Bristol Bay red king crab

Final SAFE

September 2022

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ADF&G

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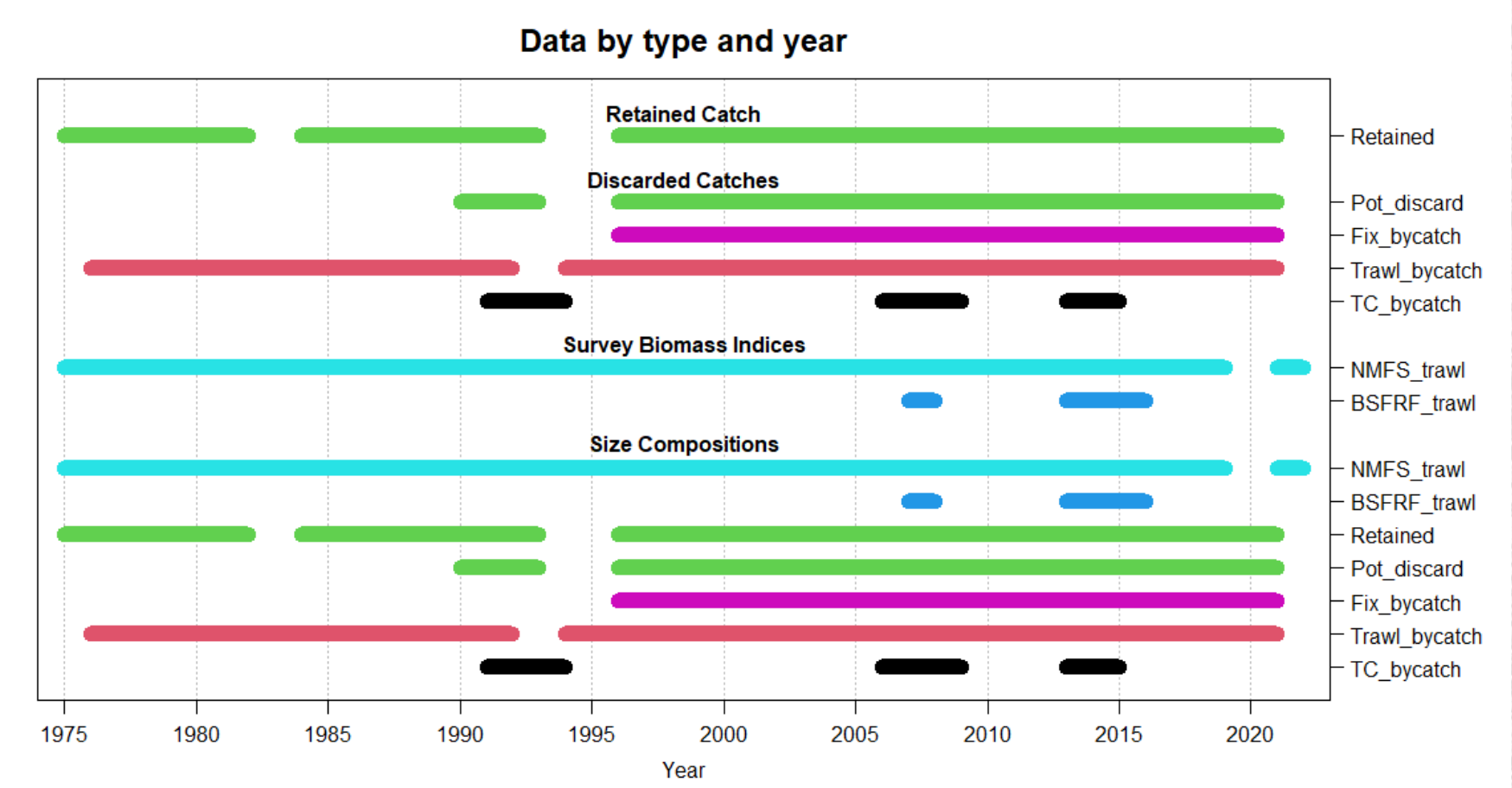
Summary

- Mature male biomass increase from 2021, still low compared to long term average
- Directed fishery was closed in 2021/22 season due to low mature female abundance.
- Estimated mature female biomass is higher than 2021 but still lower than it's been since the mid-90s
- 2022 mature female abundance does NOT meet the minimum threshold of mature female abundance (8.4 million) in the State Harvest Strategy
  - 2022 area-swept = 8.004
  - 2022 model estimate = 7.840
- Low recruitment in recent years (last 8-12 years), projected decline in biomass without a large recruitment event

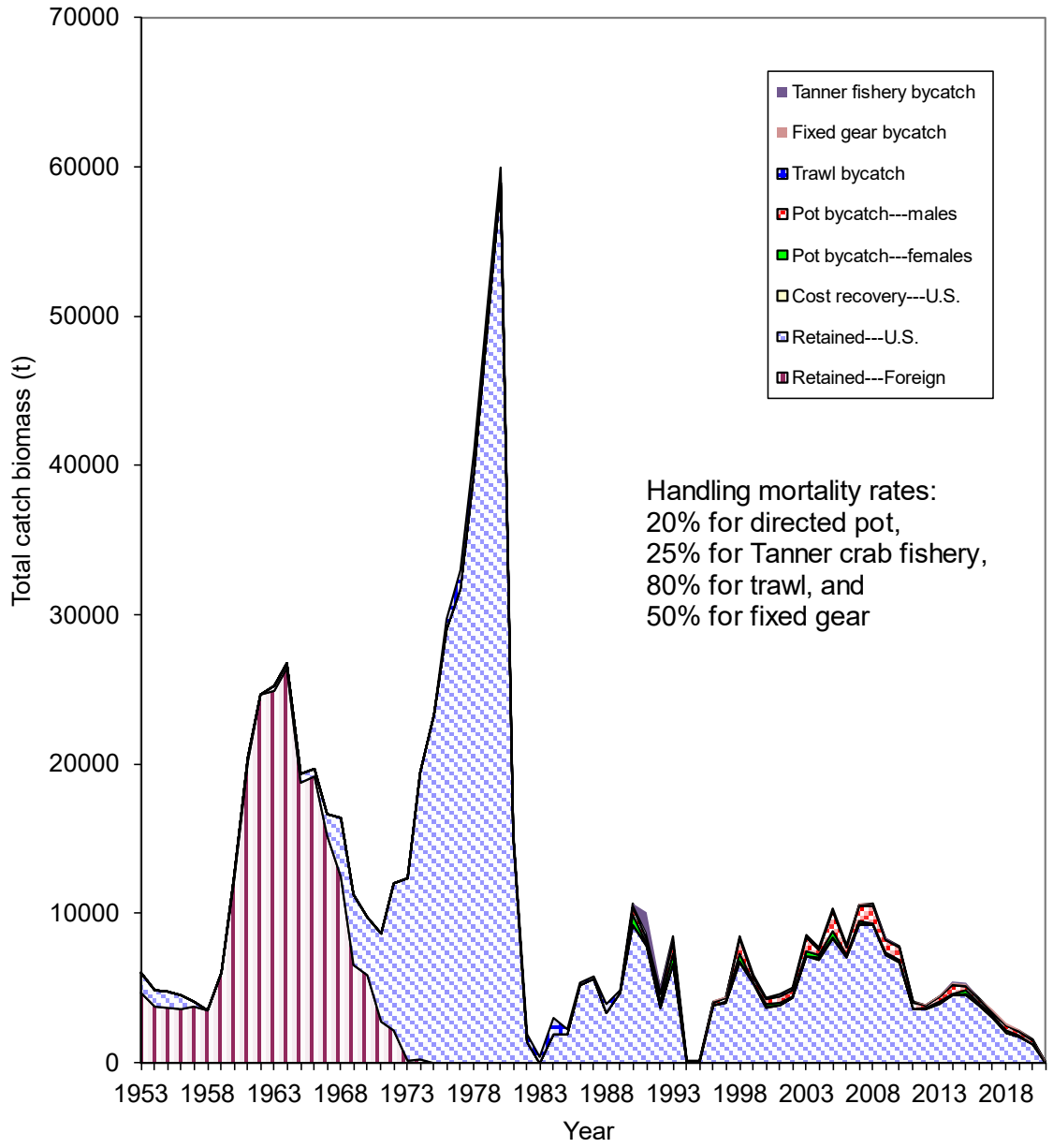
CPT / SSC comments

- No new comments addressed this cycle
- Many addressed in May 2022, work will be continued for 2023 proposed model work
- Focus here on models recommended for specification in May 2022
- June 2022 comments:
  - Produce a stock structure template for RKC (June 2023)
  - CPT develop guidelines for when to change model start date (Jan 2023?)

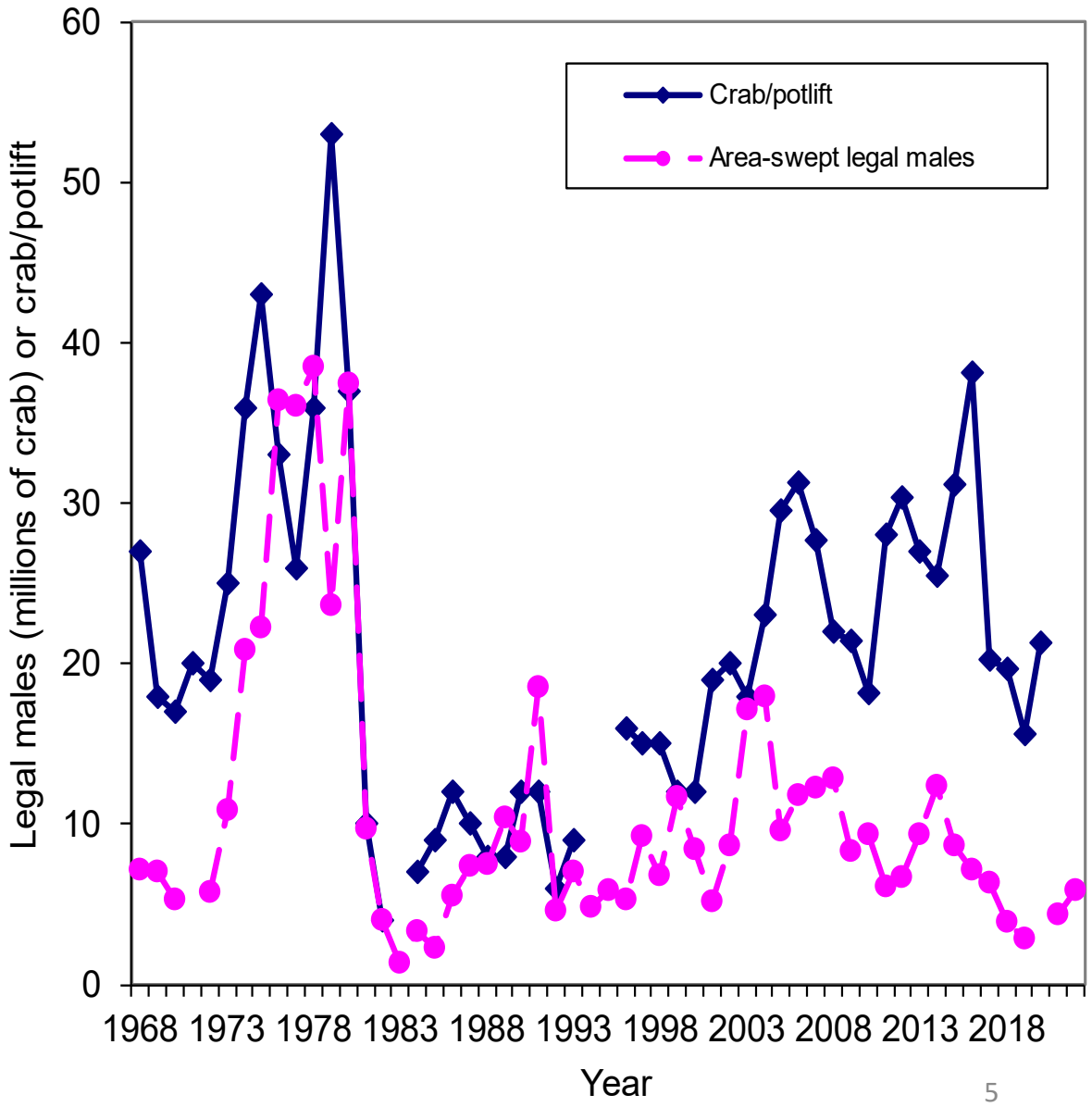
Data extent and new data for 2022



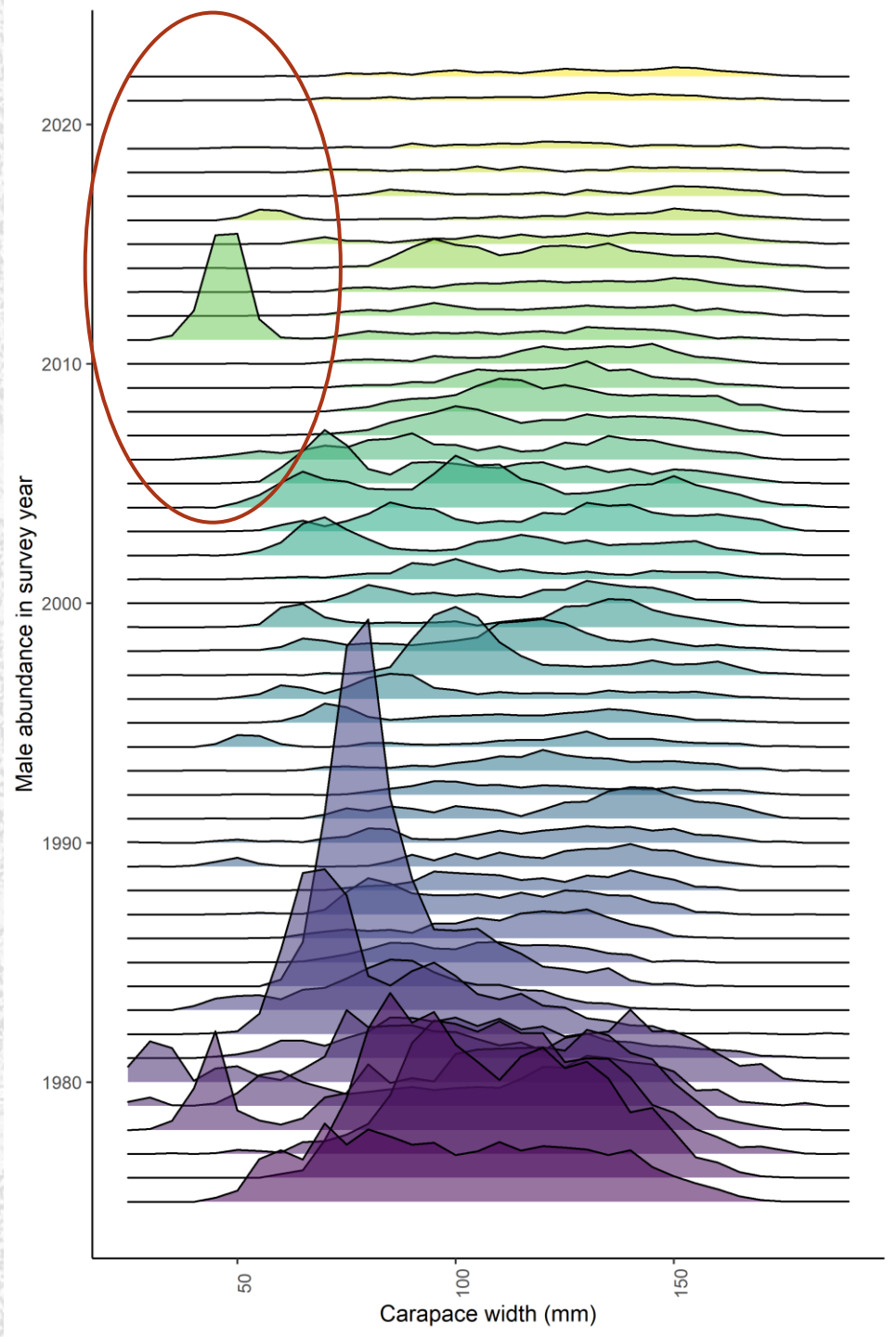
Retained and bycatch mortality (t)

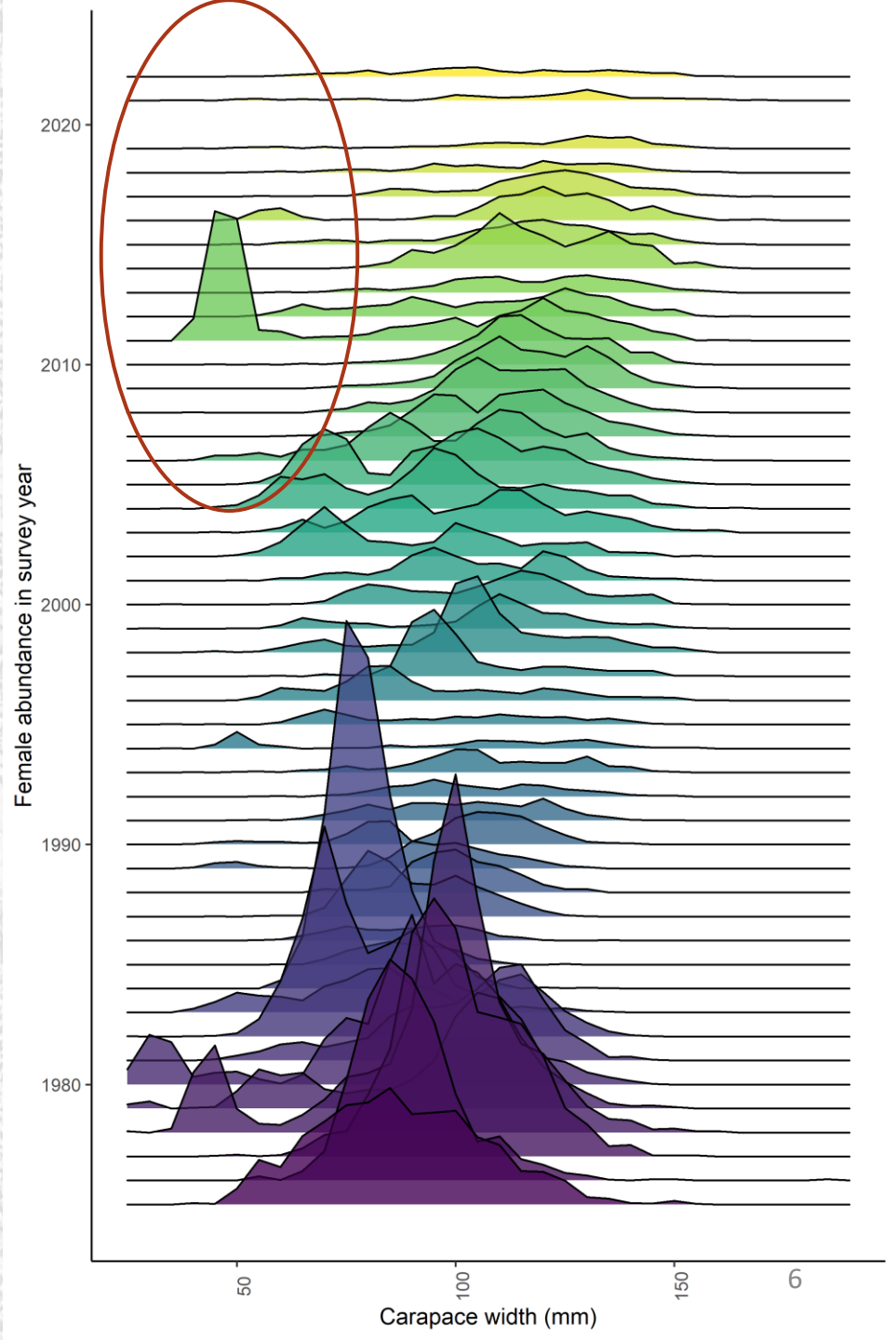


Survey legal male abundance and CPUE for directed BBRKC fishery



Length composition from NMFS survey





Model explorations

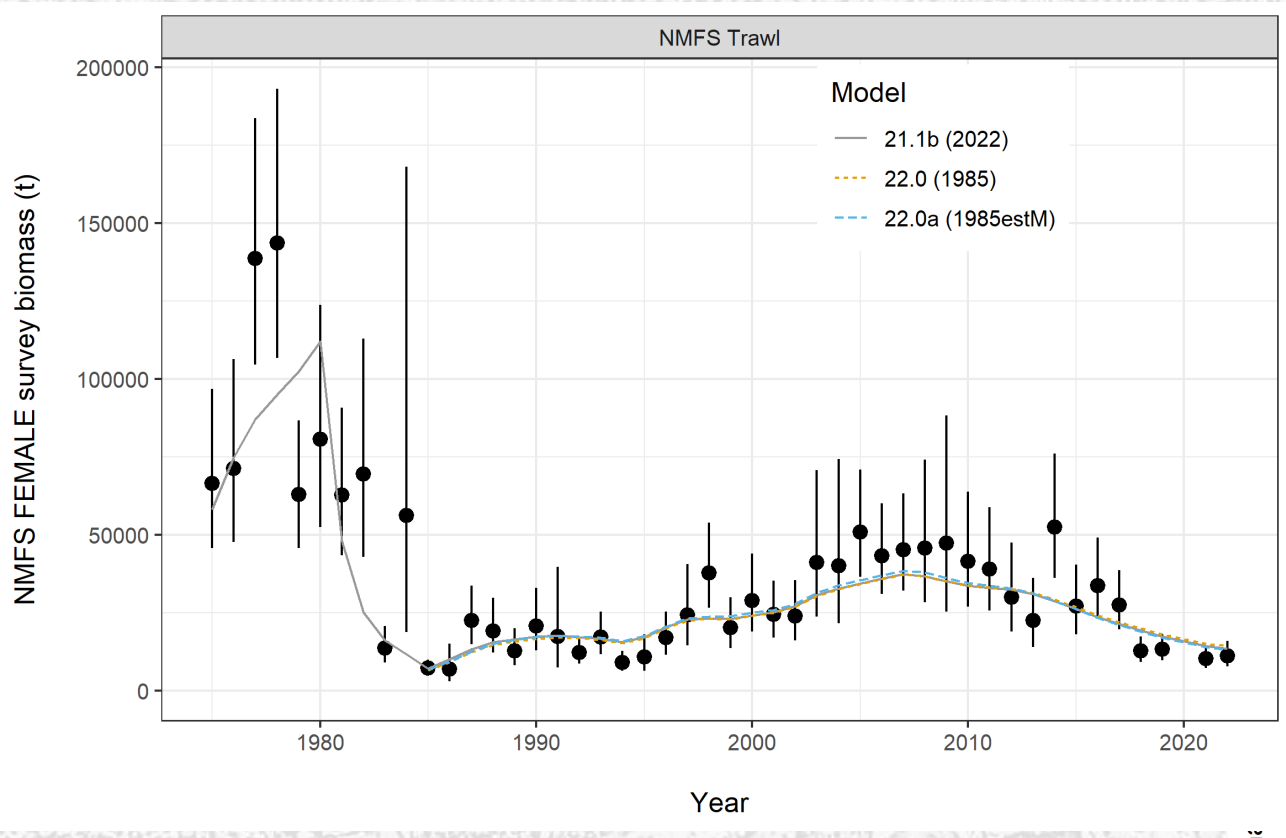
21.1b: model 21.1 (2021 accepted model – base M for males fixed at 0.18, mortality event in 80s)

+ **GMACS updated version** (version 2.01.E)

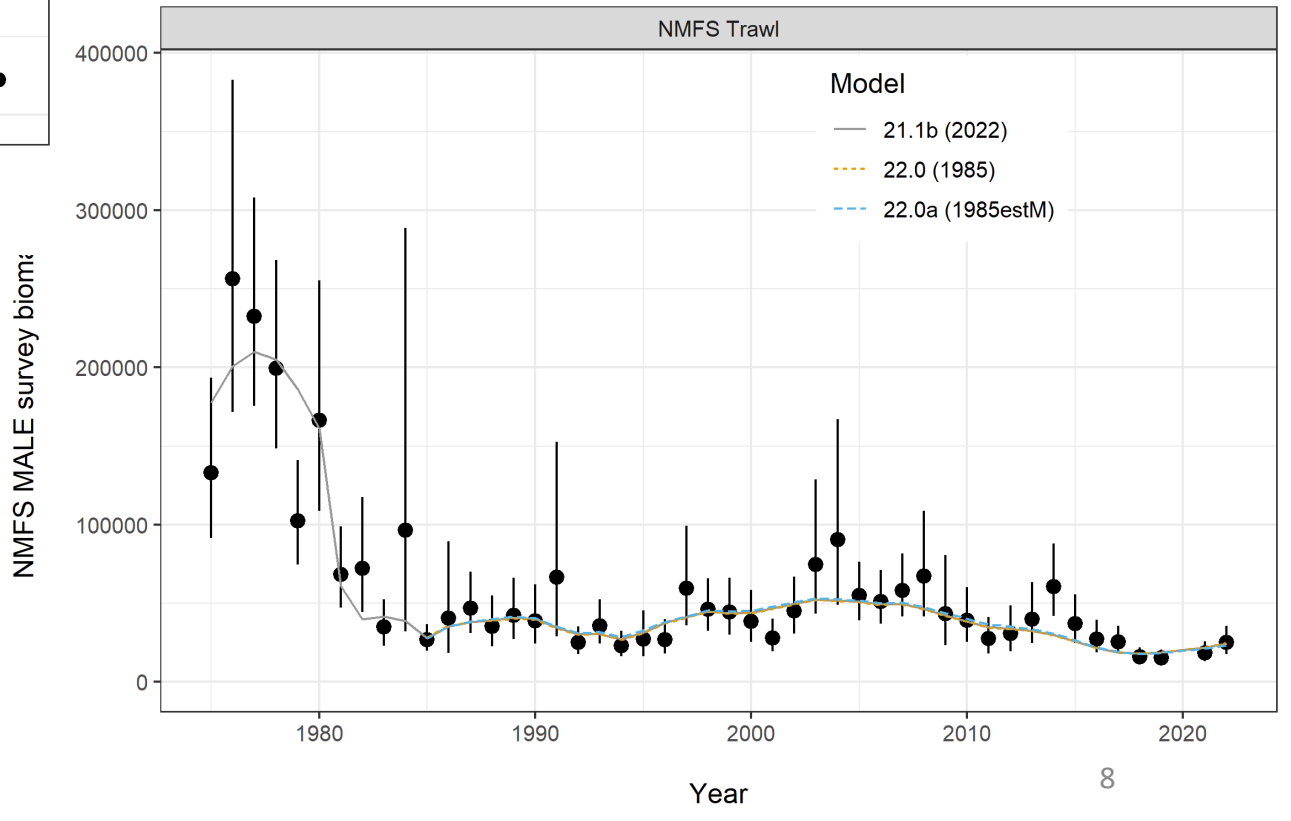
+ **updated groundfish fisheries bycatch** data.

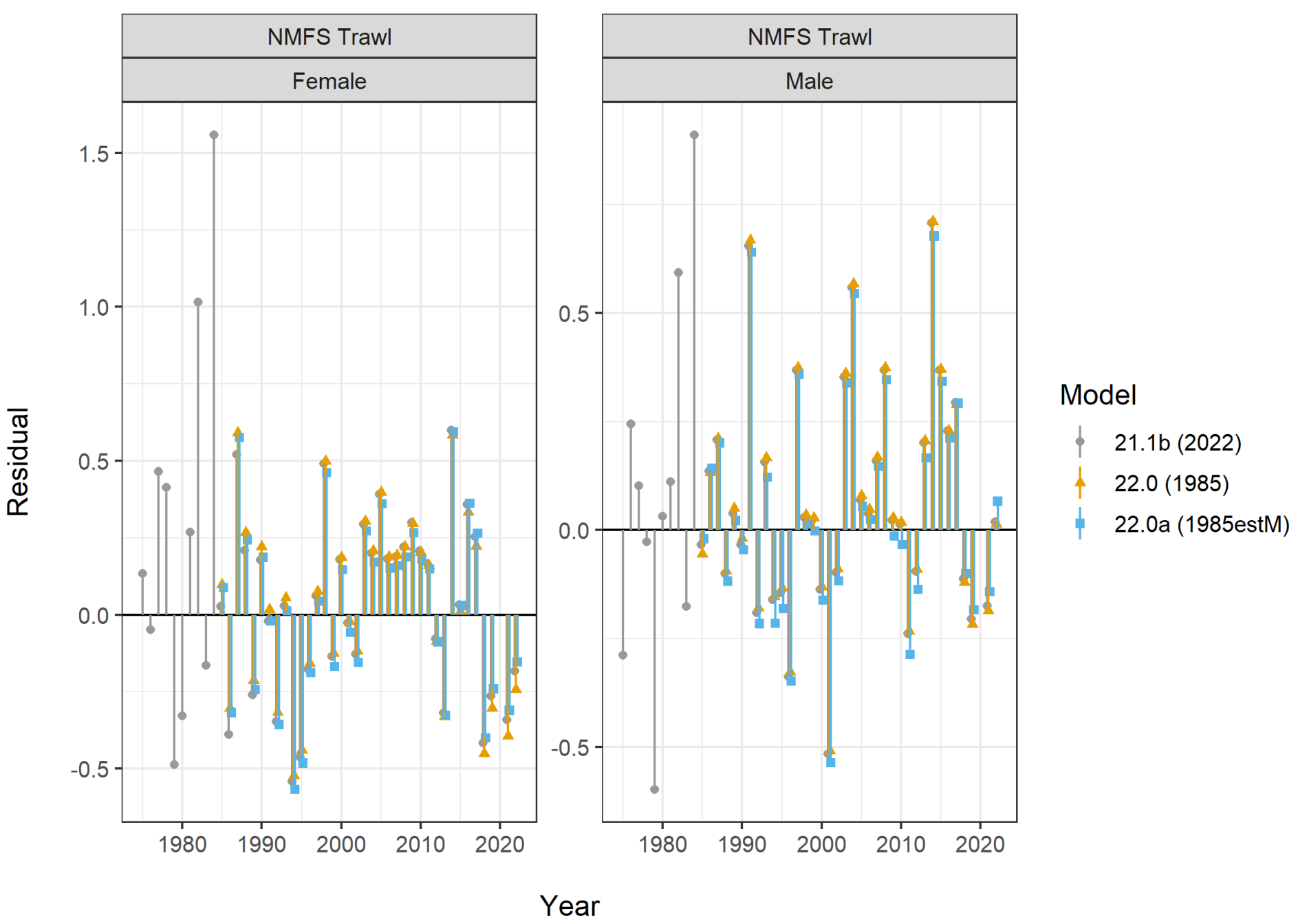
22.0: model 21.1b + starting in 1985.

22.0a: model 22.0 (start in 1985) + estimating a constant *M* for males.

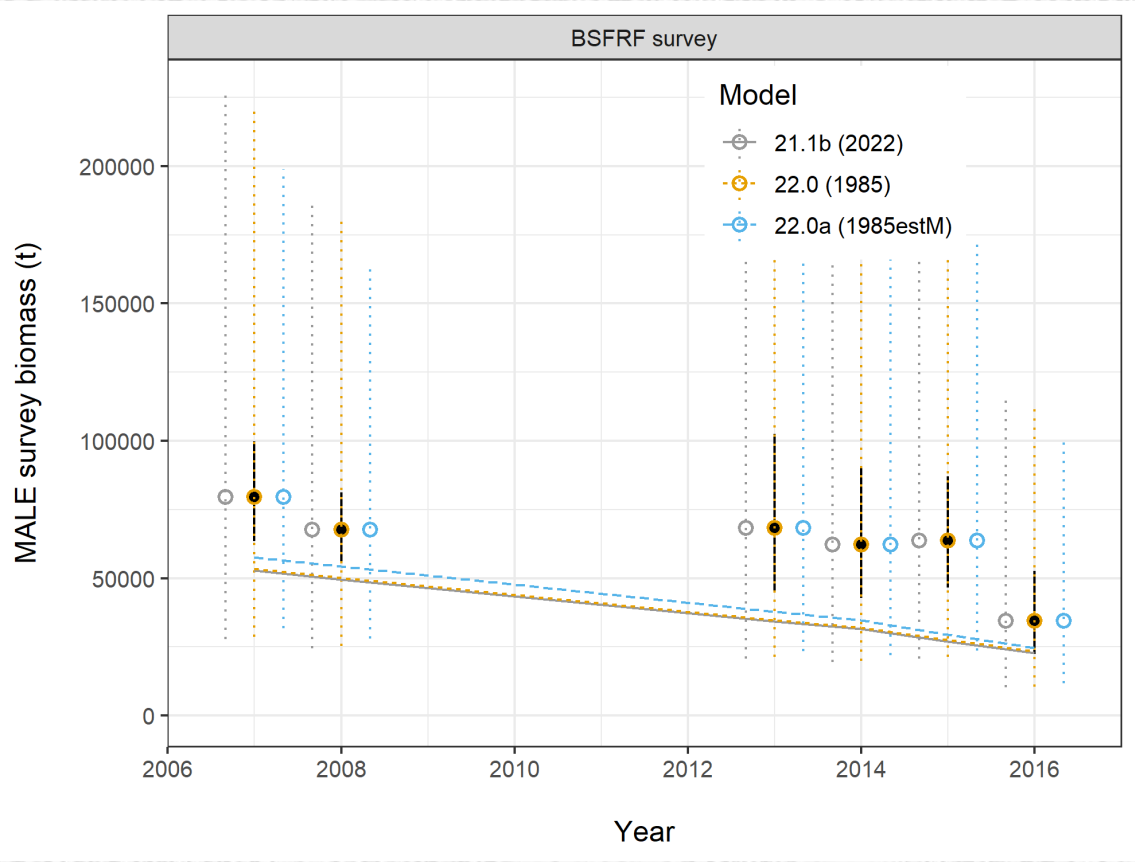


- Model fits to survey data are similar in all 3 models.

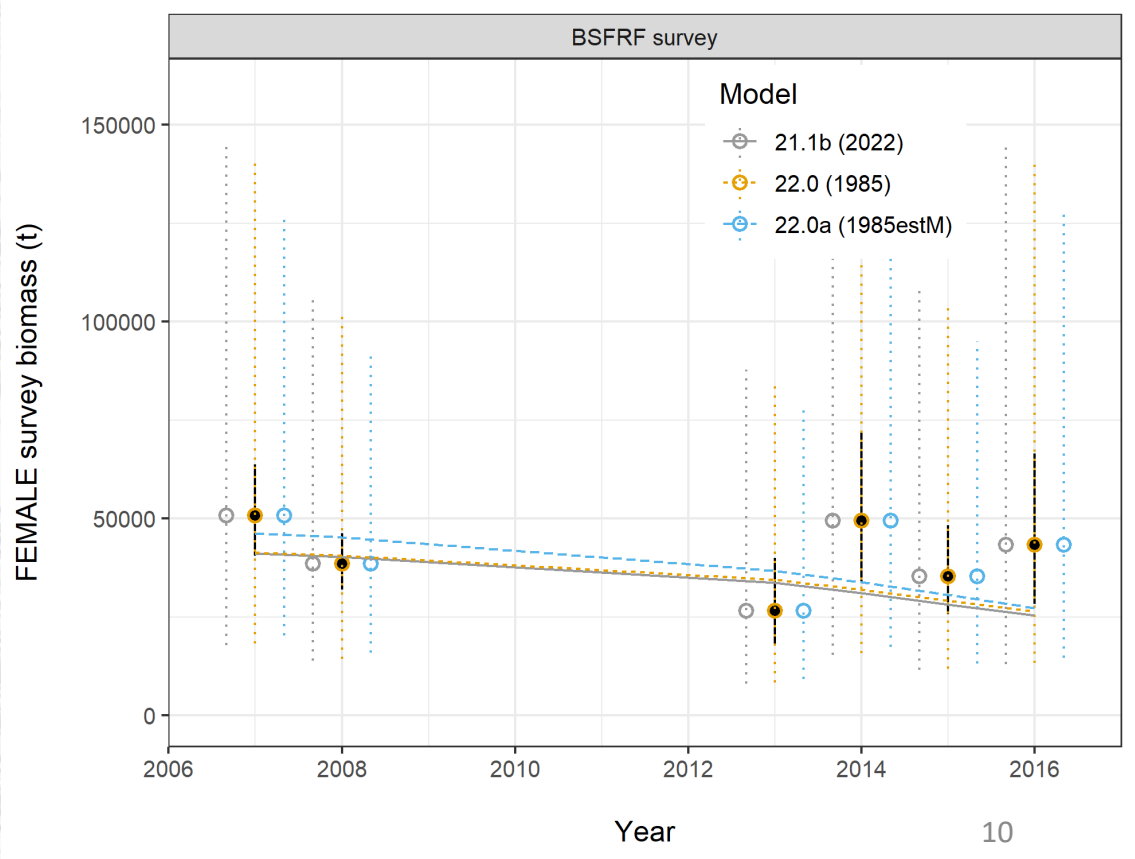




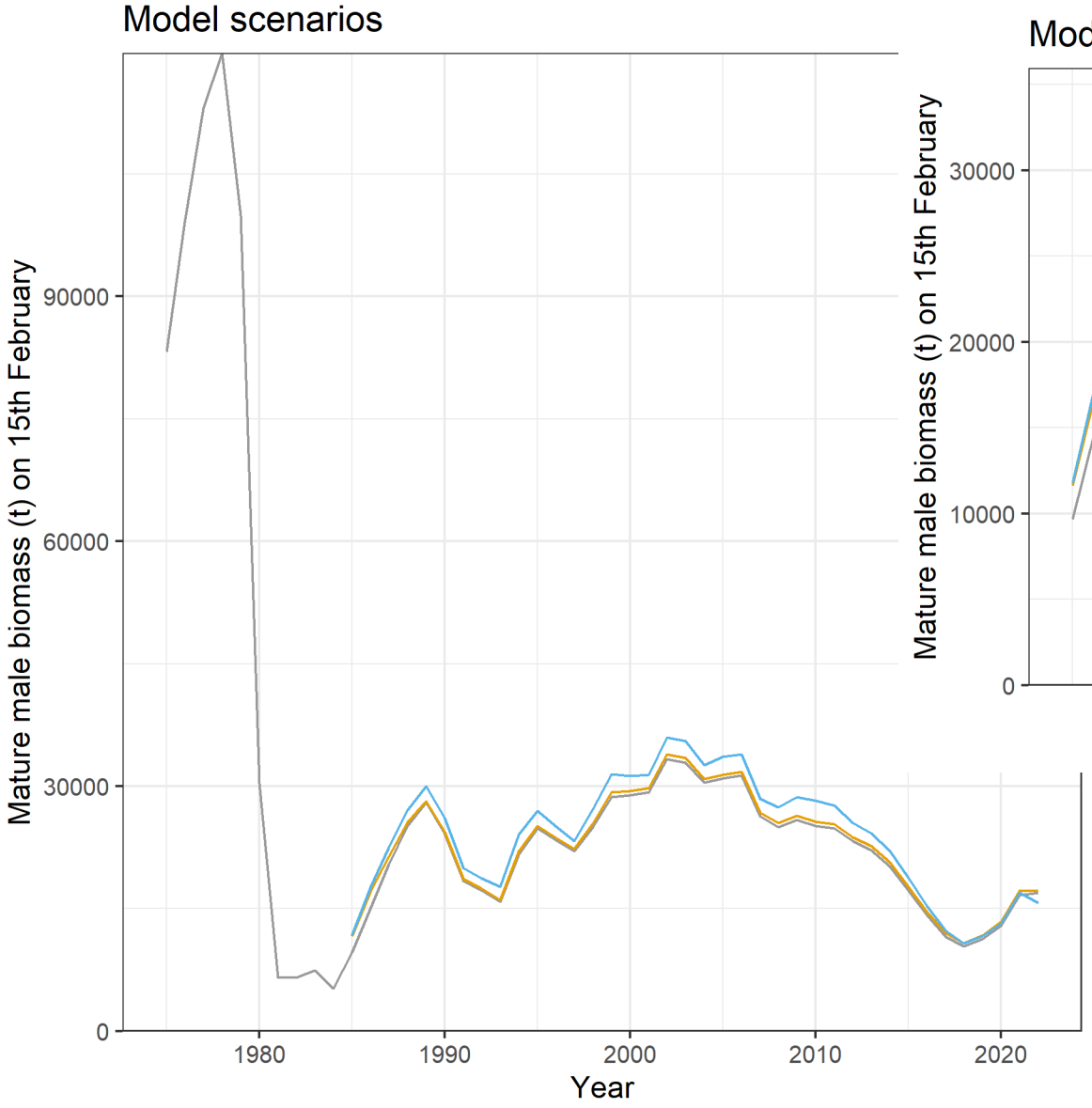
Residuals of total NMFS survey biomass

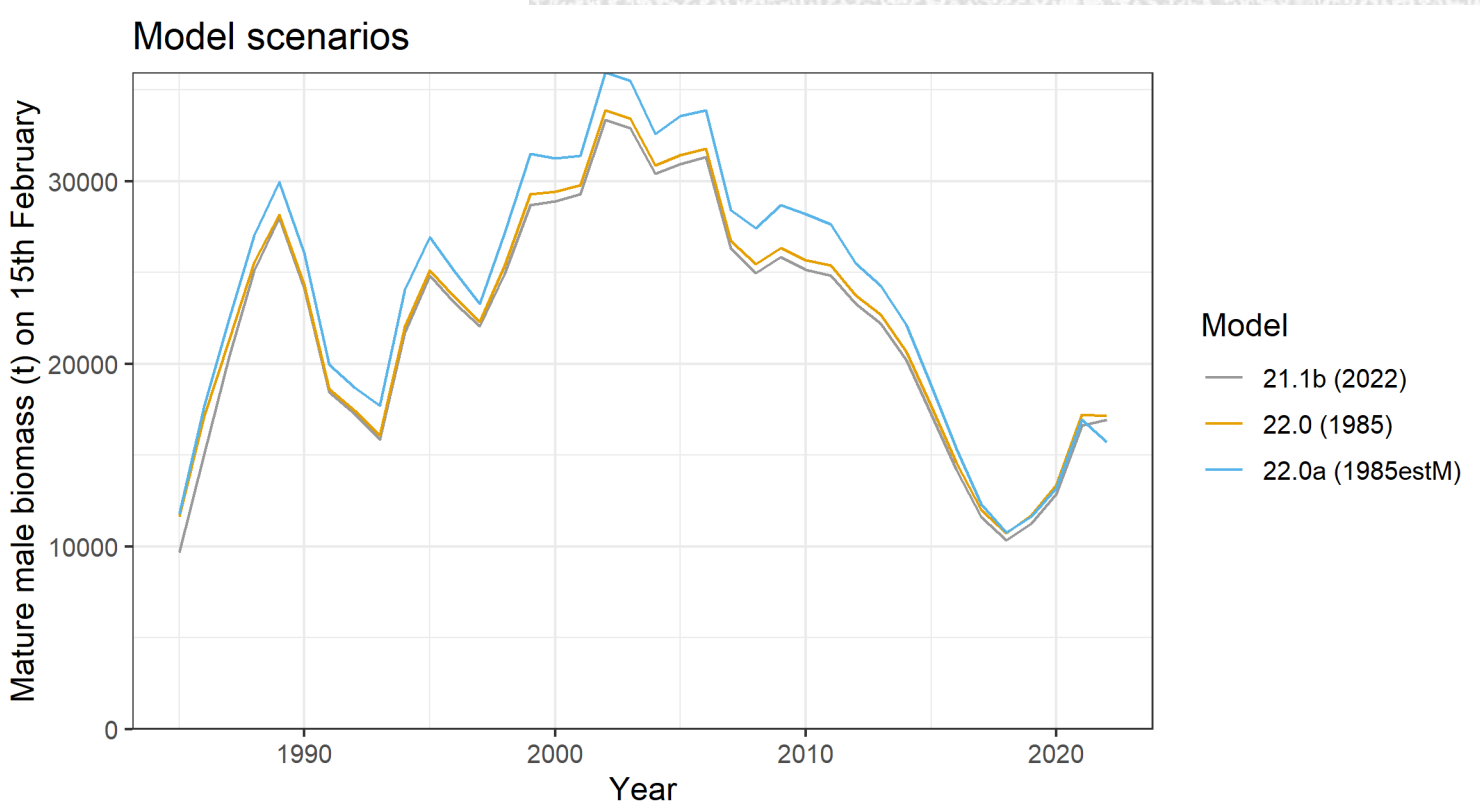


- Error bars show additional error
- BSFRF survey catchability is assumed to be 1.0
- Similar fits

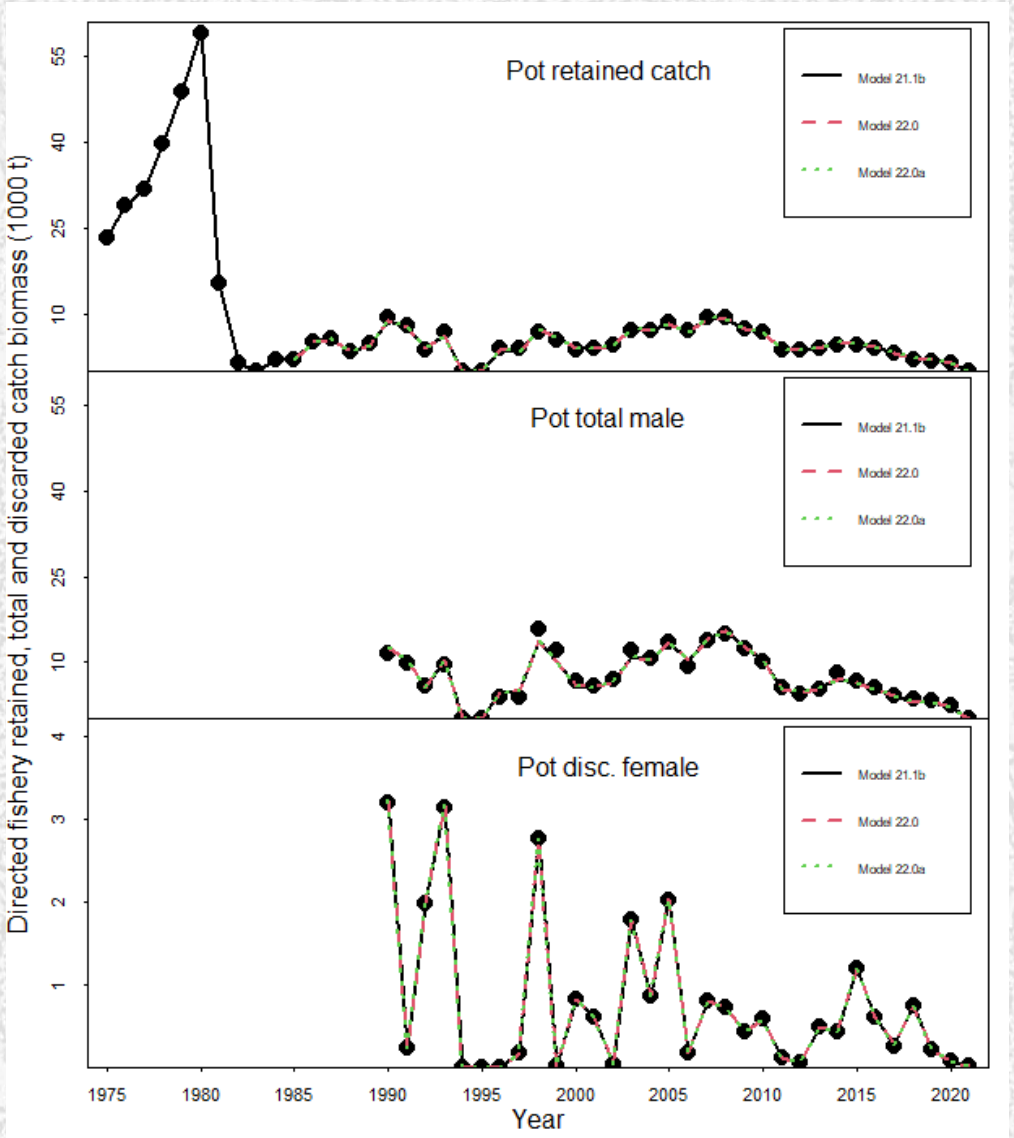


Mature male biomass





Mortality biomass (equal to catch biomass times handling mortality rate)



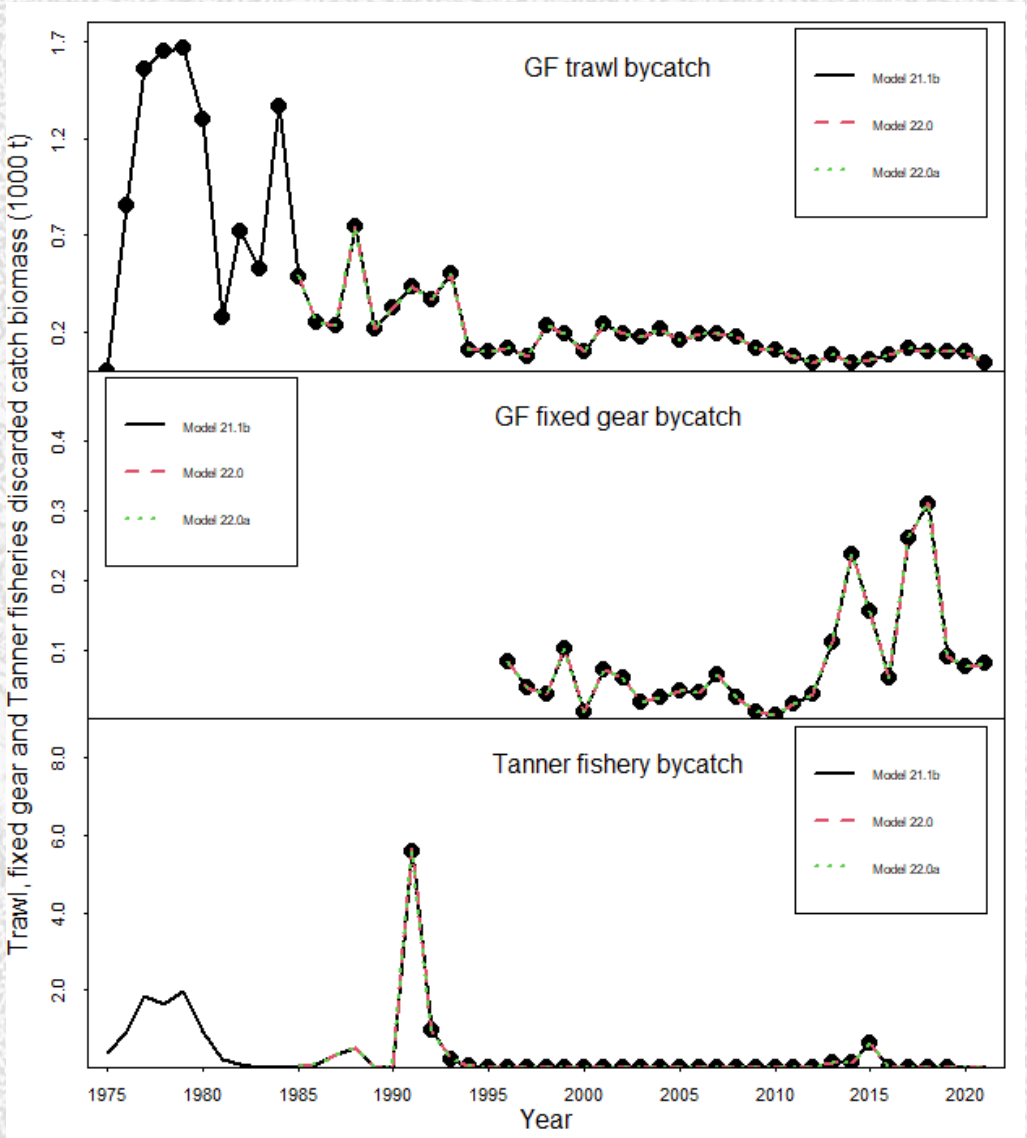
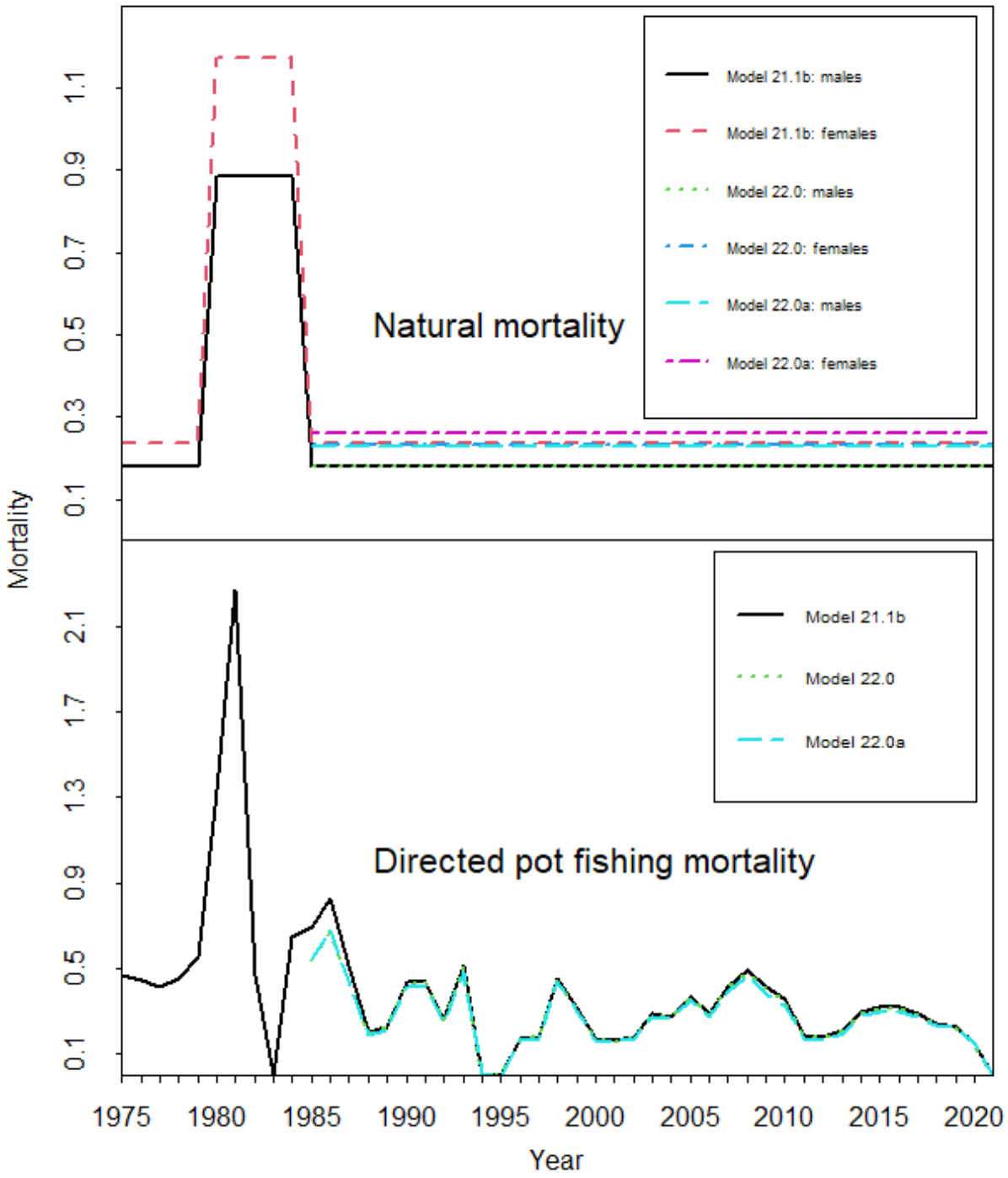
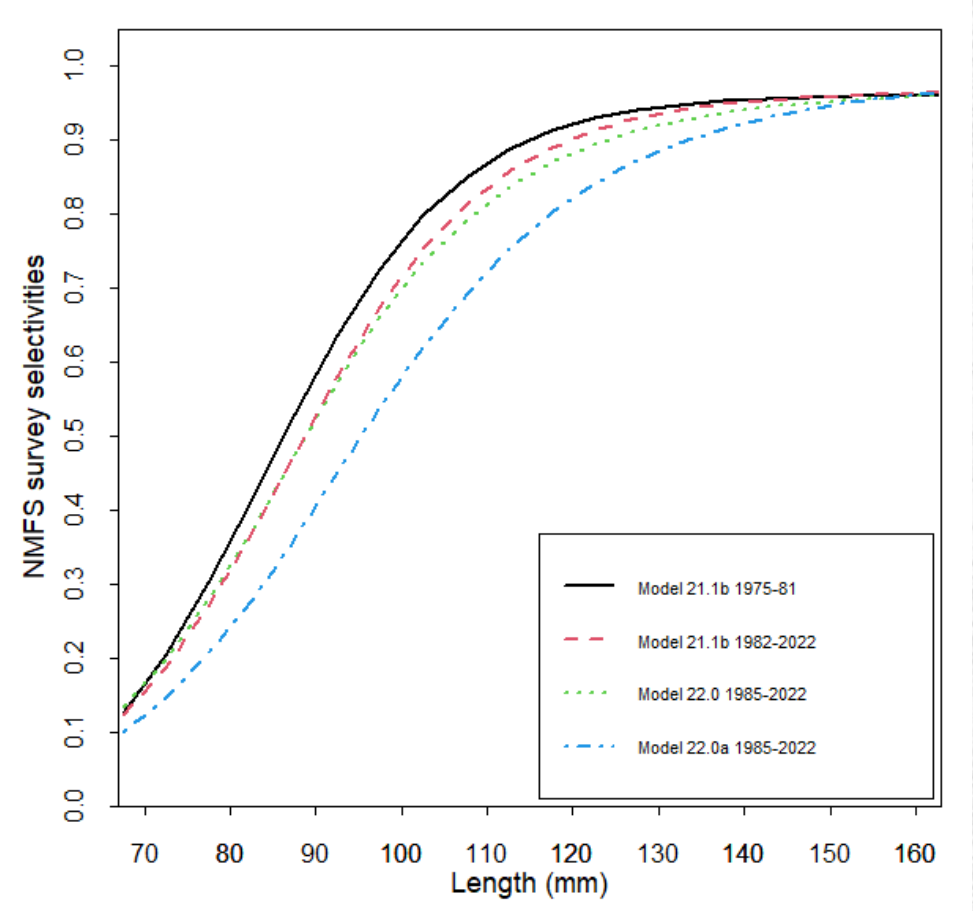
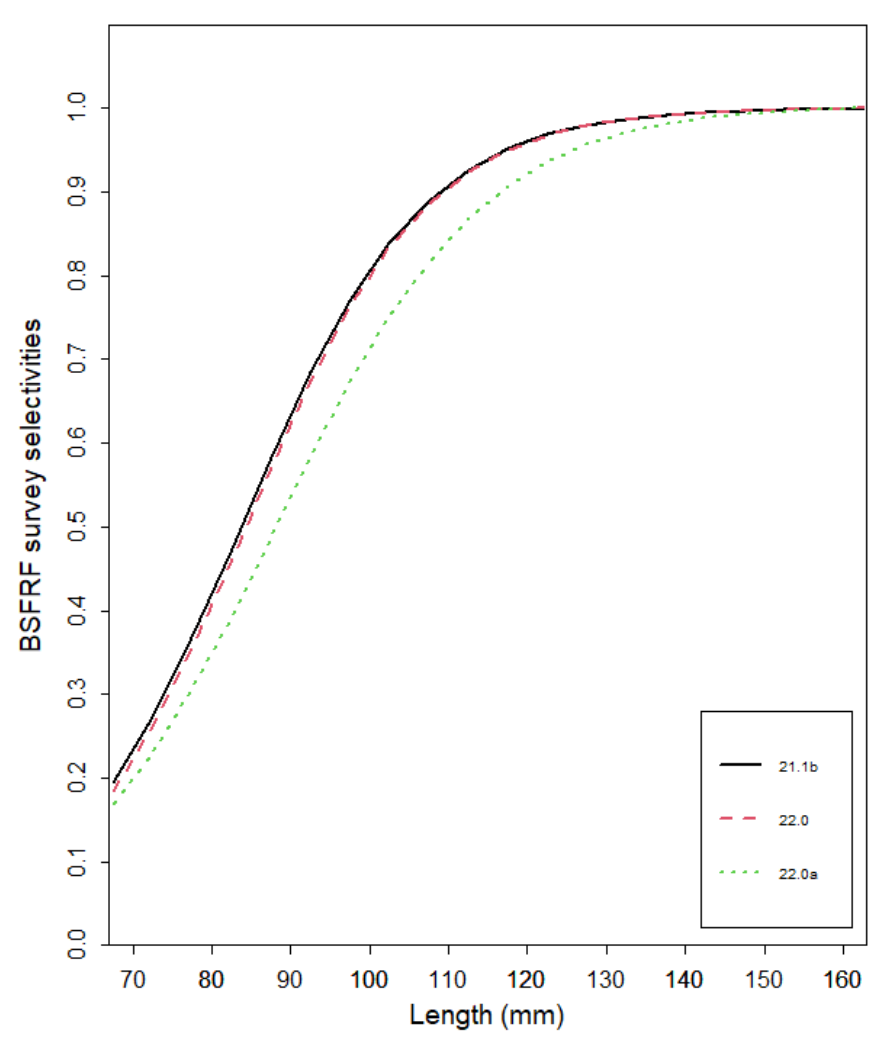


Table 7. Natural mortality estimates for three model scenarios during different year blocks.

Model	Sex	1975-1979, 1985-2022	1980-1984	1985-2022
21.1b	Males	0.180	0.886	
	Females	0.238	1.174	
22.0	Males			0.180
	Females			0.232
22.0a	Males			0.228
	Females			0.261

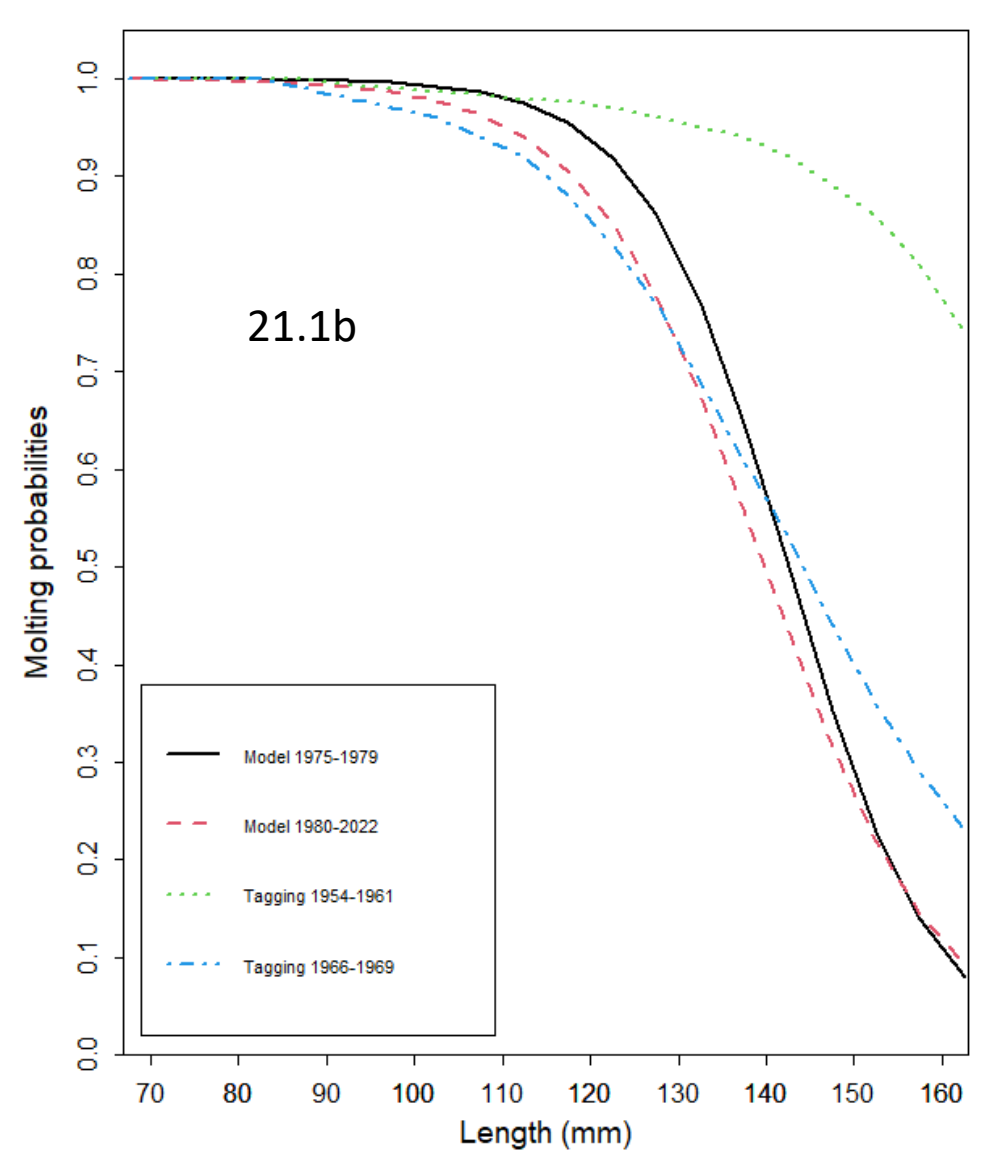


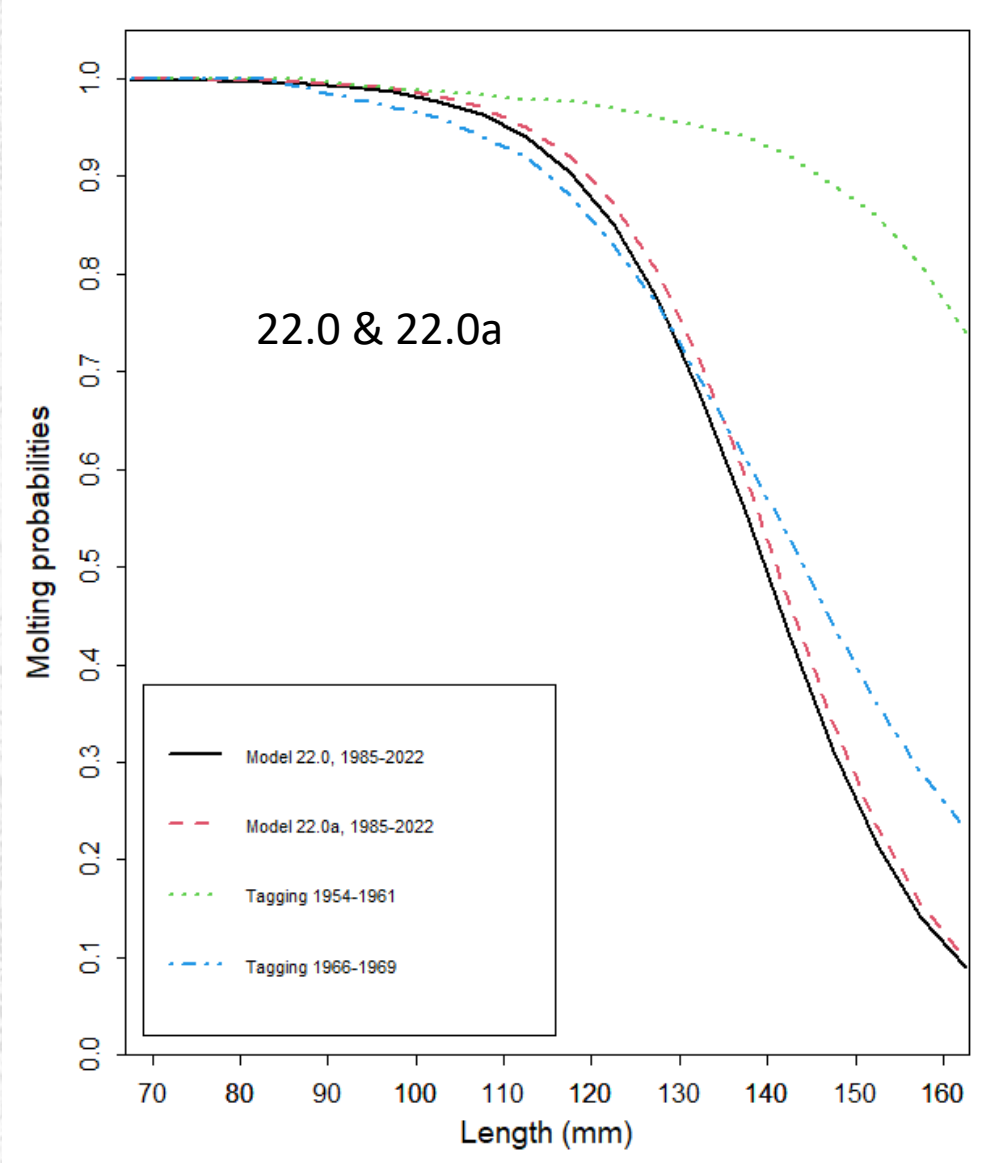




Survey selectivity:
- 22.0a (estimated base M) largest difference

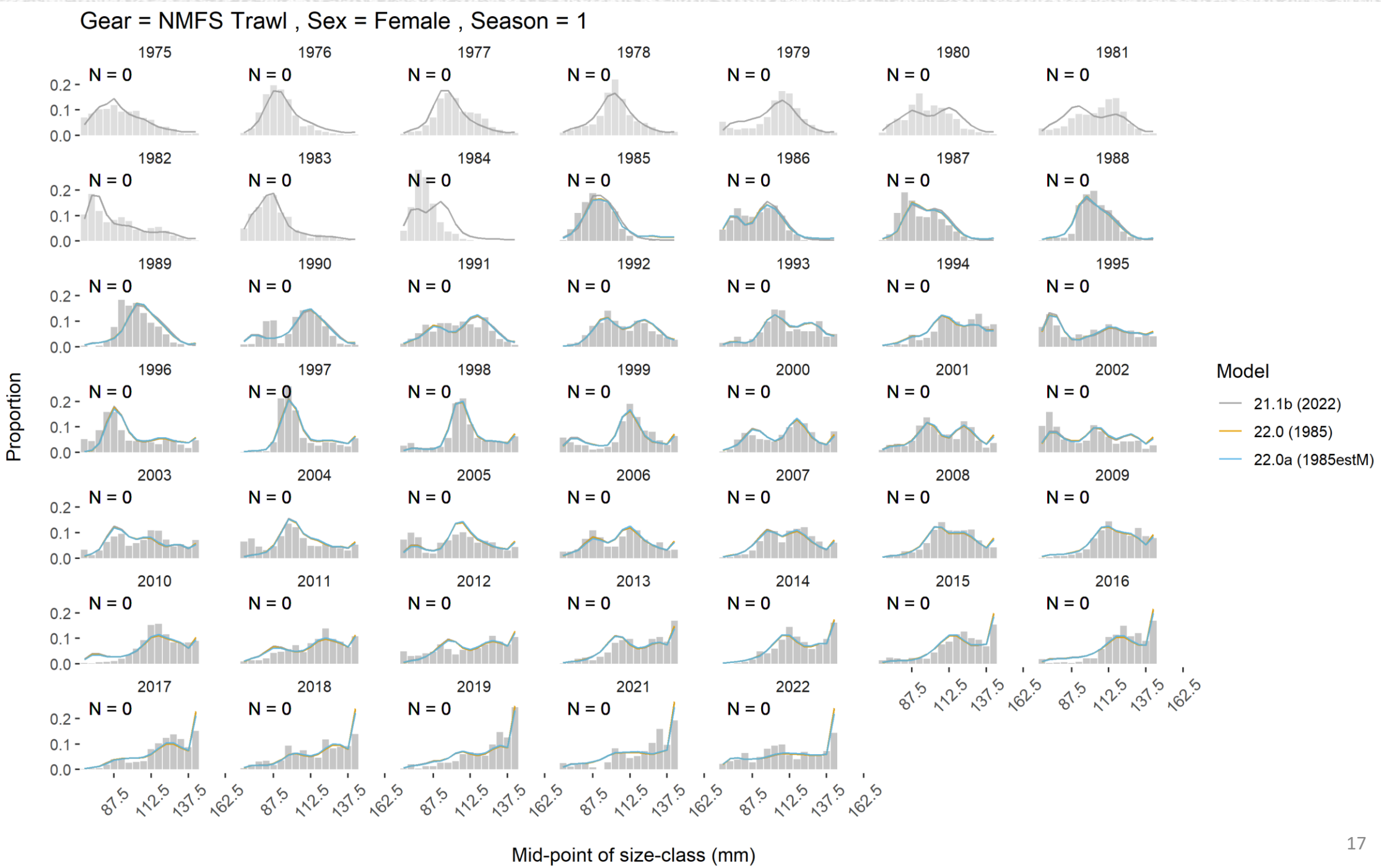
Molting probabilities





Size composition fit

- Similar for all models in bycatch and directed fisheries
- Survey selectivities are similar also (see next two slides)


Gear = NMFS Trawl , Sex = Female , Season = 1
1975 N = 0
1976 N = 0
1977 N = 0
1978 N = 0
1979 N = 0
1980 N = 0
1981 N = 0
1982 N = 0
1983 N = 0
1984 N = 0
1985 N = 0
1986 N = 0
1987 N = 0
1988 N = 0
1989 N = 0
1990 N = 0
1991 N = 0
1992 N = 0
1993 N = 0
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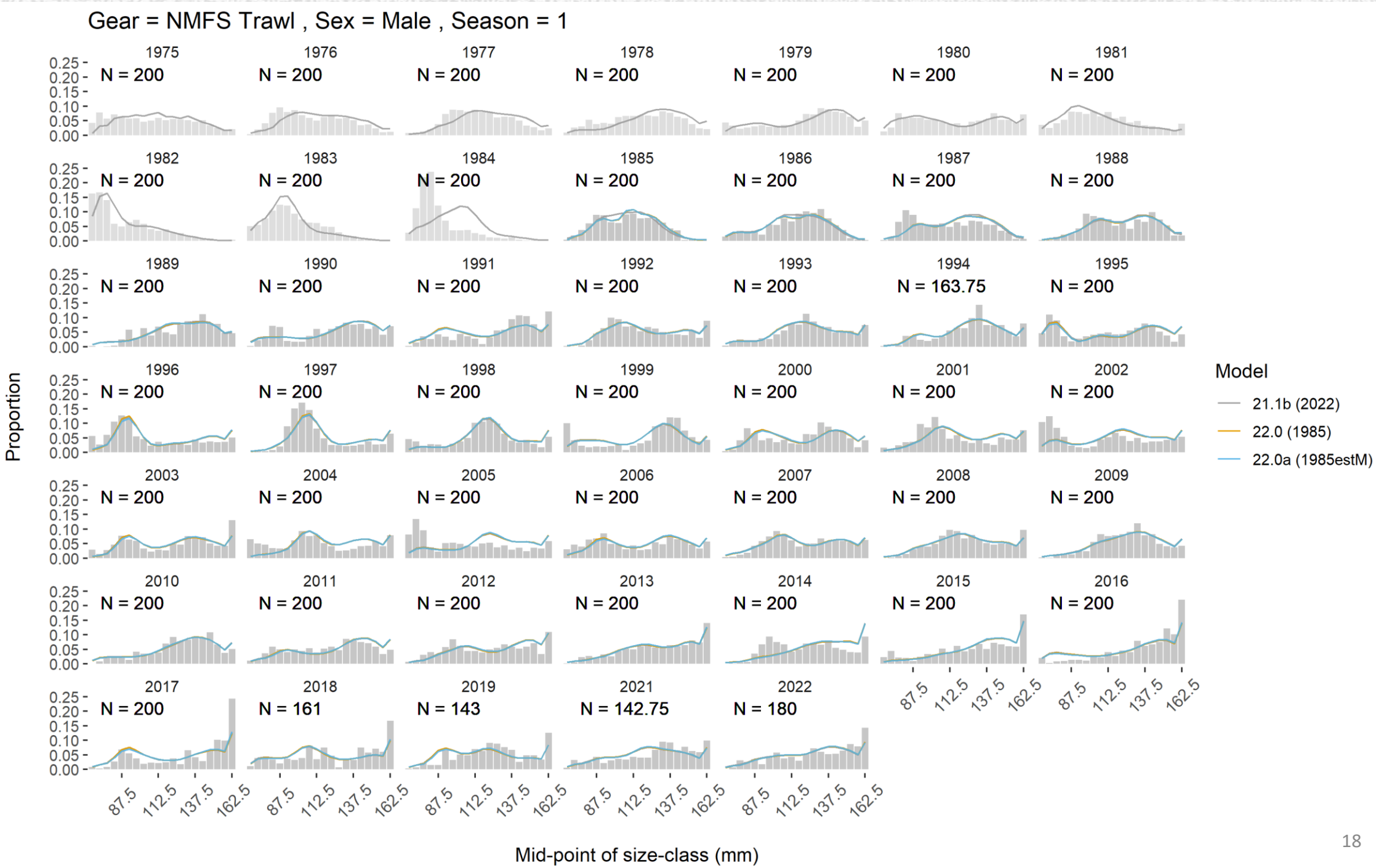
2005 N = 0
2006 N = 0
2007 N = 0
2008 N = 0
2009 N = 0
2010 N = 0
2011 N = 0
2012 N = 0
2013 N = 0
2014 N = 0
2015 N = 0
2016 N = 0
2017 N = 0
2018 N = 0
2019 N = 0
2021 N = 0
2022 N = 0
Proportion
0.0
0.1
0.2
87.5
112.5
137.5
162.5
Mid-point of size-class (mm)
Model
21.1b (2022)
22.0 (1985)
22.0a (1985estM)


Gear = NMFS Trawl , Sex = Male , Season = 1
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1978 N = 200
1979 N = 200
1980 N = 200
1981 N = 200
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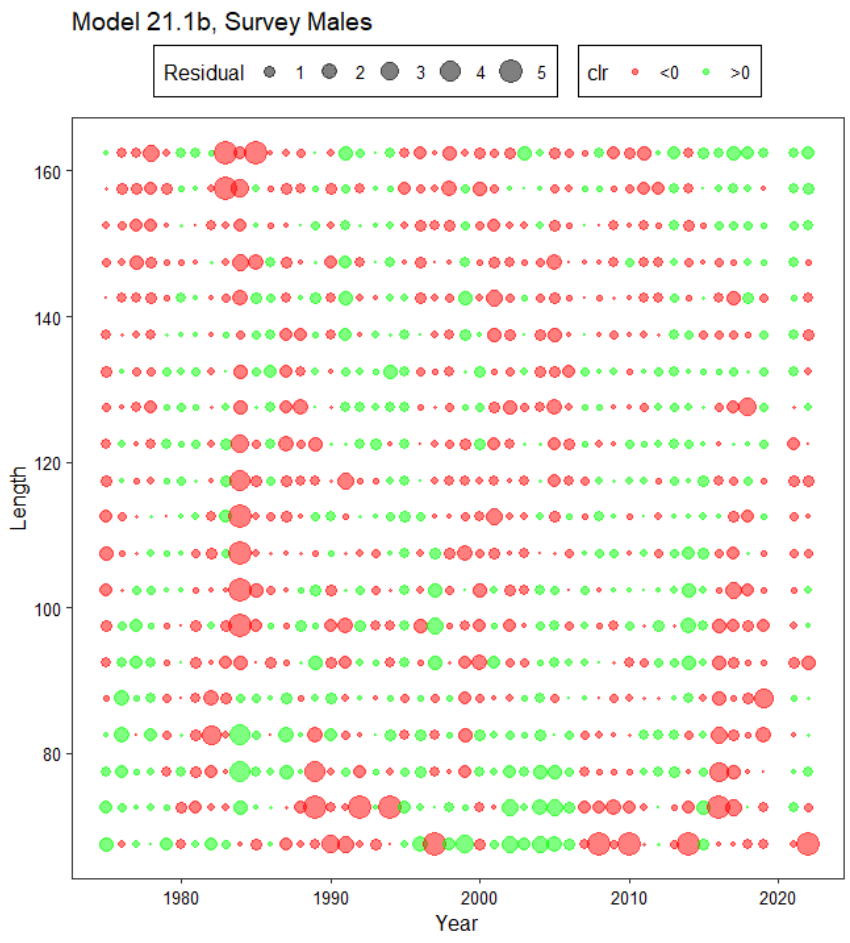
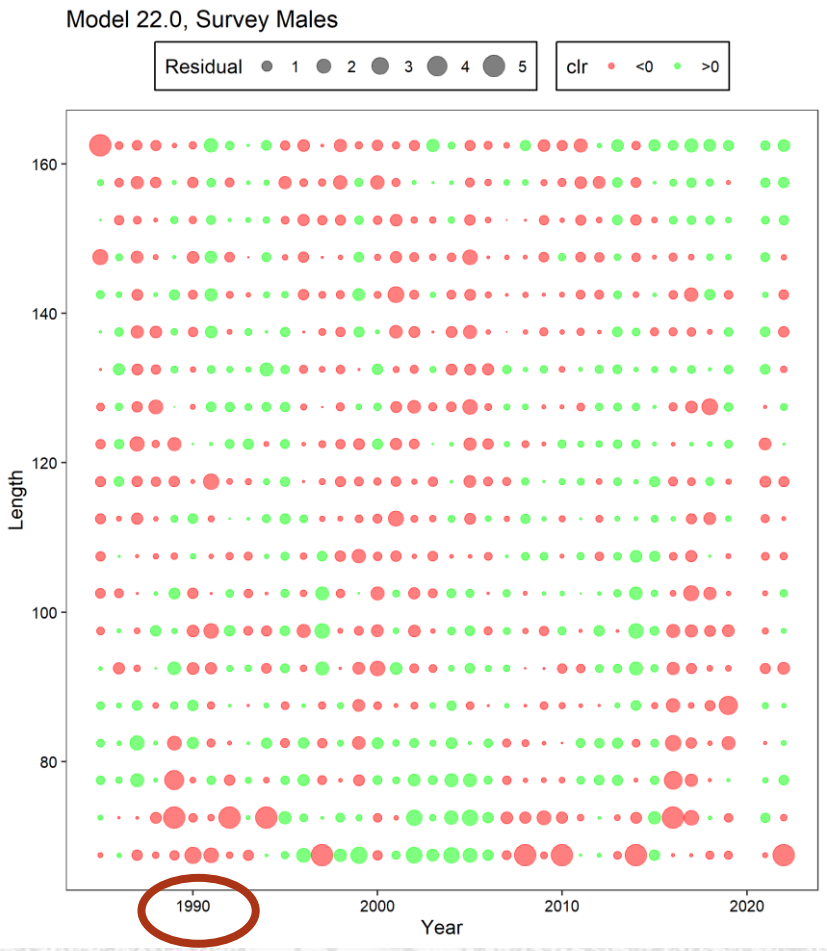
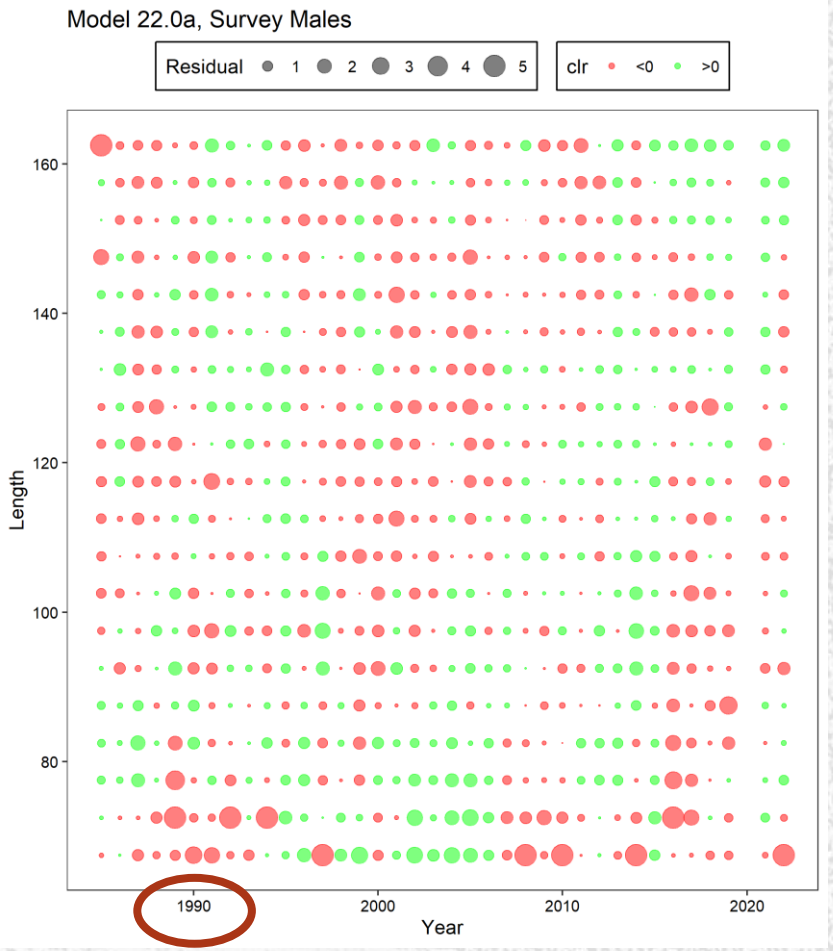
1983 N = 200
1984 N = 200
1985 N = 200
1986 N = 200
1987 N = 200
1988 N = 200
1989 N = 200
1990 N = 200
1991 N = 200
1992 N = 200
1993 N = 200
1994 N = 163.75
1995 N = 200
1996 N = 200
1997 N = 200
1998 N = 200
1999 N = 200
2000 N = 200
2001 N = 200
2002 N = 200
2003 N = 200
2004 N = 200
2005 N = 200
2006 N = 200
2007 N = 200
2008 N = 200
2009 N = 200
2010 N = 200
2011 N = 200
2012 N = 200
2013 N = 200
2014 N = 200
2015 N = 200
2016 N = 200
2017 N = 200
2018 N = 161
2019 N = 143
2021 N = 142.75
2022 N = 180
Proportion
0.25
0.20
0.15
0.10
0.05
0.00
87.5
112.5
137.5
162.5
Mid-point of size-class (mm)
Model
21.1b (2022)
22.0 (1985)
22.0a (1985estM)

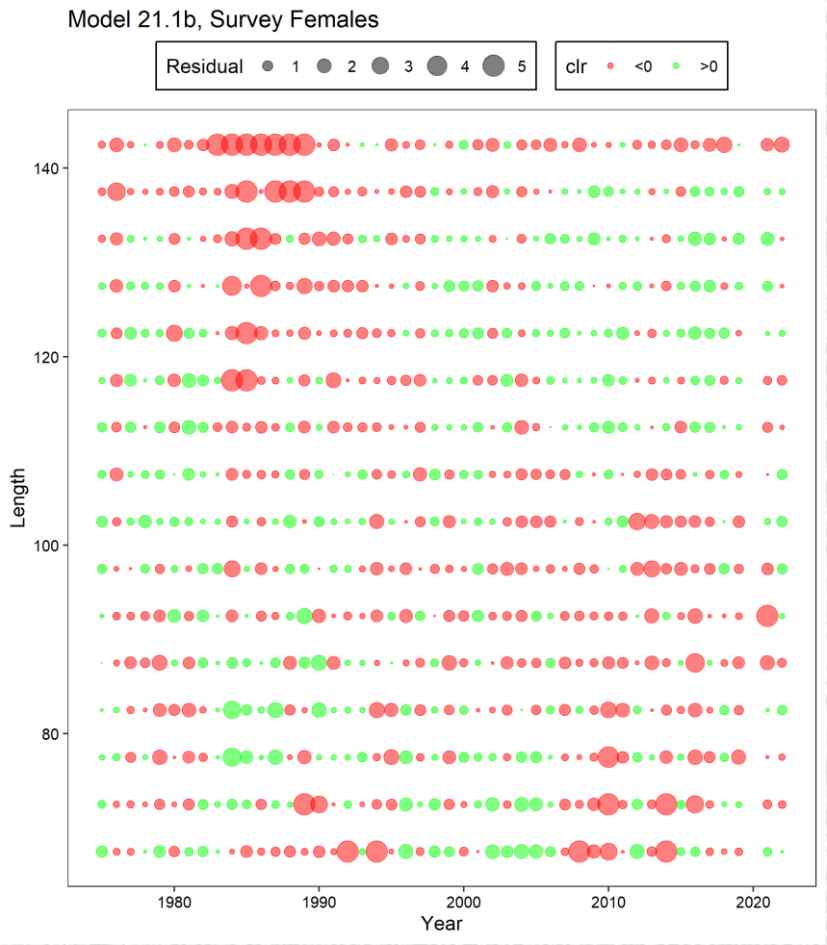
Comparison of residuals for NMFS survey males

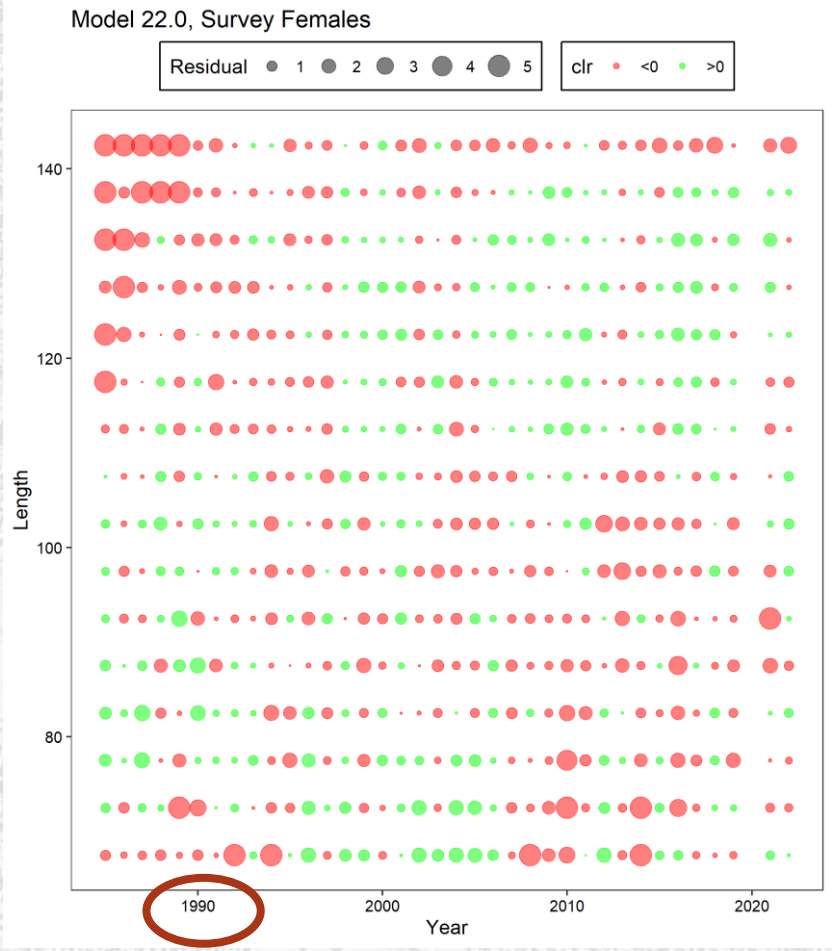


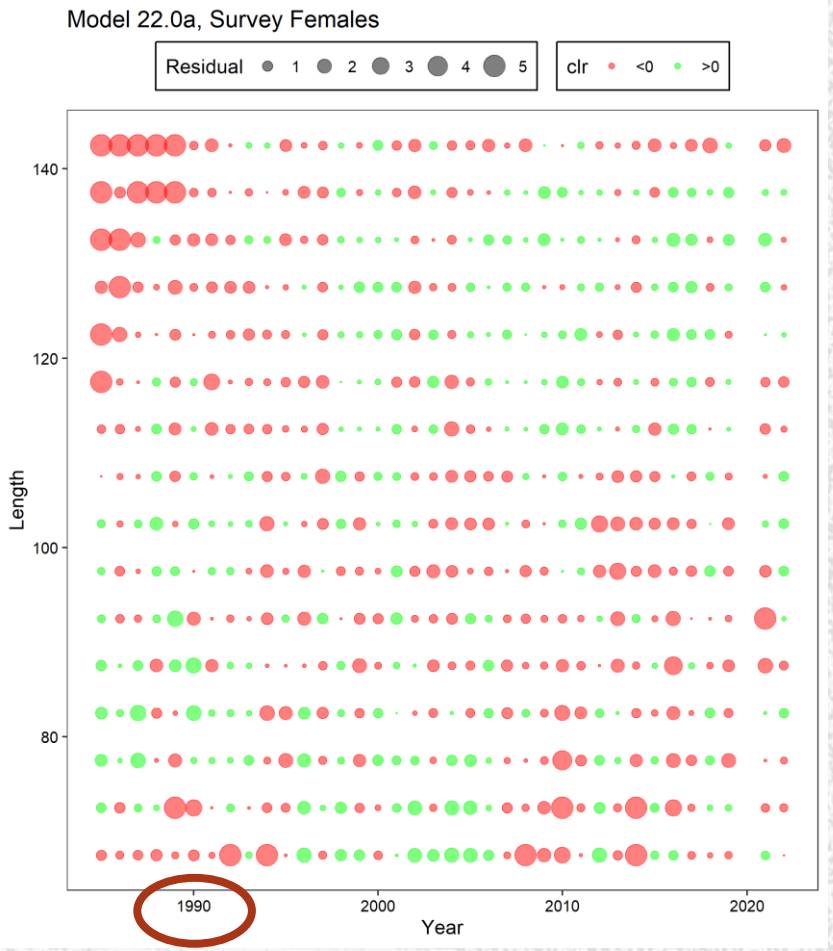




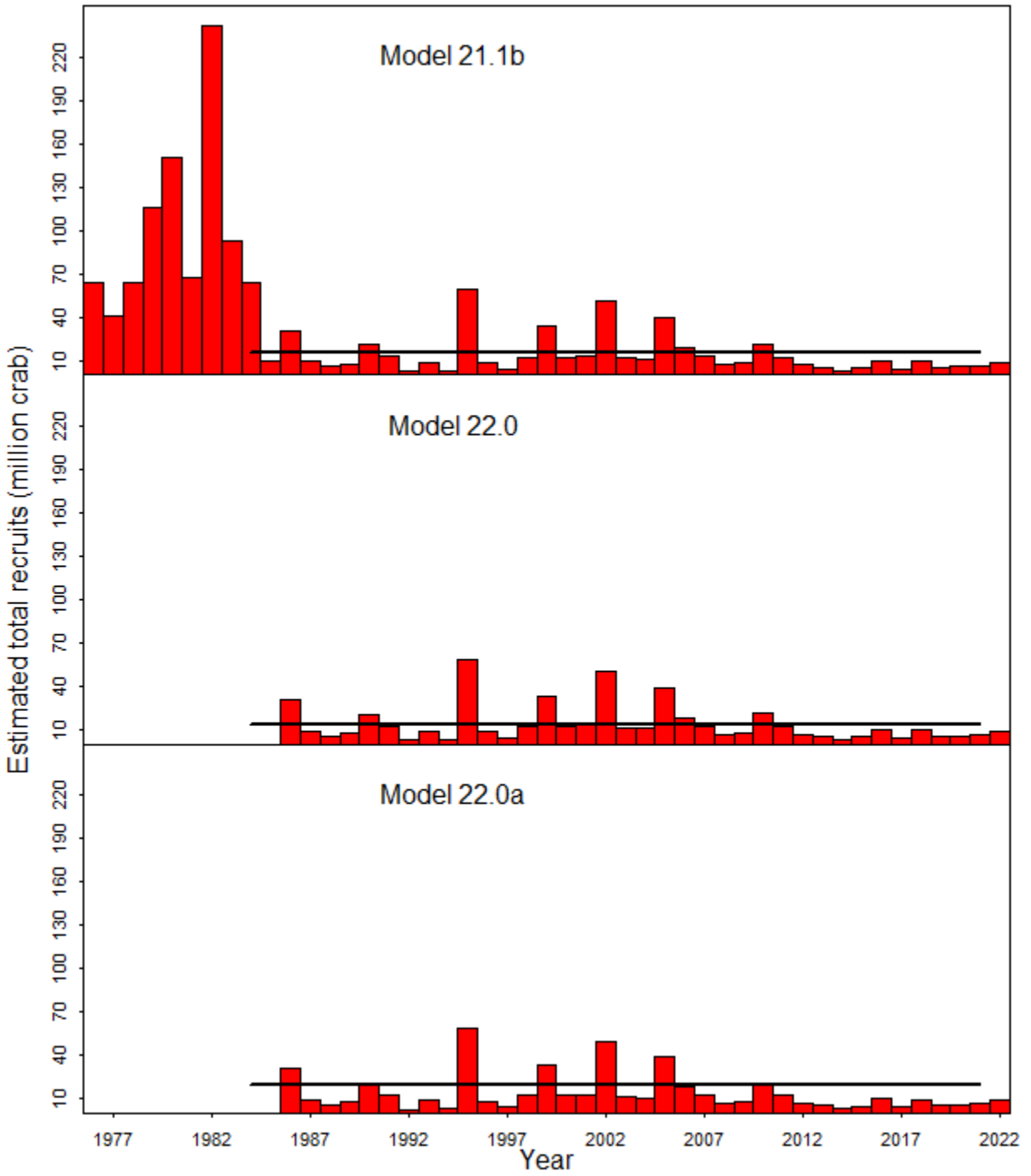
Comparison of residuals for NMFS survey females



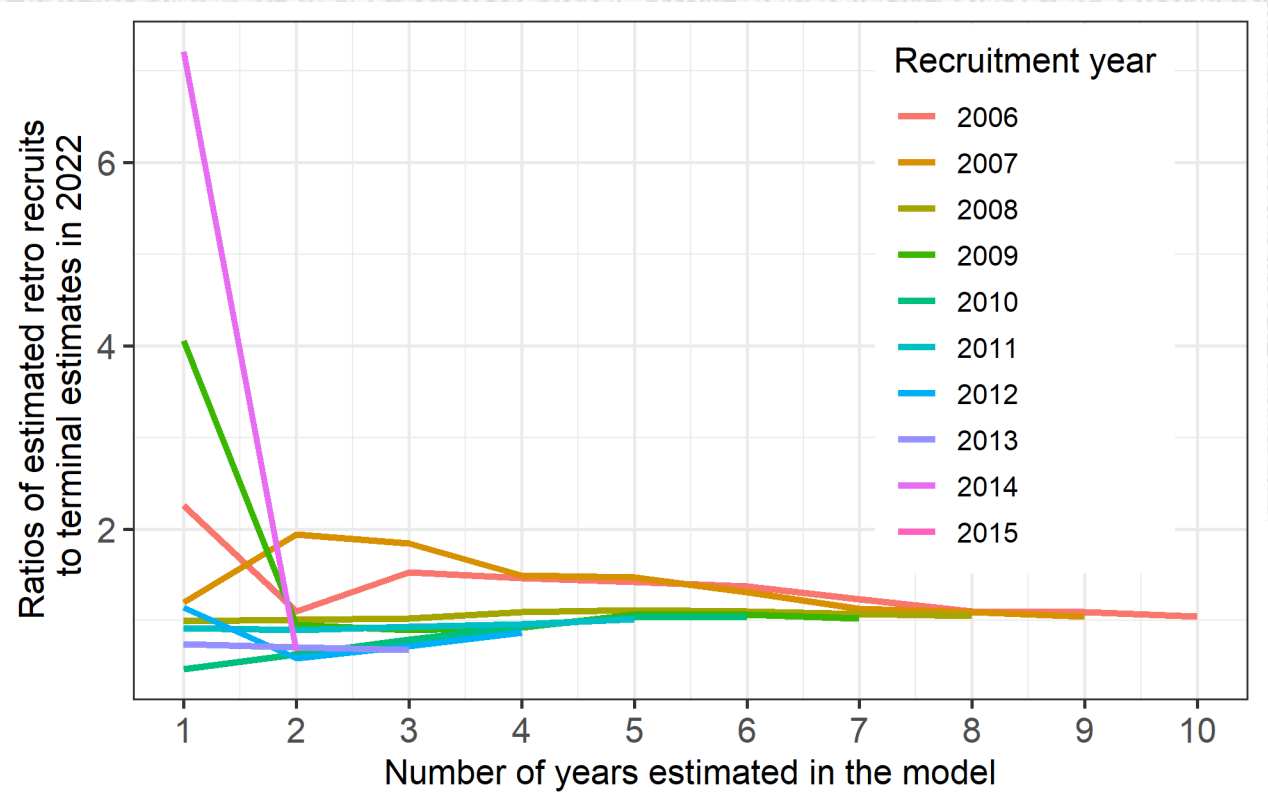


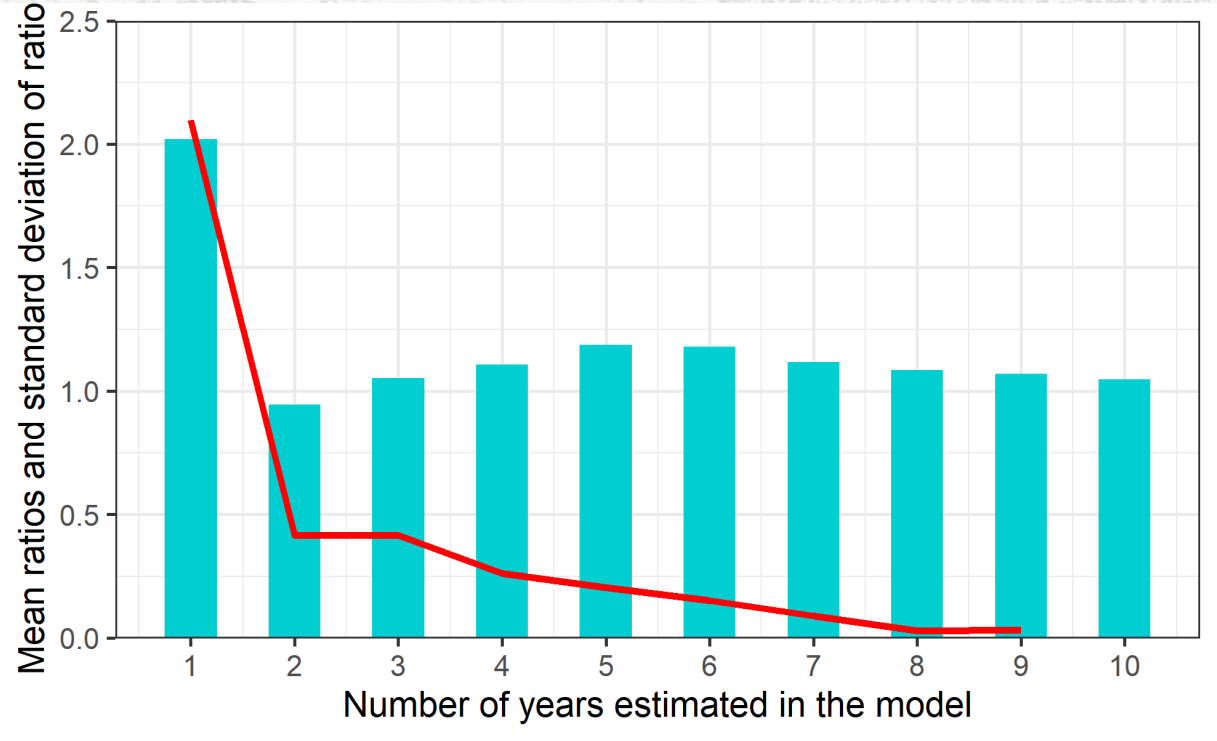


Recruitment



Recruitment to exclude from reference point calculations





Highlighted cells show prior density values and total negative likelihood values without prior densities

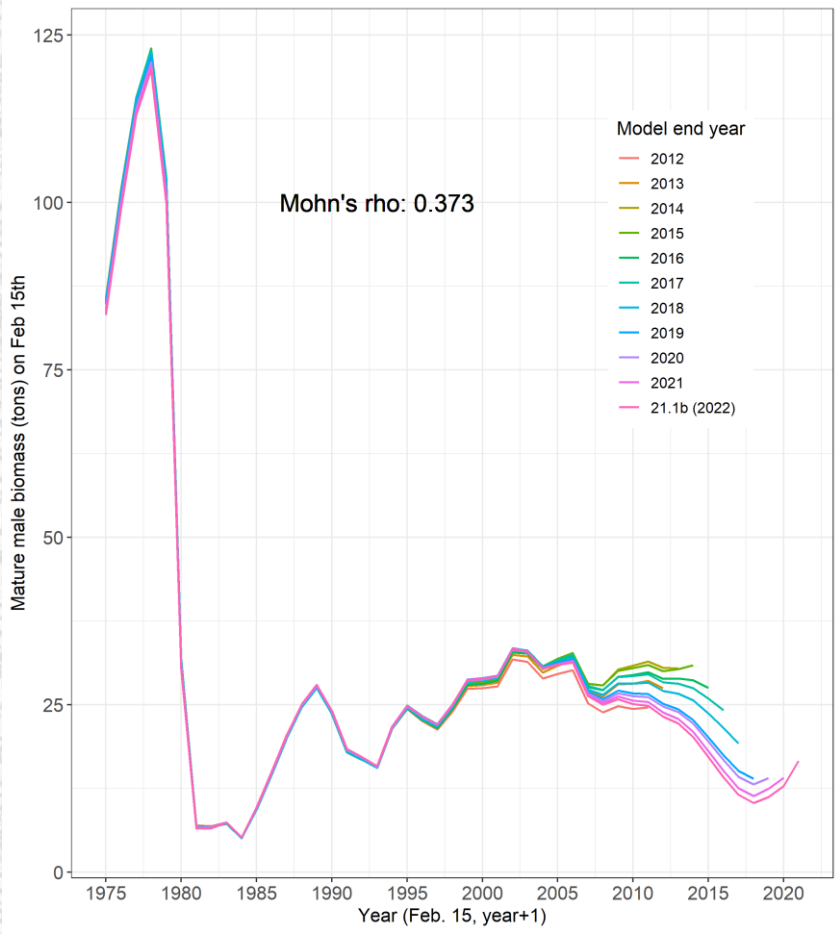
	Model			
	21.1b	22.0	22.0a	22.0a-22.0
Pot-ret-catch	-60.88	-34.88	-35.81	-0.93
Pot-totM-catch	26.54	26.55	25.62	-0.93
Pot-F-discC	-55.69	-55.70	-55.28	0.42
Trawl-discC	-63.74	-51.28	-51.28	0
Tanner-M-discC	-43.54	-26.12	-26.12	0
Tanner-F-discC	-43.48	-26.08	-26.10	-0.02
Fixed-discC	-36.04	-36.04	-36.04	0
Trawl-suv-bio	-35.47	-44.09	-47.68	-3.59
BSFRF-sur-bio	-2.94	-3.33	-4.73	-1.4
Pot-ret-comp	-3932.20	-3131.80	-3134.52	-2.72
Pot-totM-comp	-2369.46	-2370.52	-2371.39	-0.87
Pot-discF-comp	-1449.36	-1449.09	-1450.22	-1.13
Trawl-disc-comp	-5836.10	-4681.05	-4685.50	-4.45
TC-disc-comp	-1274.28	-1273.40	-1276.25	-2.85
Fixed-disc-comp	-3393.50	-3394.74	-3392.59	2.15
Trawl-sur-comp	-6984.67	-5503.89	-5516.02	-12.13
BSFRF-sur-comp	-843.53	-842.35	-844.98	-2.63
Recruit-dev	70.56	41.28	41.83	0.55
Recruit-sex-R	76.98	60.67	60.63	-0.04
Log_fdev=0	0.00	0.00	0.00	0
M-deviation	43.83	0.00	0.00	
Sex-specific-R	0.01	0.15	0.18	0.03
Ini-size-struct.	30.88	50.88	55.77	4.89
PriorDensity	267.30	233.94	221.50	-12.44
Tot-likelihood	-25908.79	-22510.90	-22549.41	-38.51
Tot-likeli-no-PD	-25641.5	-22276.96	-22317.91	-40.95
Tot-parameter	372	308	309	1
$MMB_{35\%}$	24026.11	21896.23	19512.93	-2383.3
MMB-terminal	16952.82	17157.89	15713.76	-1444.13
$F_{35\%}$	0.298	0.299	0.395	0.096
F_{ofl}	0.200	0.227	0.309	0.082
OFL	3035.63	3481.84	4319.04	837.2
ABC	2428.50	2785.47	3455.23	669.76
NMFS Q	0.967	0.940	0.922	-0.018
Mature females	10.20	10.99	11.688	0.698
Mohn's rho, 10yr	0.373	0.453	0.329	

Retrospective analysis and projections

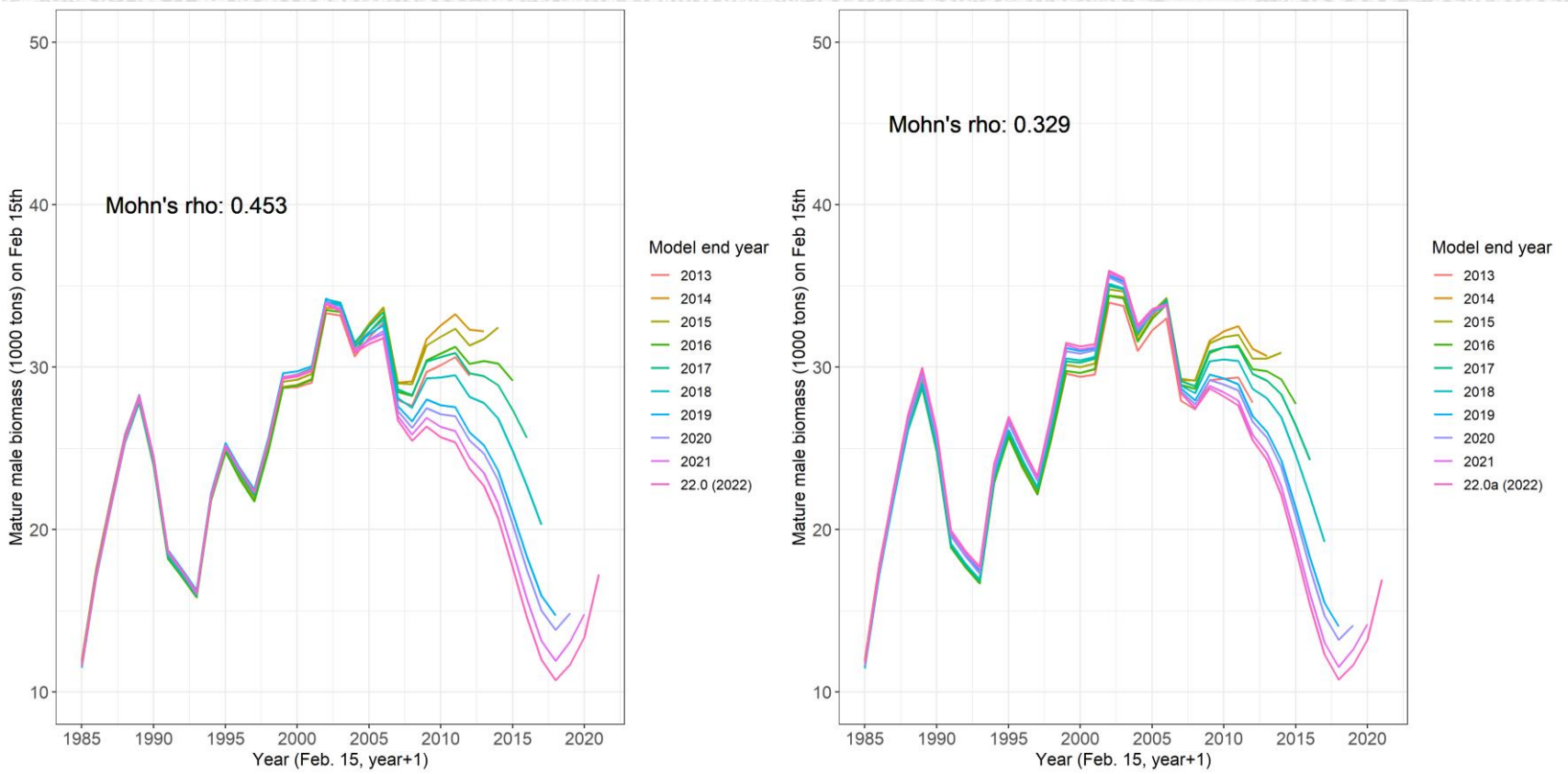
- Retrospective analysis – done for all model runs
- MCMC runs to look at model variability
  - Only performed for model 21.1b (base/reference model)
  - Time intensive – feasibility of this for all model runs?
- Projections
  - To inform population trajectory and the probability of “approaching an overfished condition”

Retrospective patterns

Model 21.1b

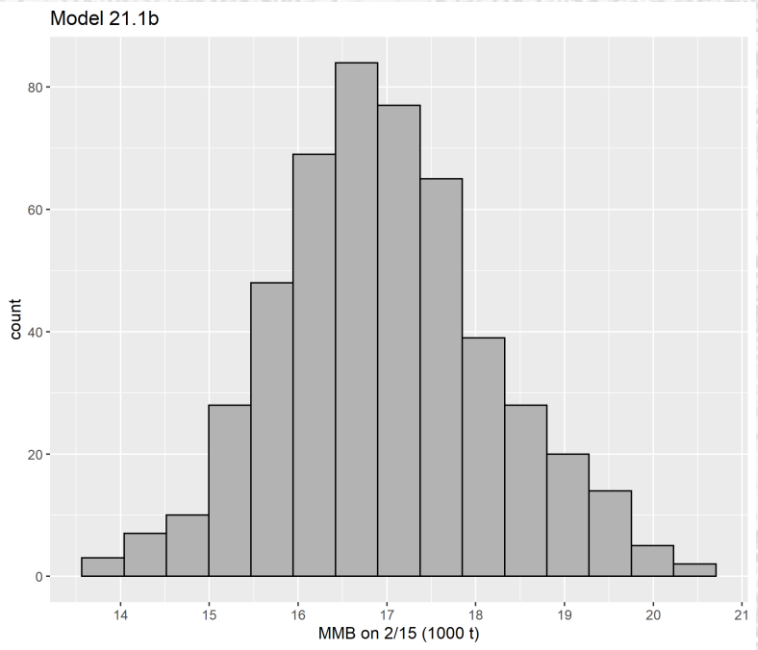


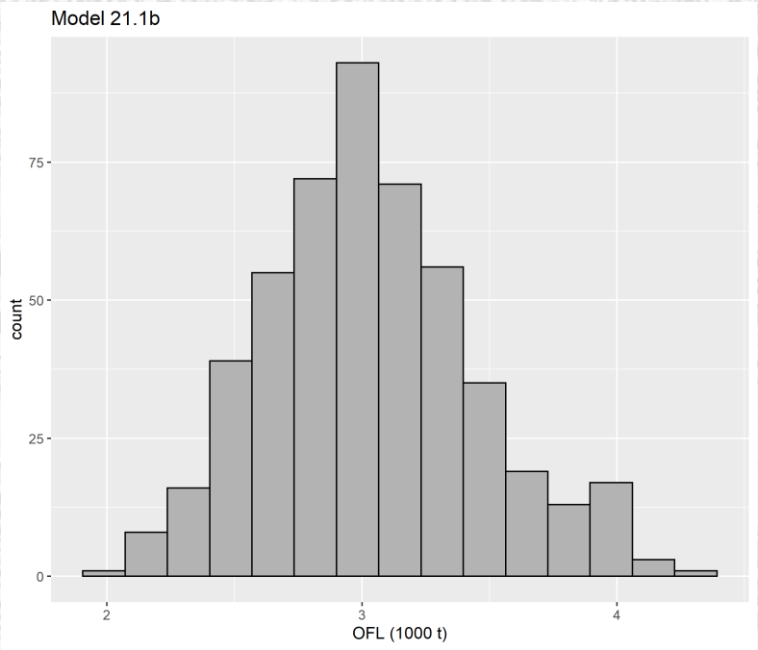
Model 22.0



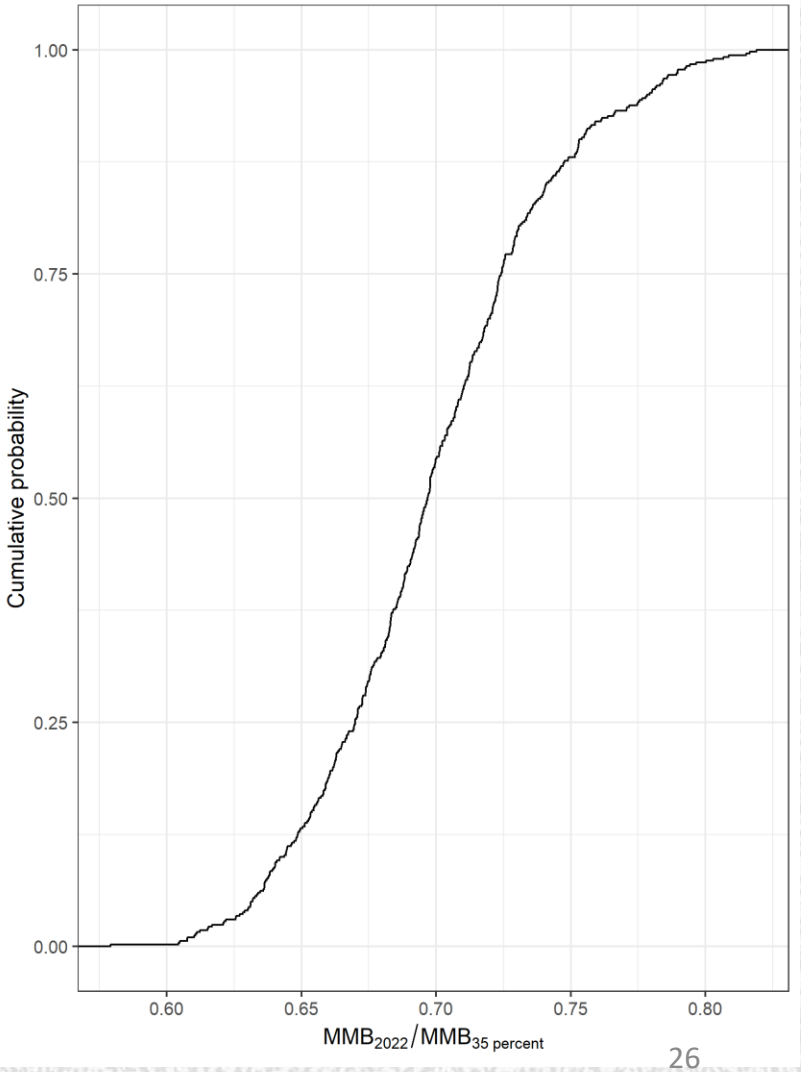
Model 22.0a

MCMC output (Model 21.1b)



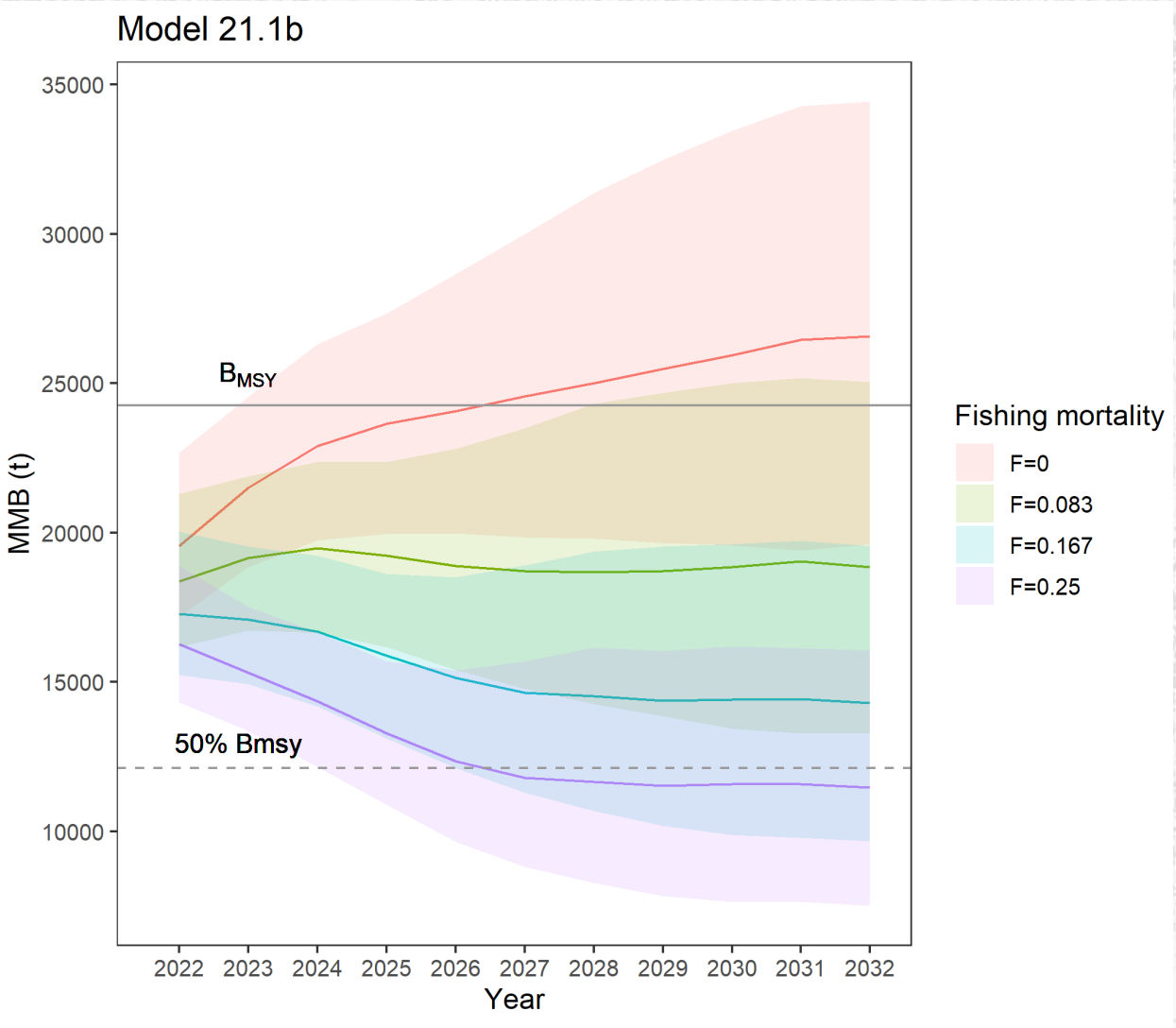


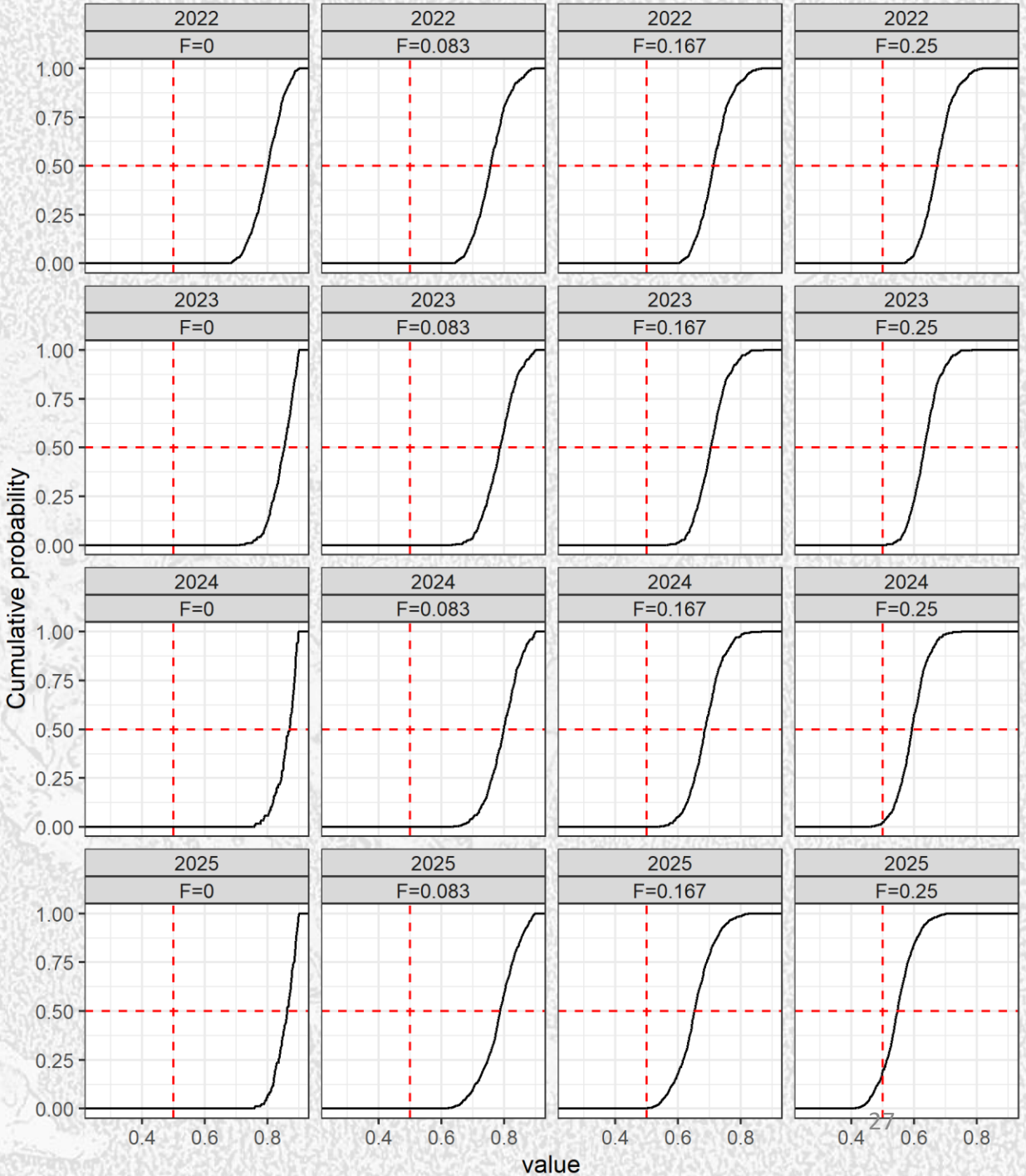
Cumulative probabilities of estimated ratios of MMB in 2022 to corresponding estimated $B_{35\%}$ values under model 21.1b with the MCMC approach.



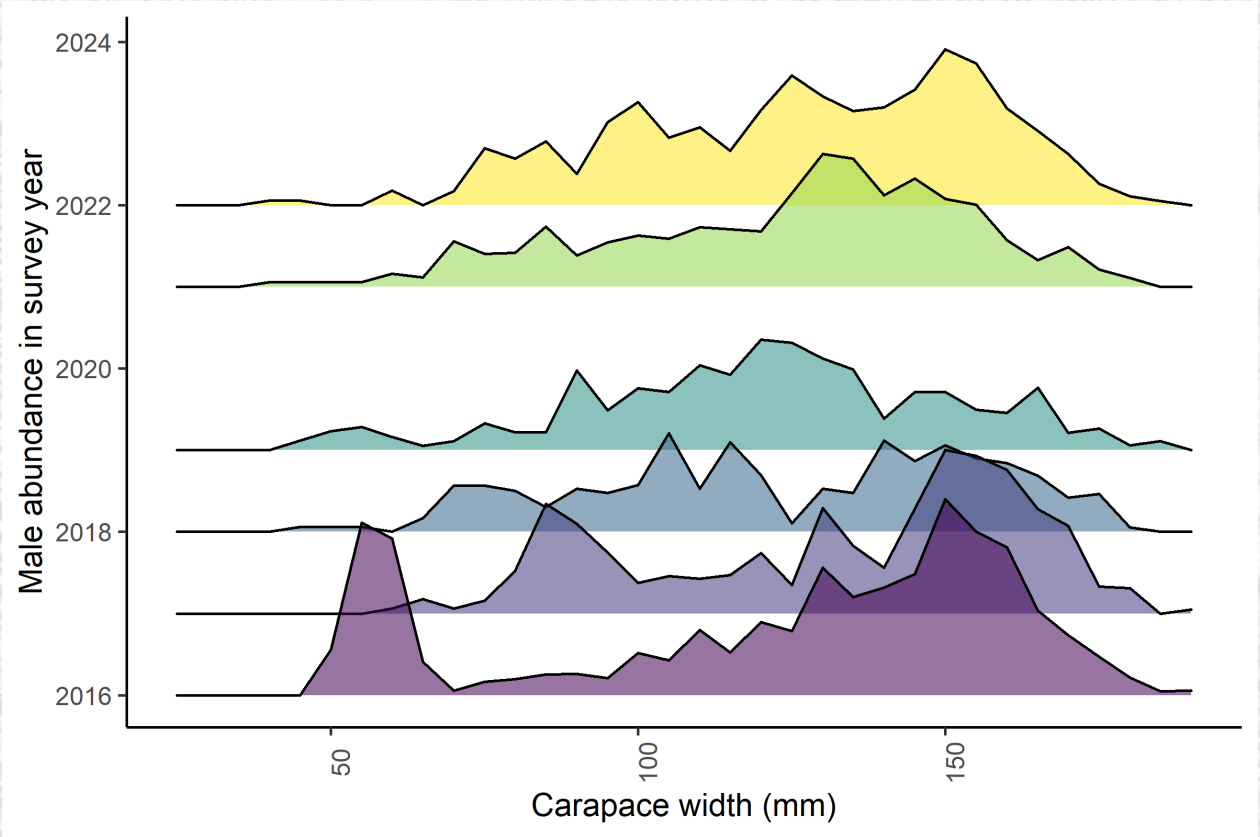
Projections for future status (21.1b MCMC output)

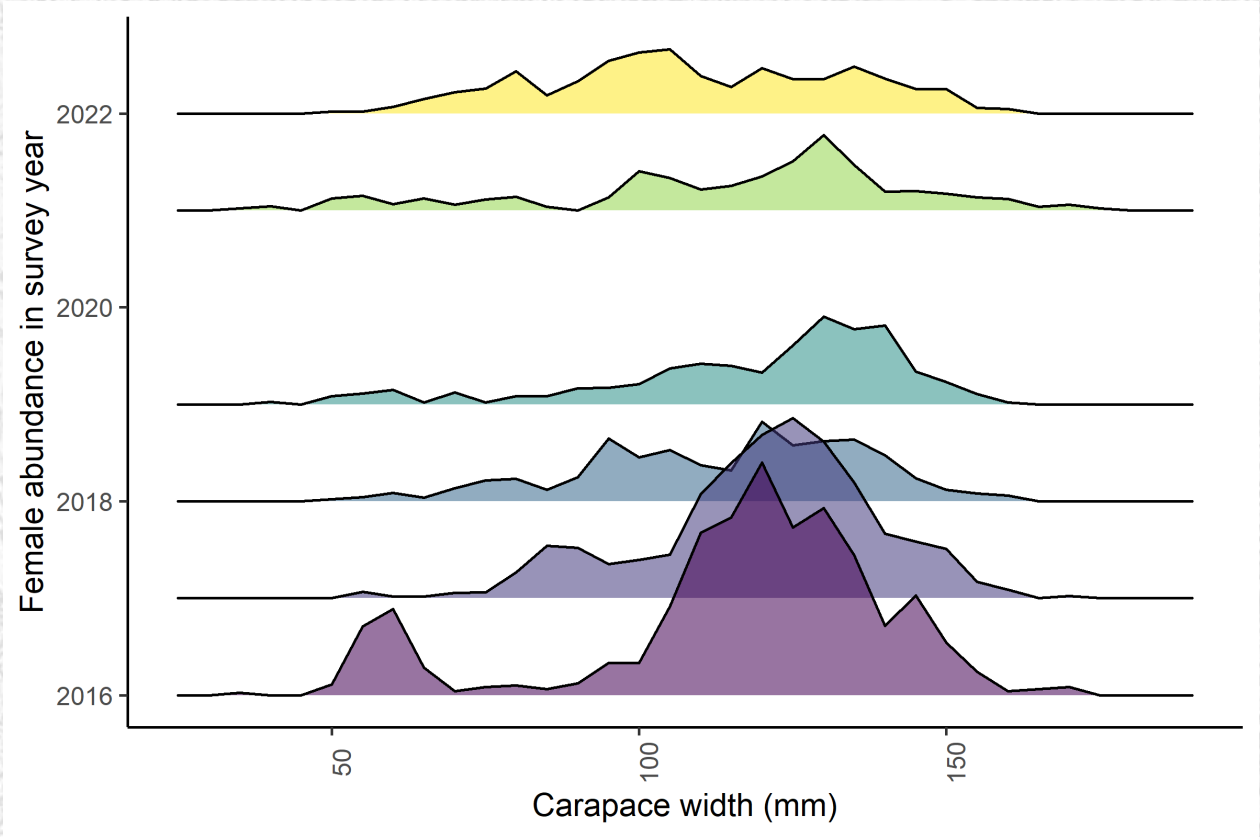
[2022 = projected MMB Feb 15th , 2023]





Last 6 years of size compositions NMFS survey data





Summary & Recommendations

- Models have similar output, some differences in model 22.0a due to estimated base M value for males
- Trend in mature male biomass similar except for terminal year for model 22.0a (not recommended for status determination, more investigation into changes in model output needed)
- Stock is not overfished in 2022 and not likely “approaching an overfished condition” in the next two years
- Recommend reference (base) model 21.1b for status determination
  - Model 22.0 is a potential transition but need a unified (for all stocks) approach to a starting date for models/data (SSC recommendation)

Status and catch specifications (1,000 t) (model 21.1b):

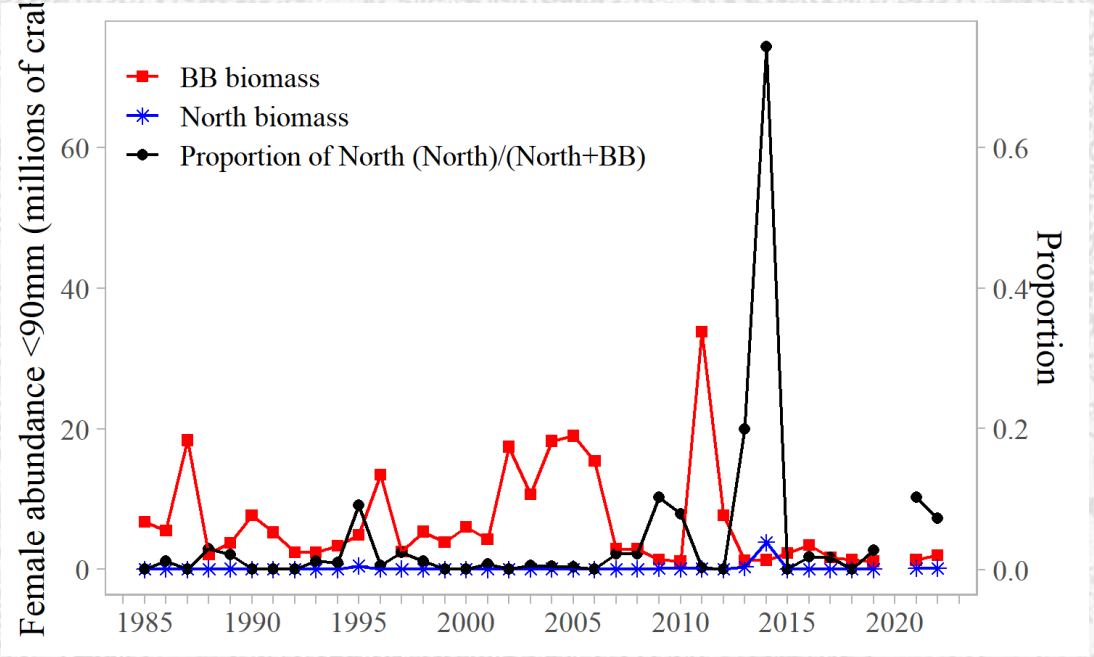
Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2018/19	10.62[B]	16.92[B]	1.95	2.03	2.65	5.34	4.27
2019/20	12.72[C]	14.24[C]	1.72	1.78	2.22	3.40	2.72
2020/21	12.12[D]	13.96[D]	1.20	1.26	1.57	2.14	1.61
2021/22	12.01	16.64	0	0.02	0.10	2.23	1.78
2022/23		16.95				3.04	2.43

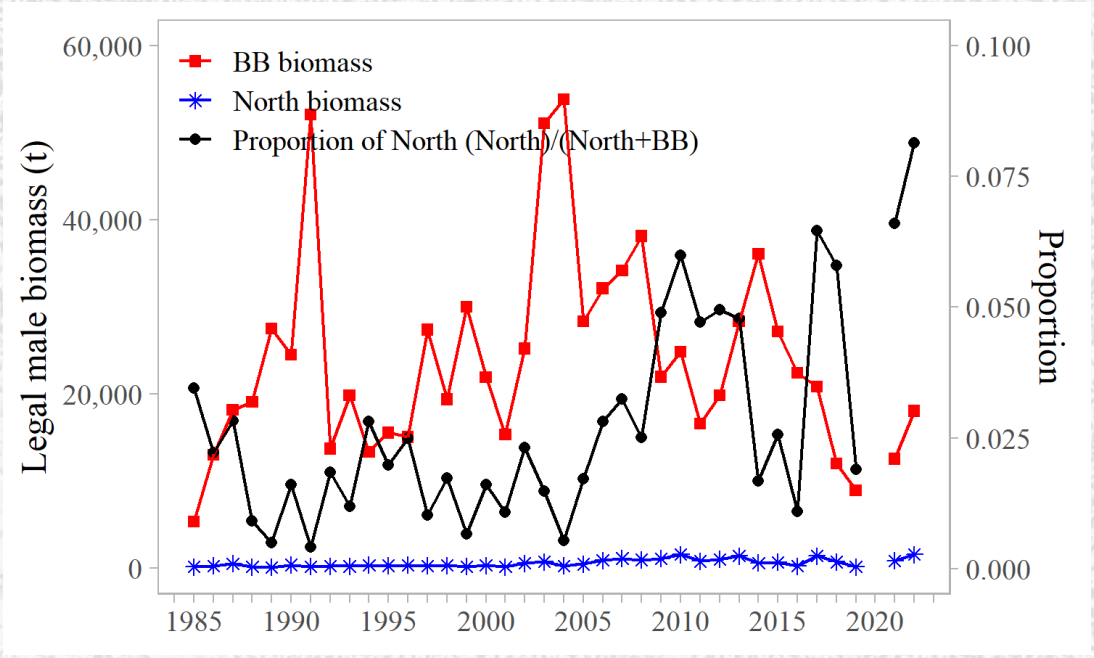
Basis for the OFL: Values are in 1,000 t (model 21.1b):

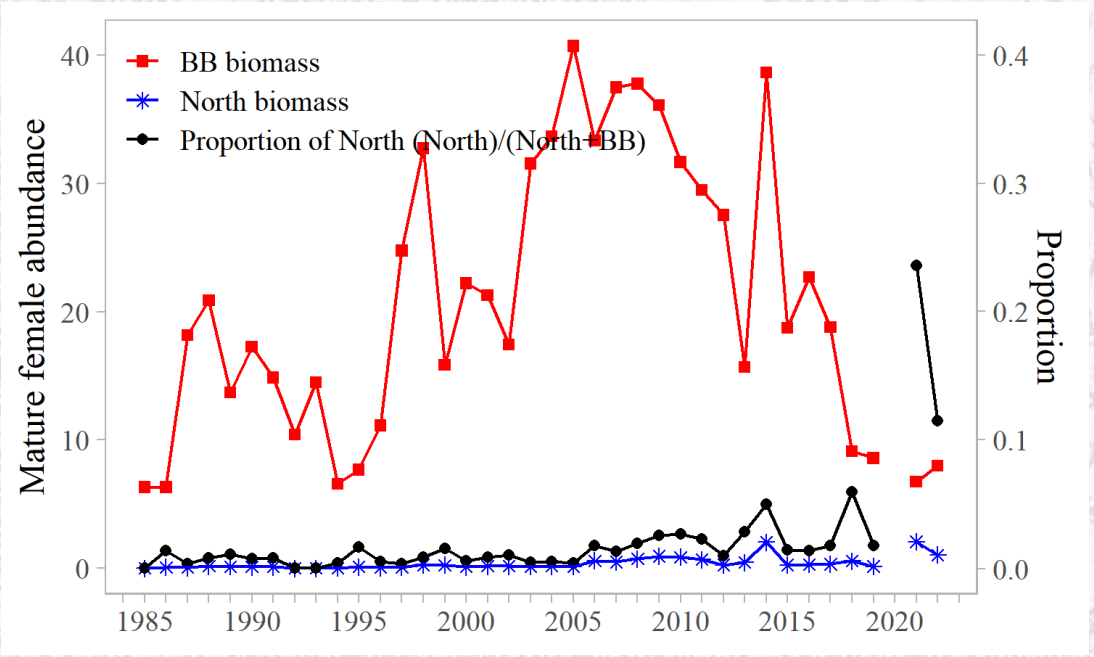
Year	Tier	B_{MSY}	Current MMB	B/B_{MSY} (MMB)	F_{OFL}	Years to define B_{MSY}	Natural Mortality
2018/19	3b	25.5	20.8	0.82	0.25	1984-2017	0.18
2019/20	3b	21.2	16.0	0.75	0.22	1984-2018	0.18
2020/21	3b	25.4	14.9	0.59	0.16	1984-2019	0.18
2021/22	3b	24.2	14.9	0.62	0.17	1984-2020	0.18
2022/23	3b	24.03	17.0	0.71	0.20	1984-2021	0.18

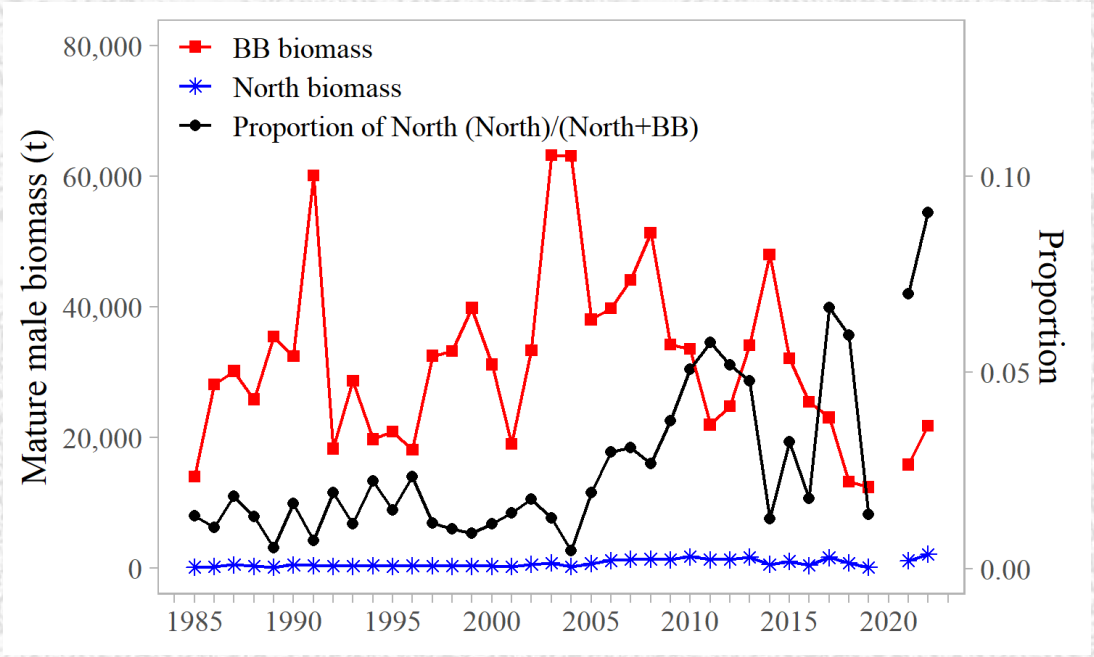
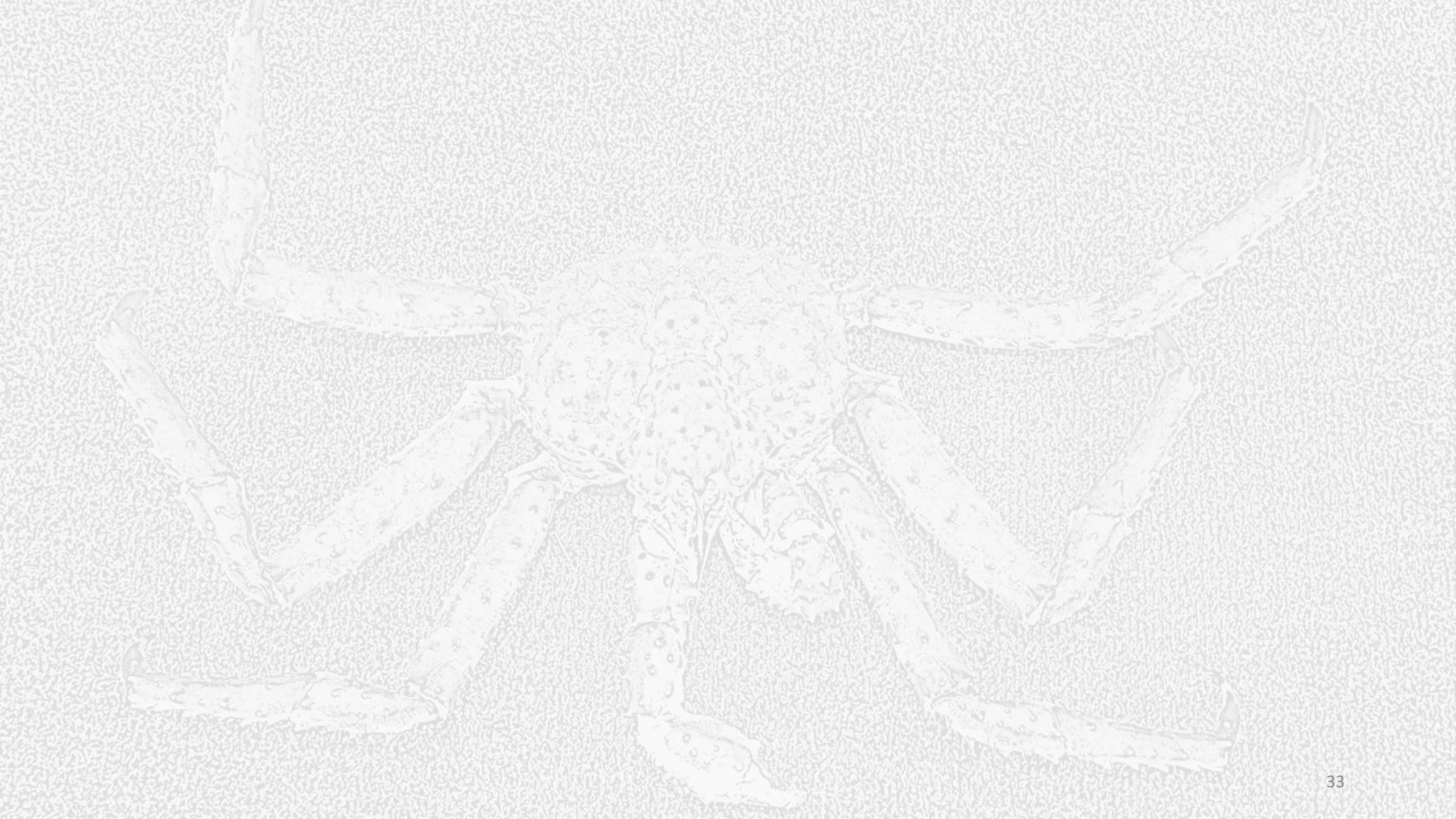
Buffer considerations

- Current at 20% - recommend 20% for upcoming year
- Cold pool distributional shifts
- Declining trend or low levels of mature male biomass and mature female biomass
- Lack of recruitment events
- Retrospective pattern


Female abundance <90mm (millions of cral
BB biomass
North biomass
Proportion of North (North)/(North+BB)
Proportion
0
20
40
60
0.0
0.2
0.4
0.6
1985
1990
1995
2000
2005
2010
2015
2020


Legal male biomass (t)
BB biomass
North biomass
Proportion of North (North)/(North+BB)
Proportion
0
20,000
40,000
60,000
0.000
0.025
0.050
0.075
0.100
1985
1990
1995
2000
2005
2010
2015
2020


Mature female abundance
BB biomass
North biomass
Proportion of North (North)/(North+BB)
Proportion
0
10
20
30
40
0.0
0.1
0.2
0.3
0.4
1985
1990
1995
2000
2005
2010
2015
2020


Mature male biomass (t)
BB biomass
North biomass
Proportion of North (North)/(North+BB)
Proportion
0
20,000
40,000
60,000
80,000
0.00
0.05
0.10
1985
1990
1995
2000
2005
2010
2015
2020