



Bristol Bay red king crab

Proposed models for 2024

May 2024

K.J. Palof

ADF&G

katie.palof@alaska.gov

Summary

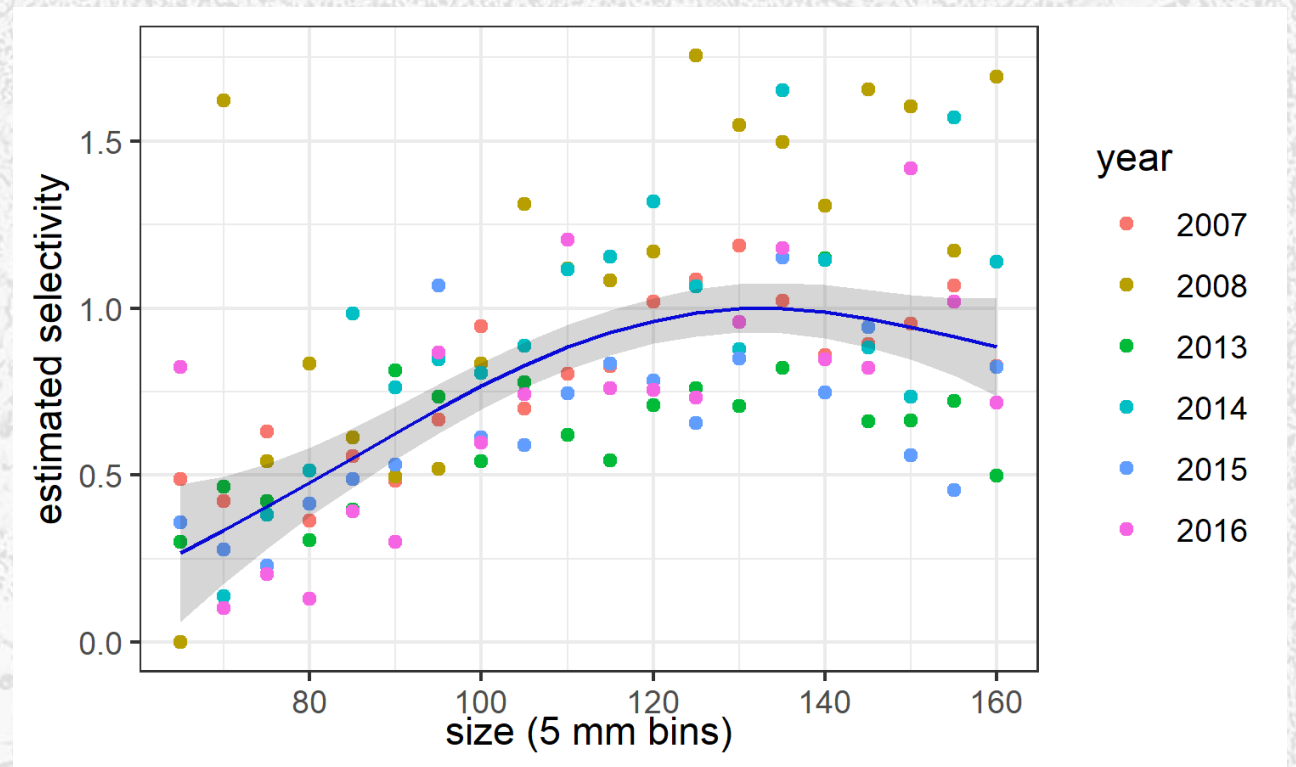
- Stable model in GMACS since 2018
- Directed fishery was open in 2023/24 after being closed for 2 seasons (2021/22, 2022/23) due to low mature female abundance
- Low recruitment in recent years (last 8-12 years), projected decline in biomass without a large recruitment event
- Model explorations around a few themes:
 - GMACS updates
 - Selectivity estimation using BSFRF data as a prior for NMFS survey
 - Molting probability time blocks

CPT / SSC comments

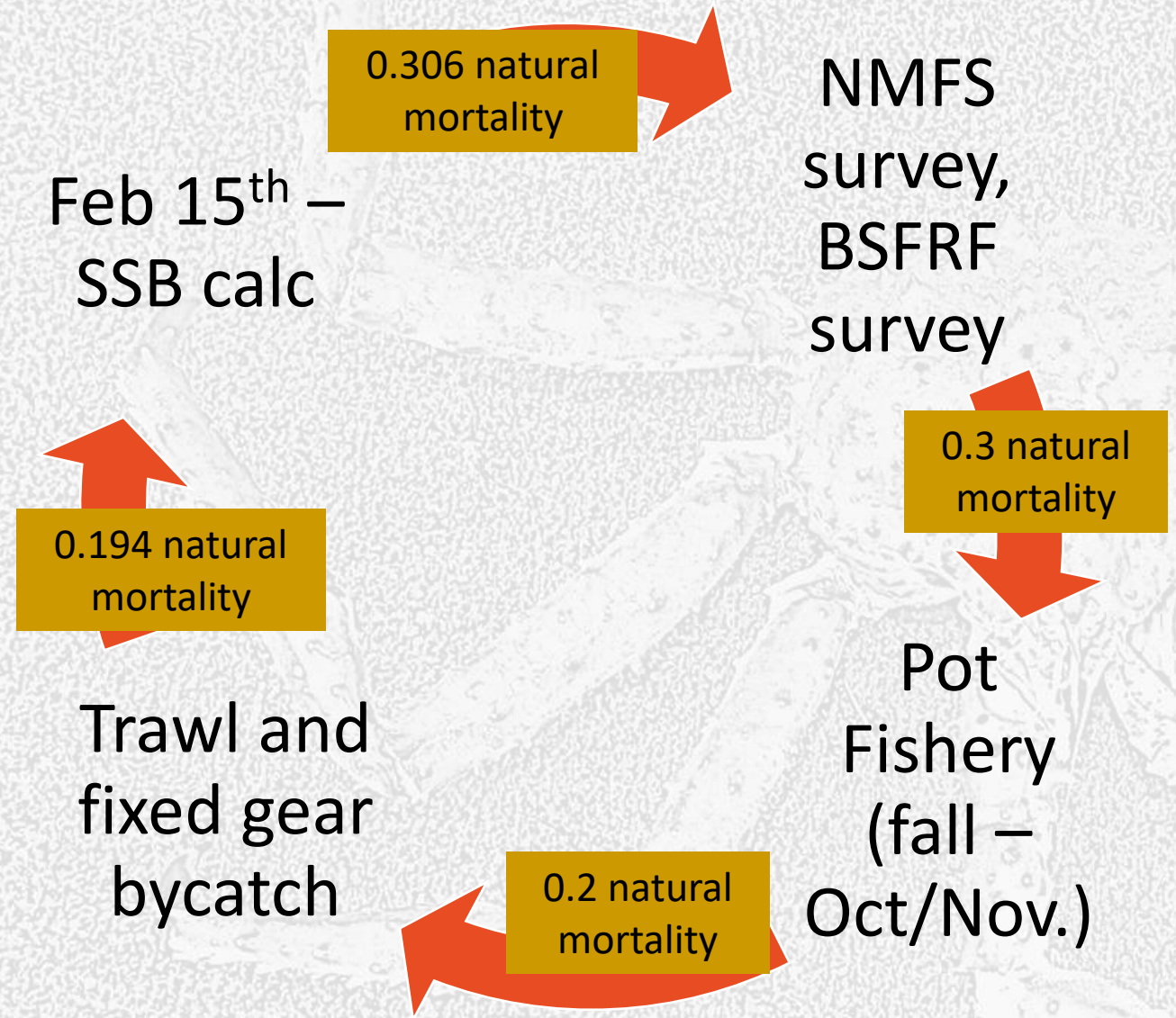
- Survey selectivity
 - Modeled after snow crab 2023, use inferred selectivity from BSFRF as a prior on selectivity for NMFS survey
- Revisit molting probability time blocks
- Retrospective patterns
 - High priority on source of these, but unable to unearth the cause yet
 - Decreases some with estimated M (model 23.0a)
- Other comment themes not yet addressed: initial conditions, VAST, re-do M likelihood profile, growth parameters

Selectivity

- 6 years of BSFRF data
- Inferred selectivity assumes BSFRF selectivity = 1
- Males and females combined
- Overall shape similar to current estimate in model – with exception of slight decrease at higher size bins



Annual timing for assessment



Season 1 NMFS survey BSFRF survey	Season 2 Natural mortality	Season 3 Pot fishery	Season 4 Natural mortality	Season 5 Trawl and fixed gear bycatch Tanner crab fishery bycatch	Season 6 Natural mortality	Season 7 SSB calculated Molting, growth, recruitment
---	-------------------------------	-------------------------	-------------------------------	---	-------------------------------	--

- Base model was estimating SSB in season 6
- Updated version estimates in season 7
- Change in season due to change in when SSB is estimated within a season in the model.

2024 Model explorations

23.0a: the base model from September 2023 (model 21.1b + estimating a constant M for males with tight prior) + **updated version of GMACS**

23.0a(.p7): model 23.0a + **updated version of GMACS** + MMB estimated in season 7.

24.0: model 23.0a (.p7) – BSFRF data + prior on NMFS selectivity based on BSFRF data

24.0b: model 23.0a (.p7) + no time blocks for molt probability

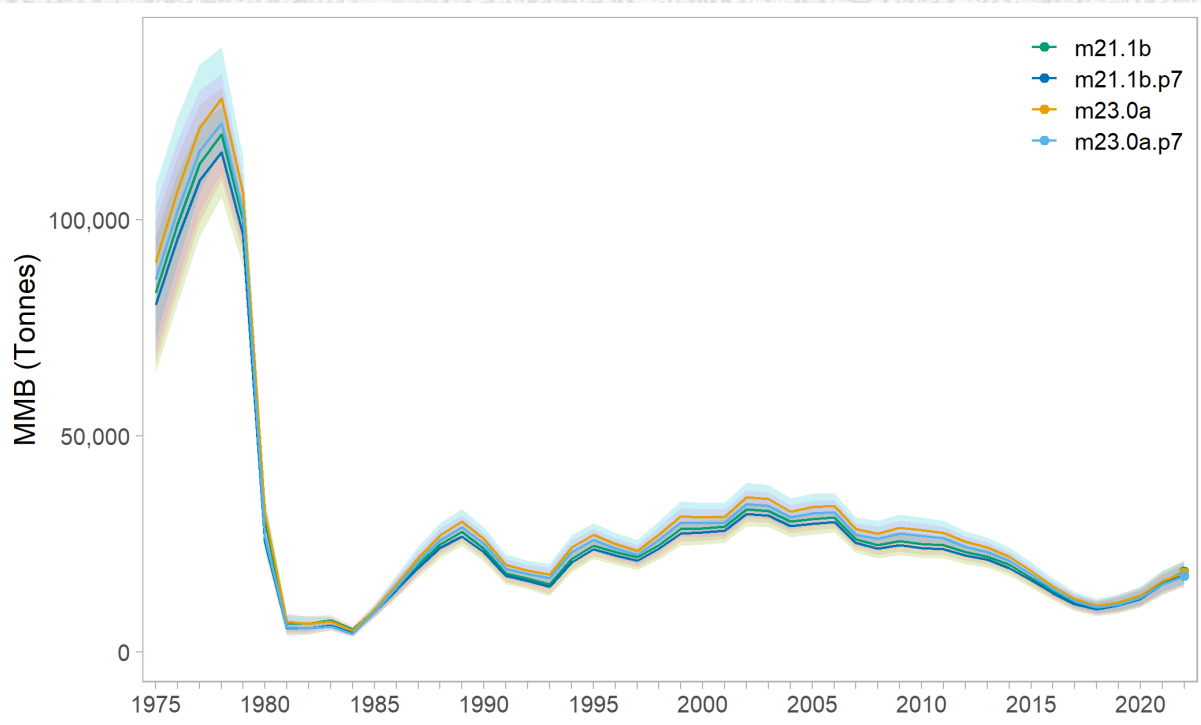
21.1b: the base model from September 2022 (fixed base M for males at 0.18) + **updated version of GMACS**

21.1b(.p7): model 21.1b + **updated version of GMACS** + MMB estimated in season 7.

24.0c: model 21.1b (.p7) – BSFRF data + prior on NMFS selectivity based on BSFRF data

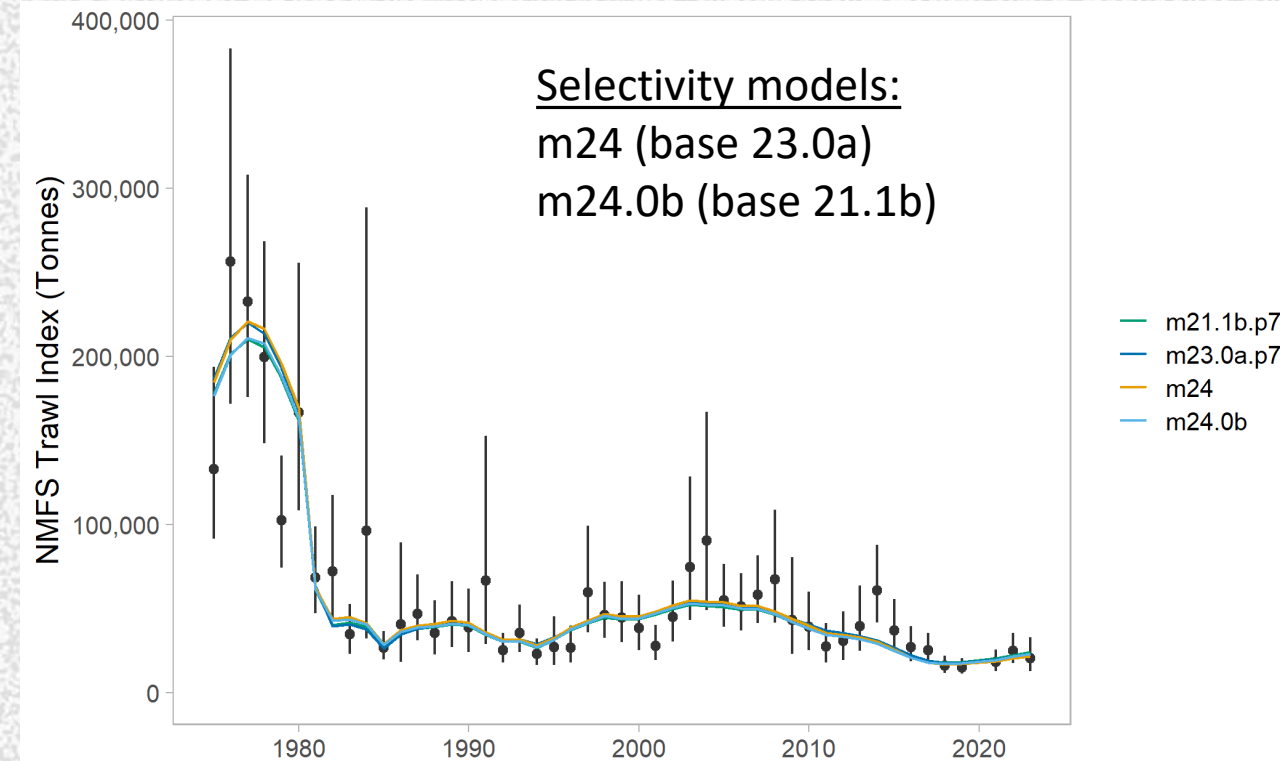
24.0d: model 21.1b (.p7) + no time blocks for molt probability

GMACS updates

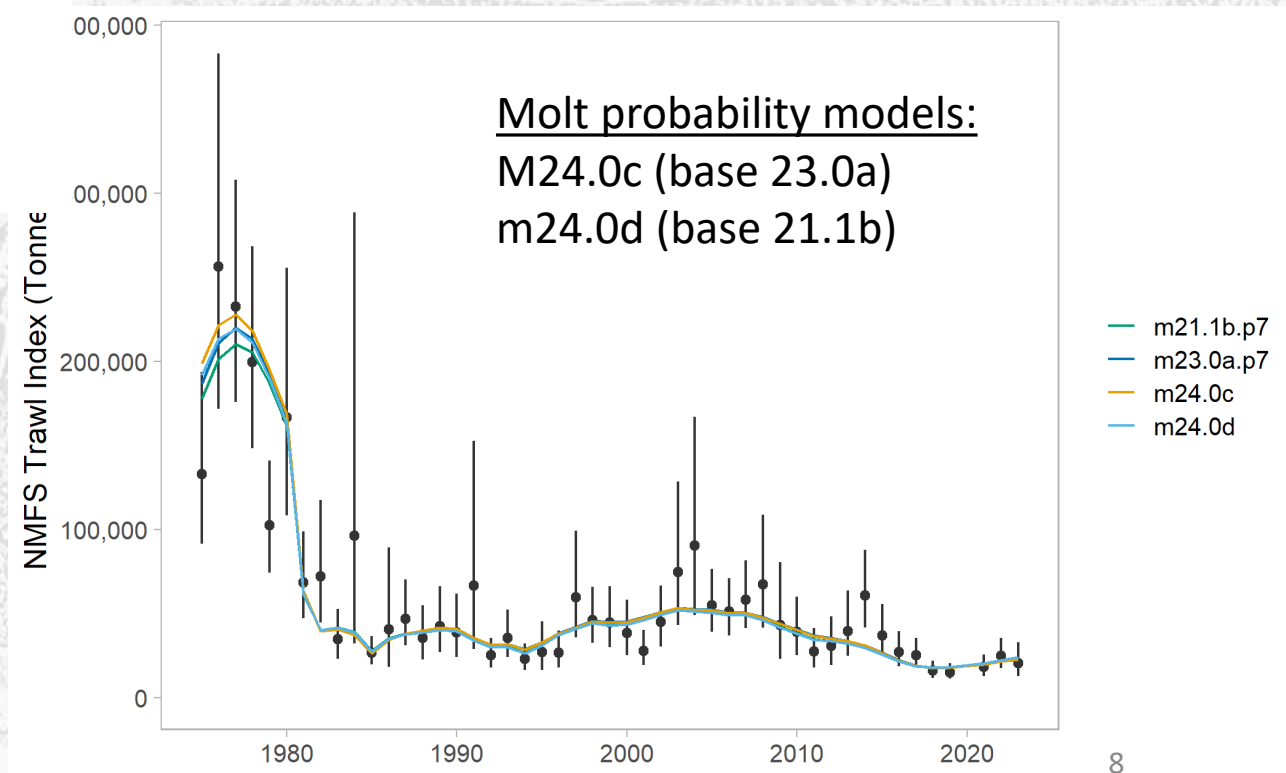


- Likelihoods identical (2 decimal places)
- Small differences in MMB trend due to timing of estimating MMB at mating (Feb 15th)
- No difference in reference points (as expected)

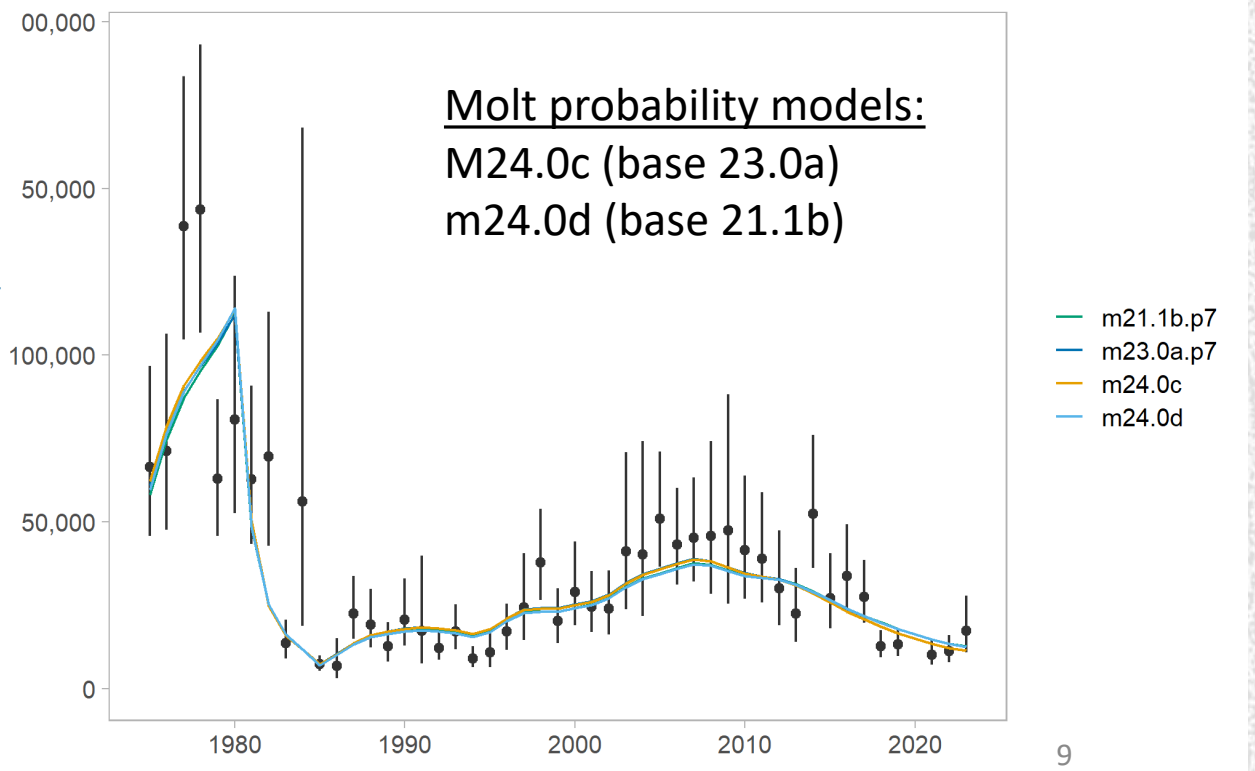
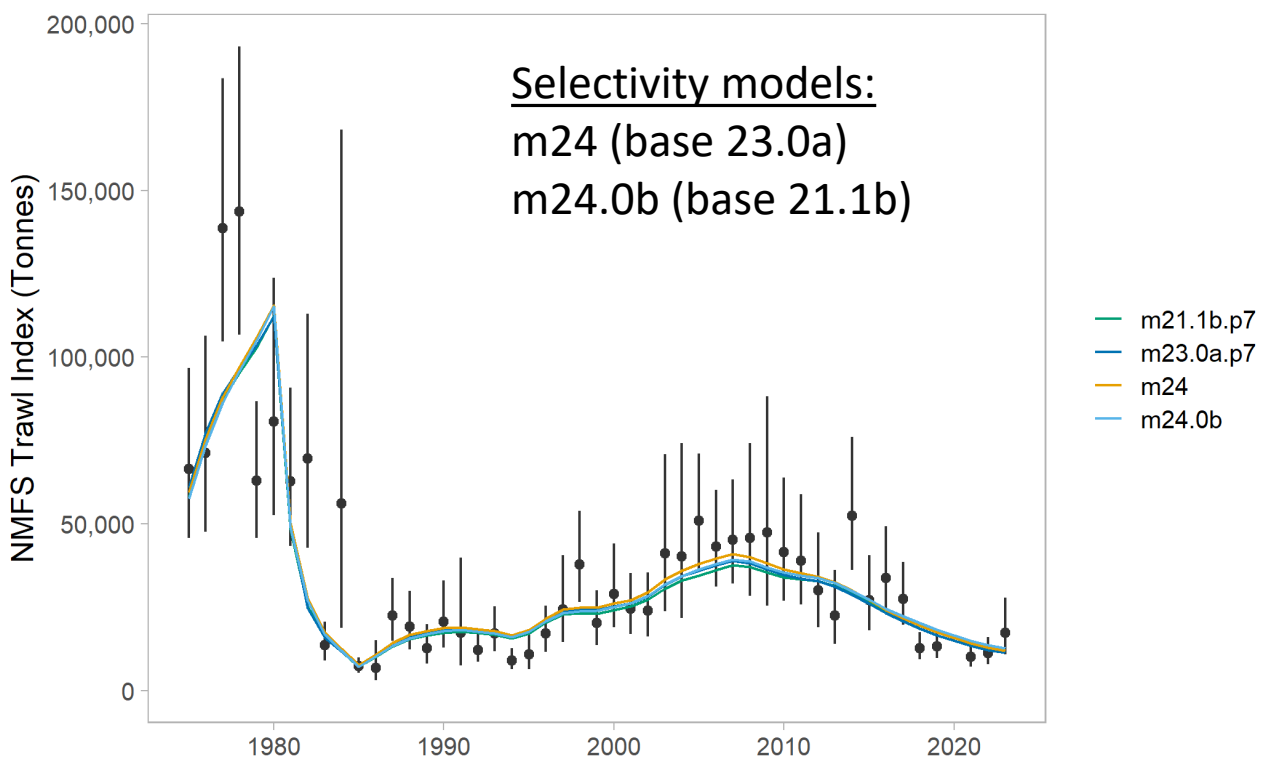
Model	Current MMB	$B_{35\%}$	MMB / B_{MSY}	$F_{35\%}$	F_{OFL}	OFL
23.0a (2023)	14.98	19.36	0.77	0.40	0.30	4.42
23.0a (p7 update)	14.32	18.51	0.77	0.40	0.30	4.42



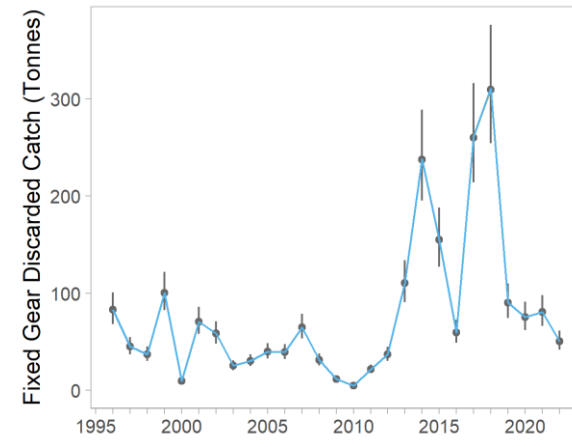
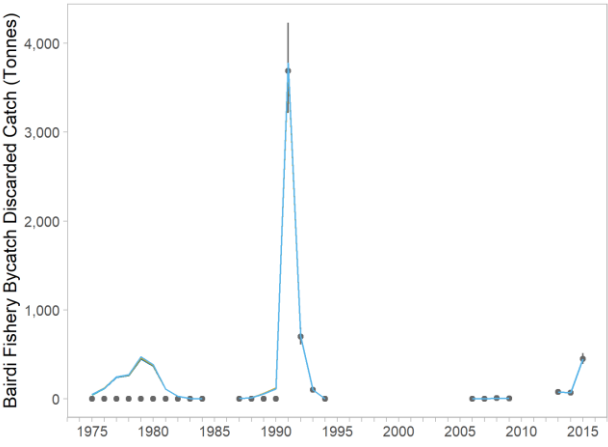
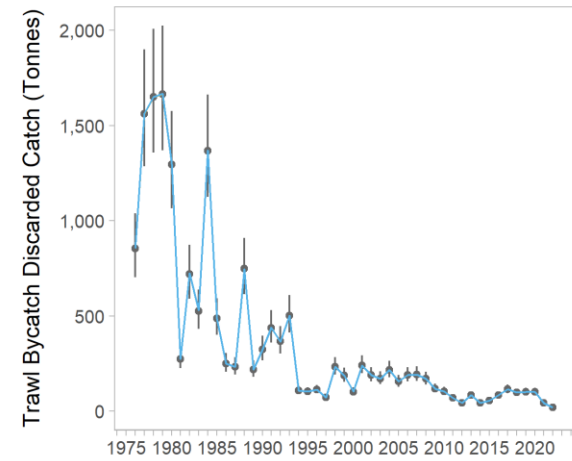
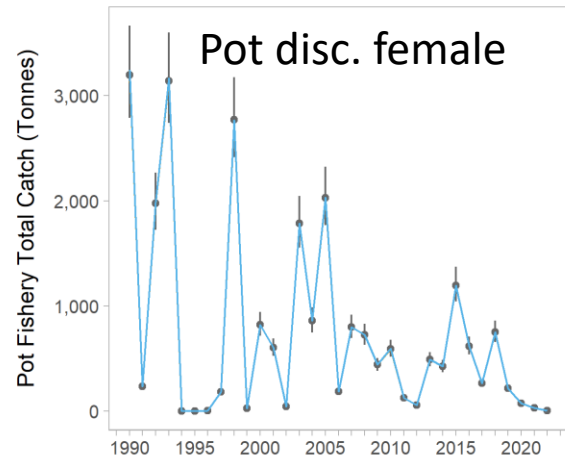
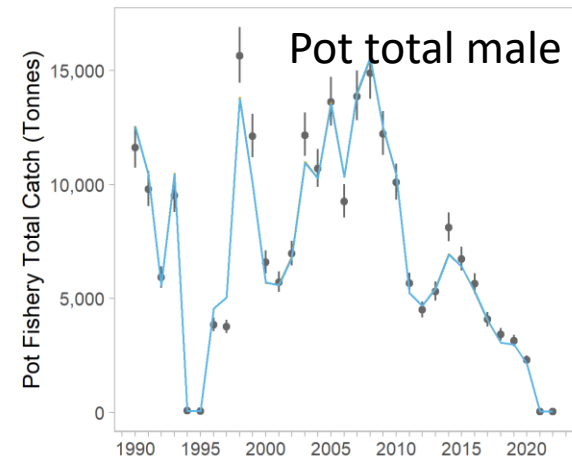
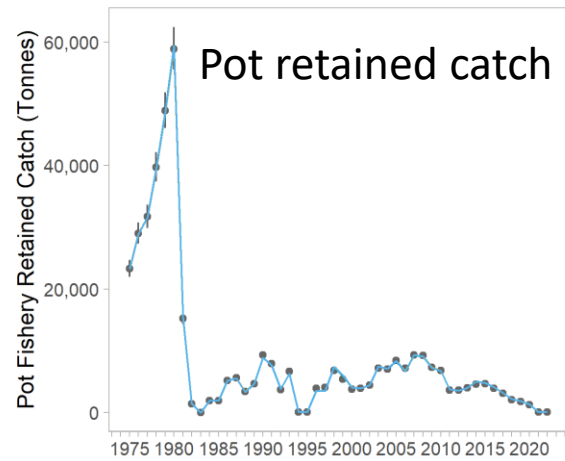
- Model fits to NMFS male trawl survey data are similar.

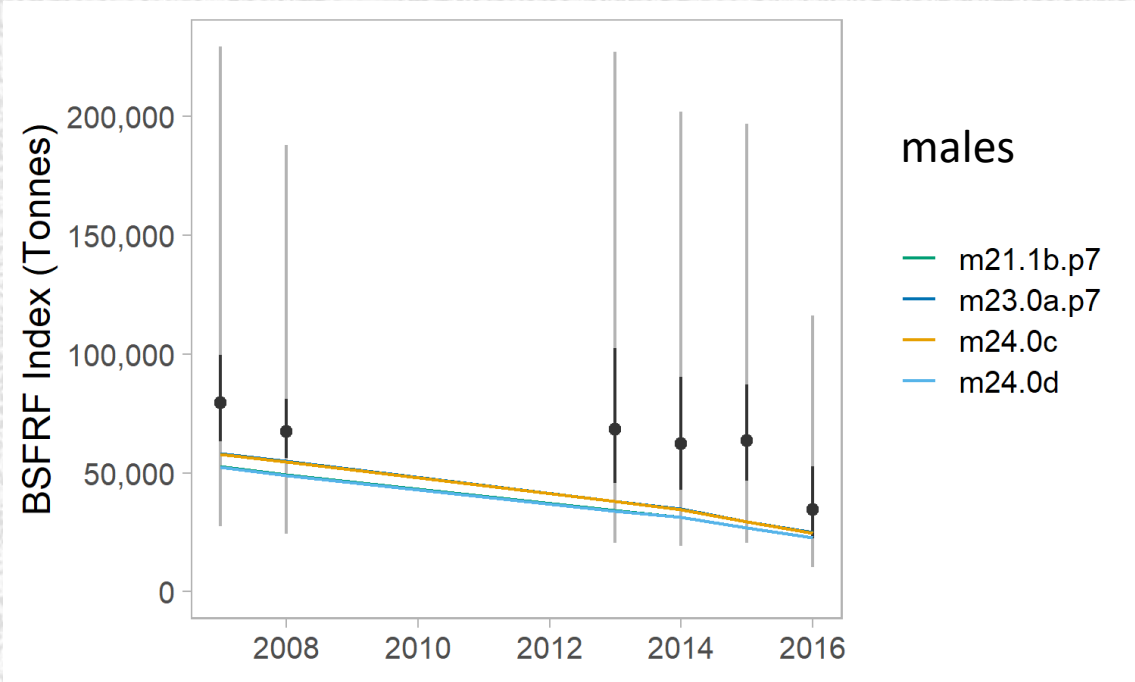


- Model fits to NMFS female trawl survey data.



Catch data fits



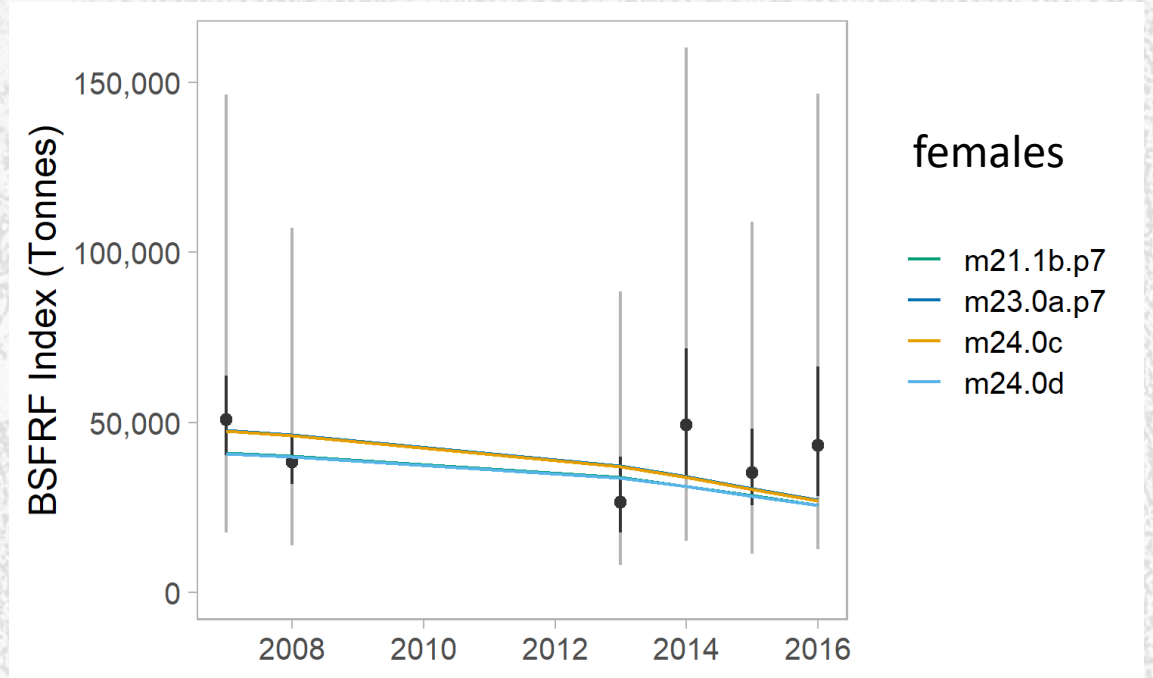


- Error bars show additional error
- BSFRF survey catchability is assumed to be 1.0
- Similar fits with change in molting probability time block

Molt probability models:

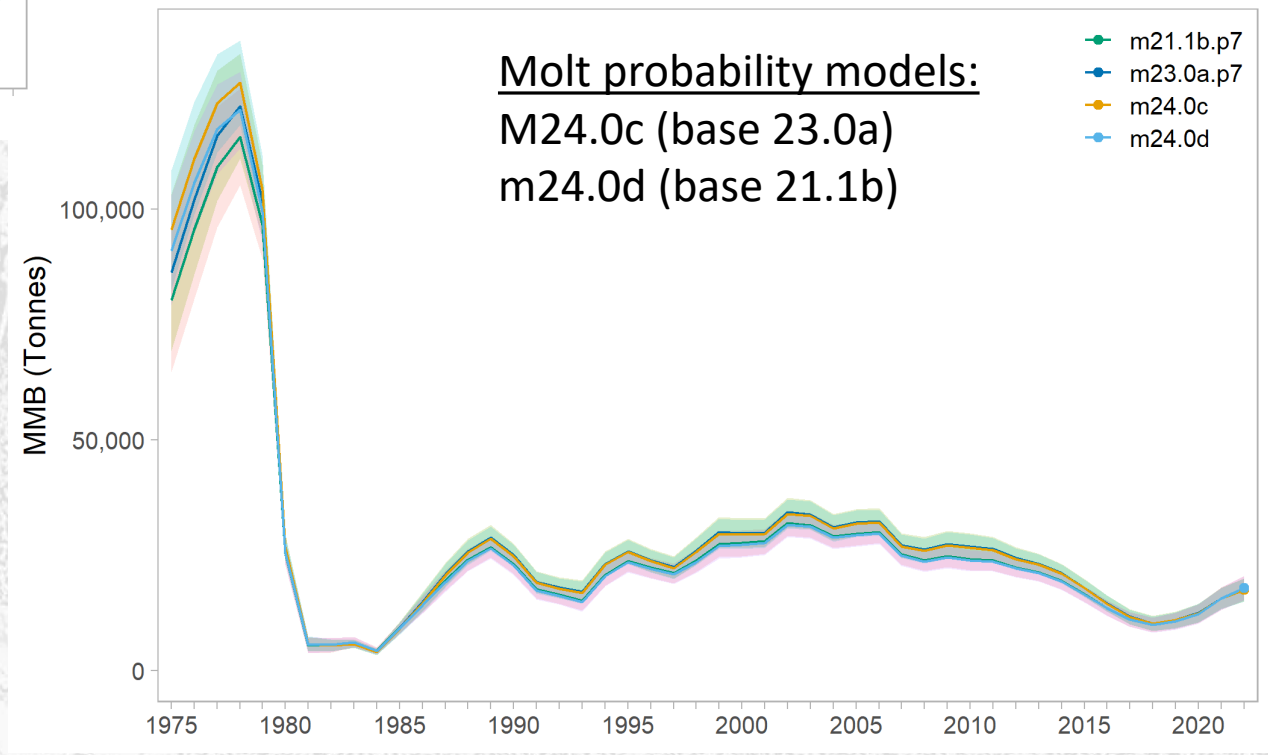
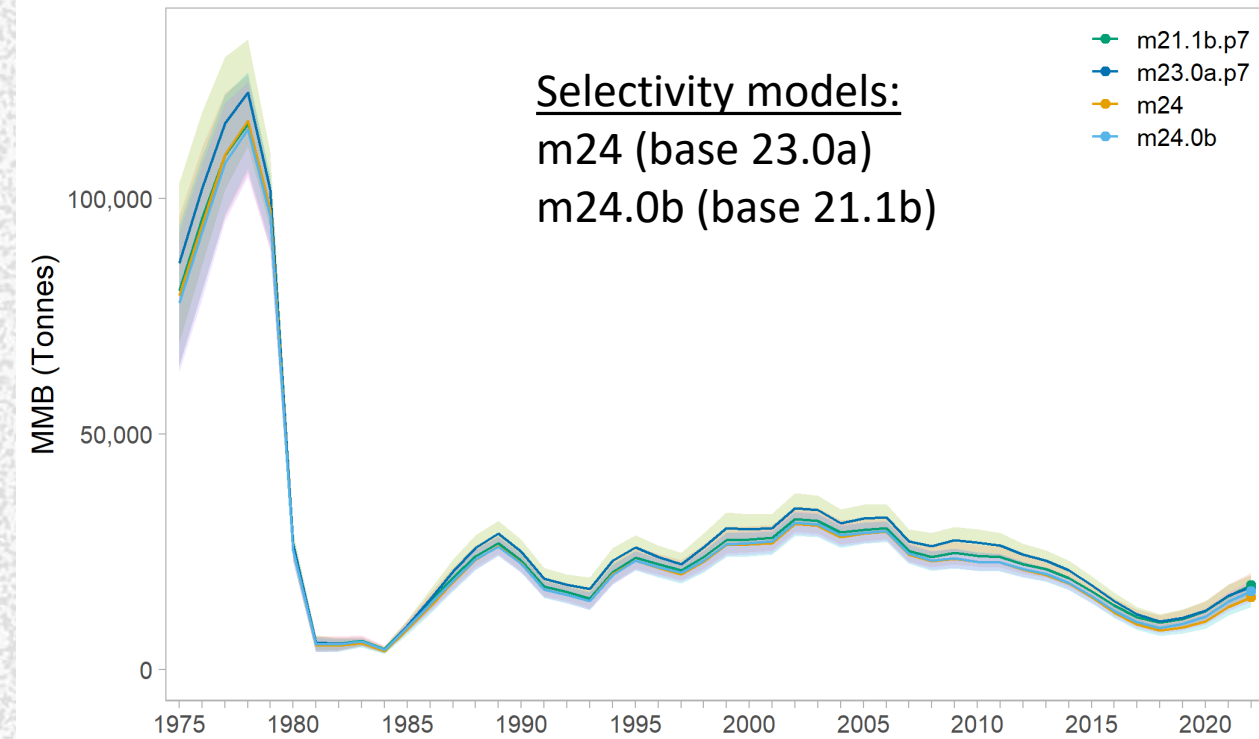
m24.0c (base 23.0a)

m24.0d (base 21.1b)



Mature male biomass

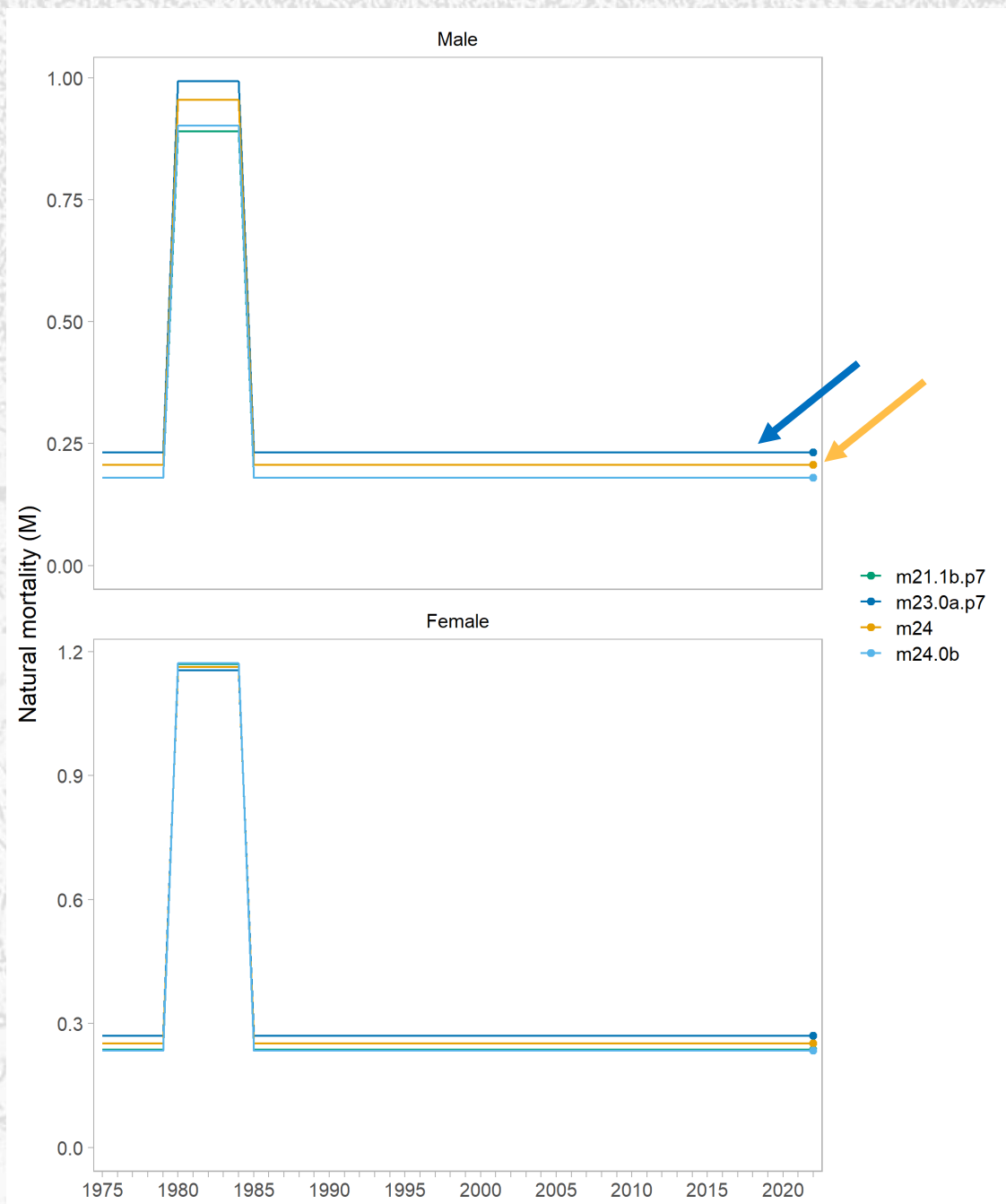
- selectivity model m24 more like models based on 21.1b
- molt models difference in early time period (expected)

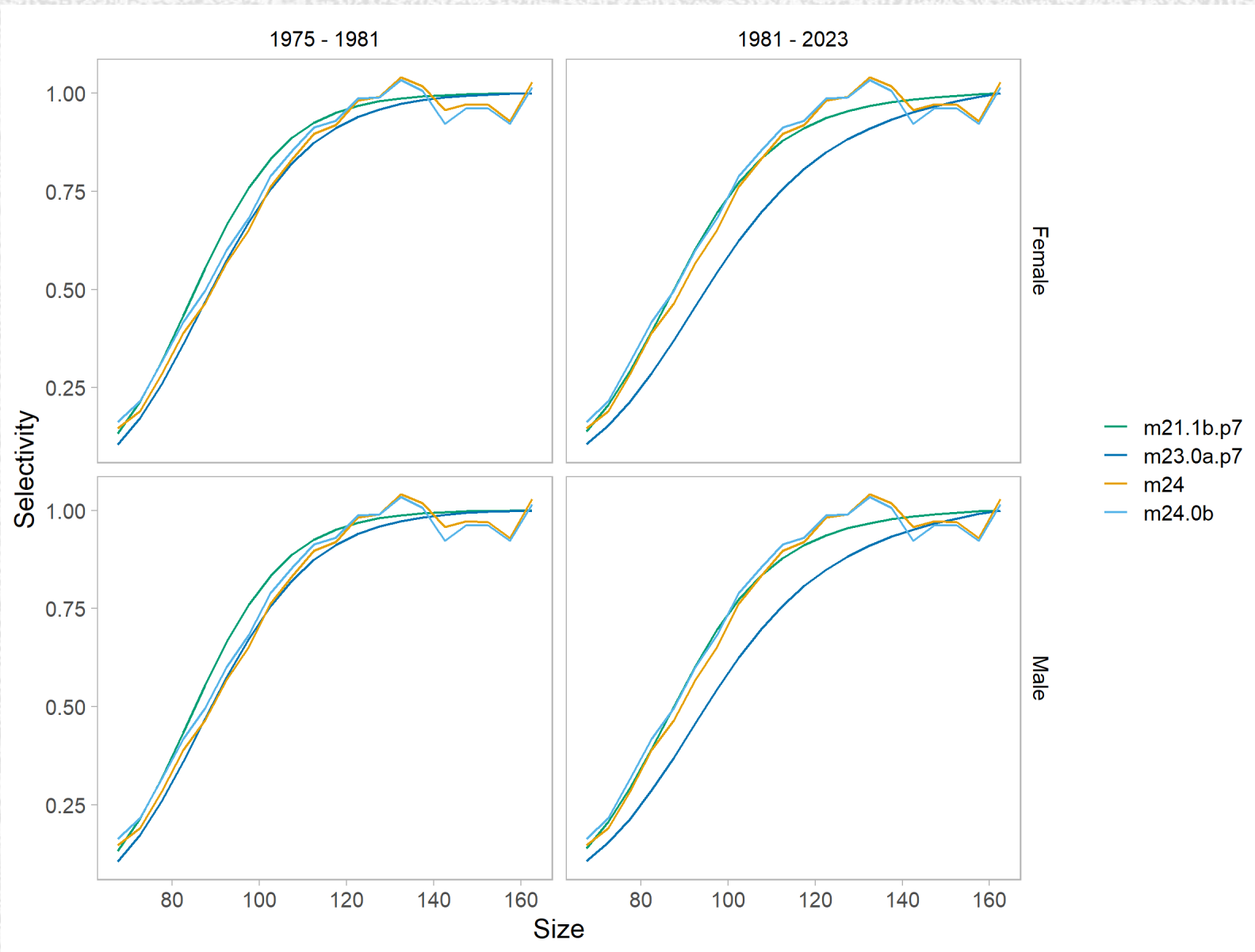


Natural Mortality

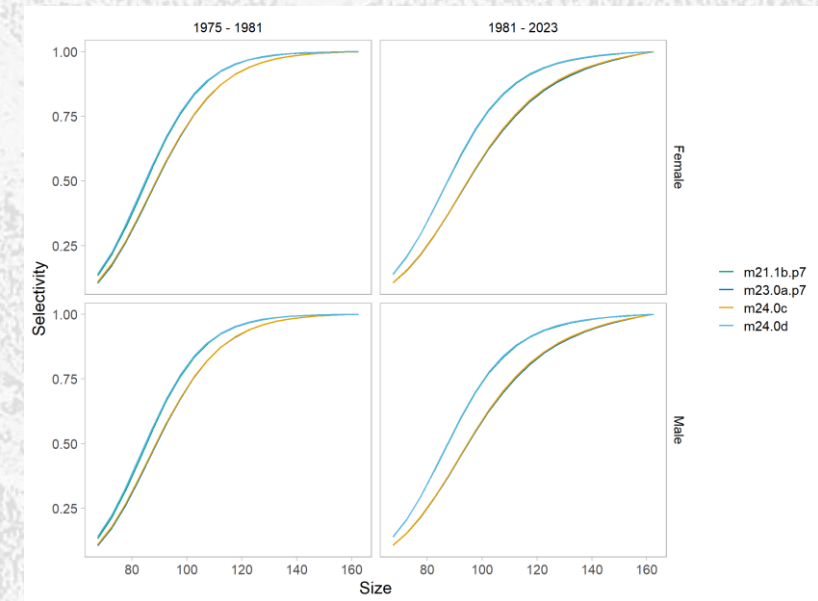
- No difference in molt models (not shown)
- Selectivity model (24.0) has lower estimated male M compared to model 23.0a

Model	Sex	baseM	1980-84
m21.1b	female	0.24	1.17
m21.1b	male	0.18	0.89
m21.1b.p7	female	0.24	1.17
m21.1b.p7	male	0.18	0.89
m23.0a	female	0.27	1.15
m23.0a	male	0.23	0.99
m23.0a.p7	female	0.27	1.15
m23.0a.p7	male	0.23	0.99
m24	female	0.25	1.17
m24	male	0.21	0.96
m24.0b	female	0.23	1.17
m24.0b	male	0.18	0.90
m24.0c	female	0.27	1.16
m24.0c	male	0.23	1.00
m24.0d	female	0.24	1.17
m24.0d	male	0.18	0.89



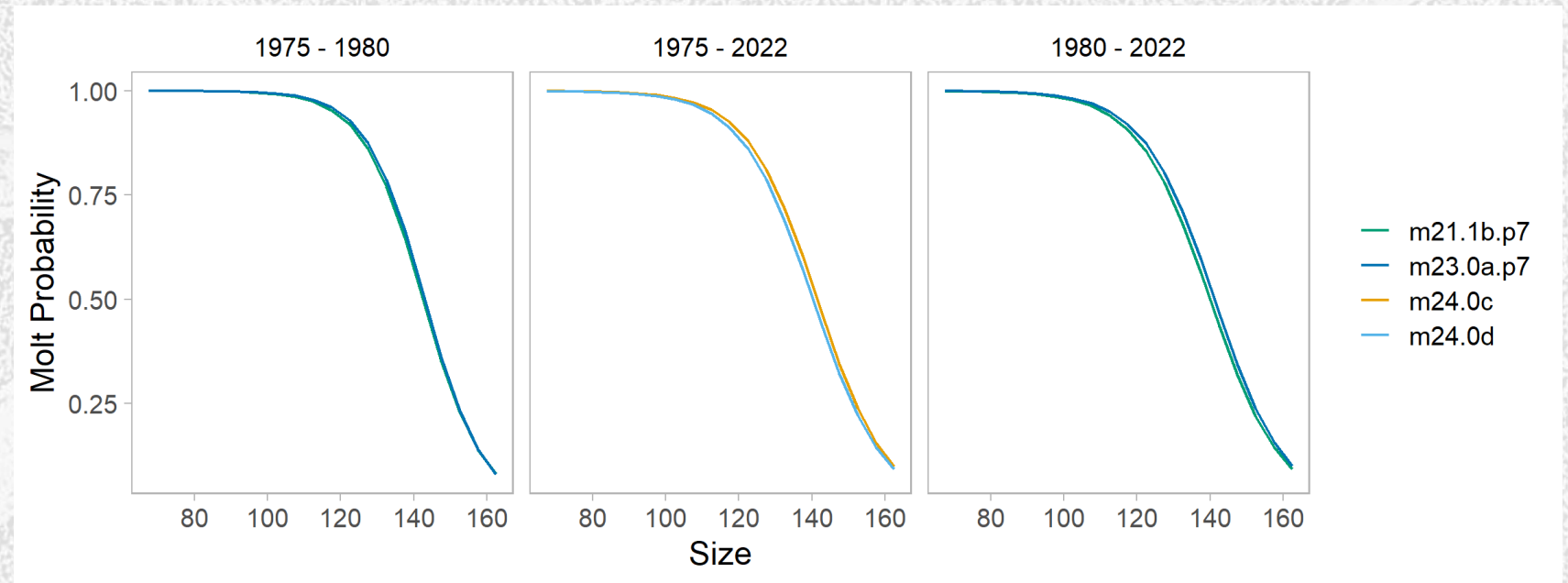


NMFS trawl survey selectivity: models with prior from BSFRF fit similarly to estimated selectivity in base model.



Molting probabilities

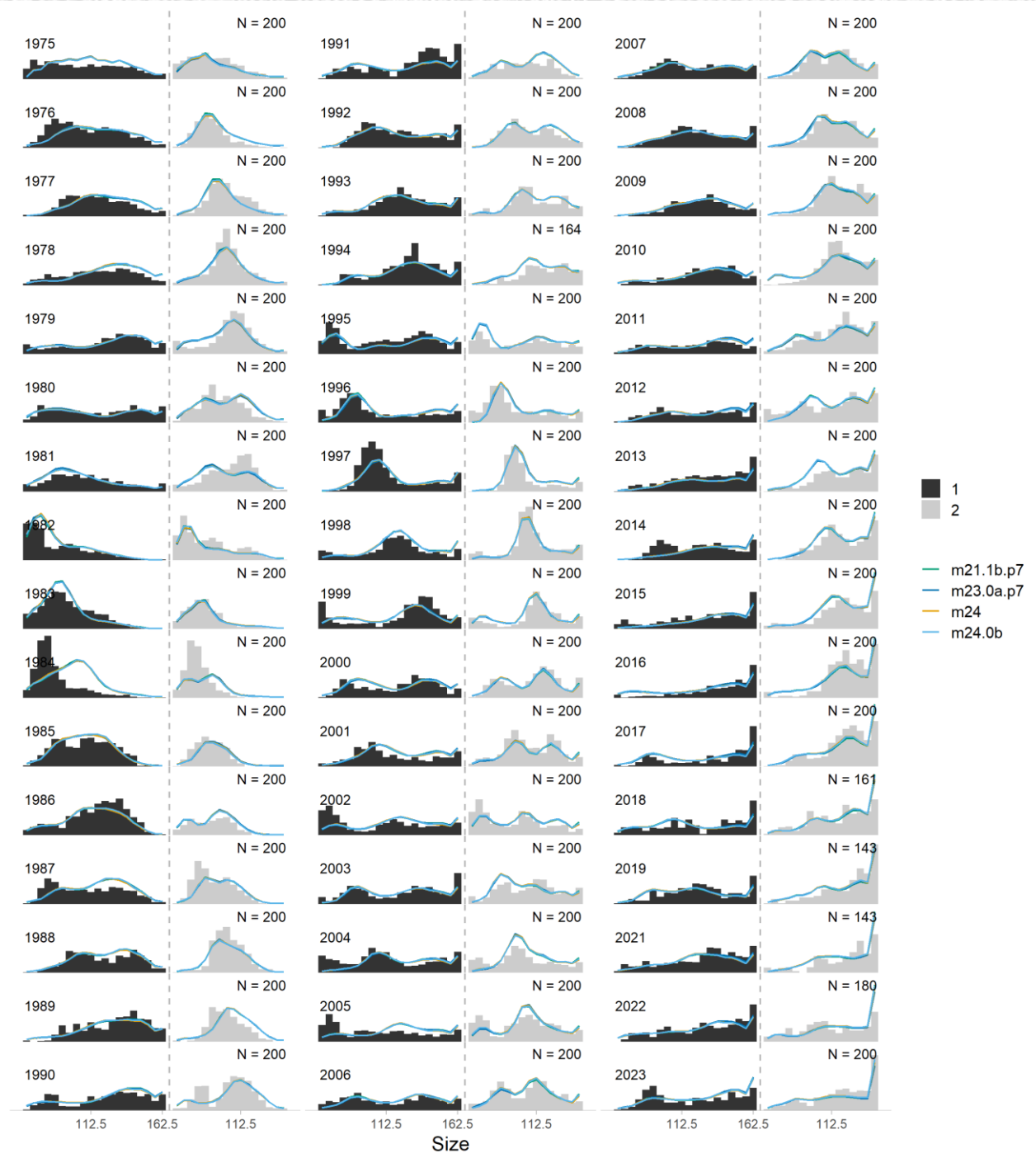
- Historic model has molting probability time block for 1975 to 1980.
- Model without this time block is nearly identical in output with 2 less parameters



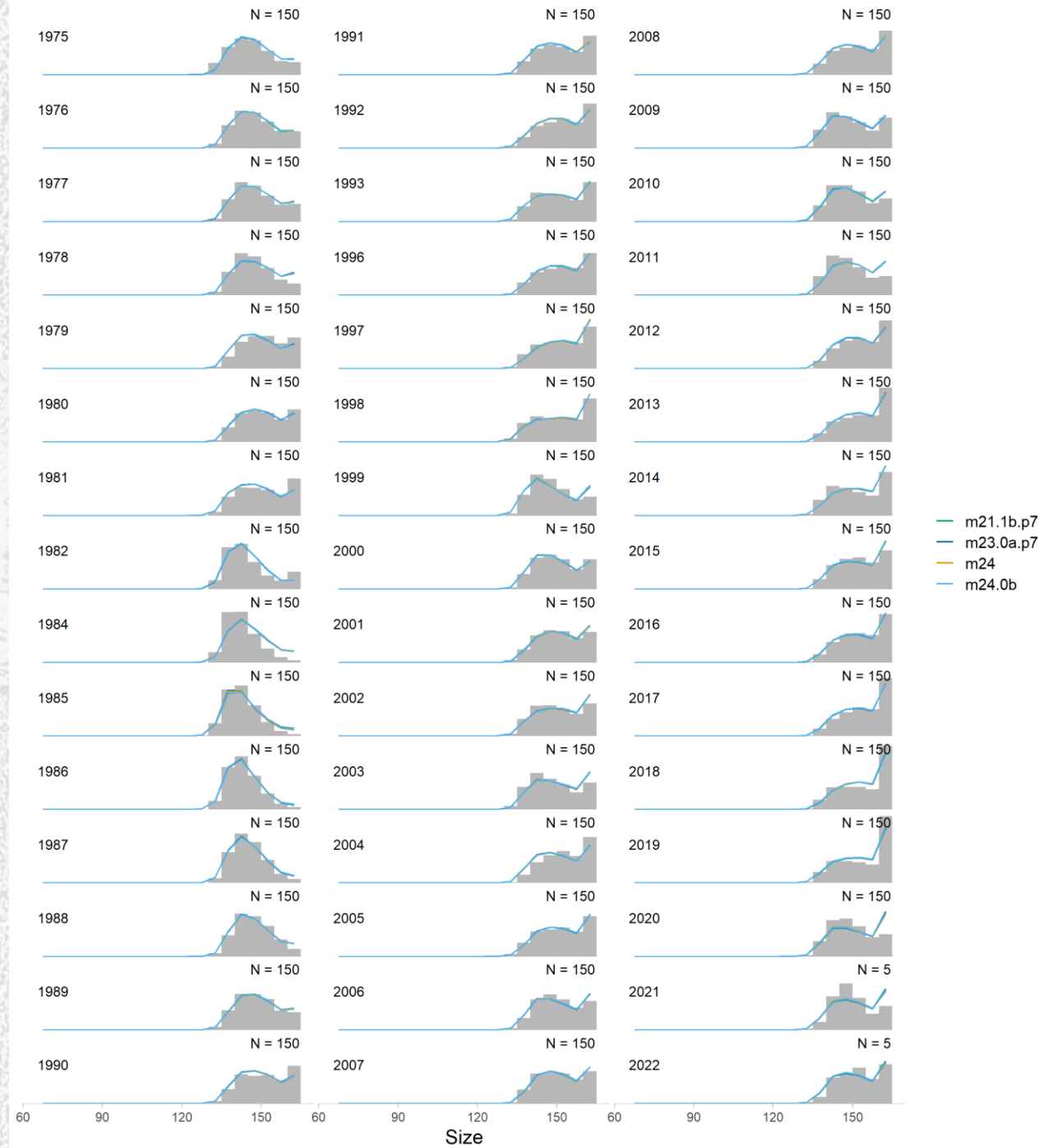
Size composition fit

- Similar for all models
- Models with higher M values fit NMFS size comps slightly better at higher sizes
- No change in fits without BSFRF data (models 24.0 and 24.0b)

NMFS trawl survey Males (1) and females (2)

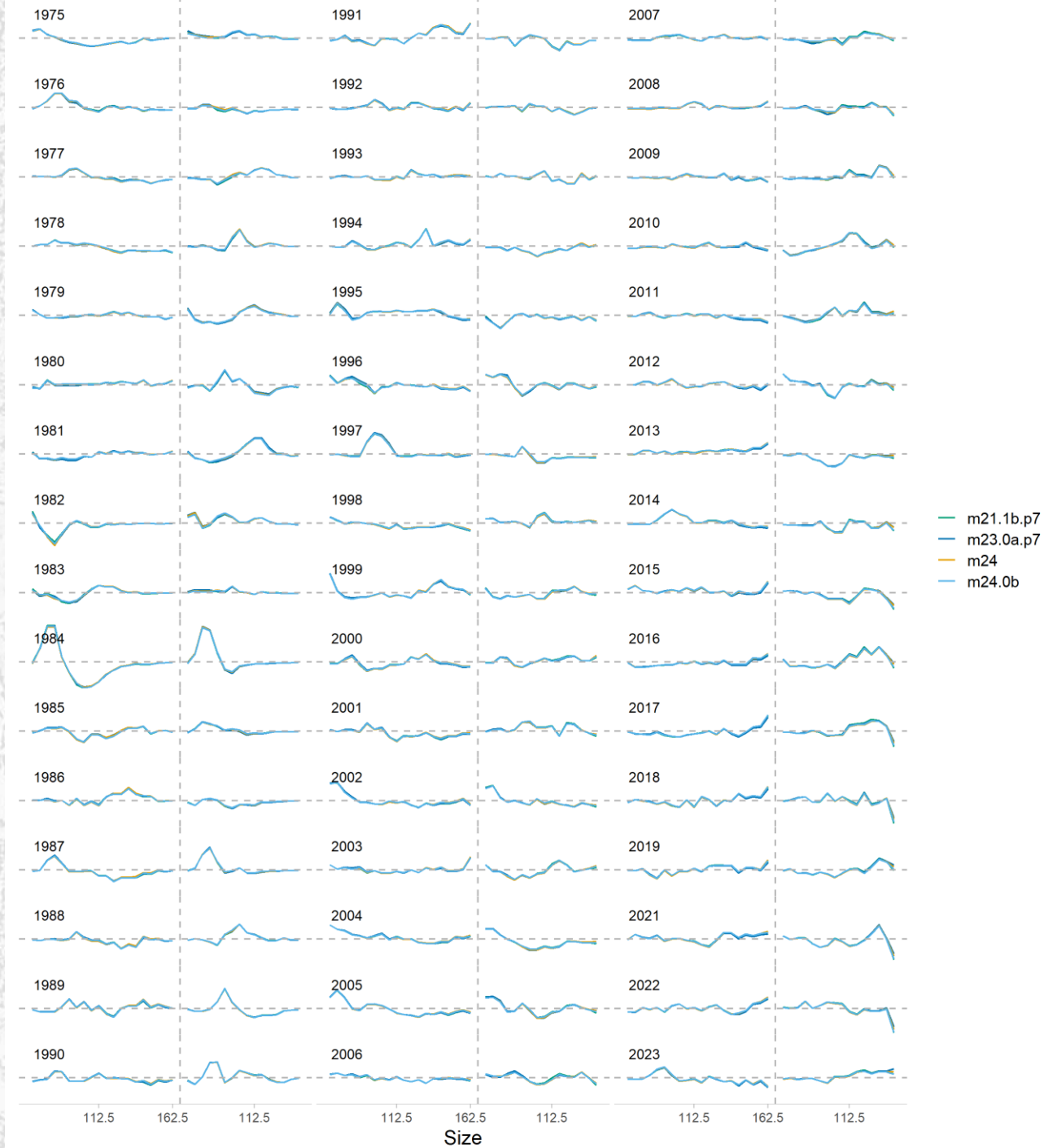
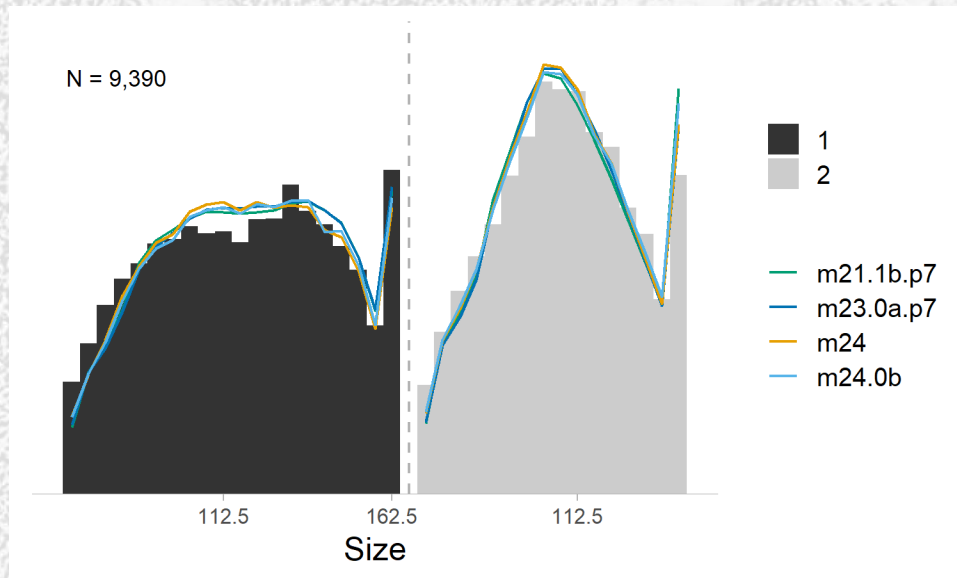


Directed Pot fishery retained

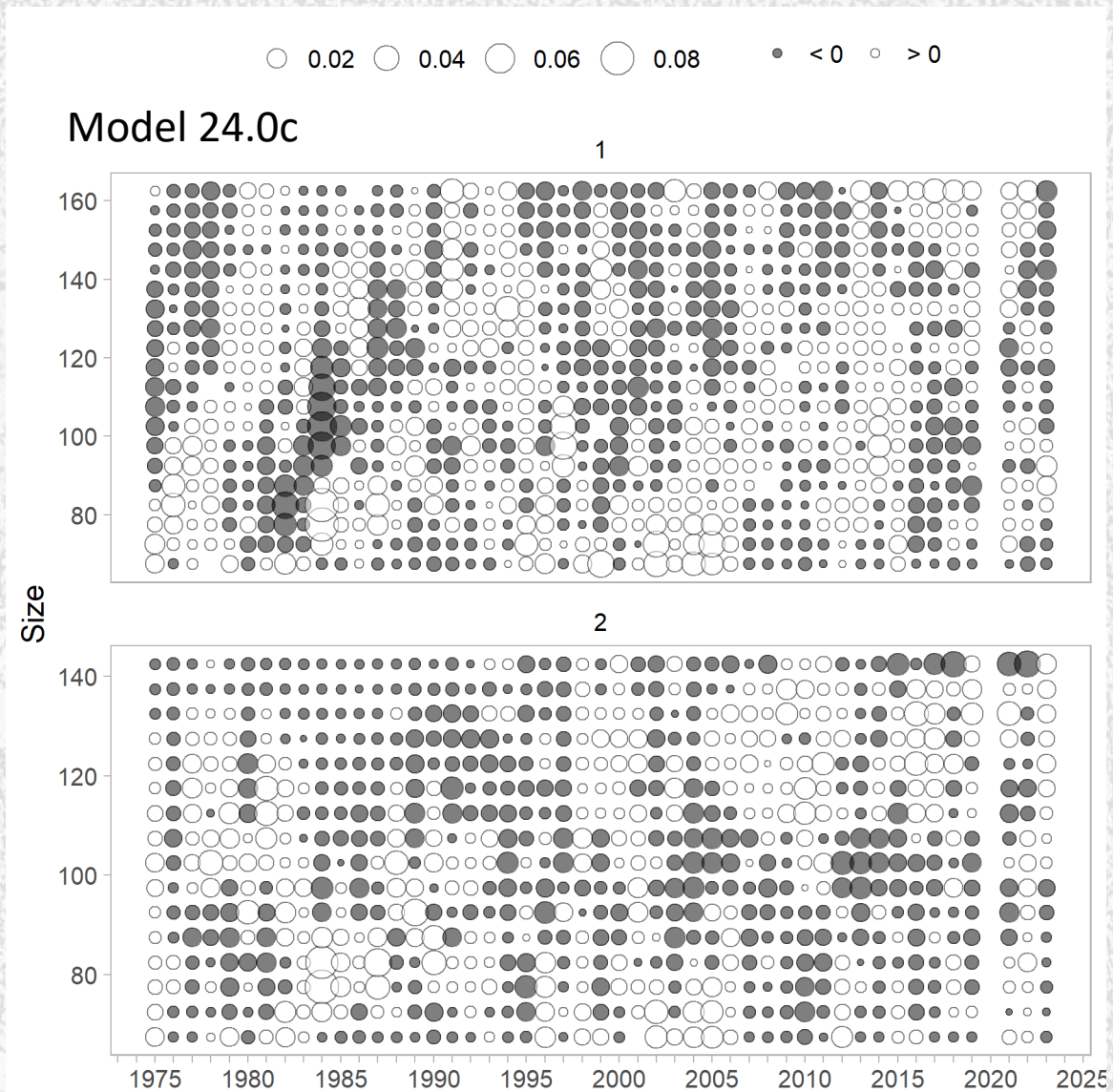
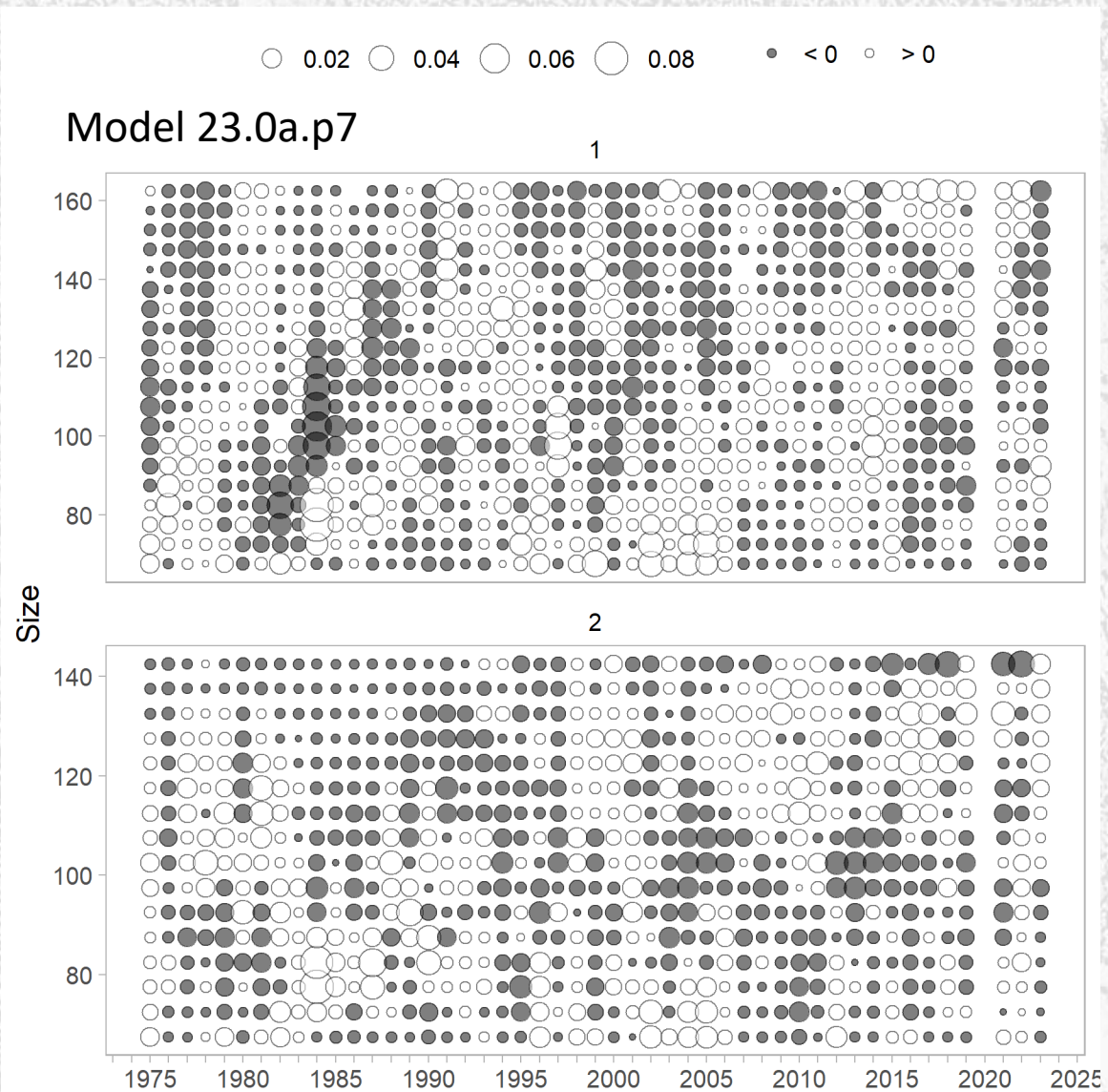


NMFS trawl survey

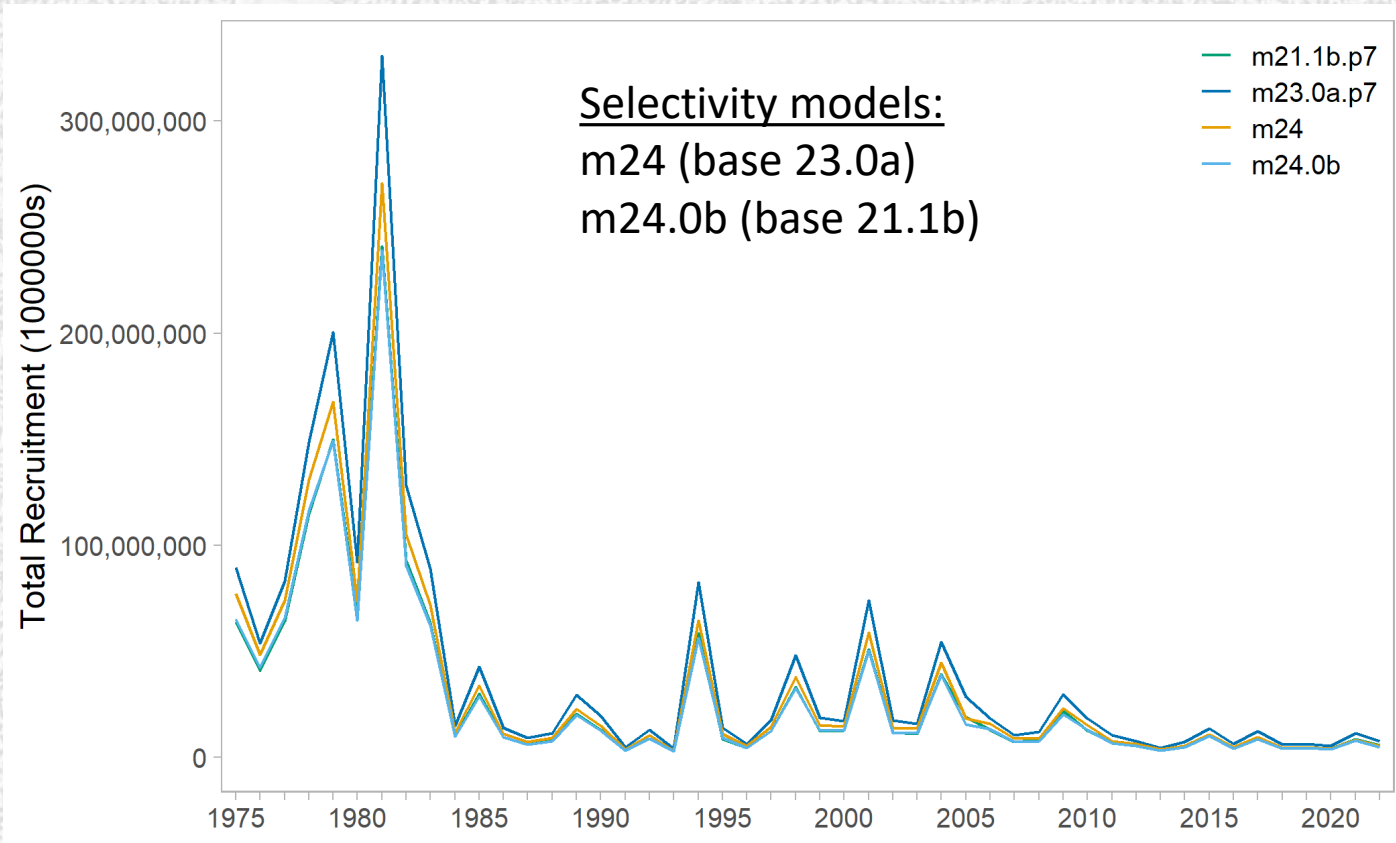
- Residual line plots
 - Dashed line (left- males, right – females)
- Aggregated size comp over all years



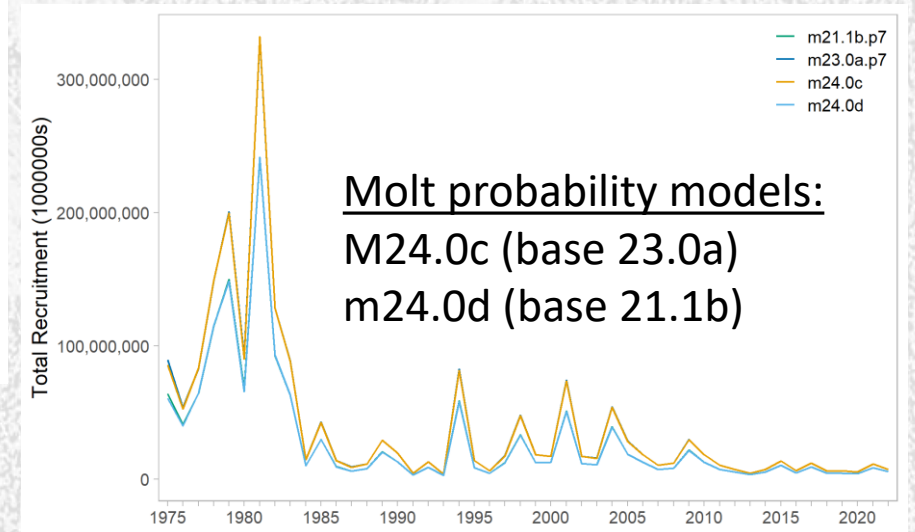
Comparison of residuals for NMFS survey males (1) and females (2)



Recruitment



- Selectivity models:
 - change in recruitment due to changes in male M.
- Molt models:
 - no difference as expected.



Highlighted cells show prior density values and total negative likelihood values. These are NOT all comparable due to parameter differences.

Table 4: Comparisons of negative log-likelihood values and some parameters for all model scenarios. Reference models are versions with MMB estimated in season 7.

Component	m23.0a(ref)	m24.0	m24.0c	m21.1b(ref)	m24.0b	m24.0d
Pot-ret-catch	-61.84	-63.46	-61.70	-60.77	-62.61	-60.64
Pot-totM-catch	27.75	26.09	27.73	28.49	26.88	28.41
Pot-F-discC	-57.45	-57.45	-57.45	-57.44	-57.44	-57.44
Trawl-discC	-65.14	-65.13	-65.14	-65.13	-65.13	-65.13
Tanner-M-discC	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54
Tanner-F-discC	-43.51	-43.49	-43.51	-43.48	-43.48	-43.48
Fixed-discC	-37.42	-37.42	-37.42	-37.42	-37.42	-37.42
Traw-suv-bio	-38.98	-40.22	-38.62	-37.28	-38.51	-36.85
BSFRF-sur-bio	-4.82		-4.72	-2.94		-2.83
Pot-ret-comp	-3998.15	-3995.34	-3996.07	-3991.77	-3993.03	-3988.77
Pot-totM-comp	-2444.35	-2446.78	-2444.54	-2443.63	-2446.17	-2443.85
Pot-discF-comp	-1494.87	-1493.04	-1494.88	-1493.90	-1492.87	-1493.92
Trawl-disc-comp	-5945.91	-5931.94	-5948.13	-5937.57	-5929.03	-5940.66
Tanner-disc-comp	-1276.68	-1275.78	-1276.73	-1274.30	-1273.78	-1274.35
Fixed-disc-comp	-3483.07	-3488.61	-3483.37	-3486.24	-3490.68	-3486.55
Trawl-sur-comp	-7137.97	-7143.71	-7135.96	-7130.66	-7141.80	-7127.86
BSFRF-sur-comp	-844.78		-844.80	-843.09		-843.15
Recruit-dev	73.83	75.27	73.66	72.95	74.02	72.73
Recruit-ini	0.00	0.00	0.00	0.00	0.00	0.00
Recruit-sex-R	78.50	78.50	78.52	78.49	78.52	78.52
M-deviation	40.42	42.23	40.52	43.92	44.29	44.05
Sex-specific-R	0.01	0.01	0.01	0.00	0.00	0.00
Ini-size-struct	33.58	32.91	33.13	30.82	31.30	30.19
PriorDensity	250.58	187.56	236.56	265.30	198.30	251.06
Tot-likelihood	-26473.80	-25683.34	-26486.44	-26429.18	-25662.17	-26441.47
Tot-parms	379.00	391.00	377.00	378.00	390.00	376.00
MMB35	18509.95	18757.79	18471.37	20973.44	20669.60	20947.76
MMB-terminal	14316.67	13353.26	14310.28	15915.19	15006.84	15930.92
F35	0.40	0.35	0.40	0.30	0.30	0.30
Fofl	0.30	0.24	0.30	0.22	0.21	0.22
OFL	4424.14	3226.77	4424.88	3522.29	3144.79	3530.48

Retrospective patterns (from fall 2023)

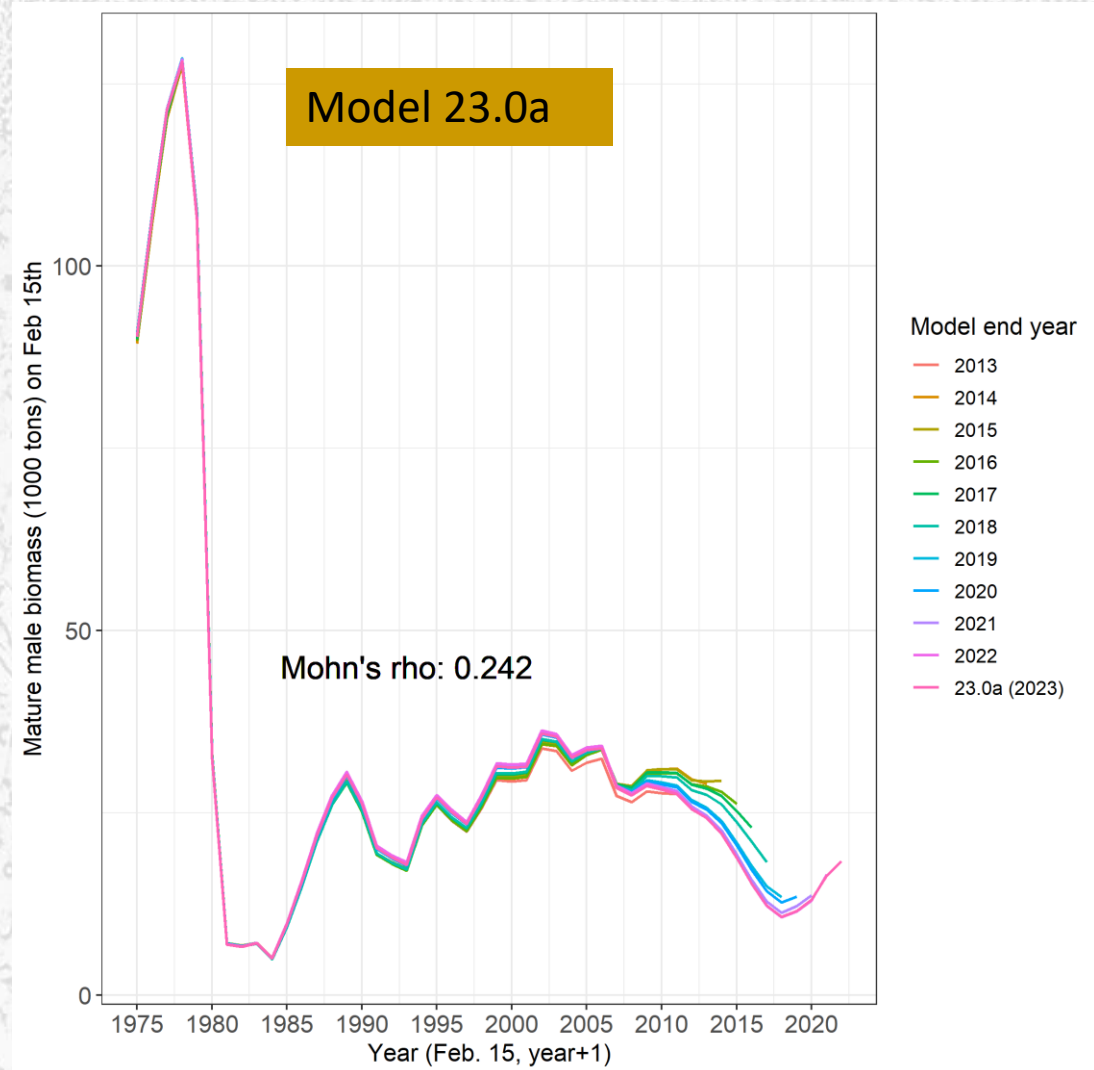
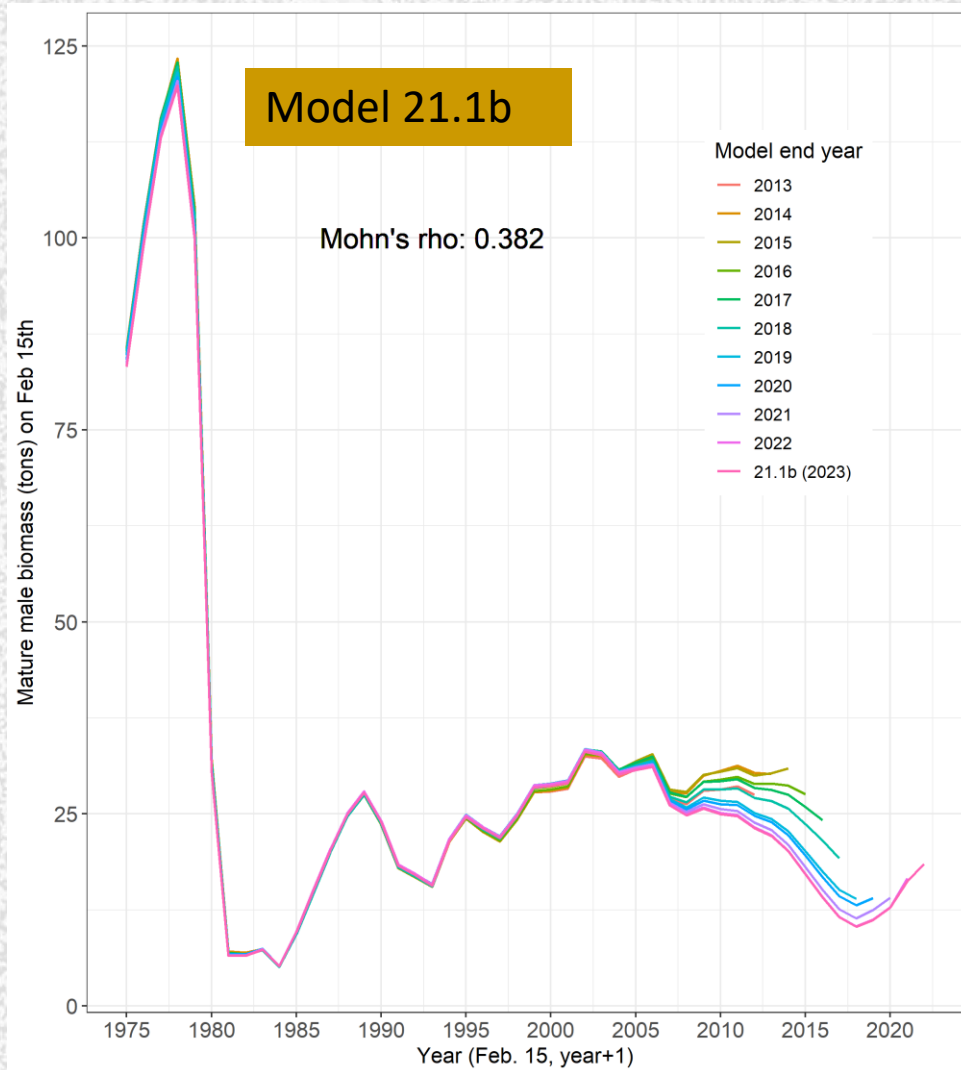






Table 2: Changes in management quantities for each scenario explored. Report quantities are derived from maximum likelihood estimates. Average recruitment is males and females combined in millions of animals.

Model		Current MMB	B35	F35	F_{OFL}	OFL	avg male rec
m21.1b		16.48	21.72	0.30	0.22	3.52	6.98
 m21.1b.p7		15.92	20.97	0.30	0.22	3.52	6.98
m24.0b	selectivity	15.01	20.67	0.30	0.21	3.14	6.82
m24.0d	molt	15.93	20.95	0.30	0.22	3.53	6.96
m23.0a		14.98	19.36	0.40	0.30	4.42	9.89
 m23.0a.p7		14.32	18.51	0.40	0.30	4.42	9.89
m24	selectivity	13.35	18.76	0.35	0.24	3.23	7.95
m24.0c	molt	14.31	18.47	0.40	0.30	4.42	9.85

 Molt model similar

 Molt model similar

Summary and Recommendations

- Model 23.0a.p7 represents updated base – GMACS updates and changes to season for MMB calculation (also model 21.1b.p7)
- Reducing the molting time blocks to 1 period simplifies model and reduces parameters estimated without a measurable difference.
- Estimating M results in higher M for males but also reduced retrospective pattern (Mohn's rho reduced from 0.373 to 0.226)
- Recommendations:
 - Base model 23.0a (with corrections in .p7 version, estimated male M)
 - Model 24.0c – model 23.0a with reduced time block for molt probability
 - Should we keep the model 21.1b (historic base, fixed male M) options also?
 - Tier 4 option from 2023 (REMA model on mature males in NMFS survey data) will be brought forward in Sept.

Future work

- Selectivity explorations – potentially dome shaped? Other suggestions?
- Initial conditions – explorations on these and suggestions for what to look at
- Sensitivity of model to growth / size increment assumptions
 - Conversations on biology side, determining best strategy for model options
- Focus on retrospective pattern
- Other work: review female biomass threshold in state harvest strategy and established spawner-recruit relationship



Questions?