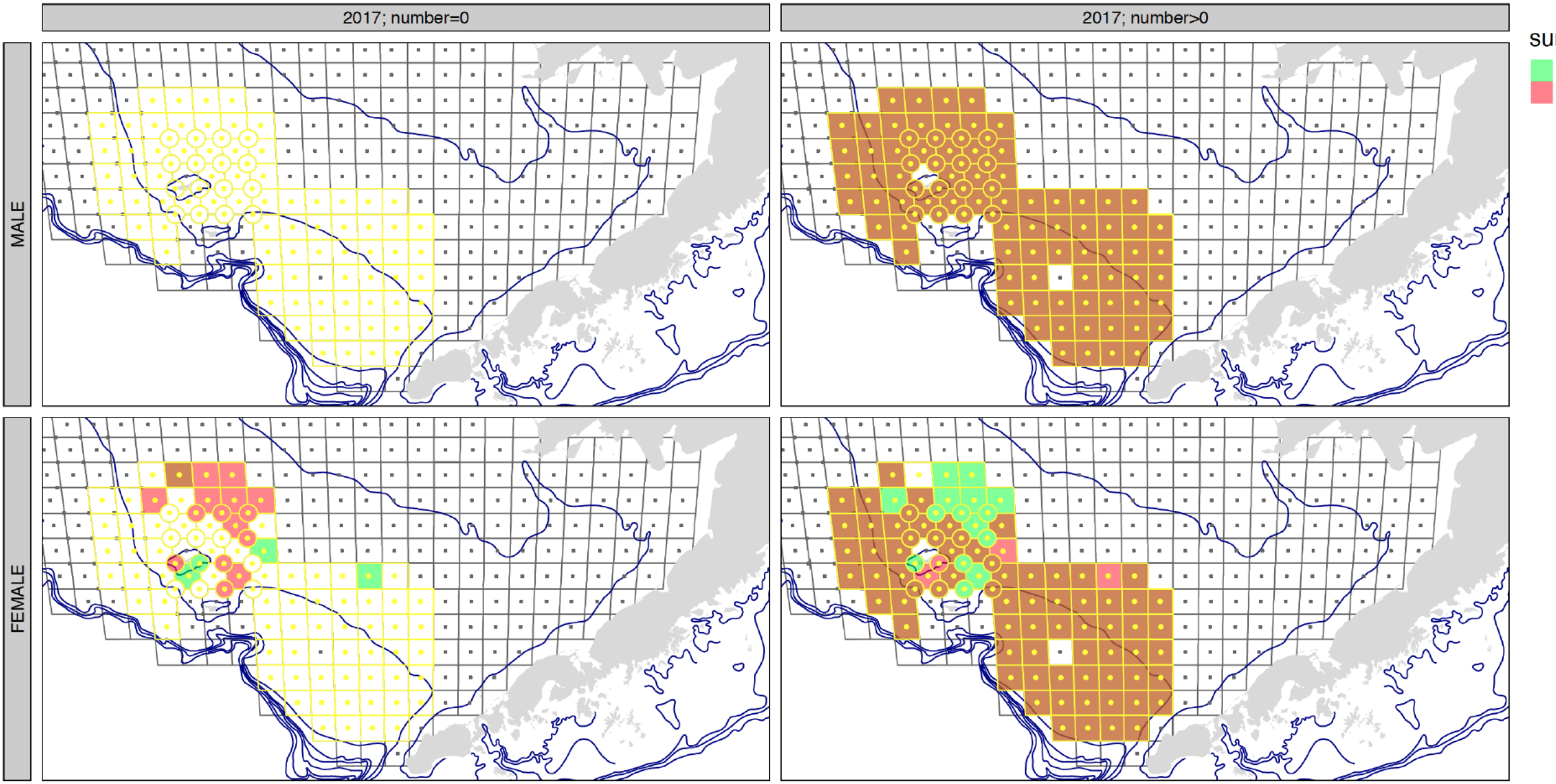
Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2015/16	12.82	73.93	8.92	8.91	11.38	27.19	21.75
2016/17	14.58	77.96	0.00	0.00	1.14	25.61	20.49
2017/18	15.15	64.09	1.13	1.13	2.37	25.42	20.33
2018/19	20.54	82.61	1.11	1.11	1.90	20.87	16.70
2019/20		39.55				28.86	23.09

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,I] (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 BBRKC, 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
- remove 1975-1981 NMFS EBS survey estimates from model fits?

title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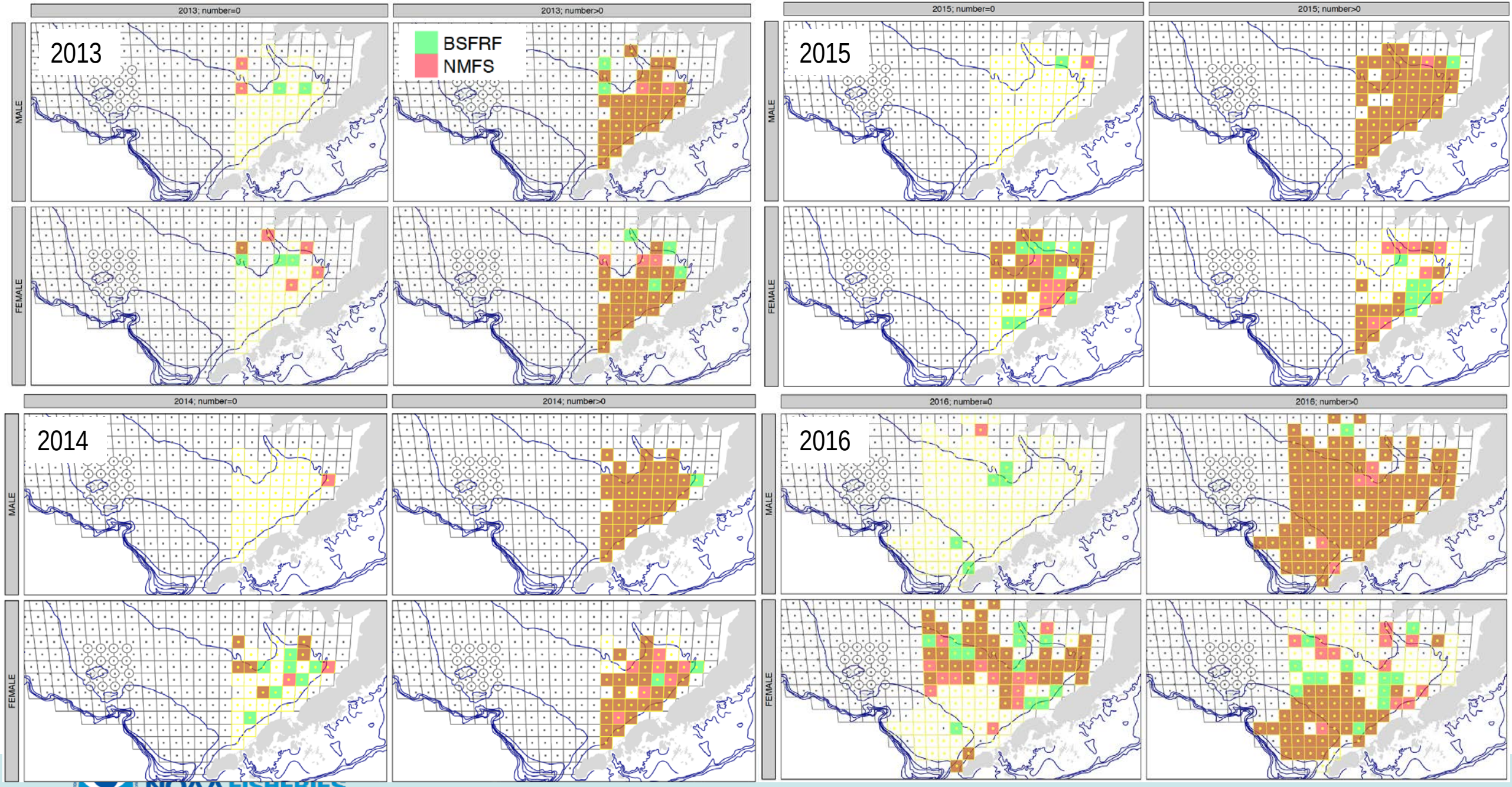
FEMALE
survey
BSFRF
NMFS



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