Bristol Bay red king crab

Proposed models for 2025

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Summary

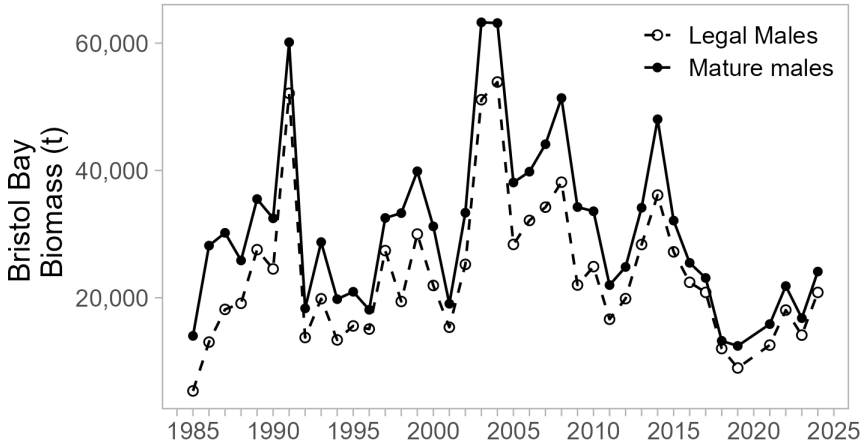
- Stable model in GMACS since 2018
- Directed fishery was open the last two seasons (2024/25, 2023/24) after being closed for 2 seasons (2021/22, 2022/23) due to low mature female abundance
- 2024/2025 fishery CPUE above last ten-year average
- Recruitment has been low in recent years (last ~15 years), projected decline in biomass without a large recruitment event/ favorable recruitment conditions
- Model explorations around a few themes:
  - GMACS updates, model simplicities, and bycatch mortality in fixed gear groundfish.
  - Selectivity estimation using BSFRF data as a prior for NMFS survey

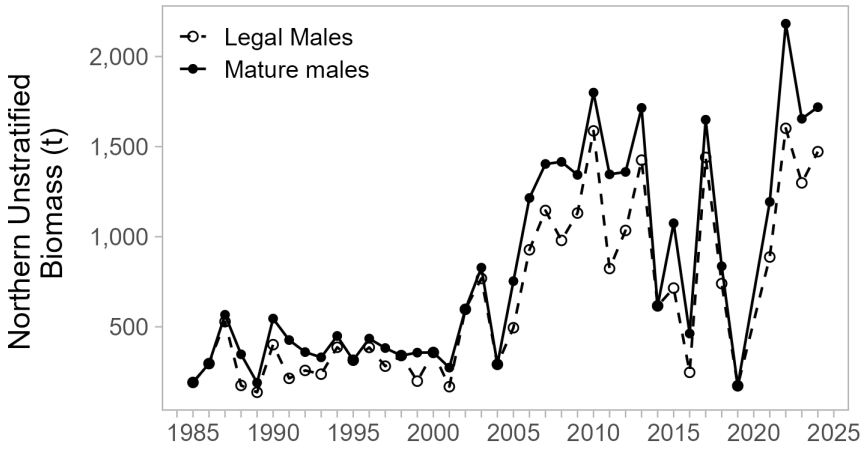
CPT / SSC comments

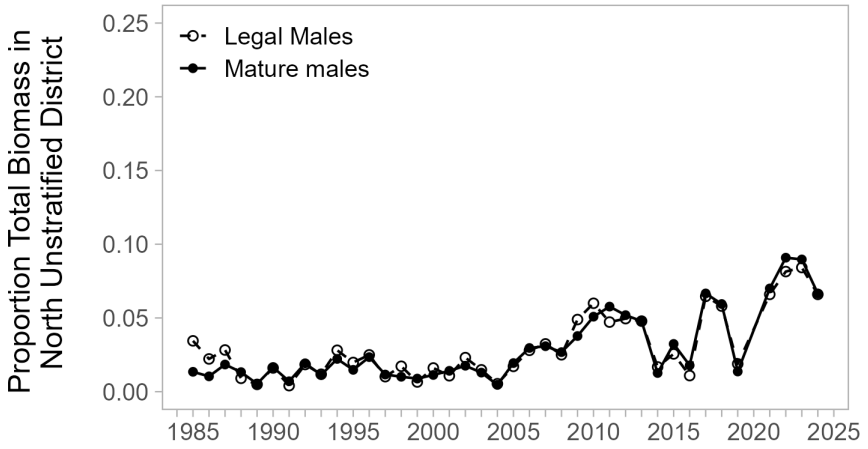
- Housekeeping comments
  - Diagnostic figures, OSA residuals, removing shell condition placeholders, etc.
- Northern area RKC – review of stats presented in SAFE, future work?
- Size composition plus group expansion – build up of larger sizes?
- Survey selectivity
  - Inferred selectivity from BSFRF as a prior on selectivity for NMFS survey (25.1a, 1b, 1b2 here), with historic time blocks
- Fixed gear groundfish handling mortality (20% vs. historic 50% - model 24.0c.1a)
- Retrospective patterns
  - High priority on source of these, but unable to unearth the cause yet
  - Decreases some with estimated M (adopted in 2023)
- Other comment themes not yet addressed: initial conditions, VAST, re-do M likelihood profile, growth parameters and size bins increases

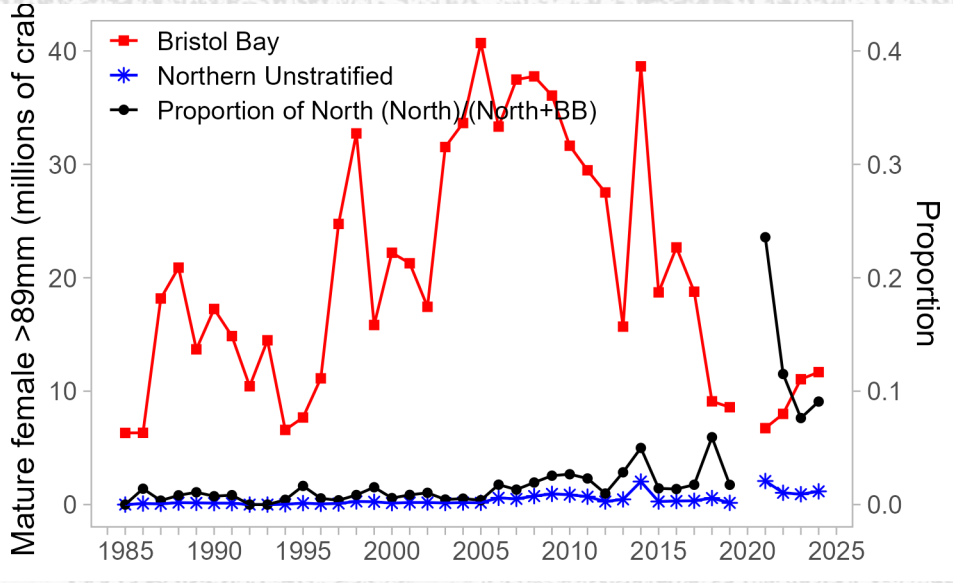
Northern area red king crab

- Tracking survey biomass in annual SAFE document
- Males – variable since ~2007
- Mature females – proportionally more the last few years?
- Are these crab part of the reproductive stock in Bristol Bay?
- Next steps:
  - Model based indices that can include these crab in prediction grid?



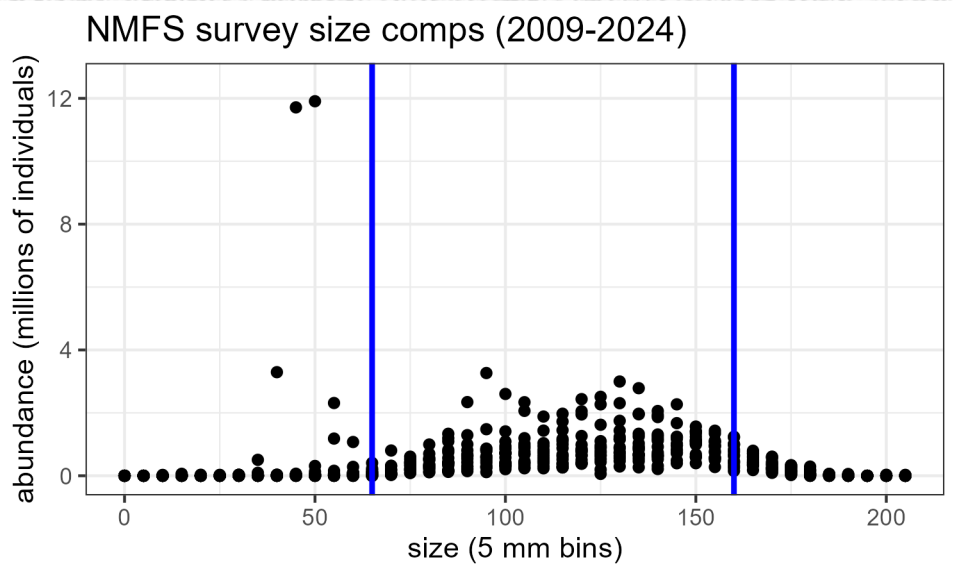


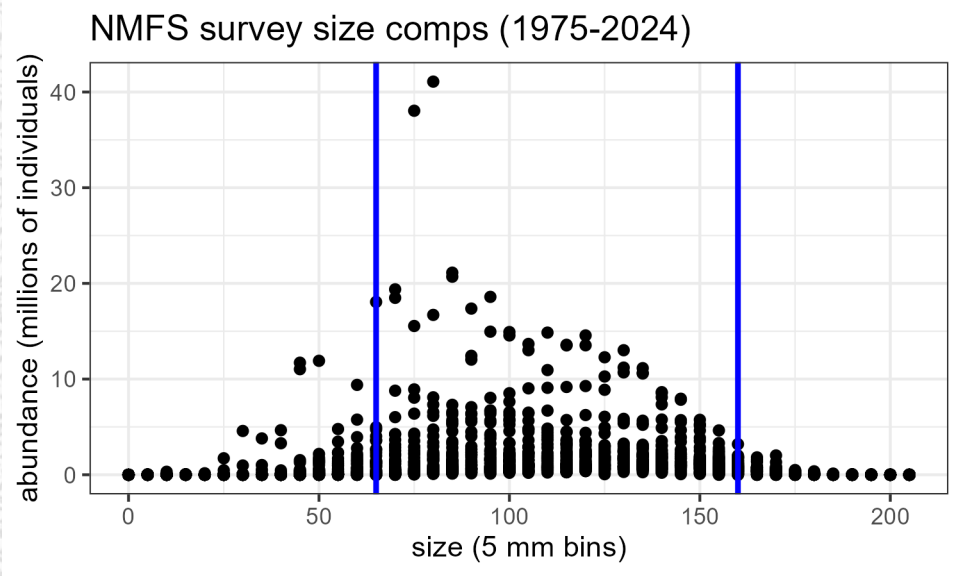


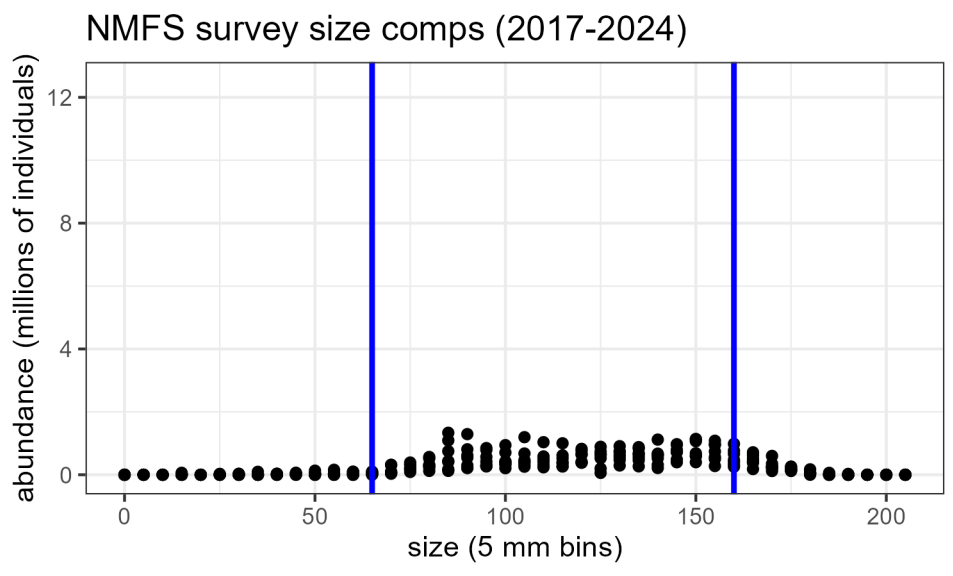


Size bins - males

- Size bins in model do capture the majority of crab (all years of survey data)
- Recent years have less recruitment and potentially larger individuals.

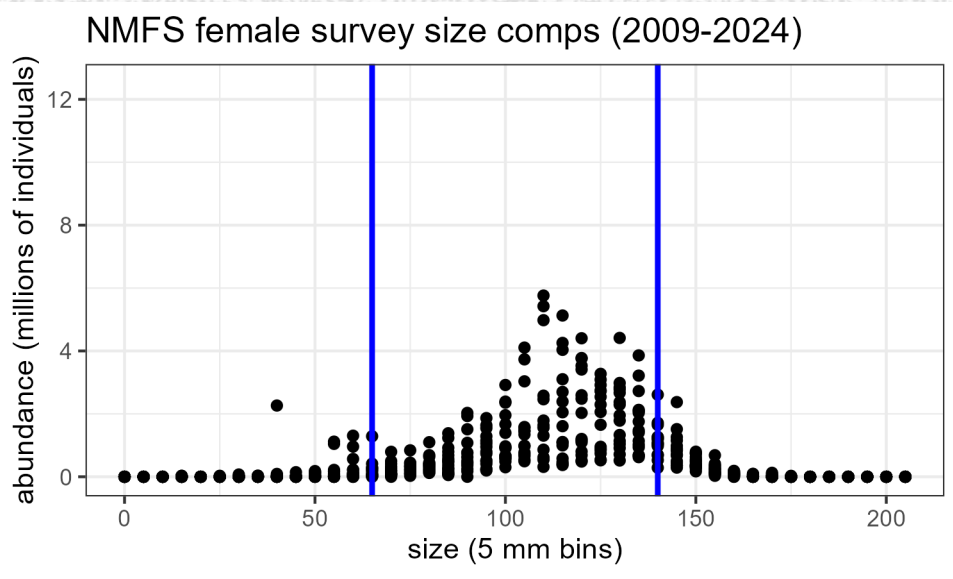


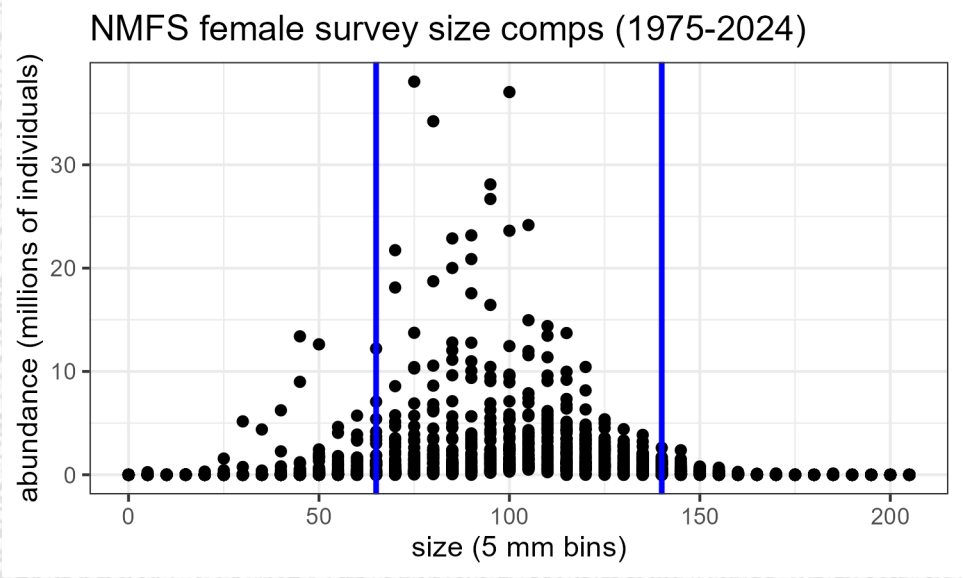


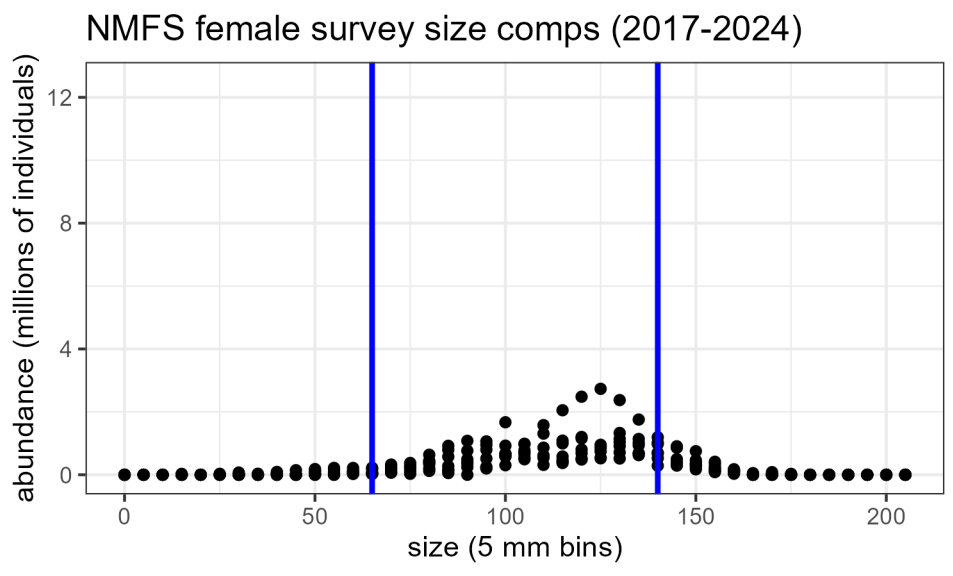


Size bins - females

- Females are a different story….
- Size bins in model do capture the majority of crab (all years of survey data)
- Recent years show potential shift in distribution.
- High priority for 2026

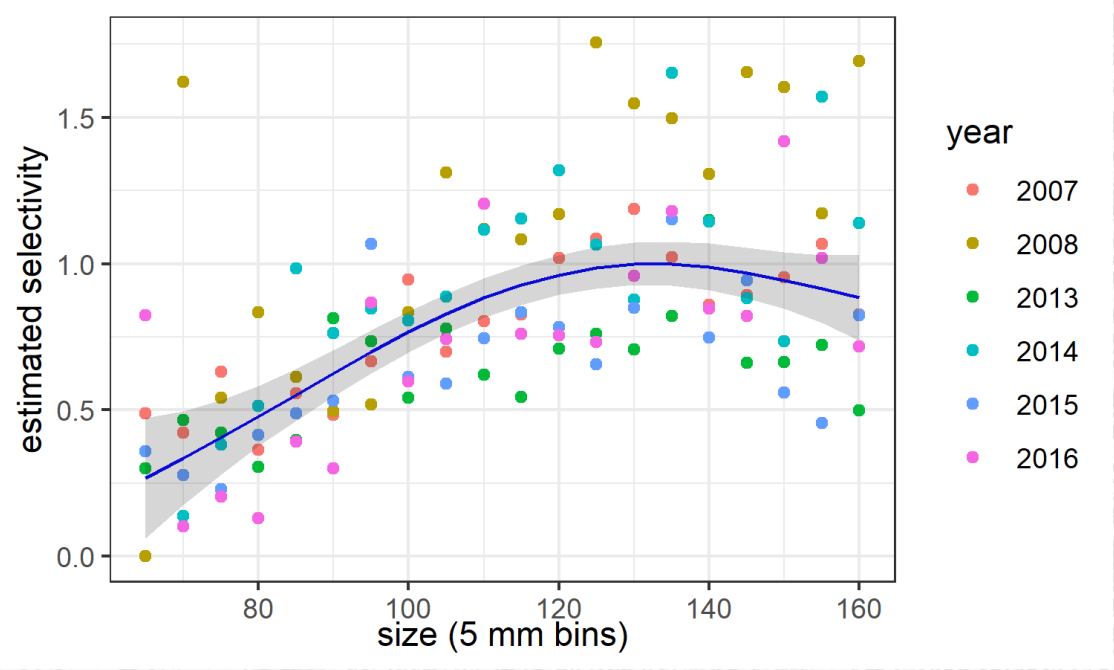


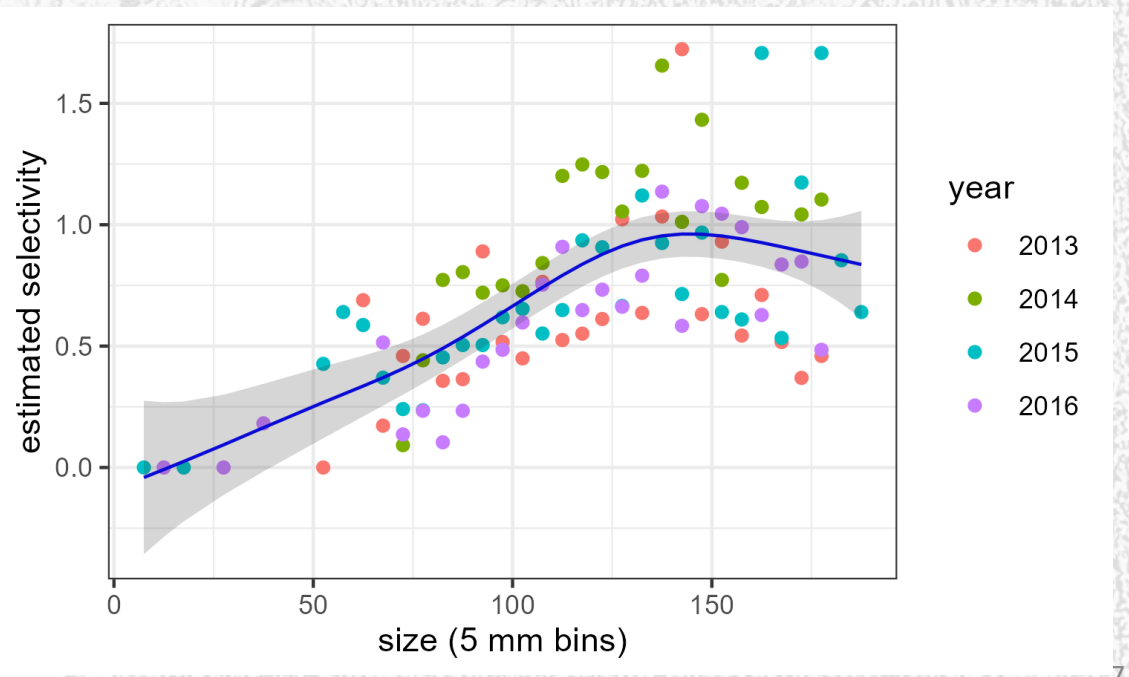




Selectivity

- Two subsets of BSFRF data
  - All years (top)
  - 4 years with side-by-side data (bottom)
- Inferred selectivity assumes BSFRF selectivity = 1
- Males and females combined
- Dome shaped?
- Changes to higher size bins?
  - Due to selectivity shape or large size build up?





Handling mortality rates – from 2010 report

- Includes immediate mortality and long-term mortality from gear interactions and handle time/conditions
- Directed BBRKC fishery – 20%
- Tanner fishery (bycatch) – 25 %
- Groundfish
  - Fixed gear – 50%
    - No direct research studies conducted
    - Historically (since 2008)
  - Trawl – 80%
    - Primarily based on Stevens (1990)

2025 Model explorations

24.0c: the base model from September 2024 (estimates a constant *M* for males with tight prior, molt time block removed) + **updated version of GMACS**

24.0c.1: model 24.0c + updated catch time series for crab fisheries via ADF&G

24.0c.1a: model 24.0c.1 + 20% handling mortality for fixed gear groundfish bycatch

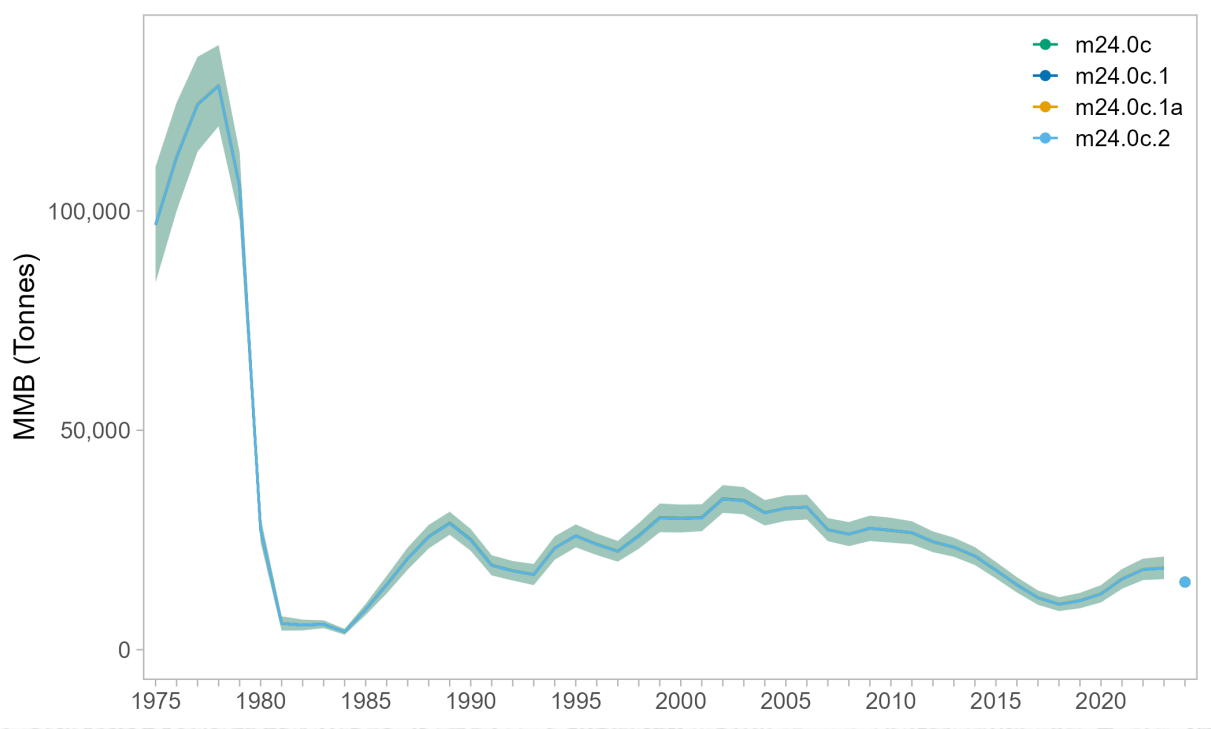
24.0c.2: model 24.0c.1 + removal of shell condition placeholders from input files

25.1a: model 24.0c.2 (updated base model) – BSFRF data + prior on NMFS selectivity based on all BSFRF data

25.1b: model 24.0c.2 (updated base model) – BSFRF data + prior on NMFS selectivity based on side-by-side subset of BSFRF data

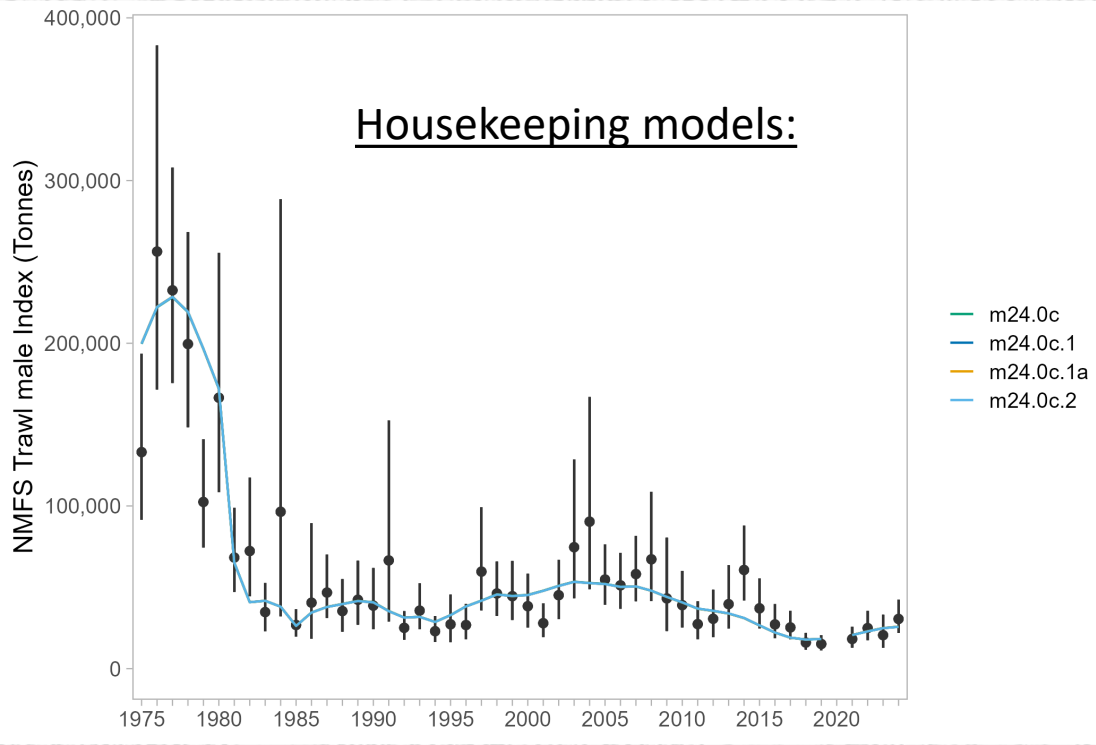
25.1b2: model 24.0c.2 (updated base model) – BSFRF data + prior on NMFS selectivity based on side-by-side subset of BSFRF data with 2x variability on prior

Update models (24 series)

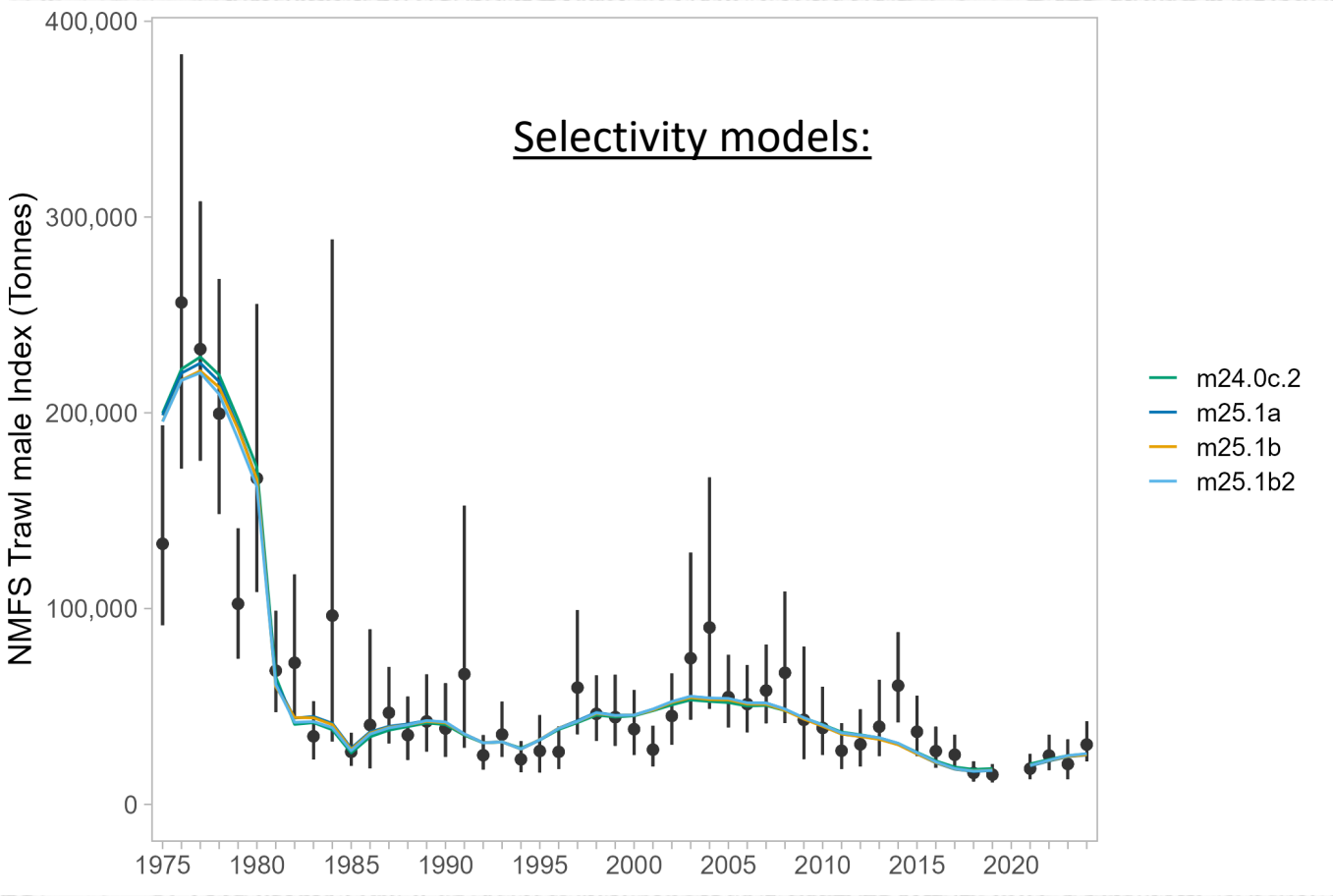


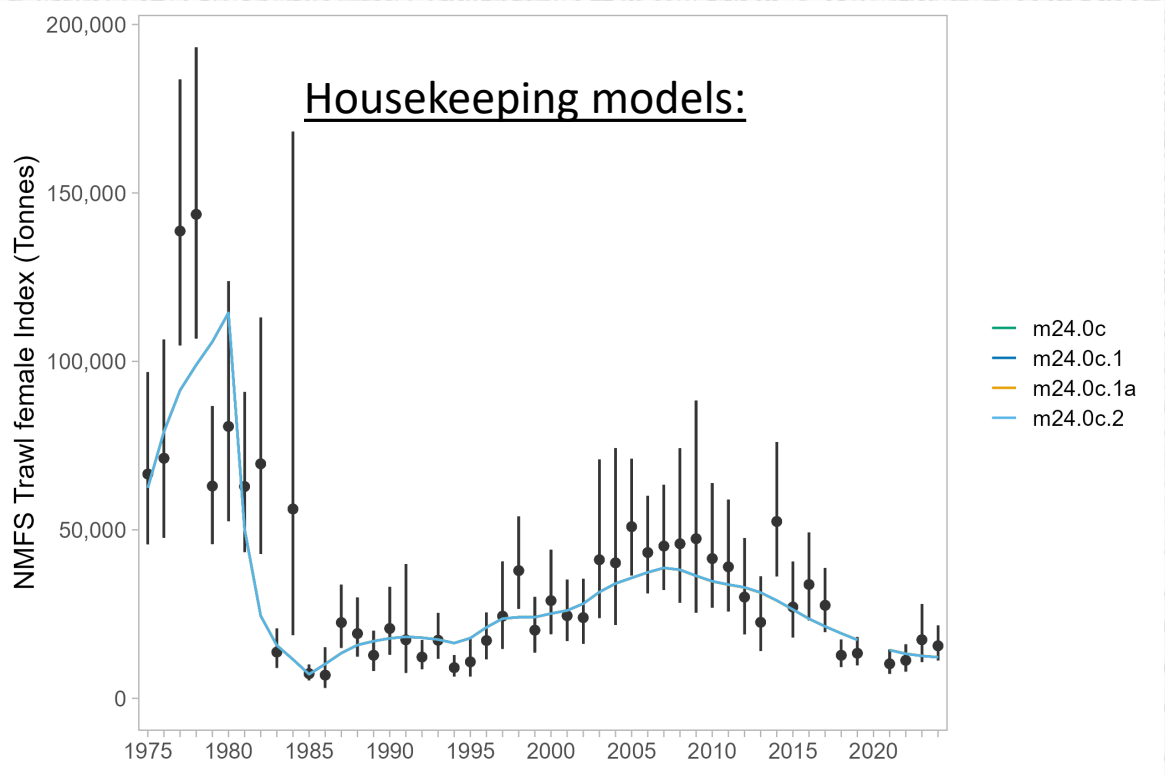
- Likelihoods similar (Table 4)
- No changes in MMB trend or estimation.
- Reference points differences related to small changes in catch data but overall not change in MMB/Bmsy
- Reduced in fixed gear HM has slight changes to OFL

Model	Current MMB	$B_{35\%}$	MMB $/B_{MSY}$	$F_{35\%}$	F_{OFL}	OFL
24.0c	15.43	18.69	0.83	0.40	0.32	5.02
24.0c.1 (catch)	15.40	18.65	0.83	0.40	0.32	5.02
24.0c.1a (HM)	15.44	18.62	0.83	0.40	0.33	5.06
24.0c.2	15.40	18.65	0.83	0.40	0.32	5.02

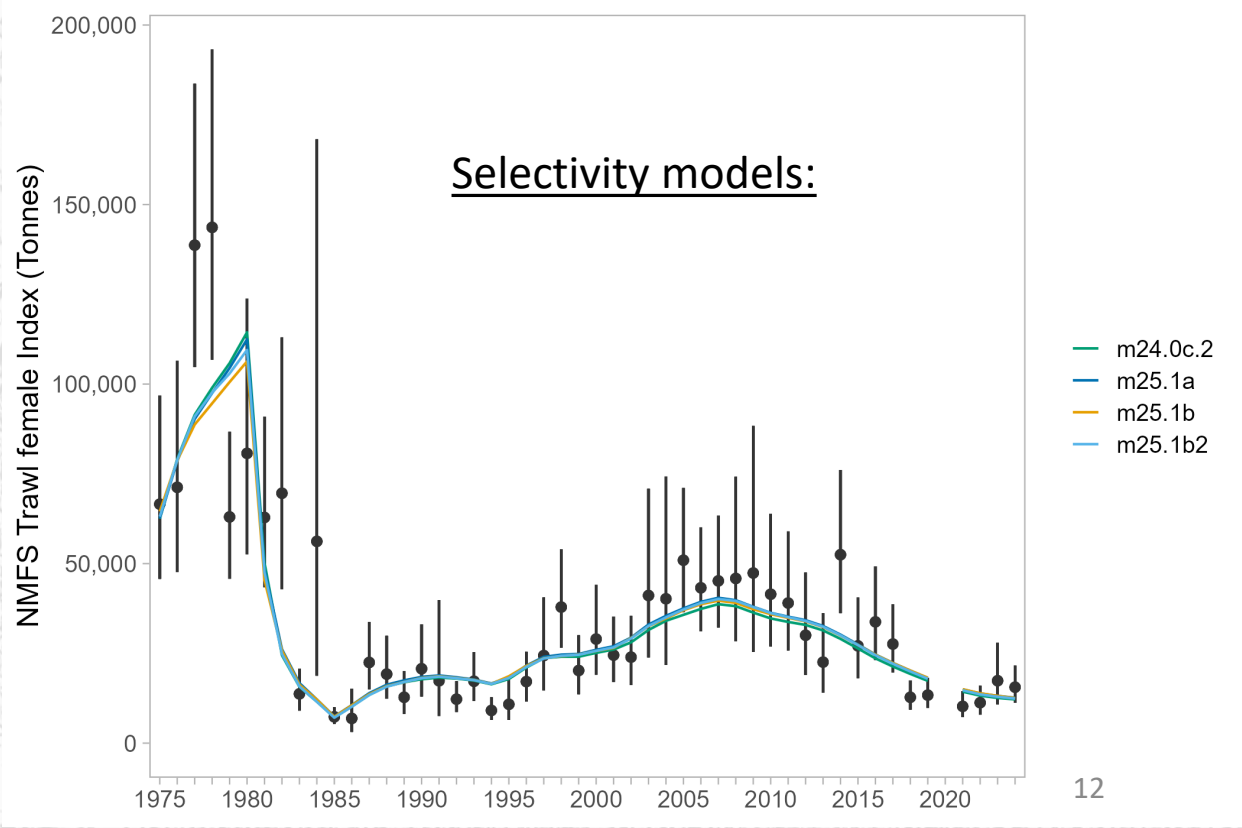


- Model fits to NMFS **male** trawl survey data are similar.



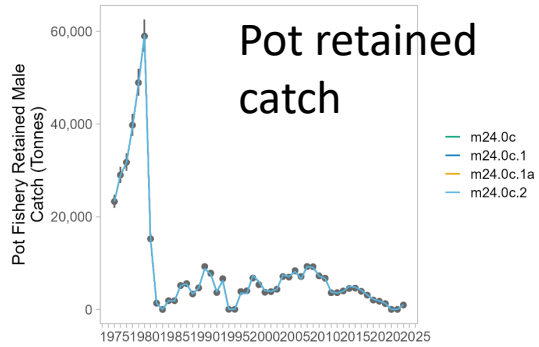


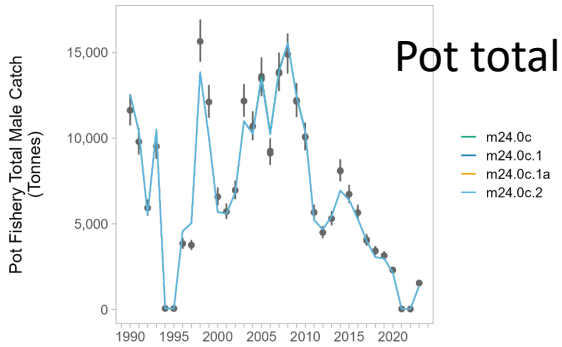
- Model fits to NMFS **female** trawl survey data.
- BSFRF survey data fits not shown due to no differences in housekeeping models

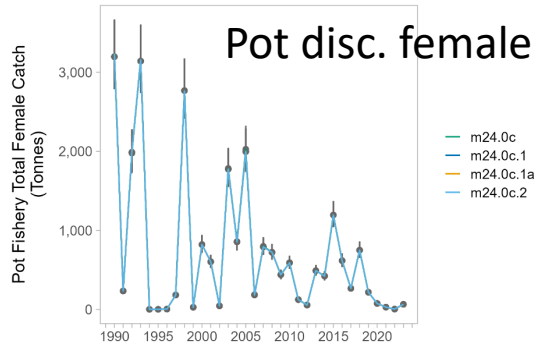


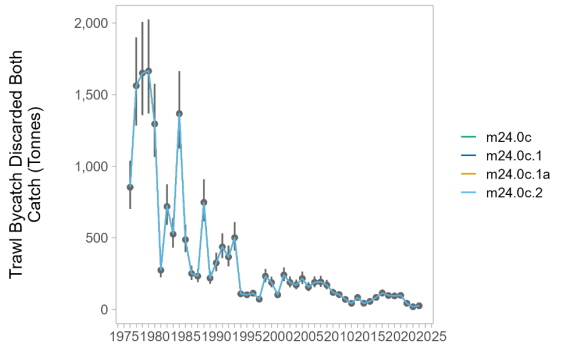
Catch data fits

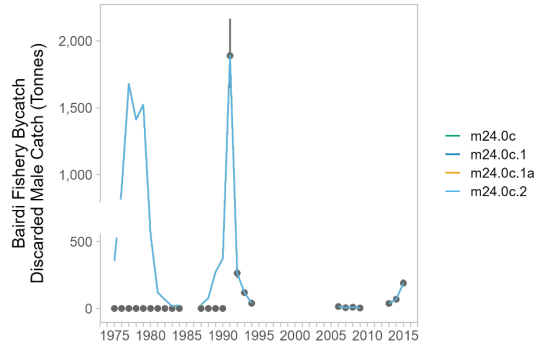
ADF&G catch data updates are minimal

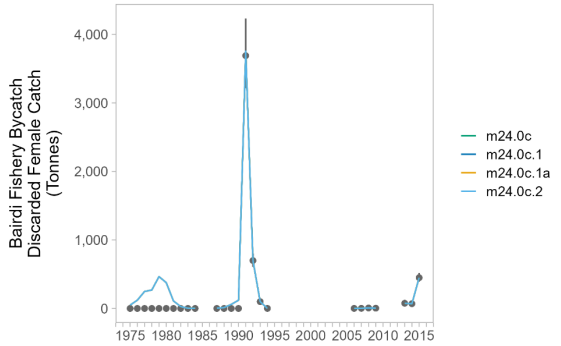


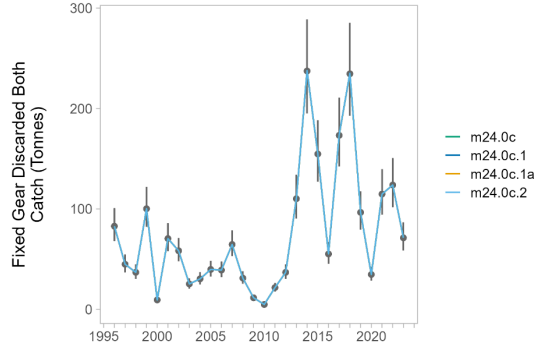


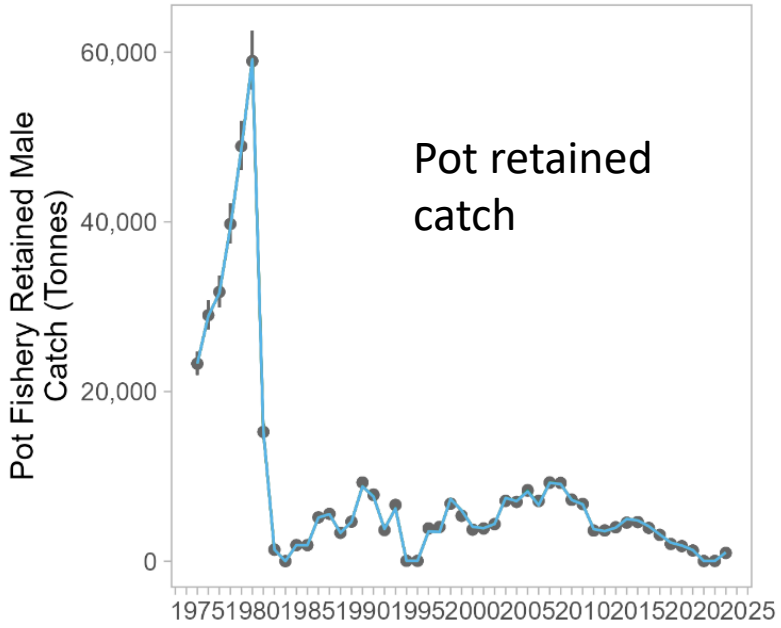


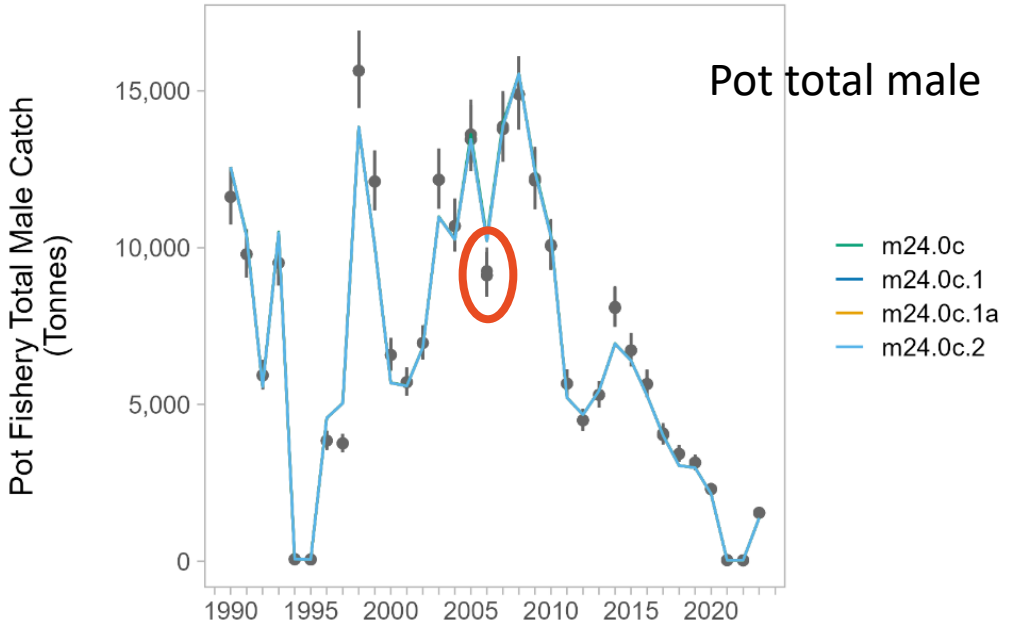


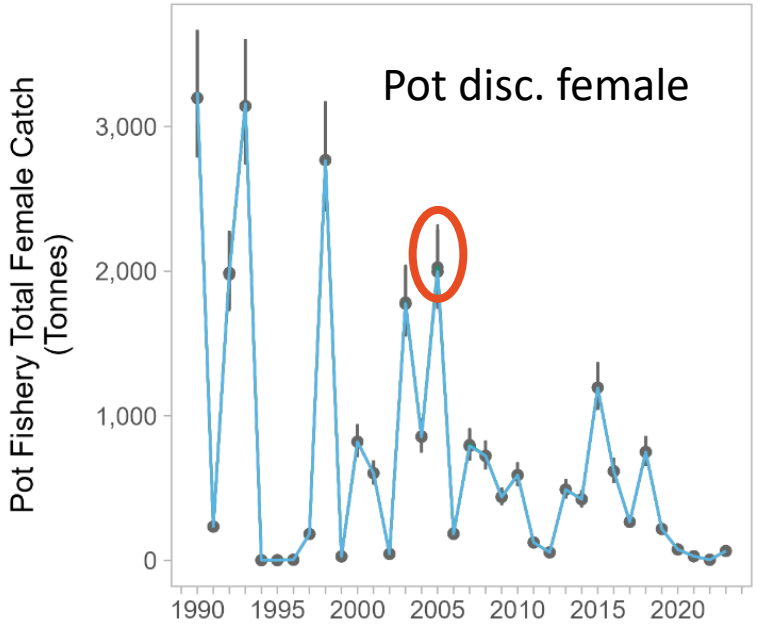


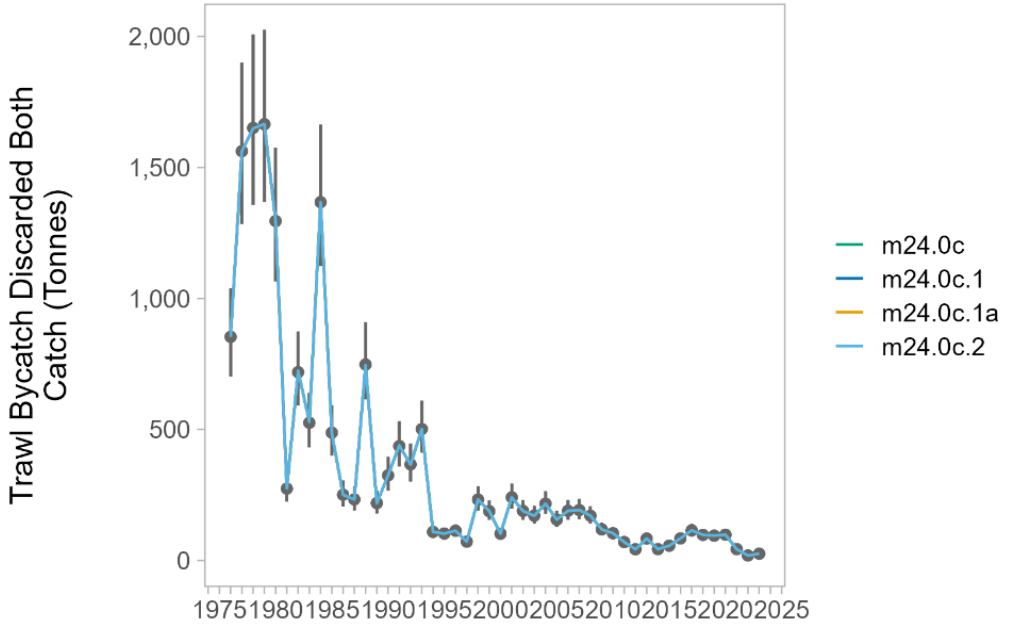


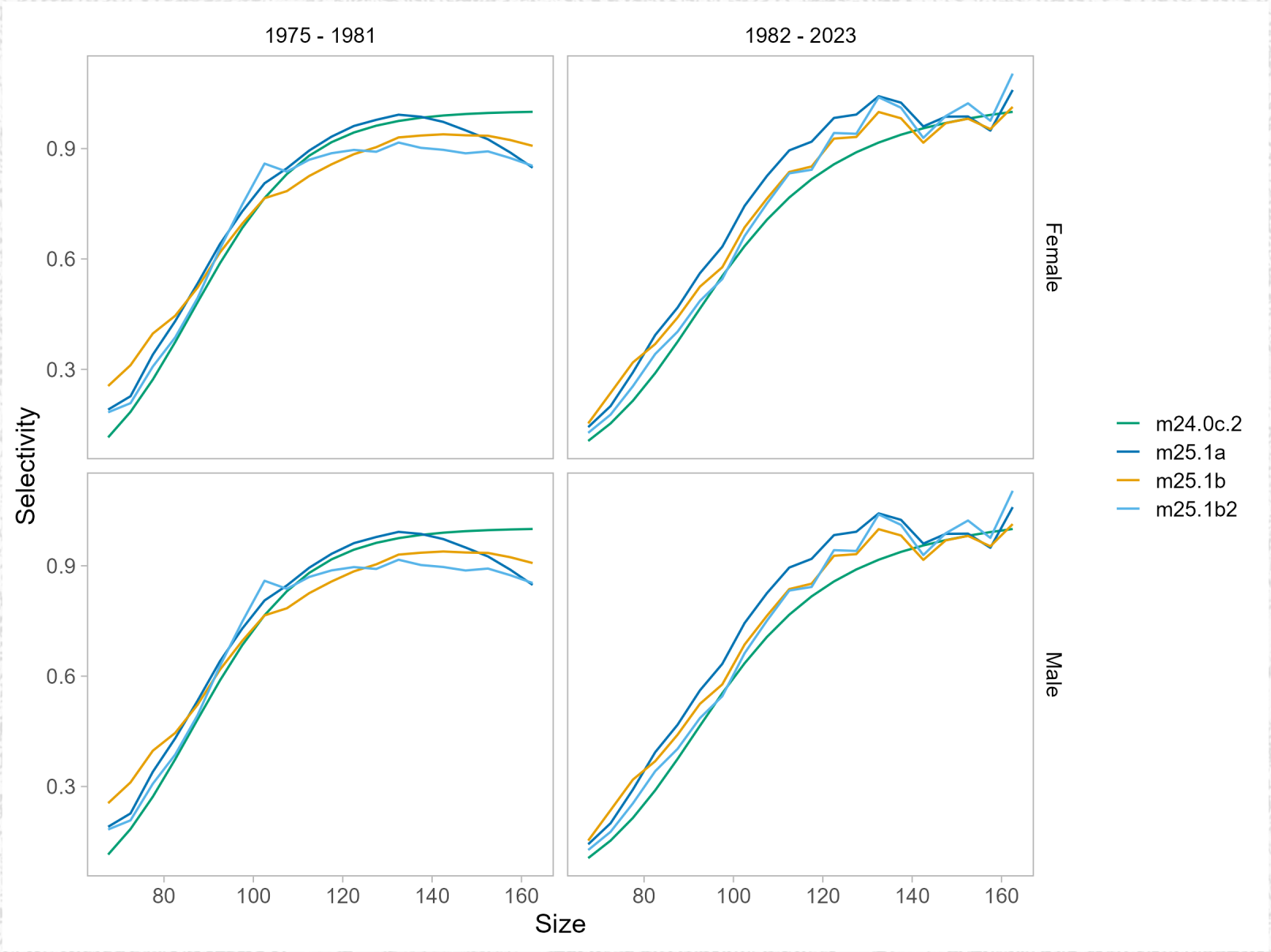



Pot retained catch
Pot Fishery Retained Male Catch (Tonnes)
60,000
40,000
20,000
0
1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025
m24.0c
m24.0c.1
m24.0c.1a
m24.0c.2

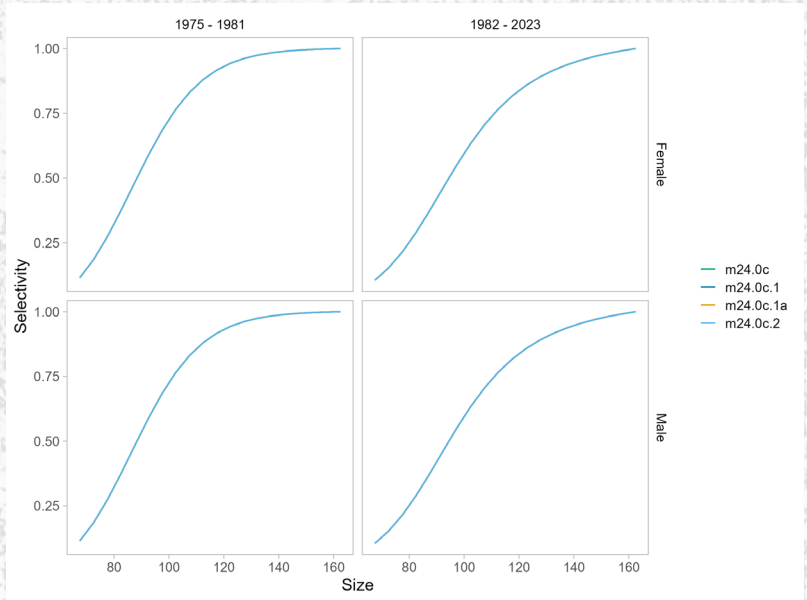

Pot total male
Pot Fishery Total Male Catch (Tonnes)
15,000
10,000
5,000
0
1990 1995 2000 2005 2010 2015 2020
m24.0c
m24.0c.1
m24.0c.1a
m24.0c.2


Pot disc. female
Pot Fishery Total Female Catch (Tonnes)
3,000
2,000
1,000
0
1990 1995 2000 2005 2010 2015 2020
m24.0c
m24.0c.1
m24.0c.1a
m24.0c.2


Trawl Bycatch Discarded Both Catch (Tonnes)
2,000
1,500
1,000
500
0
1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025
m24.0c
m24.0c.1
m24.0c.1a
m24.0c.2



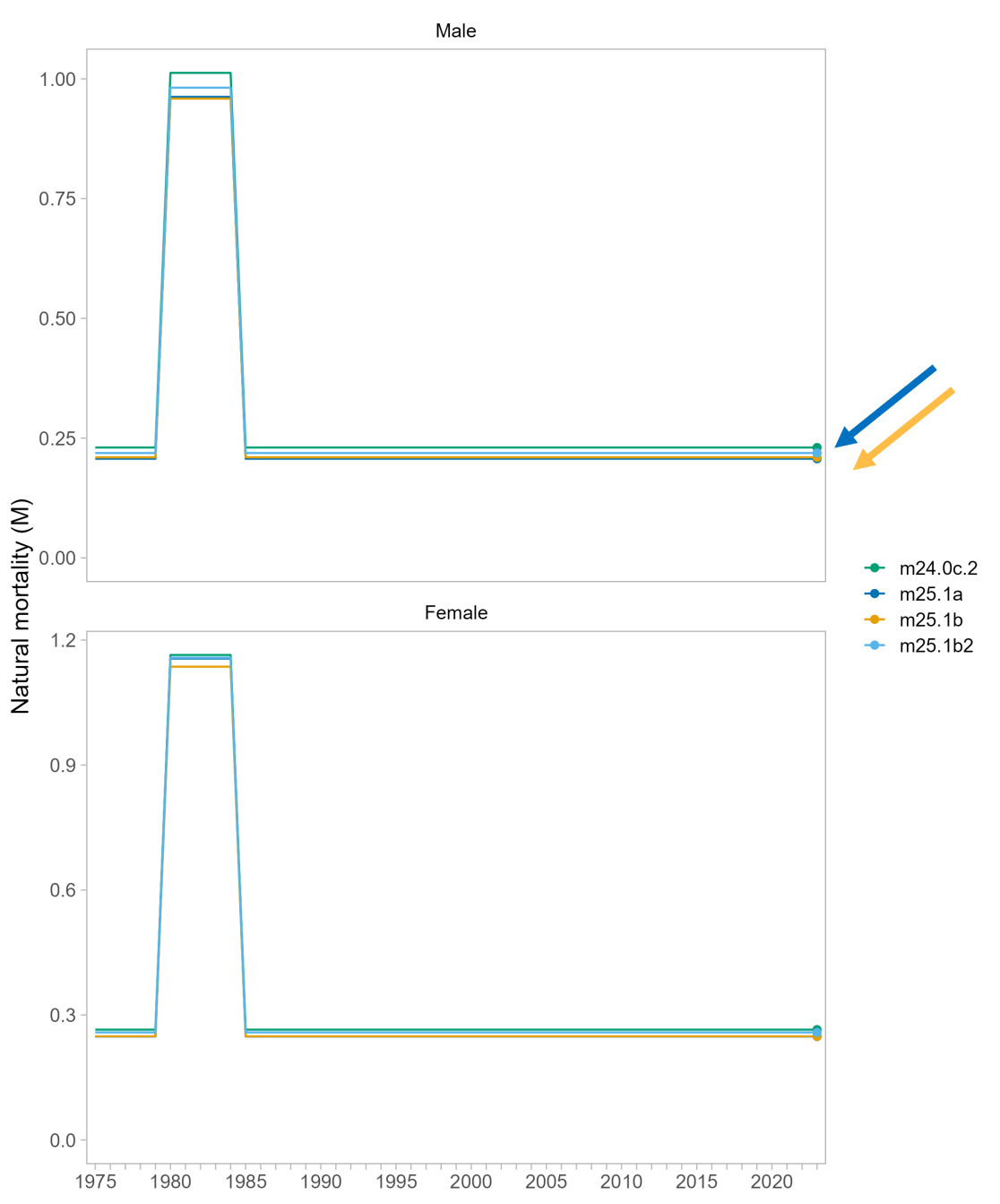
NMFS trawl survey selectivity:
models with prior from BSFRF data deal with larger size classes differently than the base model.



Natural Mortality

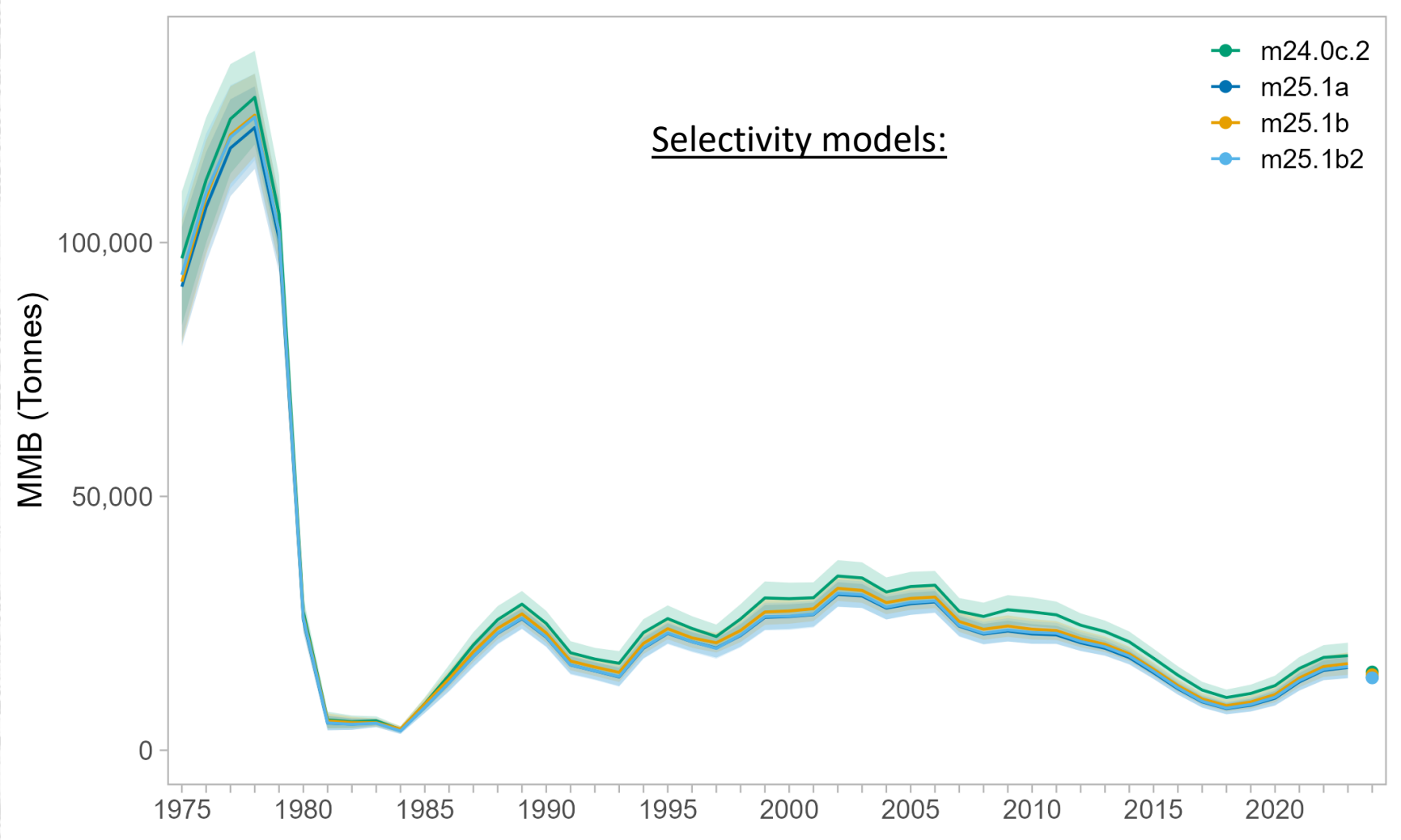
- No difference in base model explorations (24 series)
- Selectivity models have smaller estimates of base M

Model	Sex	baseM	1980-84
m24.0c	female	0.26	1.16
m24.0c	male	0.23	1.01
m24.0c.1	female	0.26	1.16
m24.0c.1	male	0.23	1.01
m24.0c.2	female	0.26	1.16
m24.0c.2	male	0.23	1.01
m25.1a	female	0.25	1.16
m25.1a	male	0.21	0.96
m25.1b	female	0.25	1.14
m25.1b	male	0.21	0.96
m25.1b2	female	0.26	1.16
m25.1b2	male	0.22	0.98



Mature male biomass

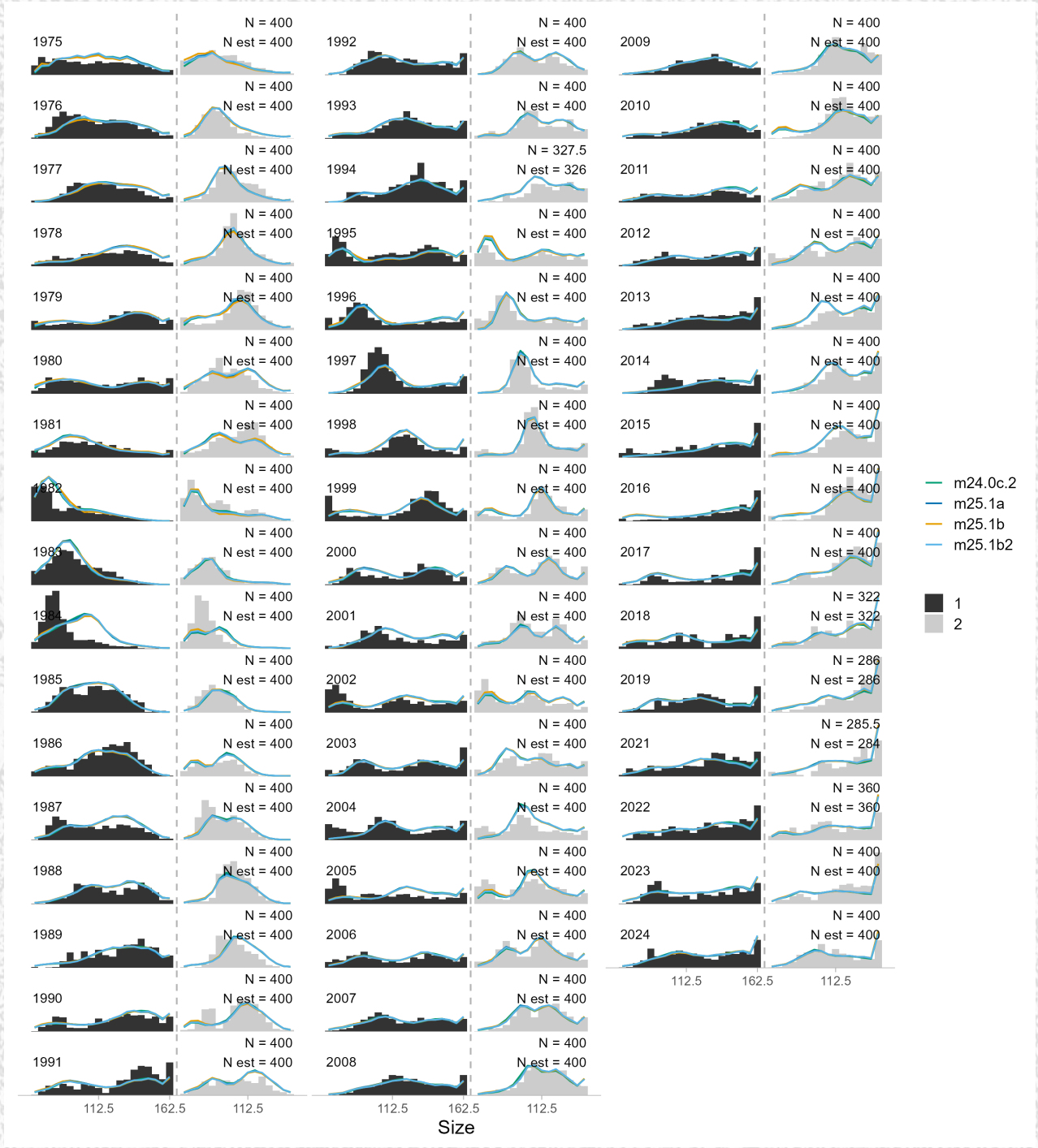
- All BSFRF selectivity informed models have overall reductions in MMB scale.
- Trends are the same



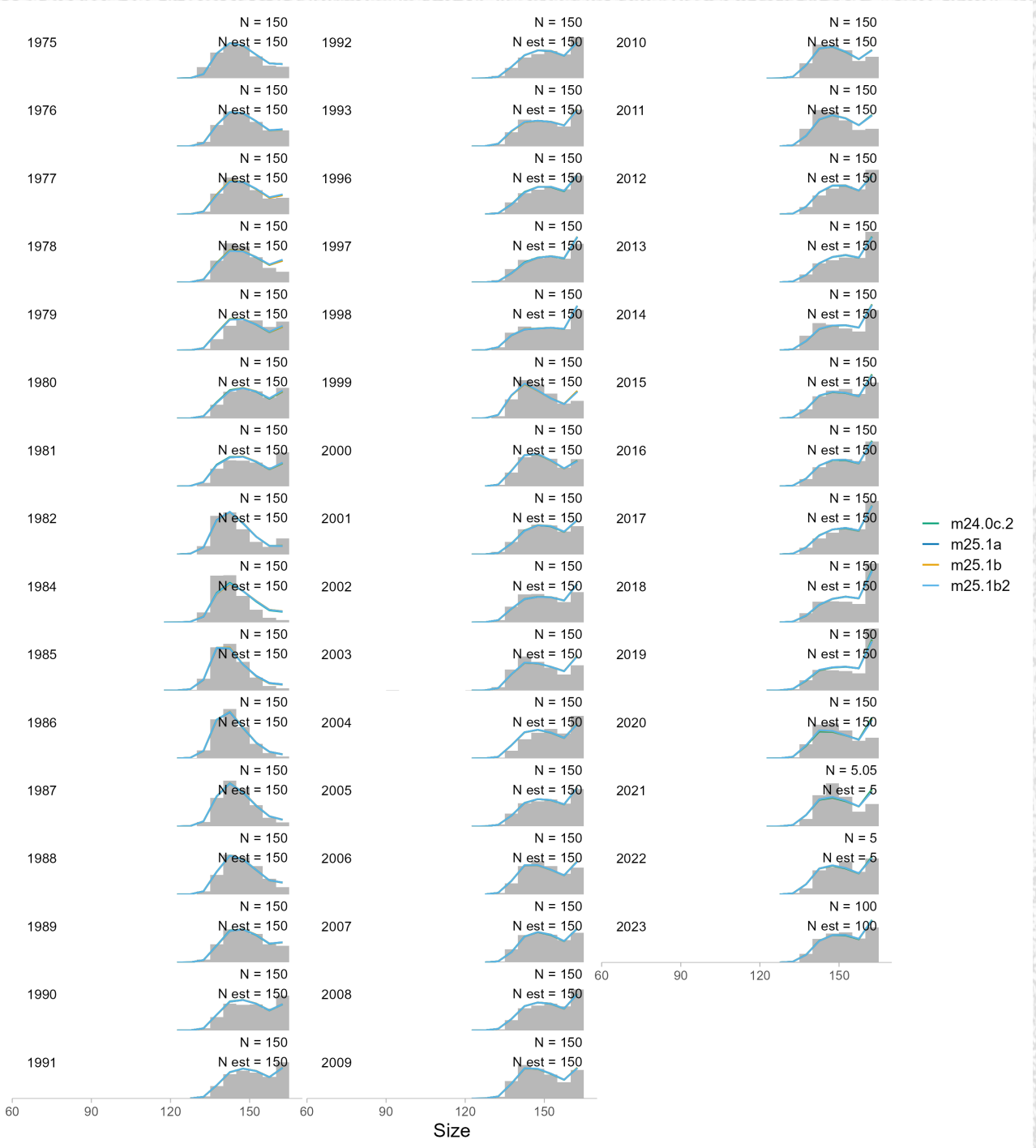
Size composition fit

- Similar for all models
- Housekeeping models show no visual difference
- Small differences for selectivity models

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

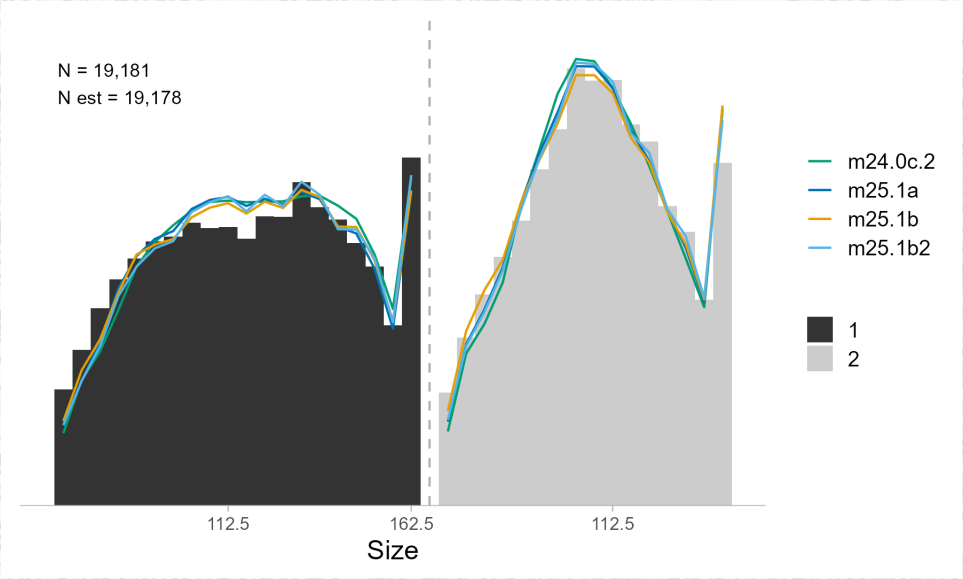


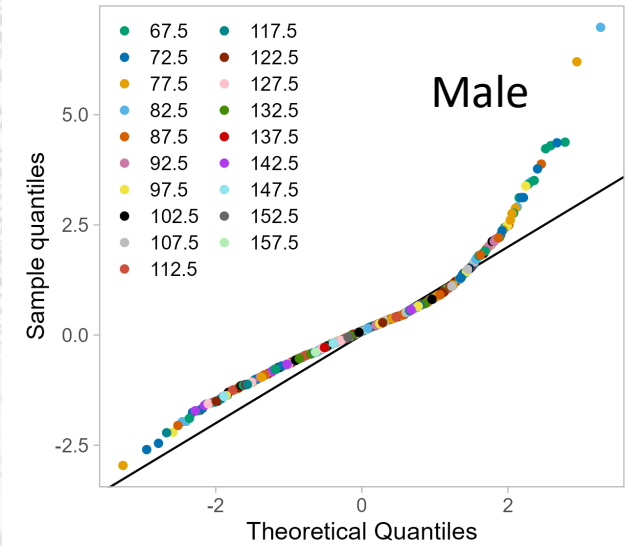
Directed Pot fishery retained

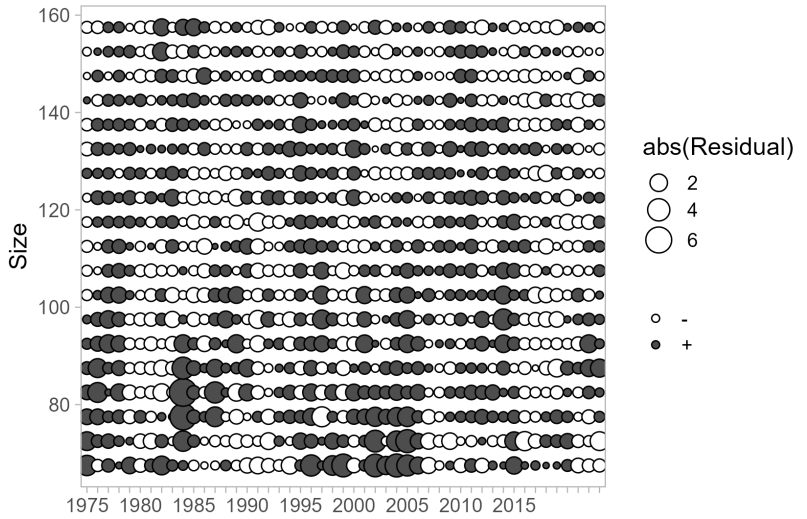


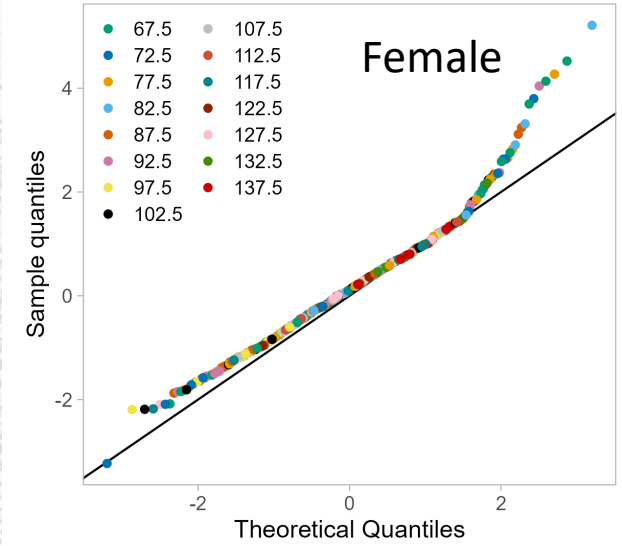
NMFS trawl survey

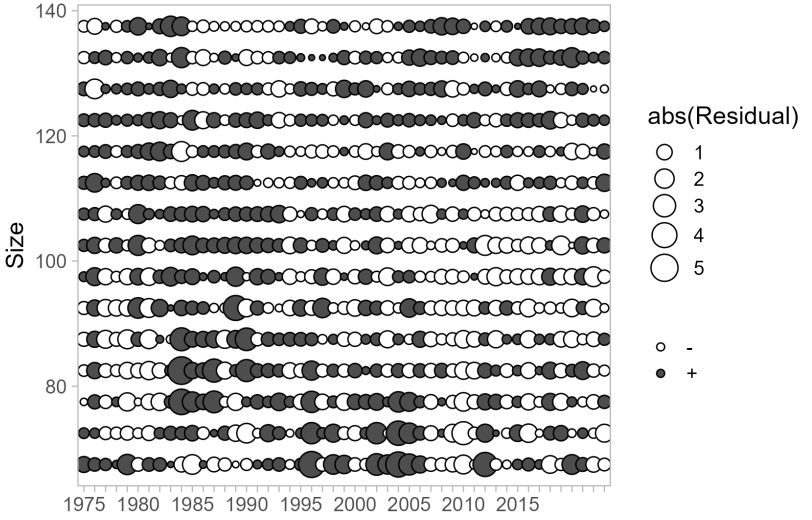
- One-step-ahead residuals - males (1), females (2)
- Aggregated size comp over all years



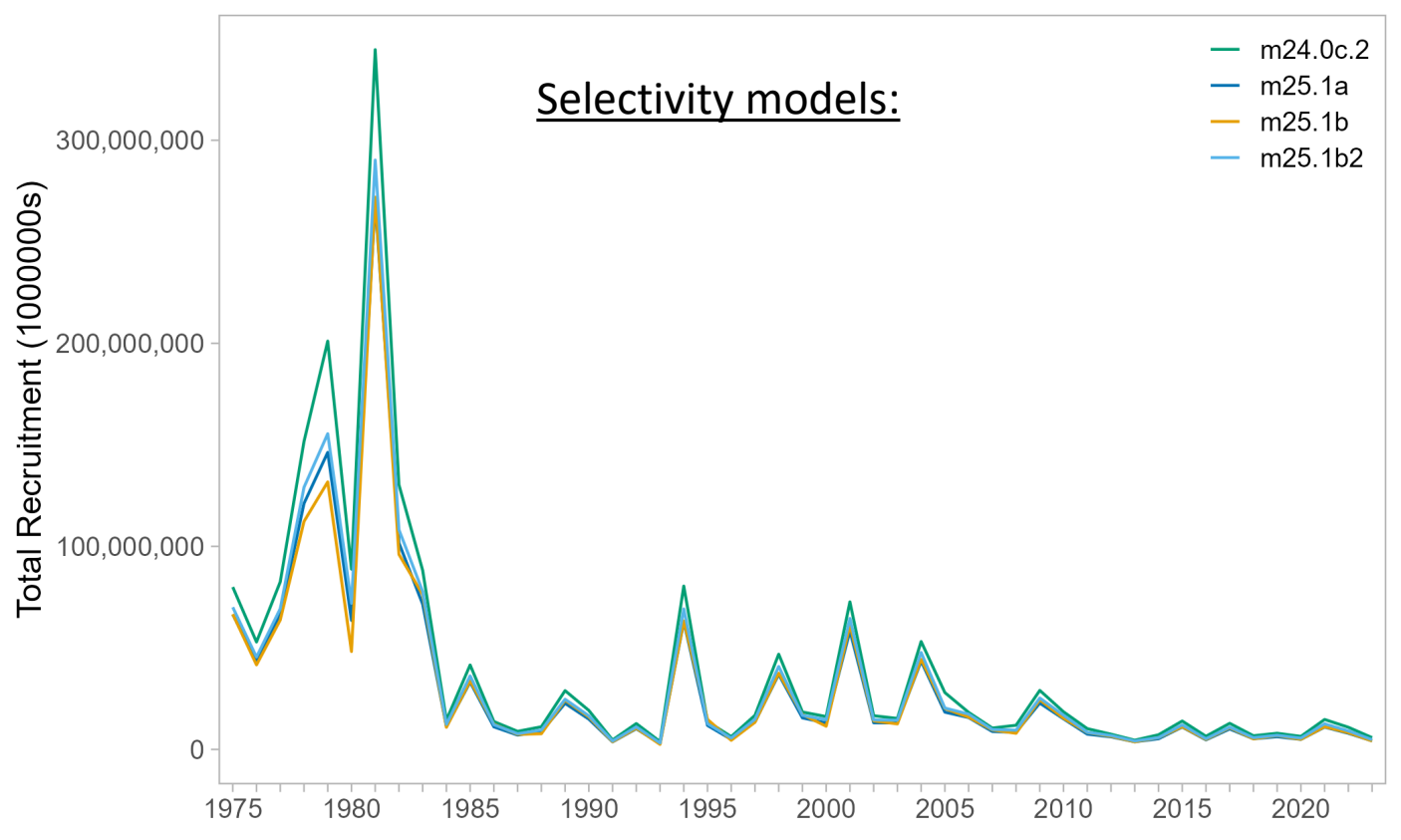








Recruitment



Selectivity models:

- change in recruitment due to changes in selectivity relationship
- Most influential in early time period

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.

Component	m24.0c(ref)	m24.0c.1	m24.0c.1a	m24.0c.2	m25.1a	m25.1b	m25.1b2
Pot-ret-catch	-61.35	-61.23	-61.18	-61.23	-62.80	-62.59	-63.30
Pot-totM-catch	30.40	30.74	30.78	30.74	29.41	30.02	28.57
Pot-F-discC	-59.19	-59.19	-59.19	-59.19	-59.19	-59.19	-59.19
Trawl-discC	-66.52	-66.52	-66.52	-66.52	-66.52	-66.52	-66.52
Tanner-M-discC	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54
Tanner-F-discC	-43.51	-43.51	-43.51	-43.51	-43.49	-43.49	-43.49
Fixed-discC	-38.81	-38.81	-38.81	-38.81	-38.81	-38.81	-38.81
Traw-suv-bio	-39.35	-39.44	-39.31	-39.44	-41.46	-40.20	-42.61
BSFRF-sur-bio	-5.00	-5.01	-5.00	-5.01			
Pot-ret-comp	-4084.32	-4084.38	-4084.36	-4084.38	-4083.62	-4085.50	-4086.42
Pot-totM-comp	-2523.39	-2523.04	-2523.02	-2523.04	-2525.67	-2524.43	-2526.21
Pot-discF-comp	-1546.63	-1546.63	-1546.60	-1546.63	-1545.33	-1546.85	-1546.08
Trawl-disc-comp	-6052.23	-6052.36	-6052.32	-6052.36	-6039.81	-6039.70	-6043.00
Tanner-disc-comp	-1276.39	-1276.45	-1276.46	-1276.45	-1275.52	-1274.90	-1276.22
Fixed-disc-comp	-3598.44	-3598.29	-3598.26	-3598.29	-3603.45	-3604.56	-3603.10
Trawl-sur-comp	-7288.60	-7288.44	-7288.33	-7288.44	-7294.50	-7280.86	-7302.88
BSFRF-sur-comp	-844.58	-844.63	-844.61	-844.63			
Recruit-dev	74.44	74.46	74.45	74.46	74.85	73.98	73.97
Recruit-ini	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Recruit-sex-R	80.45	80.46	80.45	80.46	80.69	80.72	80.48
Sex-specific-R	0.06	0.06	0.06	0.06	0.07	0.10	0.05
Ini-size-struct	33.22	33.24	33.25	33.24	31.31	31.02	31.35
PriorDensity	224.79	224.80	224.98	224.80	124.52	141.29	160.10
Tot-likelihood	-27128.48	-27127.70	-27127.04	-27127.70	-26382.87	-26354.01	-26366.85
Tot-parms	383.00	383.00	383.00	383.00	415.00	415.00	415.00
MMB35	18690.36	18648.50	18623.80	18648.50	18757.92	19003.22	18216.57
MMB-terminal	15426.70	15403.24	15439.07	15403.24	14356.20	14865.46	14259.93
F35	0.40	0.40	0.40	0.40	0.35	0.36	0.38
$Fofl$	0.32	0.32	0.33	0.32	0.26	0.27	0.29
OFL	5021.81	5018.15	5057.16	5018.15	3710.47	4017.62	4046.81

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	Model description
m24.0c	15.43	18.69	0.40	0.32	5.02	9.84	24 accepted (updated GMACS)
m24.0c.1	15.40	18.65	0.40	0.32	5.02	9.82	Updated catch
m24.0c.2	15.40	18.65	0.40	0.32	5.02	9.82	Input clean up
m25.1a	14.36	18.76	0.35	0.26	3.71	7.89	BSFRF selectivity – all data
m25.1b	14.87	19.00	0.36	0.27	4.02	8.13	BSFRF selectivity – SBS subset
m25.1b2	14.26	18.22	0.38	0.29	4.05	8.54	BSFRF selectivity – SBS subset, increased SD

Summary and Recommendations

- Model 24.0c.2 represents updated base – GMACS updates, updated ADF&G catch data, housekeeping input file clean ups.
- Recommendations:
  - Base model 24.0c.2
  - Changes to handling mortality for fixed gear – CPT decision?
  - Selectivity model ?
    - Concern over lack of correlation on prior inputs
    - Would more size bins solve this ?
  - Tier 4 option from 2024 (REMA model on mature males in NMFS survey data) will be brought forward in Sept.

Future work

- Selectivity explorations – Other suggestions?
- Size bin increases
  - Need to get all raw data for this
  - Increase both males and female – how many bins to increase ?
- Focus on retrospective pattern
- Initial conditions – explorations on these and suggestions for what to look at
- Model based indices – explore including northern area crab via this method

Questions?