Preliminary 2026 assessment for eastern Bering Sea snow crab

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B. Comments, responses and assessment summary

SSC and CPT comments + author responses from June 2025

SSC comments in italics Author response

INSERT ALL COMMENTS AND HOW THIS DOC ADDRESSES THEM (OR DOESN'T)

C. Assessment scenarios

Model summaries

The key assumptions of these models include:

- the probability of terminally molting at size varies over time and size and is specified based on observations from the survey data
- survey selectivity is estimated by era (1982-88; 1989-present) and sex as a non-parametric curve subject to priors based on the BSFRF survey efficiency experiment data
- growth is a linear function of pre-molt carapace width with a specified variability around post-molt size
- all immature crab molt
- natural mortality is estimated by sex and maturity state with additional mortality events estimated in 2018 and 2019 and subject to a prior based on an assumed longevity of 20 years
- total and retained fishery selectivity are estimated logistic curves
- all non-directed bycatch (e.g. snow crab caught in the Tanner crab fishery or crab caught in the non-pelagic trawl fisheries) is lumped into a single 'fishery' for which a single selectivity is estimated
- recruitment is estimated separately for females and males and is allocated in the first 3 size bins

F. Analytic approach

Model description

The Generalized Model for Assessing Crustacean Stocks (GMACS) was adopted as the assessment platform for snow crab in 2022 after a demonstration that GMACS could effectively reproduce the dynamics of the status quo model and offered structural improvements. GMACS is an integrated, size-structured model developed using automatic differentiation software developed as a set of libraries under C++ (ADModel Builder). ADModel Builder can estimate a large number of parameters in a non-linear model using automatic differentiation software extended from Greiwank and Corliss (1991) and developed into C++ class libraries. GMACS version 2.20.22 was used for the author-preferred model.

The snow crab population dynamics model tracks the number of crab of sex s, maturity state m, during year y at width w, $\mathrm{N}_{s,m,y,w}$. A terminal molt was modeled in which crab move from an immature to a mature state, after which no further molting occurred. The mid-points of the size bins tracked in the model spanned from 27.5 to 132.5 mm carapace width, with 5 mm size classes. For the author-preferred model, 407 parameters were estimated. Parameters estimated within the assessment included those associated with the population processes recruitment, growth, natural mortality (subject to an informative prior and two years of additional 'mortality events' estimated in 2018 and 2019), fishing mortality, selectivity (fisheries and survey), and catchability. The yearly probability of undergoing terminal molt, weight at size, discard mortality, bycatch mortality, variance in growth increment, and parameters associated with proportion of recruitment allocated to size bin were estimated outside of the model or specified. See the GMACS repo linked at the end of this document to peruse the control files that specify the populations dynamics.

A 'jittering' approach has been historically used to explore the impact of different starting values on the assessment output (Turnock, 2016). Jittering was implemented for both models with 2025 data. Retrospective analyses were also performed here in which the terminal year of data was removed sequentially from the model fitting process. Then time series of estimated MMB were compared between the most recent model and successive 'peels' of the data to identify retrospective patterns. A retrospective pattern is a consistent directional change in assessment estimates of management quantities (e.g. MMB) in a given year when additional years of data are added to an assessment. Parameter values were jittered based on a normal distribution centered on one with a standard deviation of 0.1 that was then translated to the parameter space defined by the initial value and its bounds.

A single population dynamics model is presented here, with the differences among the model runs related to data inputs and assumptions about reference points or currency of management.

Model selection and evaluation

Models were evaluated based on their fit to the data, evidence of non-convergence, the credibility of the estimated population processes, and the strength of the influence of the assumptions of the model on the outcomes of the assessment.

Results

Model convergence and comparison

Model 25.3 produced a small maximum gradient and produced a Hessian matrix. However, jittering produced two clouds of 'converged' models with OFLs that differed by 5,000 tonnes and negative log likelihoods that differed by ~0.2 units (**??**). Repeating the jittering for a model that uses large males as currency produced two clouds of OFLs with a difference of approximately 1,000 tonnes (**??**). The difference in OFLs from both of these jittering runs resulted from differences in the terminal estimates of MMB, which were driven by differences in estimated recruitment in the recent past (**??**). Bimodality in management quantities has been a reoccurring problem in the assessment for snow crab. Below, the results for '25.3 gmacs' (i.e. the model with morphometrically MMB used as currency) and '25.3 gmacs (>=95mm)' are derived from the model that had the lowest negative log likelihood from 100 jitters.

The model had difficulties fitting the terminal year of female biomass and potential fixes were explored (e.g. inputting a yearly varying probability of terminal molt), but none yielded markedly different results from model '25.3 gmacs', so were not included here. This issue will be explored more fully for the May 2026 meeting.

Model fits

Fits to the survey indices of mature biomass were similar among models, even with the revision of the data (Figure 1). Updating the version of GMACS resulted in a downward revision of the 2018 mature female biomass estimate.

In May 2025, convergence issues arose with the addition of new growth data. This was solved in this assessment by only including data points for sizes modeled within the assessment model and using smaller input CVs for the points over 35 mm pre-molt carapace width for females. This is a range in which there were fewer observations which were historically poorly fit because of the abundance of data at smaller sizes. No changes were made to the CVs for male growth increment data. Updating the growth data in this manner resulted in changes in estimated molt increments given pre-molt carapace width for both males and females (Figure 2).The estimated molt increments for males were smaller than historical estimates for smaller pre-molt carapace width until approximately 60mm carapace width, when the estimated molt increments began to be larger than historical estimates.

Fits to the non-directed fishery catches were good for both the original and revised data sets (Figure 3). However, in the directed fishery, fits deteriorated somewhat with the updated dataset. Although most of the retained catch data were still fit well, the model was unable to capture several years of discarded data that historically were well fit (e.g. 1991, 1994 and 2019).

Only small differences were observed among models in the fits to size composition data for retained catch in the directed fishery, with the most recently occuring fishery (2021) showing the largest differences (Figure 4). Fits to the total size composition data from the directed fishery were distinctly different once the growth data were updated in the models (Figure 5). No visually discernible differences among models existed for female discards from the directed fishery (Figure 6). Fits to the non-directed fishery had some of the largest misfits of all data sources (particularly for male data), but this is unsurprising given a single estimated selectivity curve and potential changes in fishery behavior over time (Figure 7 & Figure 8).

Fits to the survey size composition data were broadly similar between the two models in most years (Figure 9 - Figure 16). Both models had issues fitting the size composition data for mature males immediately after the collapse, which could suggest some unmodelled size-based mortality (Figure 11).

Estimated population processes

The estimated abundance of commercially preferred of male crab (arguably the most important output of the assessment) varied among models (Figure 17). The early years during which differences in survey selectivity occurred were particularly different. Both models agreed that the abundance in recent years have been the lowest in the time series. The estimates of the most recent era of survey selectivity were fairly similar across models for both sexes (Figure 18).

Estimated fisheries selectivities were similar for both models (Figure 19). Estimated fully-selected fishing mortality for the directed fishery was highly variable and relatively high for most of the fishery history (Figure 20). The total fishery selectivity curve is shifted far to the right, so only the largest crab are experiencing the fully-selected fishing mortality. The probability of undergoing terminal molt used to separate crab into immature and mature survey indices were input as data to the assessment (Figure 21).

Trends in recruitment were very similar across models, with some variability in scale and differences in timing between the sexes (Figure 22). Differences in estimated recruitment in the most recent years were also observed for males among models and this appears to have contributed to the differences in OFLs among jittering runs.

Base estimates of natural mortality were similar for mature animals of both sexes, except for immature females, which were much higher with the new growth data and weighting scheme (Figure 23). All models estimated mortality events that removed at least 80% of crab by sex and maturity state (except for mature females) at some point during the marine heatwave of 2018-19.

MMB and management quantities

Estimated MMB time series had similar trends but the scales differed by up to ~50% in some years (Figure 24). The scale of MMB when large males were used in the calculation was predictably much lower than when morphometrically mature males were used, but the trends were similar. It should be noted that these values are calculated after the fishery, so the declining trends in these estimates are much larger, particularly for the large males, if MMB is calculated before the fishery (see discussion below). Changes in these estimates over the last ten assessment can be seen in **??**.

Differences in estimates and currencies of MMB resulted in large differences in the management targets and advice (Table 4; discussed below). All models that use morphometrically mature male biomass as the currency of management produced target fishing mortality rates that would allow for the removal of all of the largest male crab.

G. Calculation of the OFL

Methodology for OFL

Tier 3

Historically, the tier 3 OFL was calculated using proxies for biomass and fishing mortality reference points and a sloped control rule. Proxies for biomass and fishing mortality reference points were calculated using spawning-biomass-per-recruit methods (e.g. Clark, 1991). After fitting the assessment model to the data and estimating population parameters, the model was projected forward 100 years using the estimated parameters under no exploitation and constant recruitment to determine 'unfished' mature male biomass-per-recruit. Projections were repeated in which the bisection method was used to identify a fishing mortality that reduced the mature male biomass-per-recruit to 35% of the unfished level (i.e. $F_{35\%}$ and $B_{35\%}$). Calculations of $F_{35\%}$ were made under the assumption that bycatch fishing mortality was equal to the estimated average value over the last 10 years.

Calculated values of $F_{35\%}$ and $B_{35\%}$ were used in conjunction with a Tier 3 control rule to adjust the proportion of $F_{35\%}$ that is applied to the stock based on the status of the population relative to $B_{35\%}$ (Amendment 24, NMFS). To determine the F_{OFL}, the population is projected to the time of fishing for the upcoming fishery under no fishing. If the MMB at that time exceeds 25% of $B_{35\%}$, a fishery can occur and the F_{OFL} is calculated as:

$$F_{OFL} = \begin{cases} Bycatch & if \frac{MMB}{B_{35}} \leq 0.25 \\ \frac{F_{35}(\frac{MMB}{B_{35}} - \alpha)}{1-\alpha} & if 0.25 < \frac{MMB}{B_{35}} < 1 \\ F_{35} & if MMB > B_{35} \end{cases} \tag{1}$$

Where MMB is the projected morphometrically mature male biomass in the current survey year after fishing at the F_{OFL}, $B_{35\%}$ is the mature male biomass at the time of mating resulting from fishing at $F_{35\%}$, $F_{35\%}$ is the fishing mortality that reduces the morphometrically mature male biomass per recruit to 35% of unfished levels, and α determines the slope of the descending limb of the harvest control rule (set to 0.1 here).

In addition to the status quo tier 3 control rule, a variation in which >=95mm carapace width mature male biomass was used as the currency of management is presented here.

Calculated tier 3 OFLs ranged from 3.26 to 44.29 kt (Table 4). Differences in OFLs were a result of differences in estimated MMB and the currency used for MMB.

Tier 4

Tier 4 HCRs were applied to rema-smoothed survey biomass estimates of three different size ranges: morphometrically mature males, large males (>=95mm), and preferred males (>101mm). The target biomass was set as the average of the time series from 1982-2024 and the target fishing mortality was set as 0.27, the median of the prior on natural mortality used in the integrated assessment. No kink exists in this harvest control rule. The resulting OFLs were 28.41 kt, 8.64 kt, and 6.11 kt for morphometric, large, and preferred males, respectively (**??**).

Calculation of the ABC

The recommended acceptable biological catch (ABC) was calculated by subtracting a 20% buffer from the OFL to account for scientific uncertainty.

The buffers for the last five years used by the SSC were: 65% (2024), 50% (2023), (October 2022 SSC reports are not available online), 25% (2021), and 25% (2020).

Author recommendations

I. Data gaps and research priorities

K. Supplemental information

Input and output for the models described here can be found at https://github.com/szuwalski/snow_2025_9.

GMACS code and documentation can be found at: https://github.com/GMACS-project.

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Table 1: Likelihood components by category and model.

	25.1 gmacs	25.1 gmacs (tbd)
Catch	372.68	372.68
Index	142.06	142.06
Size	-28986.35	-28986.35
SRR	185.42	185.42
Tag	7965.08	7965.08
Penalties:	760.35	760.35
Priors:	386.98	386.98
Total:	-19173.78	-19173.78

Table 2: Parameters estimated in the assessment. 'Theta' parameters are primarily the values for initial numbers at size. See control file for more in depth descriptions.

param	25.1 gmacs	25.1 gmacs (TBD)
G_pars_est[1]	0.98	0.98
G_pars_est[2]	-0.24	-0.24
G_pars_est[3]	0.25	0.25
G_pars_est[4]	-4.81	-4.81
G_pars_est[5]	-0.43	-0.43
G_pars_est[6]	0.25	0.25
log_add_cv[1]	-9.21	-9.21
log_add_cv[2]	-9.21	-9.21
log_add_cv[3]	-9.21	-9.21
log_add_cv[4]	-9.21	-9.21
log_fbar[1]	-0.21	-0.21
log_fbar[2]	-5.22	-5.22
log_fbar[3]	-4.00	-4.00
log_fbar[4]	-4.00	-4.00
log_fdev[1]	0.00	0.00
log_fdev[2]	0.00	0.00
log_fdev[3]	0.00	0.00
log_fdev[4]	0.00	0.00
log_fdov[1]	0.00	0.00
log_fdov[2]	0.00	0.00
log_fdov[3]	0.00	0.00
log_fdov[4]	0.00	0.00
log_foff[1]	-6.79	-6.79
log_foff[2]	0.00	0.00
log_foff[3]	0.00	0.00
log_foff[4]	0.00	0.00
log_vn[1]	0.00	0.00
log_vn[10]	0.00	0.00
log_vn[11]	0.00	0.00
log_vn[12]	0.00	0.00
log_vn[13]	0.00	0.00
log_vn[2]	0.00	0.00
log_vn[3]	0.00	0.00
log_vn[4]	0.00	0.00
log_vn[5]	0.00	0.00
log_vn[6]	0.00	0.00
log_vn[7]	0.00	0.00
log_vn[8]	0.00	0.00
log_vn[9]	0.00	0.00
logit_rec_prop_est:	0.00	0.00
M_pars_est[1]	0.28	0.28
M_pars_est[10]	-0.47	-0.47
M_pars_est[11]	0.91	0.91
M_pars_est[12]	0.00	0.00
M_pars_est[13]	1.00	1.00
M_pars_est[14]	1.67	1.67
M_pars_est[15]	1.10	1.10
M_pars_est[16]	0.00	0.00

param	25.1 gmacs	25.1 gmacs (TBD)
M_pars_est[2]	1.59	1.59
M_pars_est[3]	0.41	0.41
M_pars_est[4]	0.00	0.00
M_pars_est[5]	0.03	0.03
M_pars_est[6]	0.00	0.00
M_pars_est[7]	2.35	2.35
M_pars_est[8]	0.00	0.00
M_pars_est[9]	0.27	0.27
max gradient	0.00	0.00
number of parameters	407.00	407.00
objective function	-19173.78	-19173.78
par_devs[1]	0.00	0.00
rec_dev_est:	-0.08	-0.08
S_pars_est[1]	4.67	4.67
S_pars_est[10]	-1.32	-1.32
S_pars_est[11]	-1.02	-1.02
S_pars_est[12]	-1.00	-1.00
S_pars_est[13]	-1.13	-1.13
S_pars_est[14]	-1.10	-1.10
S_pars_est[15]	-1.03	-1.03
S_pars_est[16]	-1.00	-1.00
S_pars_est[17]	-0.98	-0.98
S_pars_est[18]	-0.87	-0.87
S_pars_est[19]	-0.86	-0.86
S_pars_est[2]	1.67	1.67
S_pars_est[20]	-0.99	-0.99
S_pars_est[21]	-0.85	-0.85
S_pars_est[22]	-0.74	-0.74
S_pars_est[23]	-0.51	-0.51
S_pars_est[24]	-0.33	-0.33
S_pars_est[25]	-0.24	-0.24
S_pars_est[26]	-0.32	-0.32
S_pars_est[27]	-4.33	-4.33
S_pars_est[28]	-3.48	-3.48
S_pars_est[29]	-2.75	-2.75
S_pars_est[3]	4.78	4.78
S_pars_est[30]	-1.93	-1.93
S_pars_est[31]	-1.72	-1.72
S_pars_est[32]	-1.49	-1.49
S_pars_est[33]	-1.25	-1.25
S_pars_est[34]	-1.17	-1.17
S_pars_est[35]	-1.23	-1.23
S_pars_est[36]	-1.24	-1.24
S_pars_est[37]	-1.21	-1.21
S_pars_est[38]	-1.16	-1.16
S_pars_est[39]	-1.13	-1.13
S_pars_est[4]	2.39	2.39
S_pars_est[40]	-0.98	-0.98
S_pars_est[41]	-0.78	-0.78
S_pars_est[42]	-0.46	-0.46
S_pars_est[43]	-0.32	-0.32
S_pars_est[44]	-0.20	-0.20

param	25.1 gmacs	25.1 gmacs (TBD)
S_pars_est[45]	-0.16	-0.16
S_pars_est[46]	-0.13	-0.13
S_pars_est[47]	-0.12	-0.12
S_pars_est[48]	-0.15	-0.15
S_pars_est[49]	4.21	4.21
S_pars_est[5]	-3.24	-3.24
S_pars_est[50]	0.99	0.99
S_pars_est[51]	-5.15	-5.15
S_pars_est[52]	-5.26	-5.26
S_pars_est[53]	-4.05	-4.05
S_pars_est[54]	-1.72	-1.72
S_pars_est[55]	-1.16	-1.16
S_pars_est[56]	-0.55	-0.55
S_pars_est[57]	-0.55	-0.55
S_pars_est[58]	-0.76	-0.76
S_pars_est[59]	-0.83	-0.83
S_pars_est[6]	-2.74	-2.74
S_pars_est[60]	-0.92	-0.92
S_pars_est[61]	-0.91	-0.91
S_pars_est[62]	-0.87	-0.87
S_pars_est[63]	-0.84	-0.84
S_pars_est[64]	-0.79	-0.79
S_pars_est[65]	-0.72	-0.72
S_pars_est[66]	-0.63	-0.63
S_pars_est[67]	-0.53	-0.53
S_pars_est[68]	-0.42	-0.42
S_pars_est[69]	-0.31	-0.31
S_pars_est[7]	-2.29	-2.29
S_pars_est[70]	-0.20	-0.20
S_pars_est[71]	-0.08	-0.08
S_pars_est[72]	0.00	0.00
S_pars_est[73]	-4.17	-4.17
S_pars_est[74]	-3.29	-3.29
S_pars_est[75]	-2.68	-2.68
S_pars_est[76]	-1.01	-1.01
S_pars_est[77]	-0.51	-0.51
S_pars_est[78]	-0.24	-0.24
S_pars_est[79]	-0.34	-0.34
S_pars_est[8]	-1.53	-1.53
S_pars_est[80]	-0.90	-0.90
S_pars_est[81]	-1.06	-1.06
S_pars_est[82]	-1.27	-1.27
S_pars_est[83]	-1.24	-1.24
S_pars_est[84]	-0.95	-0.95
S_pars_est[85]	-0.83	-0.83
S_pars_est[86]	-0.78	-0.78
S_pars_est[87]	-0.71	-0.71
S_pars_est[88]	-0.62	-0.62
S_pars_est[89]	-0.52	-0.52
S_pars_est[9]	-1.51	-1.51
S_pars_est[90]	-0.42	-0.42
S_pars_est[91]	-0.31	-0.31

param	25.1 gmacs	25.1 gmacs (TBD)
S_pars_est[92]	-0.20	-0.20
S_pars_est[93]	-0.08	-0.08
S_pars_est[94]	0.00	0.00
S_pars_est[95]	4.60	4.60
S_pars_est[96]	0.31	0.31
survey_q[1]	1.00	1.00
survey_q[2]	1.00	1.00
survey_q[3]	1.00	1.00
survey_q[4]	1.00	1.00
theta[1]	16.50	16.50
theta[10]	0.01	0.01
theta[11]	9.62	9.62
theta[12]	9.63	9.63
theta[13]	9.67	9.67
theta[14]	9.78	9.78
theta[15]	10.22	10.22
theta[16]	10.77	10.77
theta[17]	11.21	11.21
theta[18]	11.41	11.41
theta[19]	11.50	11.50
theta[2]	15.00	15.00
theta[20]	11.54	11.54
theta[21]	11.51	11.51
theta[22]	11.26	11.26
theta[23]	10.95	10.95
theta[24]	10.70	10.70
theta[25]	10.83	10.83
theta[26]	11.88	11.88
theta[27]	11.38	11.38
theta[28]	10.40	10.40
theta[29]	9.35	9.35
theta[3]	14.38	14.38
theta[30]	8.35	8.35
theta[31]	7.53	7.53
theta[32]	7.14	7.14
theta[33]	12.29	12.29
theta[34]	12.41	12.41
theta[35]	13.24	13.24
theta[36]	13.74	13.74
theta[37]	13.05	13.05
theta[38]	13.14	13.14
theta[39]	12.86	12.86
theta[4]	32.50	32.50
theta[40]	12.62	12.62
theta[41]	12.56	12.56
theta[42]	12.03	12.03
theta[43]	11.37	11.37
theta[44]	11.25	11.25
theta[45]	11.40	11.40
theta[46]	10.48	10.48
theta[47]	9.11	9.11
theta[48]	8.05	8.05

param	25.1 gmacs	25.1 gmacs (TBD)
theta[49]	7.28	7.28
theta[5]	1.00	1.00
theta[50]	6.75	6.75
theta[51]	6.36	6.36
theta[52]	6.08	6.08
theta[53]	5.87	5.87
theta[54]	5.77	5.77
theta[55]	12.16	12.16
theta[56]	12.18	12.18
theta[57]	12.23	12.23
theta[58]	12.37	12.37
theta[59]	13.53	13.53
theta[6]	0.00	0.00
theta[60]	13.59	13.59
theta[61]	12.99	12.99
theta[62]	12.15	12.15
theta[63]	11.03	11.03
theta[64]	9.97	9.97
theta[65]	9.25	9.25
theta[66]	8.83	8.83
theta[67]	8.63	8.63
theta[68]	8.58	8.58
theta[69]	8.48	8.48
theta[7]	0.00	0.00
theta[70]	8.28	8.28
theta[71]	8.02	8.02
theta[72]	7.77	7.77
theta[73]	7.53	7.53
theta[74]	7.30	7.30
theta[75]	7.14	7.14
theta[76]	7.05	7.05
theta[77]	-13.82	-13.82
theta[78]	-13.87	-13.87
theta[79]	-13.97	-13.97
theta[8]	-0.90	-0.90
theta[80]	-14.12	-14.12
theta[81]	-13.64	-13.64
theta[82]	-13.47	-13.47
theta[83]	-14.60	-14.60
theta[84]	-15.62	-15.62
theta[85]	-16.42	-16.42
theta[86]	-17.05	-17.05
theta[87]	-17.50	-17.50
theta[88]	-17.84	-17.84
theta[89]	-18.11	-18.11
theta[9]	0.75	0.75
theta[90]	-18.34	-18.34
theta[91]	-18.54	-18.54
theta[92]	-18.71	-18.71
theta[93]	-18.86	-18.86
theta[94]	-19.00	-19.00
theta[95]	-19.00	-19.00

param	25.1 gmacs	25.1 gmacs (TBD)
theta[96]	-19.00	-19.00
theta[97]	-19.00	-19.00
theta[98]	-19.00	-19.00

Table 3: Observed retained catches, discarded catch, and bycatch. Discards and bycatch do not have assumed mortalities applied. Units are 1,000 tonnes.

Year	Discard (females)	Discard (males)	Retained catch	Non-directed bycatch
1982	0.02	1.27	11.85	0.37
1983	0.01	1.24	12.16	0.47
1984	0.01	2.76	29.94	0.5
1985	0.01	4.01	44.45	0.43
1986	0.02	4.25	46.22	0
1987	0.03	5.52	61.4	0
1988	0.04	5.82	67.79	0
1989	0.05	6.68	73.33	0.1
1990	1.52	35.55	149.1	0.33
1991	0.2	9.03	143	4.45
1992	0.28	21.18	104.7	2.05
1993	0.12	22.27	67.94	1.13
1994	0.08	7.78	34.16	0.7
1995	0.02	14.73	29.8	1.04
1996	0.1	23.23	54.24	1.22
1997	0.1	7.1	110.4	0.73
1998	0.01	19.5	88.15	0.58
1999	0.01	4.13	15.1	0.24
2000	0	3.25	11.46	0.25
2001	0.02	3.98	14.8	0.18
2002	0	4.5	12.84	0.1
2003	0	2.4	10.86	0.14
2004	0	3.58	11.29	0.18
2005	0	0.62	16.77	0.19
2006	0	4.17	16.49	0.36
2007	0.02	5.77	28.59	0.31
2008	0.02	5.11	26.56	0.19
2009	0.01	4.28	21.78	0.39
2010	0.01	4.47	24.61	0.14
2011	0.19	3.73	40.29	0.14
2012	0.06	5.53	30.05	0.15
2013	0.12	10.61	24.49	0.16
2014	0.3	11.62	30.82	0.62
2015	0.12	10.9	18.42	1.58
2016	0.03	4.51	9.78	0.04
2017	0.03	5.88	8.6	0.1
2018	0.02	8.63	12.51	0.4
2019	0.02	15.61	15.43	0.21
2020	0	6.12	20.41	0.19
2021	0	1.68	2.52	0.13
2022	0	0	0	0.06
2023	0	0	0	0.11
2024	0	0.66	2.15	0.09

Table 4: Management quantities derived from maximum likelihood estimates by model using Tier 3 reference points. Reported natural mortality is for mature males, average recruitment is for males, and status and MMB were estimates for February 15 of the completed crab year.

	BMSY	Bcurr/BMSY	OFL(tot)	Fmsy	Fofl
25_gmacs/	180.06	0.88	44.29	39.52	34.37
25_gmacs_v2/	180.06	0.88	44.29	39.52	34.37

Table 5: Maximum likelihood estimates of morphometrically mature male biomass (MMB), mature female biomass (FMB). Columns 2-6 are subject to survey selectivity; columns 7-11 are the population values.

Survey year	FMB	MMB	MMB_95	MMB_101	Abund_101	FMB_tot	MMB_tot	MMB_95_tot	MMB_101_tot	abund_95_tot
1982	71.36	111.8	93.66	68.9	127.7	132.4	233.9	137.8	94.11	123
1983	54.57	167	123.9	95.56	167	104.6	340.6	177.9	126.1	170.5
1984	42.38	213.5	160.1	127.5	211.1	91.17	419.4	224.8	164.2	221
1985	35.58	227.8	167.1	134.7	216.6	122.6	441.2	232.4	171.4	228.8
1986	40.68	222.3	148	119.2	189.6	237.5	438.6	205.7	151	200.6
1987	74.25	223.5	127.4	98.3	157.8	313	456.9	181.2	125.2	164.1
1988	123.4	243.3	130.9	99.11	160.9	363.6	503.4	188.2	126.5	166.8
1989	187.9	282.4	143.3	108.5	175.1	341.1	509.9	206	138.2	181.8
1990	180.9	292.6	154.1	117.5	190.5	310.6	514.8	221	149.5	199.5
1991	155.5	296.2	170.1	140.8	215.9	264.8	484	232	174.6	236.2
1992	132.6	265.1	146.3	118.4	181.1	232.7	447.1	202	147.1	195.8
1993	114.7	198.8	89.64	64.5	103.8	207.8	380.8	132	82.02	107.1
1994	102.8	153.4	49.67	32.16	52.66	195.4	334.3	76.59	41.23	52.84
1995	95.9	169.1	52.4	32.68	54.72	178.5	371.6	82.1	42.39	53.69
1996	90.02	207.8	84.21	56.66	95.11	158.2	416.2	128.2	73.36	95.43
1997	80.26	227.9	116.5	89.6	142.9	158.7	404.2	166.1	113	152.1
1998	75.21	205.3	111.3	88.91	137.2	134.8	348.9	155	110.8	148
1999	70.79	118.9	50.24	35.29	56.01	127	233.2	74.69	44.57	58.03
2000	62.18	96.32	40.41	28.33	44.51	113.5	189.5	60.1	35.78	45.88
2001	56.49	77.94	31.04	21.19	33.95	98.64	157.2	46.78	26.95	34.67
2002	49.98	66.83	24.8	16	26.53	85.48	138.8	38.35	20.68	26.33
2003	42.68	71.21	31.01	22.44	36.6	171.4	138.6	45.67	28.58	38.23
2004	65.93	87.23	42.53	33.06	51.51	171.9	159.4	60.17	41.44	54.87
2005	96.49	94.99	45.4	36.27	55.35	175.5	176.3	63.15	45.13	59.46
2006	92.6	103	43.11	32.92	51.06	155.8	205.1	61.51	41.35	53.62
2007	78.5	123.4	52.66	40	64.27	126.1	243.2	75.63	50.82	67.23
2008	63.65	136.9	61.2	47.49	74.87	103.8	262.6	86.73	59.81	79.08
2009	50.94	128.9	58.81	46.14	72.57	194.8	245.2	82.87	58.04	77.03
2010	75.06	181.2	102.4	83.91	129.5	196.1	302.6	140.6	104.7	139.7
2011	109.1	141.4	75.01	59.91	93	202.4	247.2	104.5	75.05	99.13
2012	106.2	108.8	47.75	35.12	56.1	185.2	211.7	69.55	44.63	57.68
2013	92.76	101	40.48	27.17	45.28	171.7	204.9	61.59	35.15	44.86
2014	83.31	91.25	37.37	25.65	41.84	146.7	183.2	56.25	32.86	42.2
2015	74.99	74.98	27.32	18.42	30.03	150.3	157.2	41.45	23.54	30.55
2016	70.59	64.21	17.64	11.1	18.38	185.4	150	27.55	14.25	18.53
2017	84.56	96.02	21.49	13.41	22.51	291.8	240.1	33.67	17.4	22.17
2018	129.7	163.1	15.61	9.42	16.32	217.6	204.9	24.82	12.4	15.66
2019	112.4	141.8	39.6	23.74	42.33	129.9	289.1	63.2	31.69	39.72
2020	45.41	72.12	24.72	13.39	24.09	88.49	209.9	40.77	18.01	21.64
2021	40.46	58.2	19.19	11.17	18.82	83.5	168.2	30.81	14.53	18.08
2022	41.78	49.78	16.22	10.02	16.47	83.22	134.8	25.46	12.88	16.23
2023	49.73	56.68	13.64	8.79	14.11	106.2	116.6	21.03	11.21	14.11
2024	60.53	86.93	13.43	8.48	13.94	119	140.1	20.92	10.93	13.76

Table 6: Maximum likelihood estimates of total numbers of crab (billions), not subject to survey selectivity at the time of the survey.

Survey year	Total numbers
1982	7.235
1983	9.488
1984	9.847
1985	13.74
1986	22.03
1987	19.78
1988	18.53
1989	14.24
1990	12.21
1991	12.64
1992	14.18
1993	11.59
1994	10.51
1995	8.582
1996	6.876
1997	7.074
1998	5.566
1999	5.352
2000	5.119
2001	4.095
2002	4.889
2003	12.08
2004	9.563
2005	9.024
2006	7.473
2007	5.939
2008	5.448
2009	13.37
2010	9.27
2011	7.518
2012	6.412
2013	7.112
2014	6.578
2015	15.18
2016	20.99
2017	24.27
2018	12.09
2019	5.056
2020	4.082
2021	5.175
2022	6.934
2023	12.4
2024	12.14

Table 7: Maximum likelihood estimates of large mature male biomass at mating, male recruitment (billions), and fully-selected total fishing mortaltiy.

Survey year	Mature male biomass	Male recruits	Fishing mortality
1982	221.2	4.57	0.19
1983	327.5	2.5	0.13
1984	388.8	3.83	0.25
1985	396.8	4.74	0.36
1986	393.9	0.23	0.42
1987	404.8	2.04	0.64
1988	448.3	1.38	0.67
1989	447.6	0.75	0.7
1990	385.1	3.82	1.96
1991	367.2	4.56	1.19
1992	329.8	0.22	1.64
1993	308.5	0.77	1.84
1994	302.2	0.25	1.33
1995	337.6	0.32	1.36
1996	359.9	0.27	1.4
1997	325.9	0.94	1.28
1998	246.1	0.58	2.27
1999	215.8	0.87	0.53
2000	175.8	0.19	0.51
2001	140.9	1.96	0.95
2002	124.8	1.78	1.12
2003	127.6	1.88	0.55
2004	145.6	2.22	0.46
2005	163.4	0.67	0.38
2006	185.8	0.54	0.69
2007	213.7	0.88	0.97
2008	233.8	1.89	0.74
2009	223.3	0.31	0.54
2010	272.9	0.49	0.39
2011	209.9	0.44	0.79
2012	181.5	1.39	1.21
2013	177.1	1.58	1.49
2014	150	10.11	2.3
2015	132.9	7.35	2.19
2016	138.9	1.38	1.32
2017	228.5	0.44	1.02
2018	188.5	1.38	2.39
2019	267.1	0.97	1.13
2020	191.1	1.37	1.96
2021	164.4	2.79	0.28
2022	134.4	6.22	0
2023	116.2	2.33	0
2024	137.5	2.14	0.26

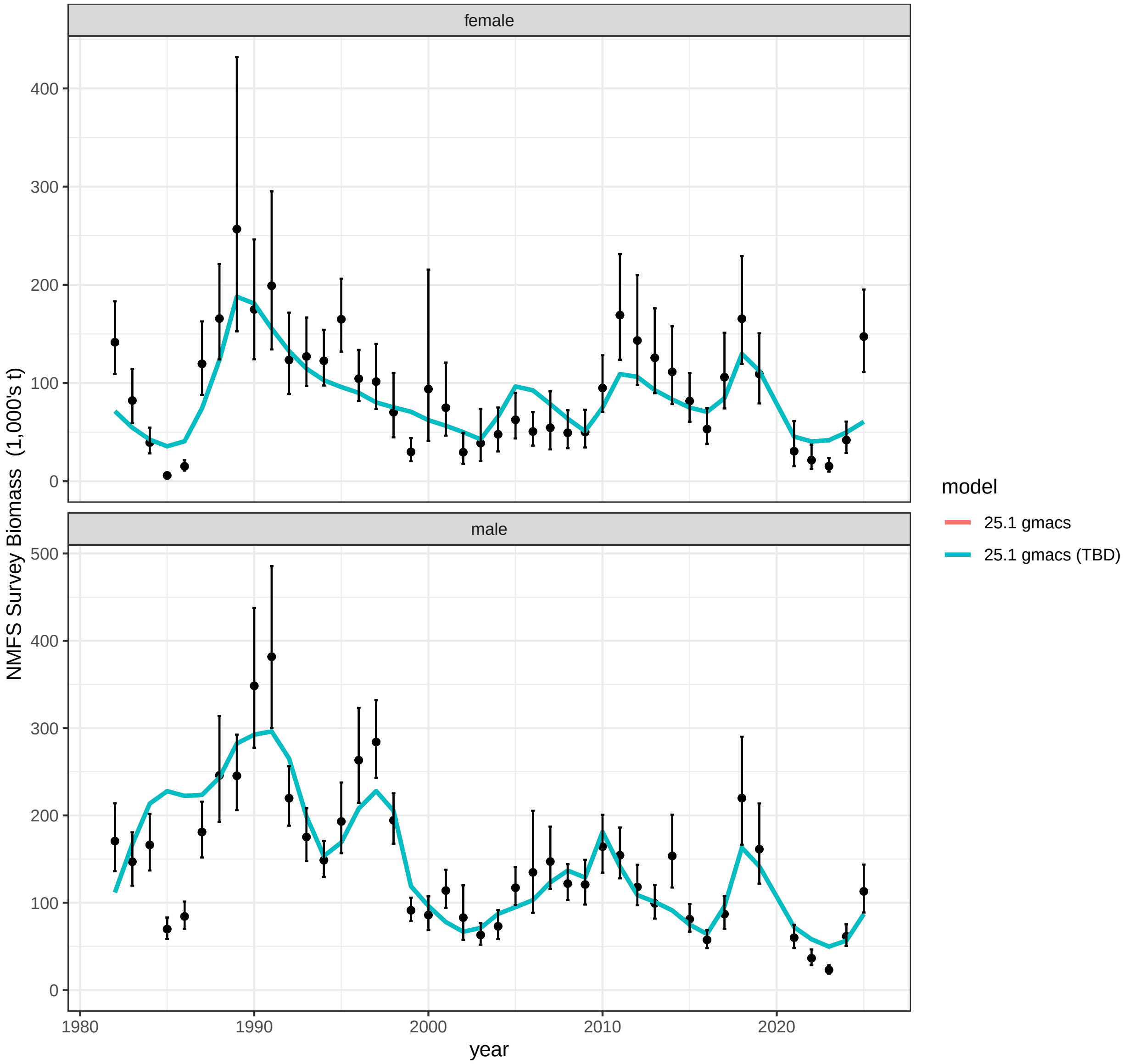

Figure 1: Model fits to the observed mature biomass at survey.

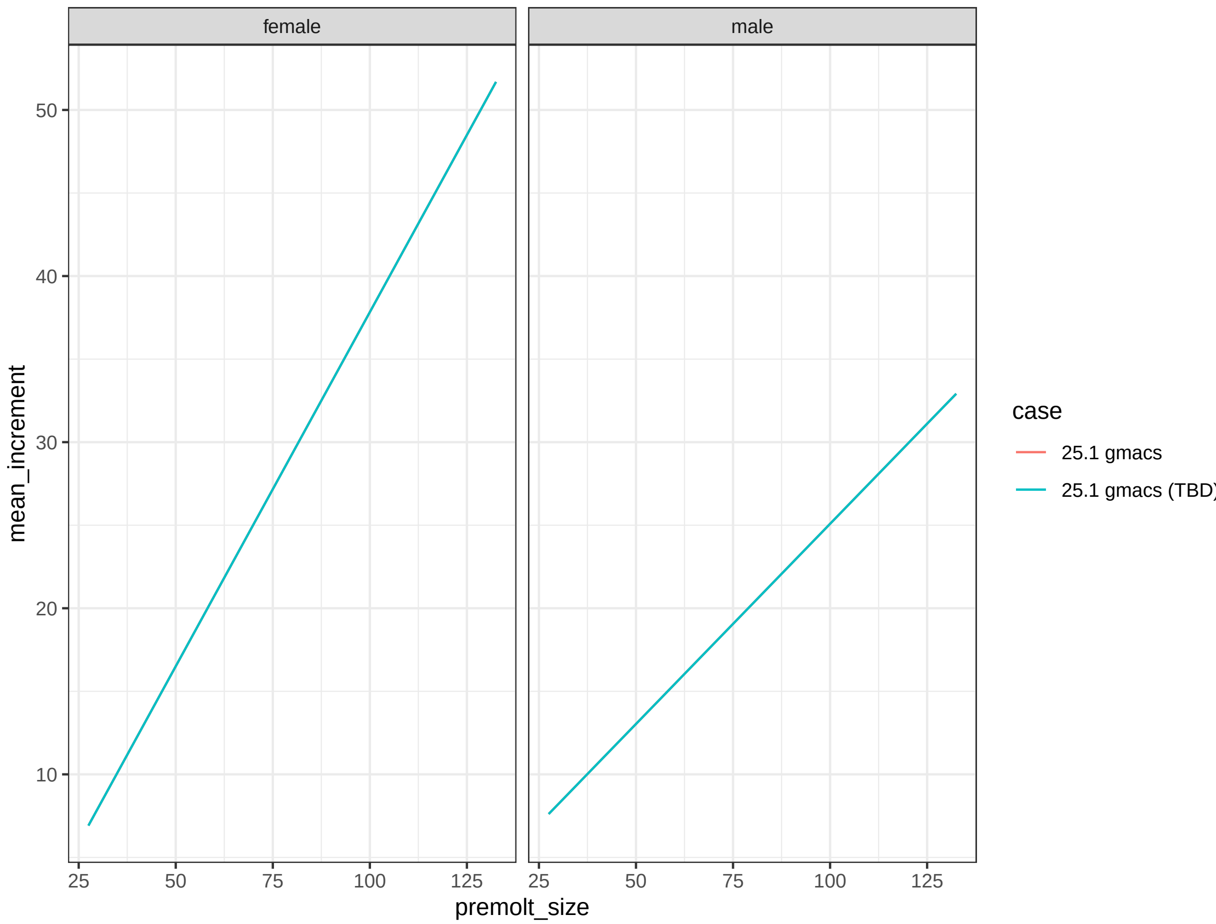

Figure 2: Model fits (colored lines) to the growth data (dots). Black dots are historical observations; red dots are new data for 2025.

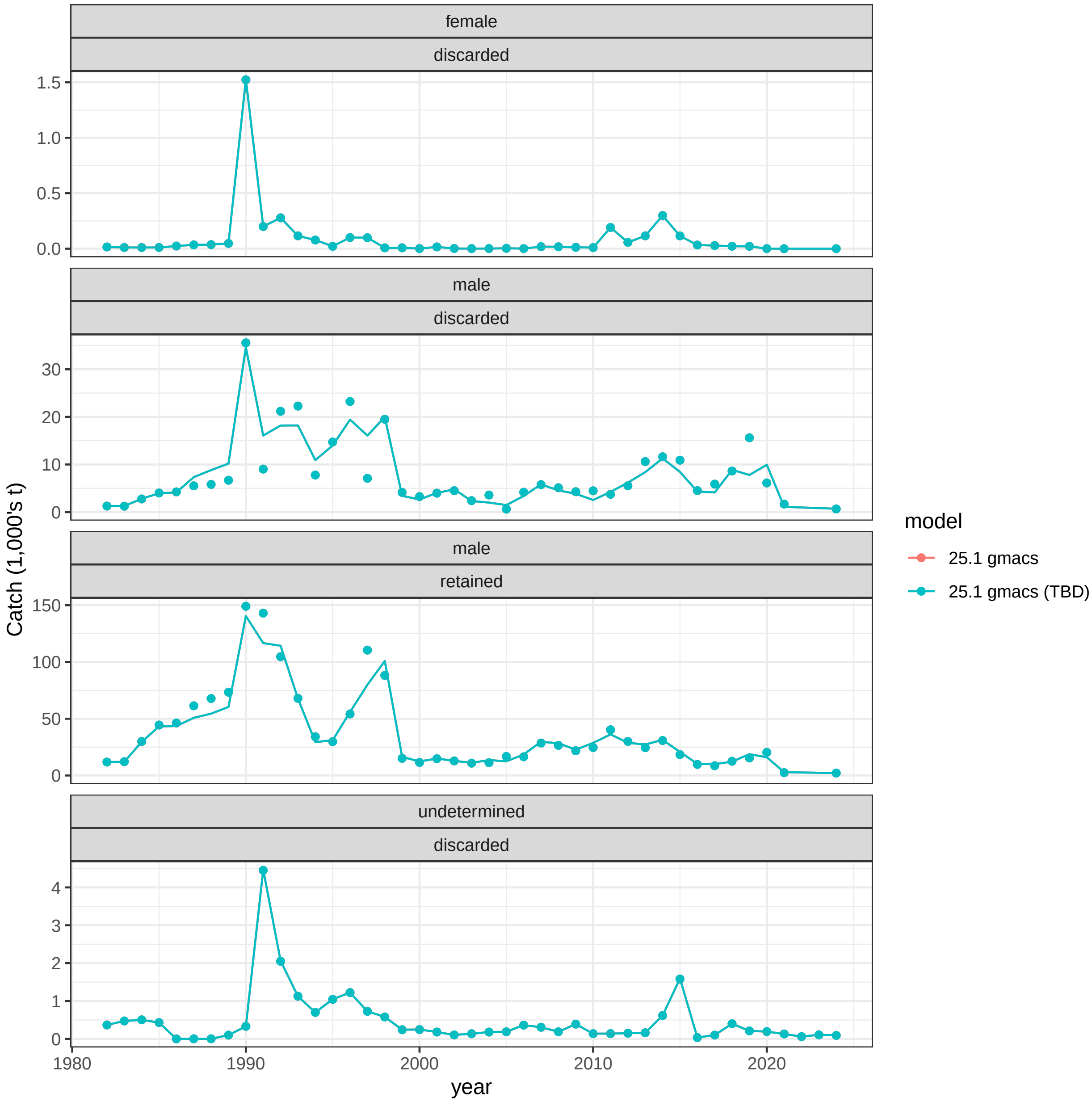

Figure 3: Model fits to catch data.

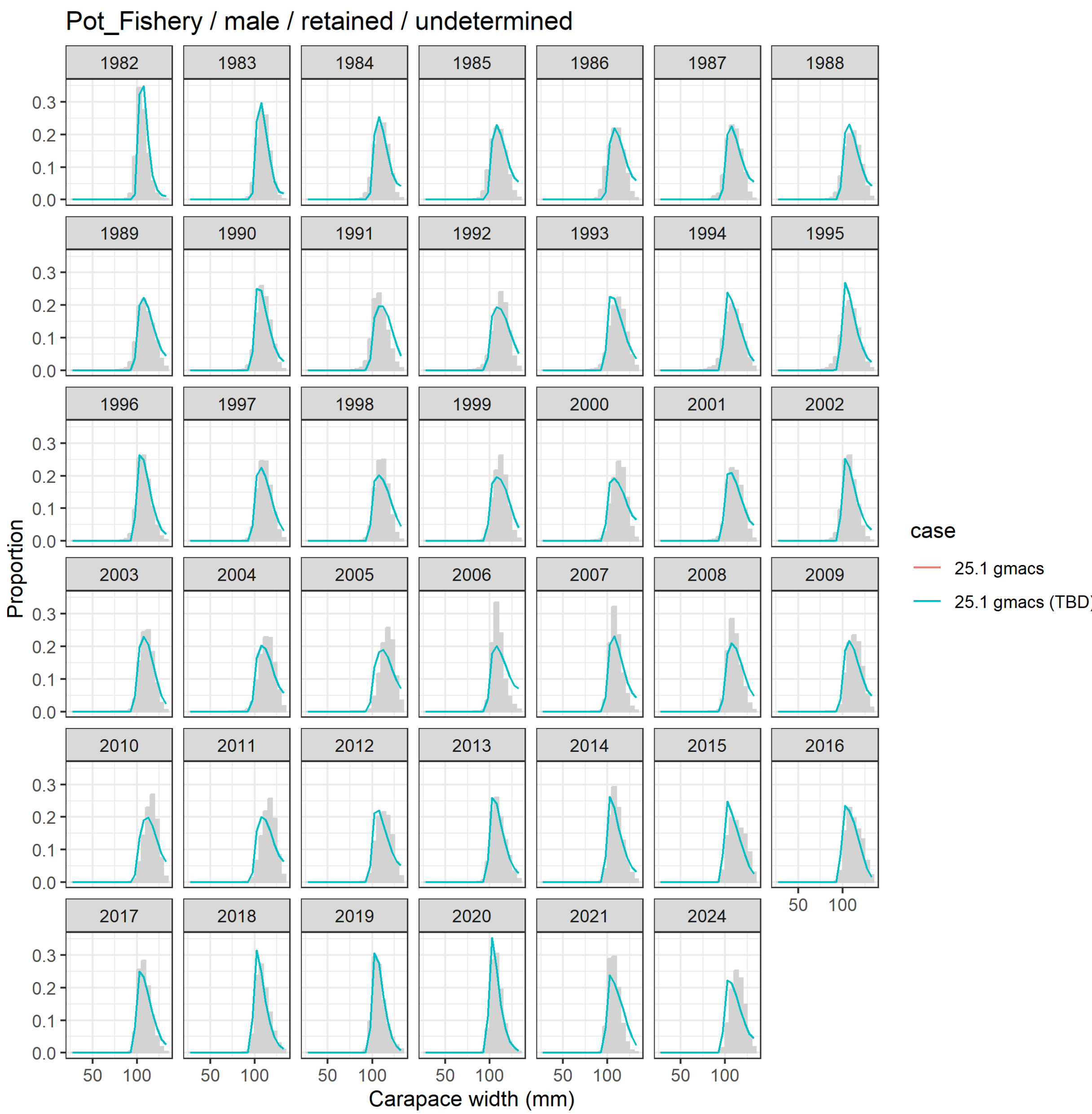

Figure 4: Model fits (lines) to the retained catch size composition data (grey bars).

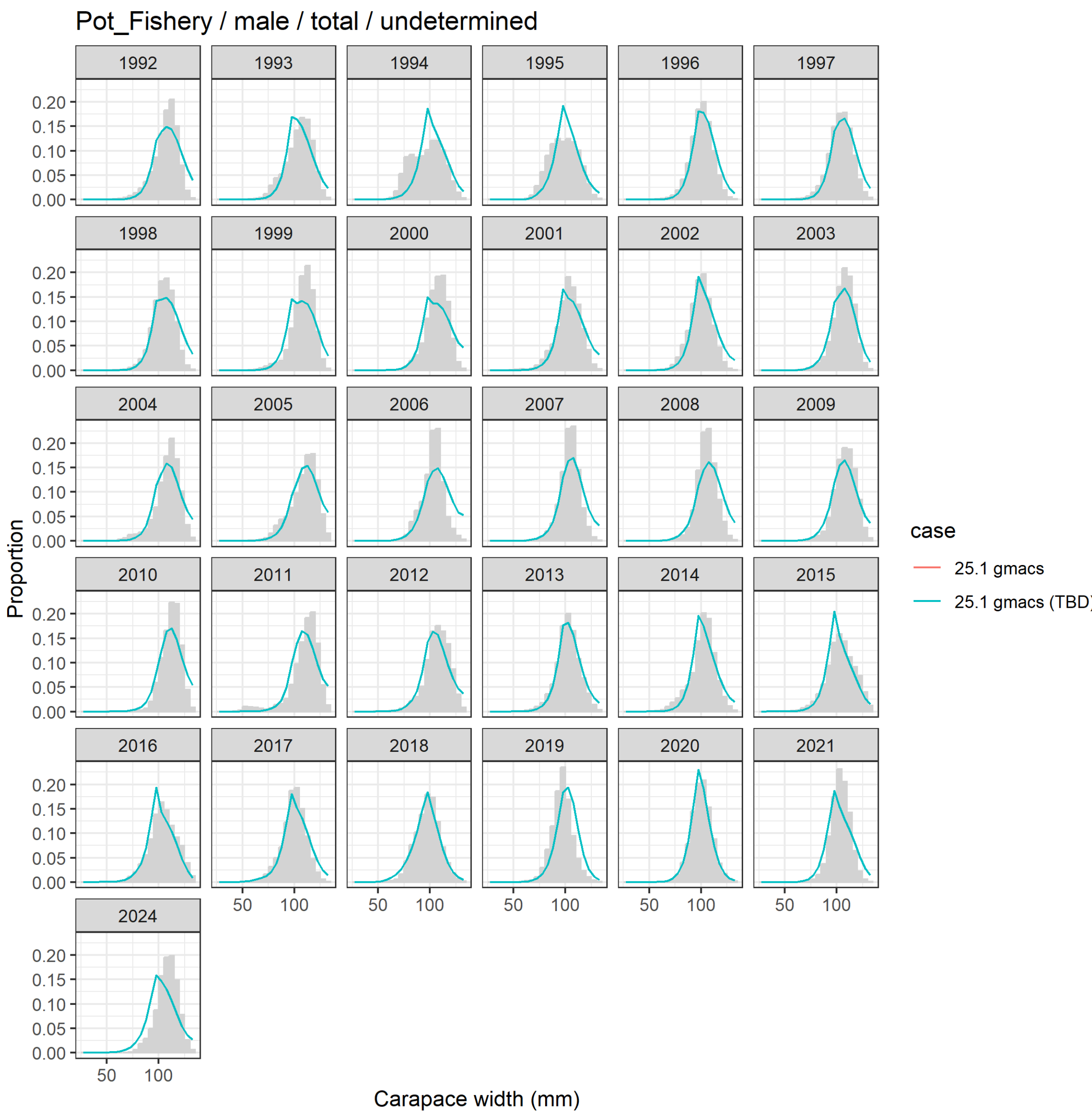

Figure 5: Model fits (lines) to the total catch size composition data (grey bars).

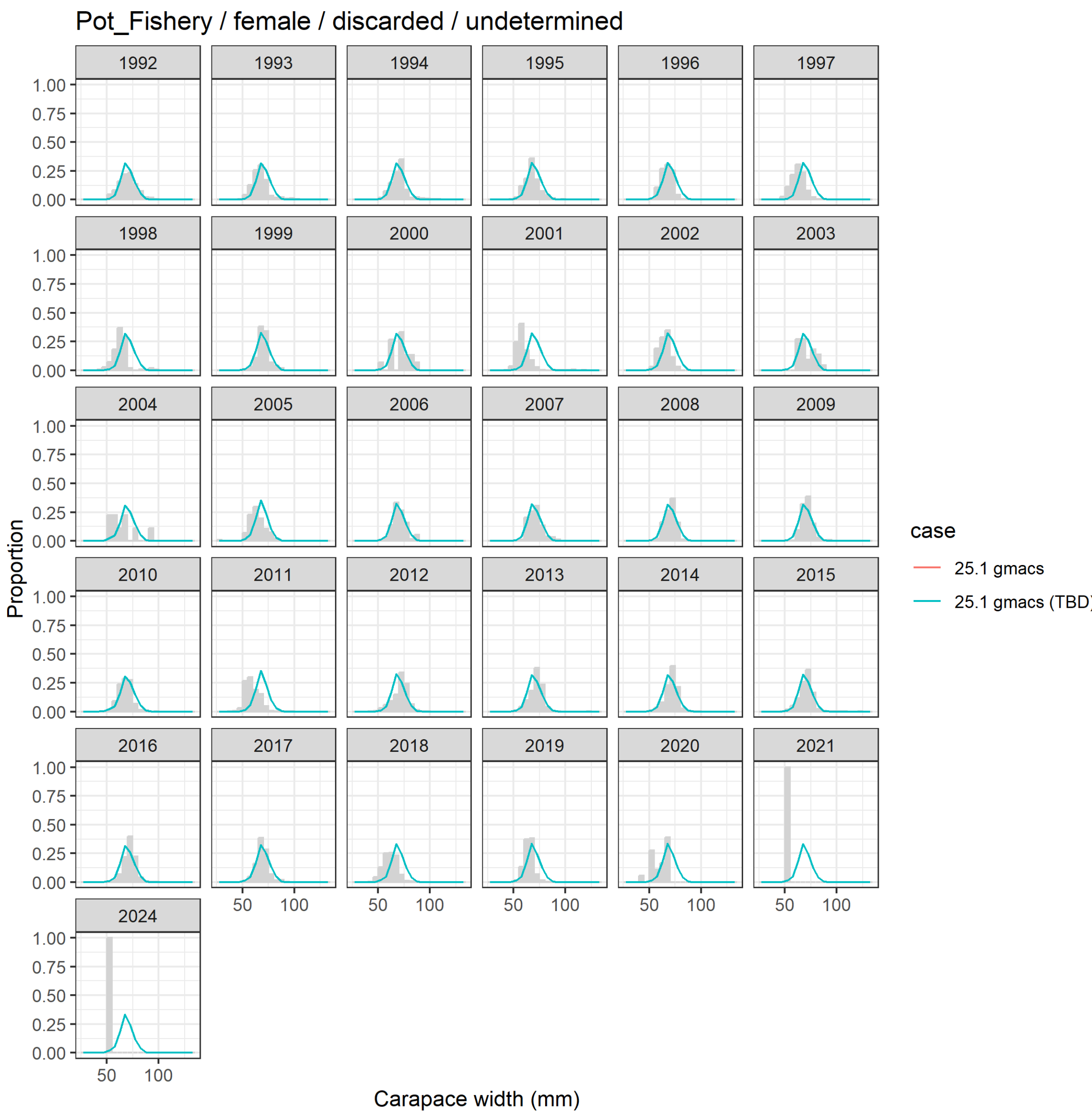

Figure 6: Model fits (lines) to the female discard size composition data (grey bars).

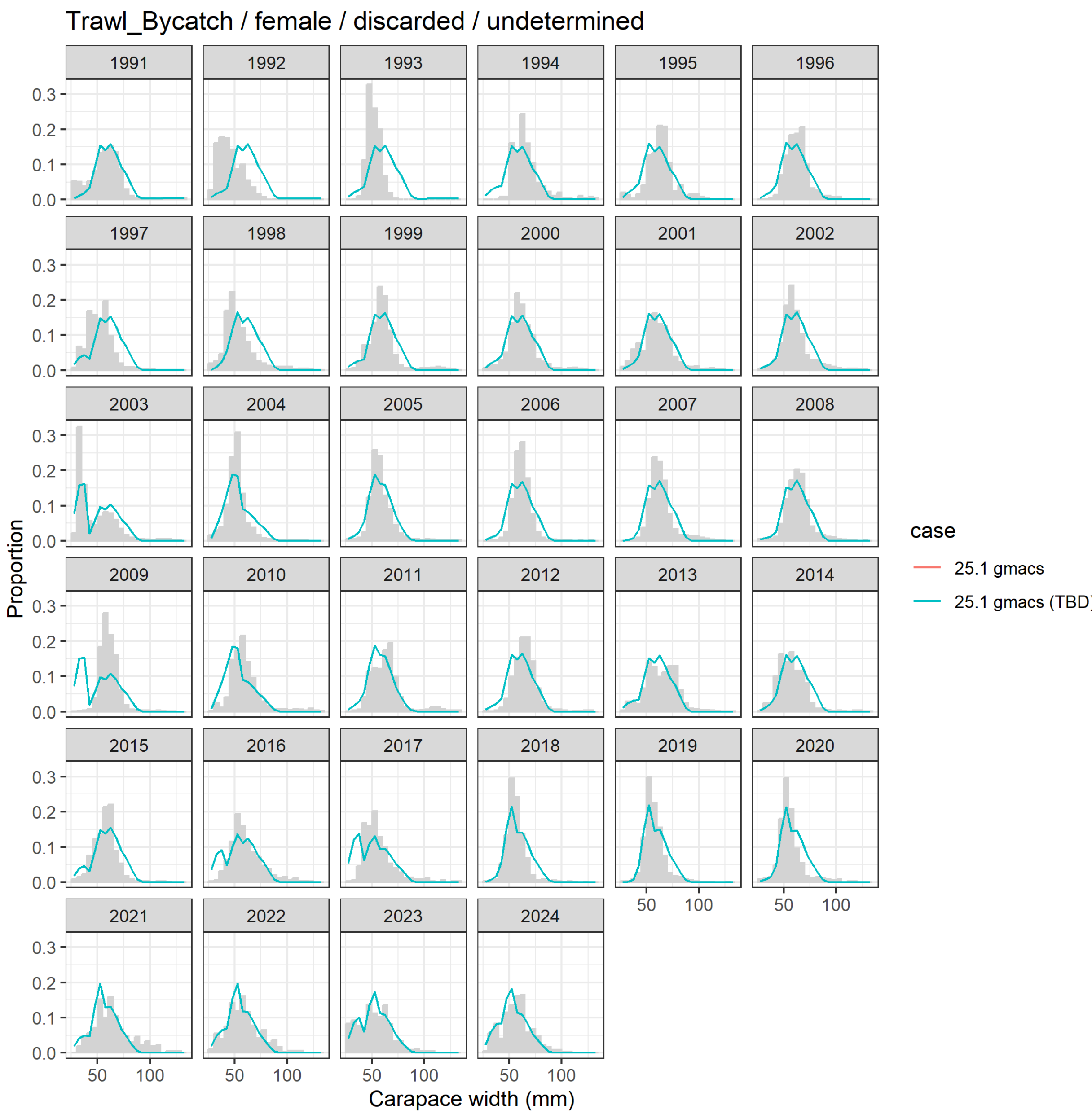

Figure 7: Model fits (lines) to the male non-directed fishery size composition data (grey bars).

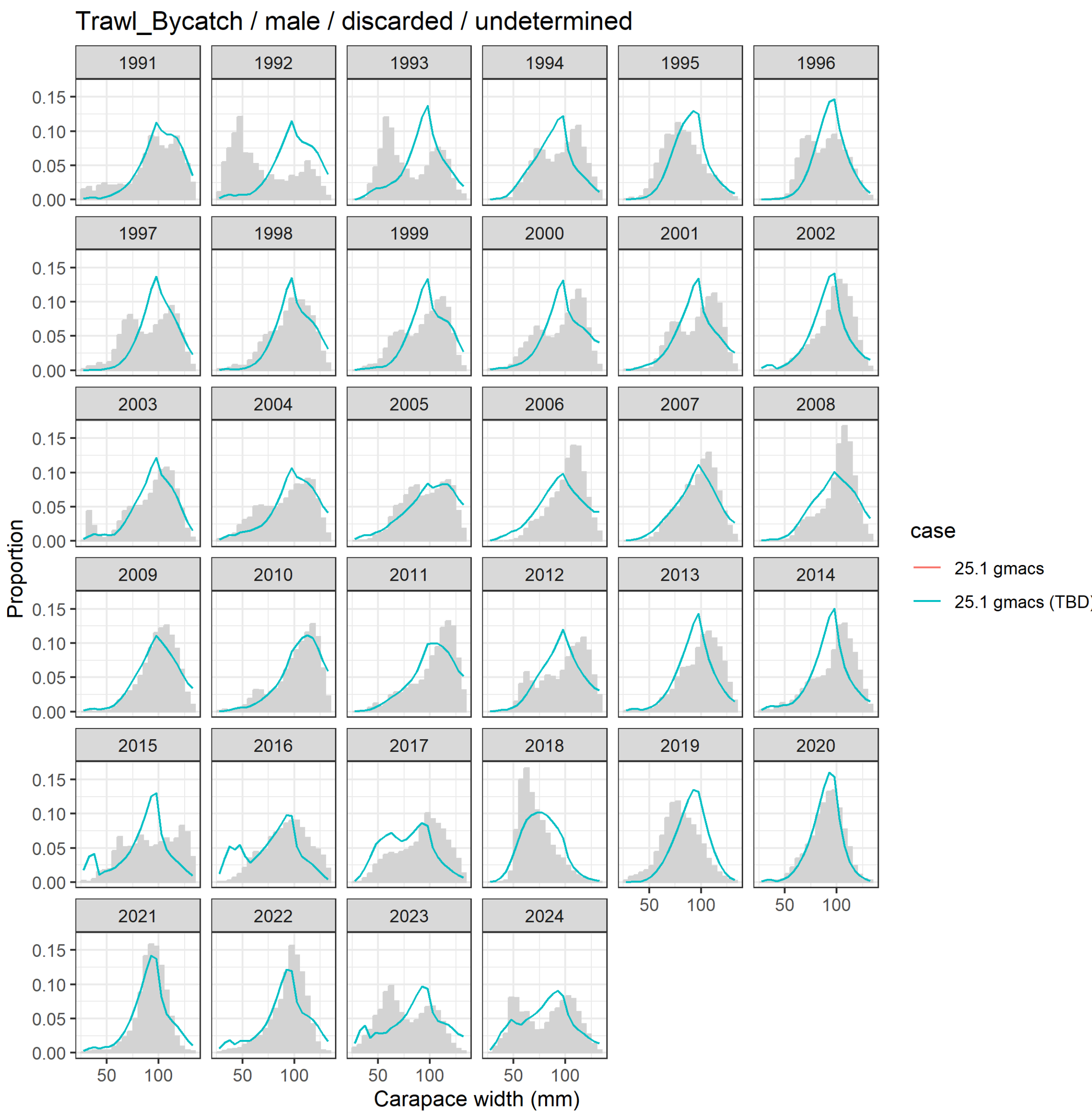

Figure 8: Model fits (lines) to the female non-directed size composition data (grey bars).

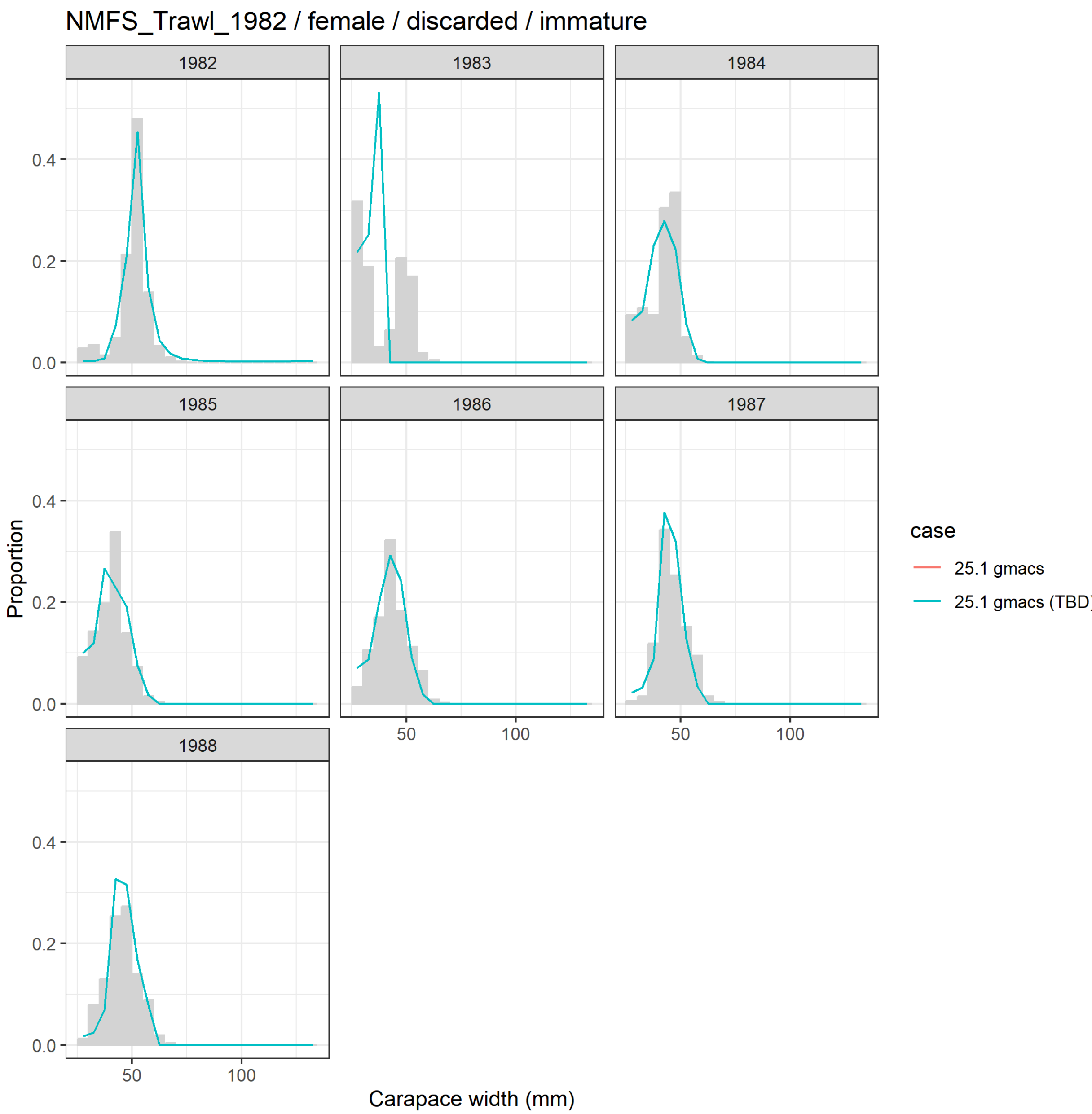

Figure 9: Model fits to immature male survey size composition data from 1982-1988.

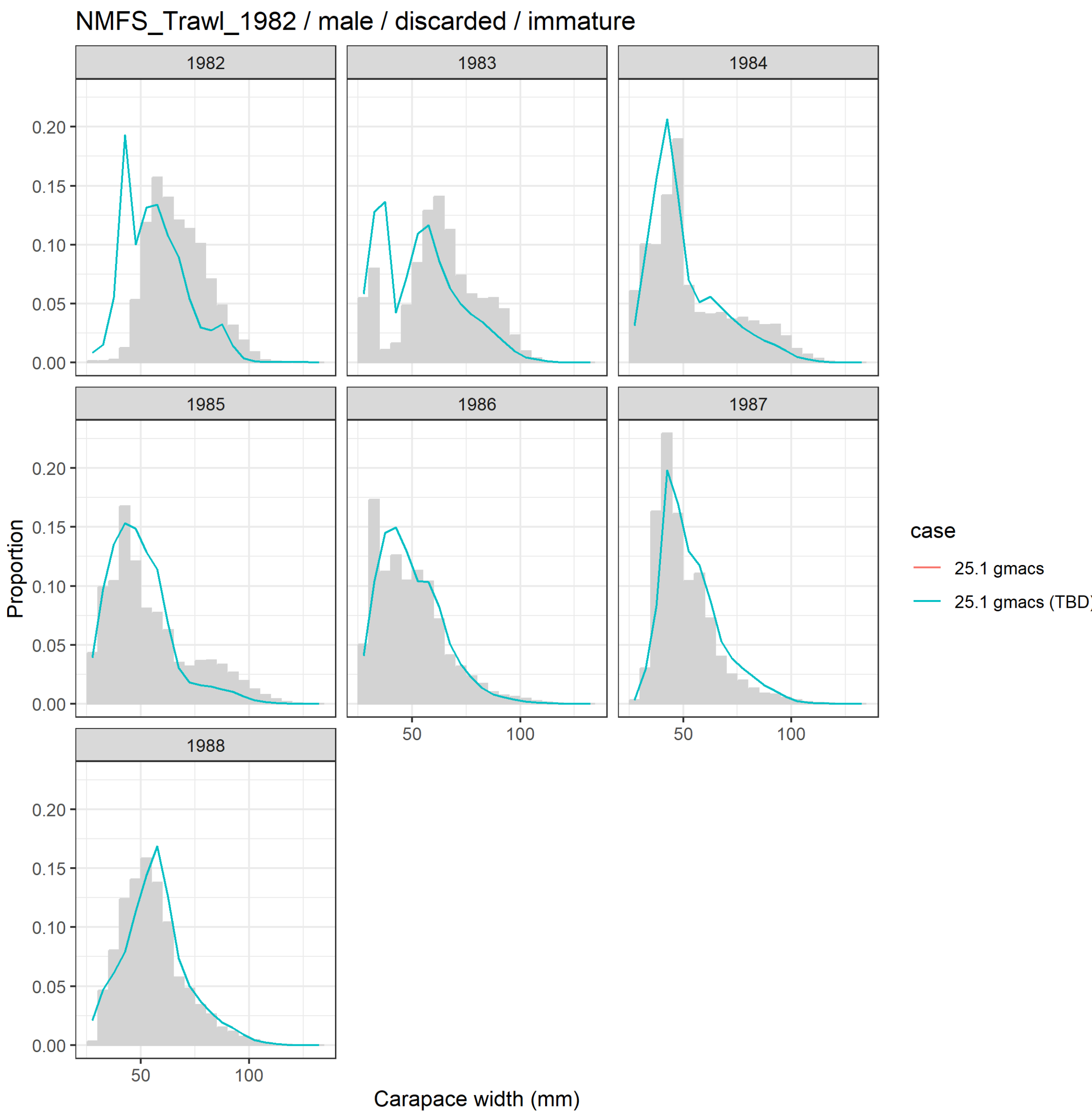

Figure 10: Model fits to immature female survey size composition data from 1982-1988.

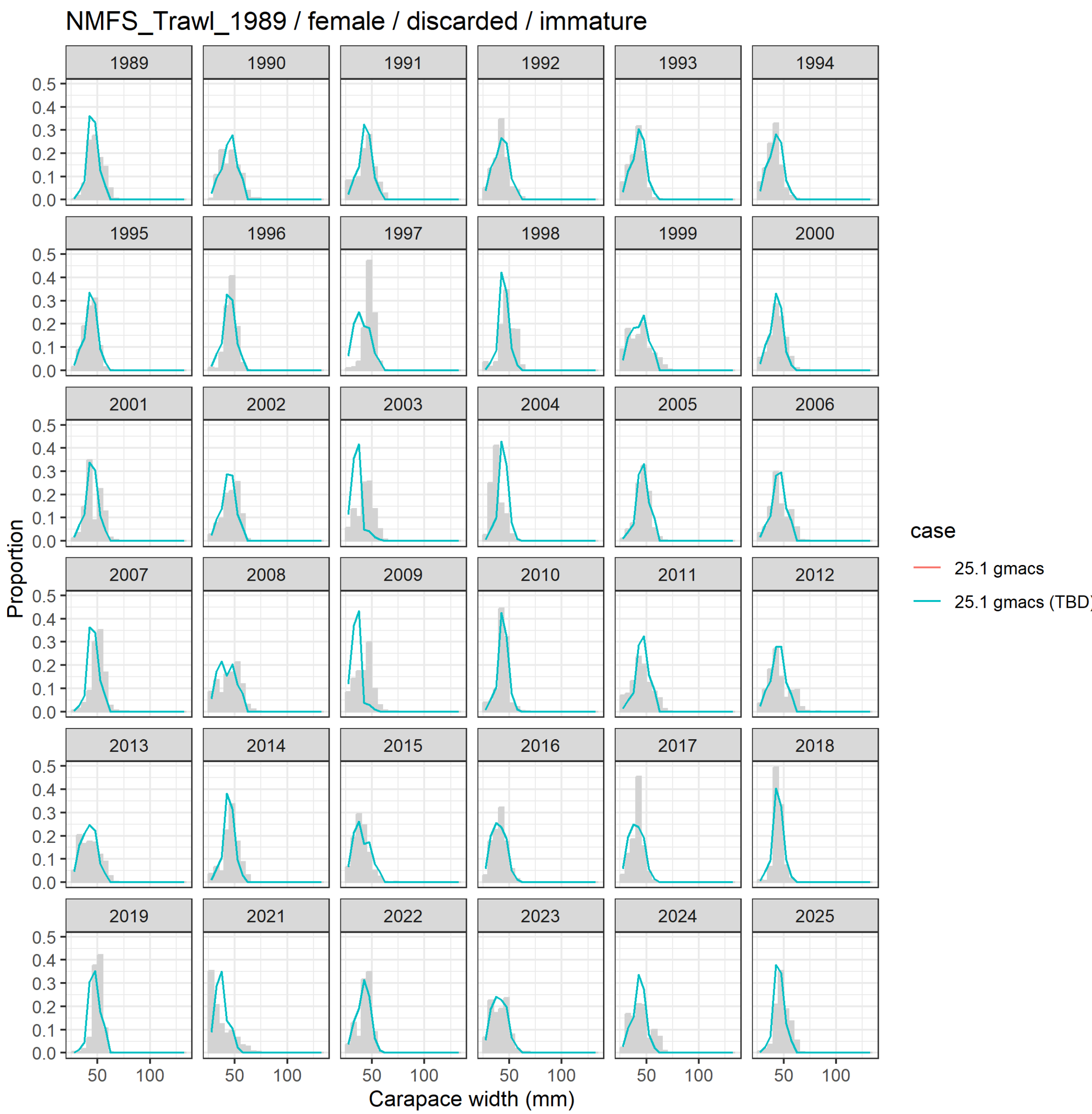

Figure 11: Model fits to mature male survey size composition data from 1982-1988.

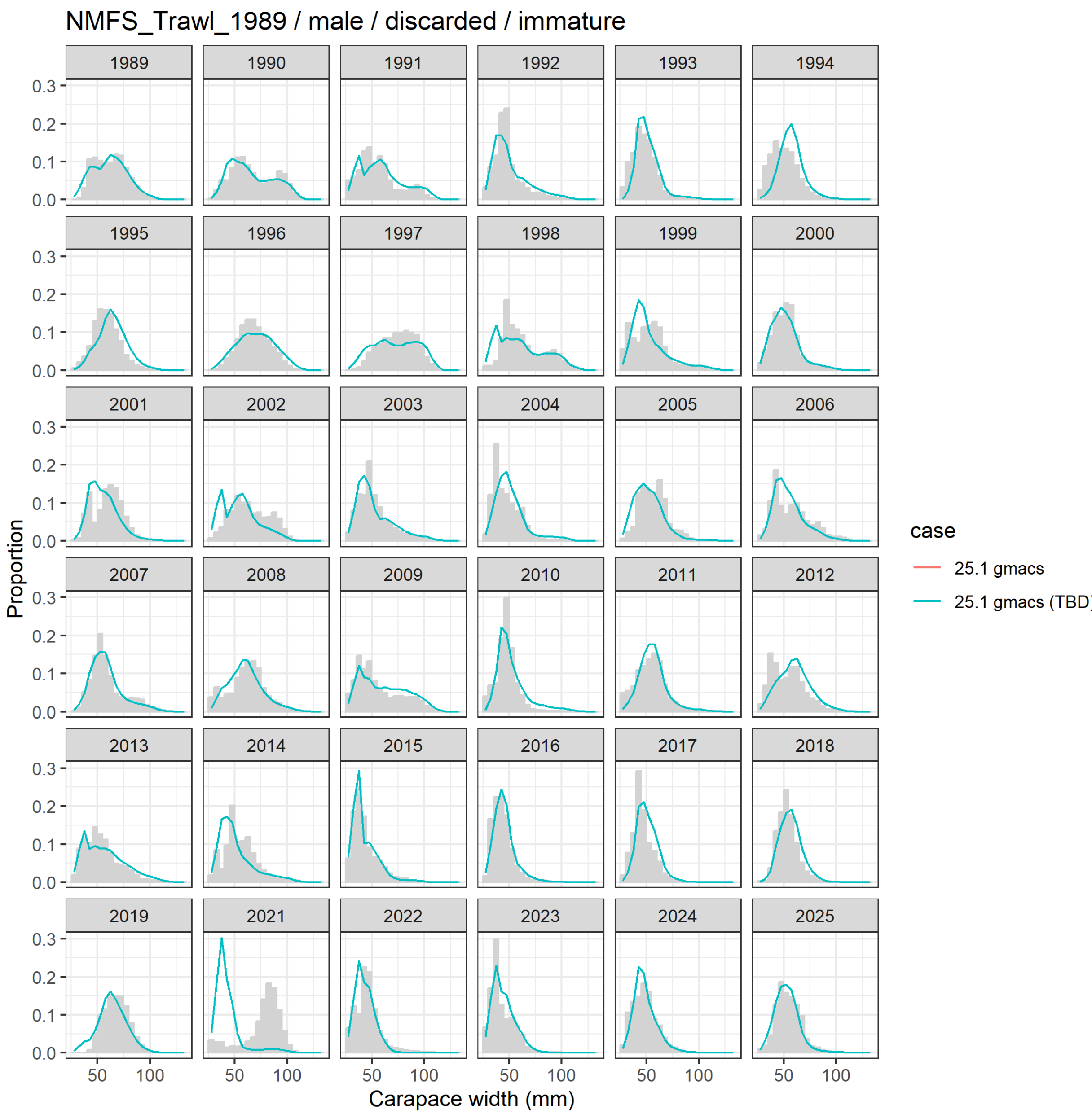

Figure 12: Model fits to mature female survey size composition data from 1982-1988.

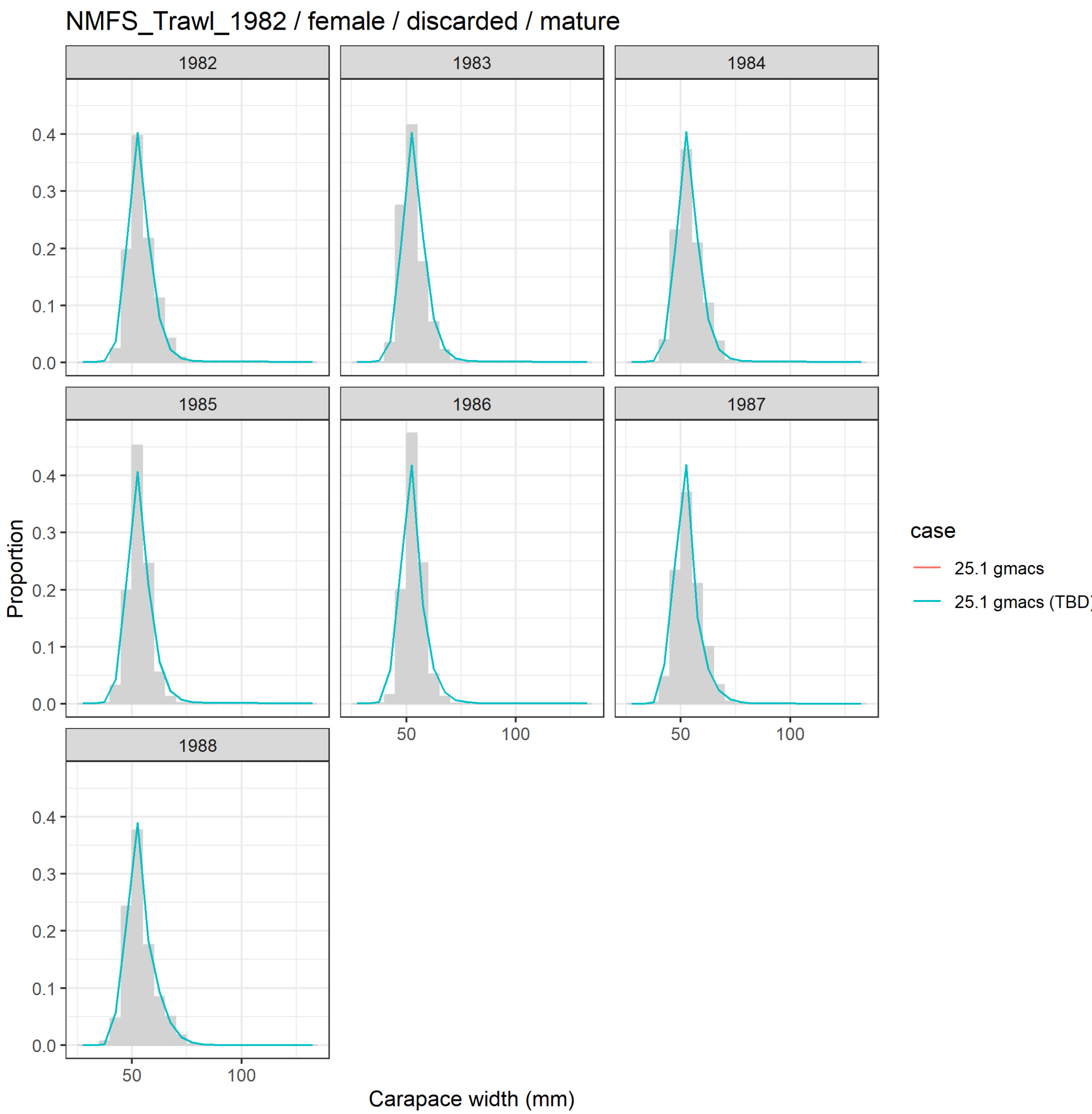

Figure 13: Model fits to immature male survey size composition data from 1989-present.

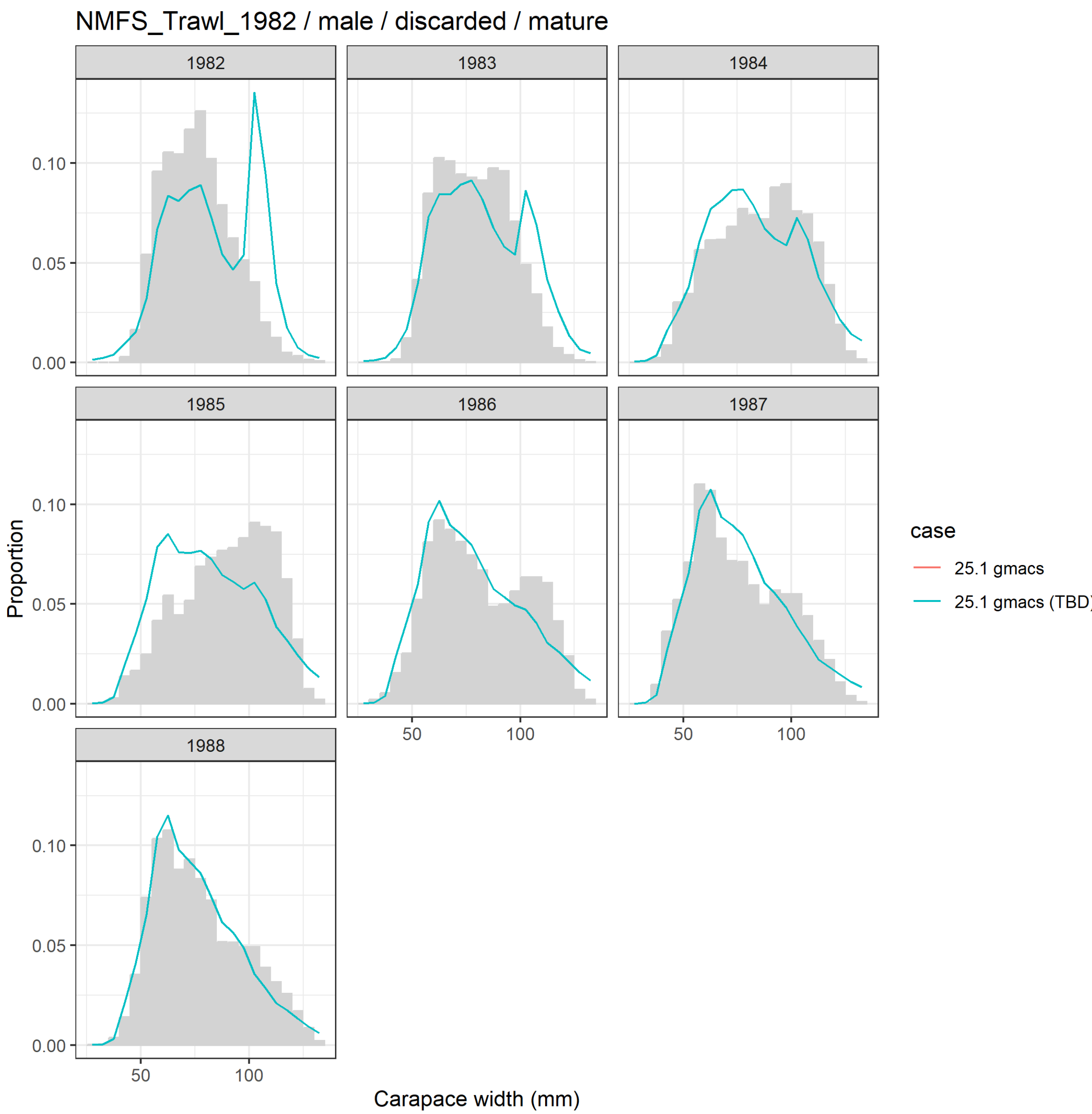

Figure 14: Model fits to immature female survey size composition data from 1989-present.

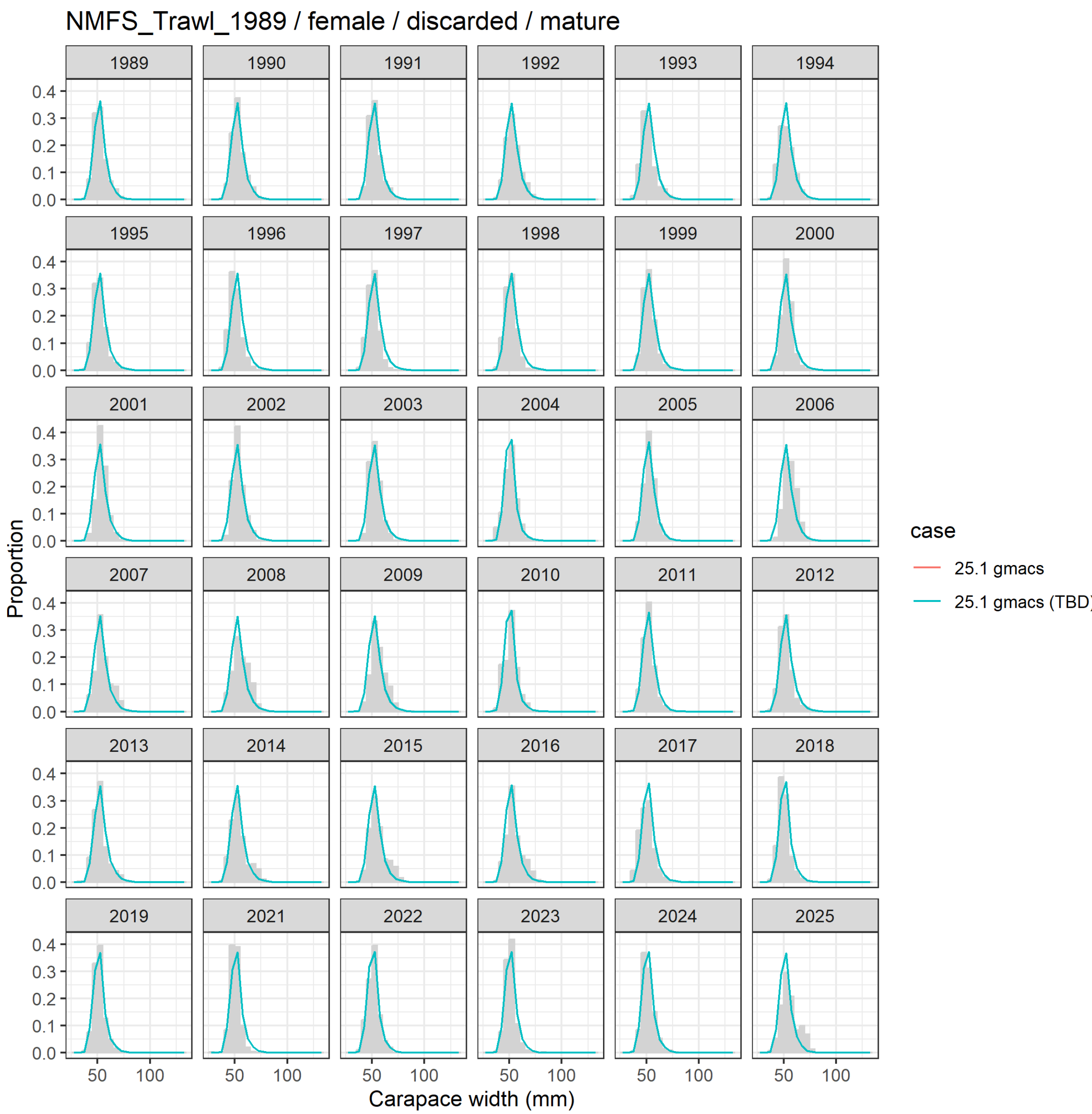

Figure 15: Model fits to mature male survey size composition data from 1989-present.

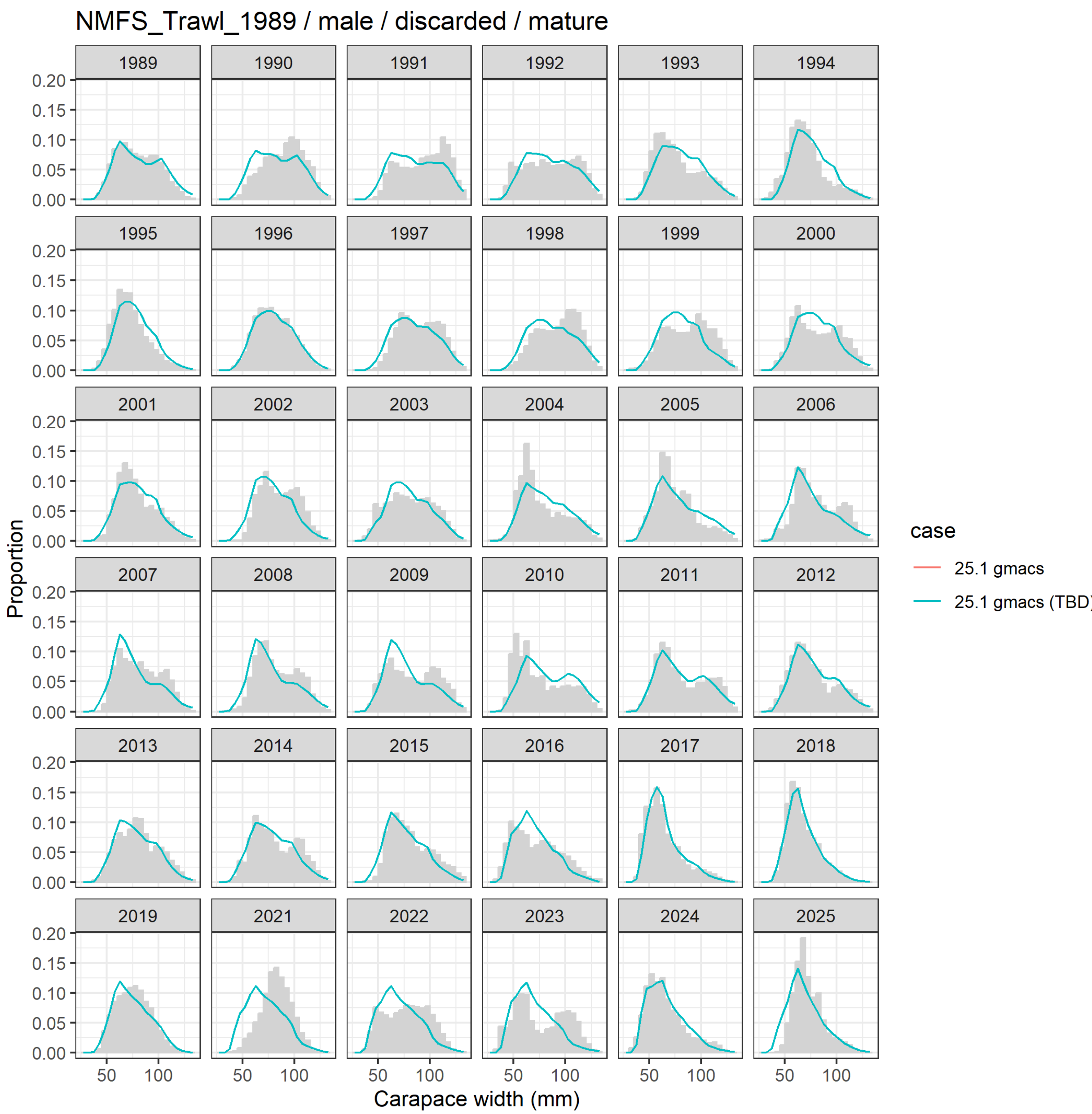

Figure 16: Model fits to mature female survey size composition data from 1989-present.

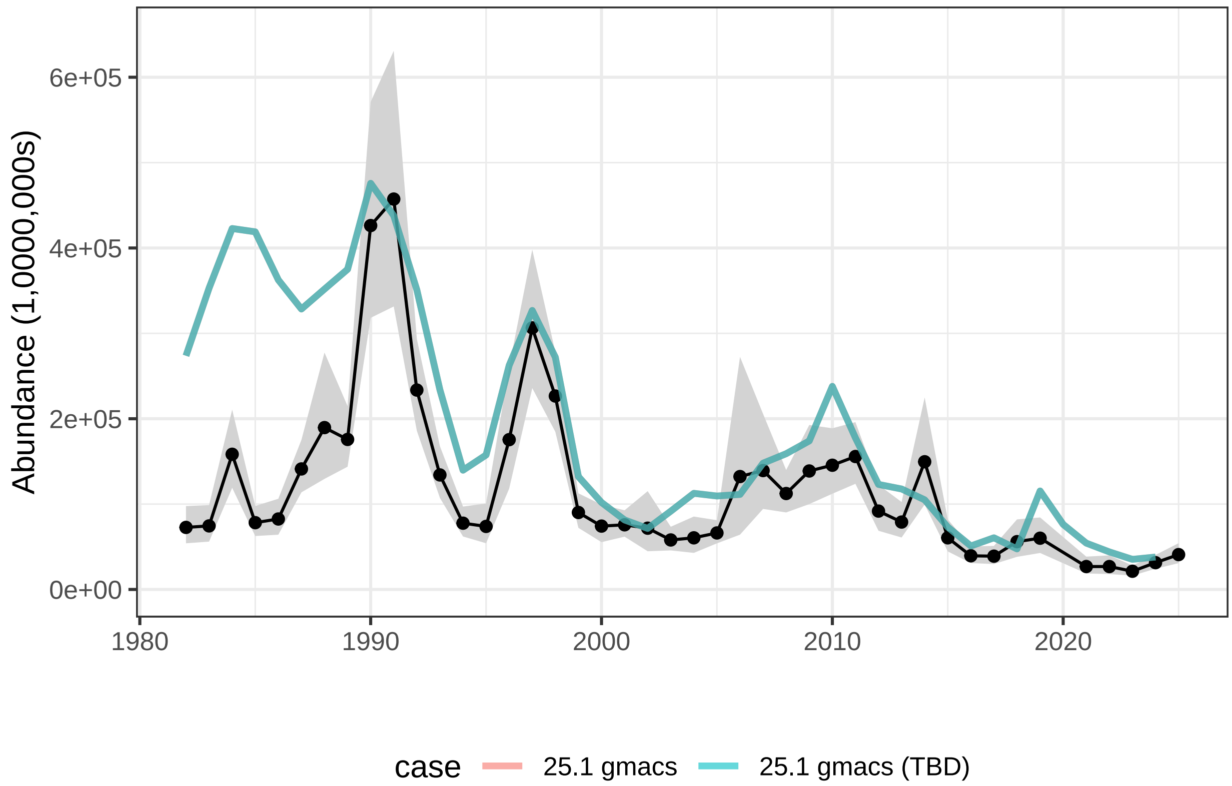

Figure 17: Estimated biomass of male crab >101mm carapace width from the survey (black line and dots with gray 95th CI) and from each model in the assessment (colored lines).

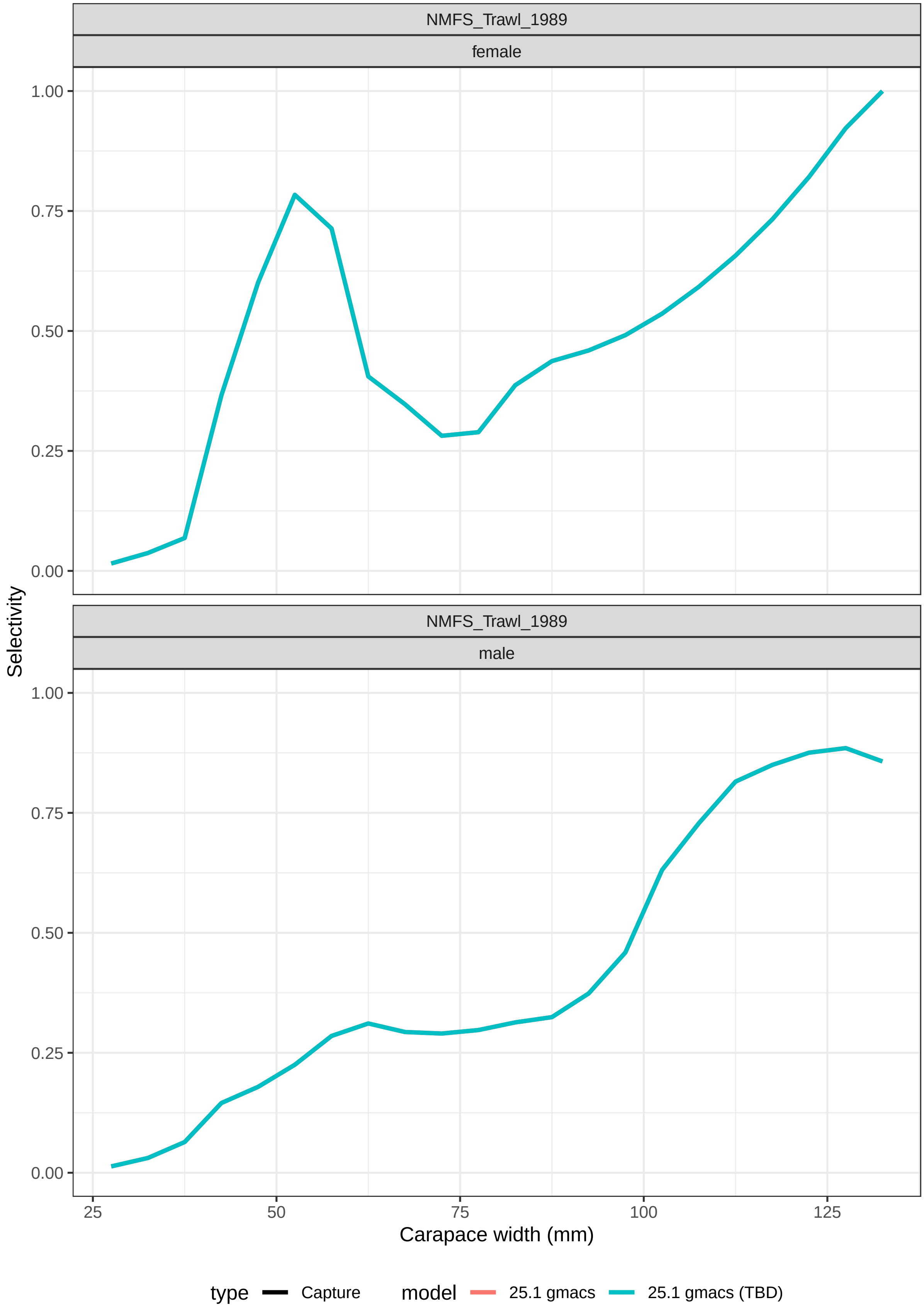

Figure 18: Estimated survey selectivity (lines) with normal priors derived from BSFRF selectivity experiment data. Points are the mean of the prior at a given size; intervals are 95th quantiles based on input CVs.

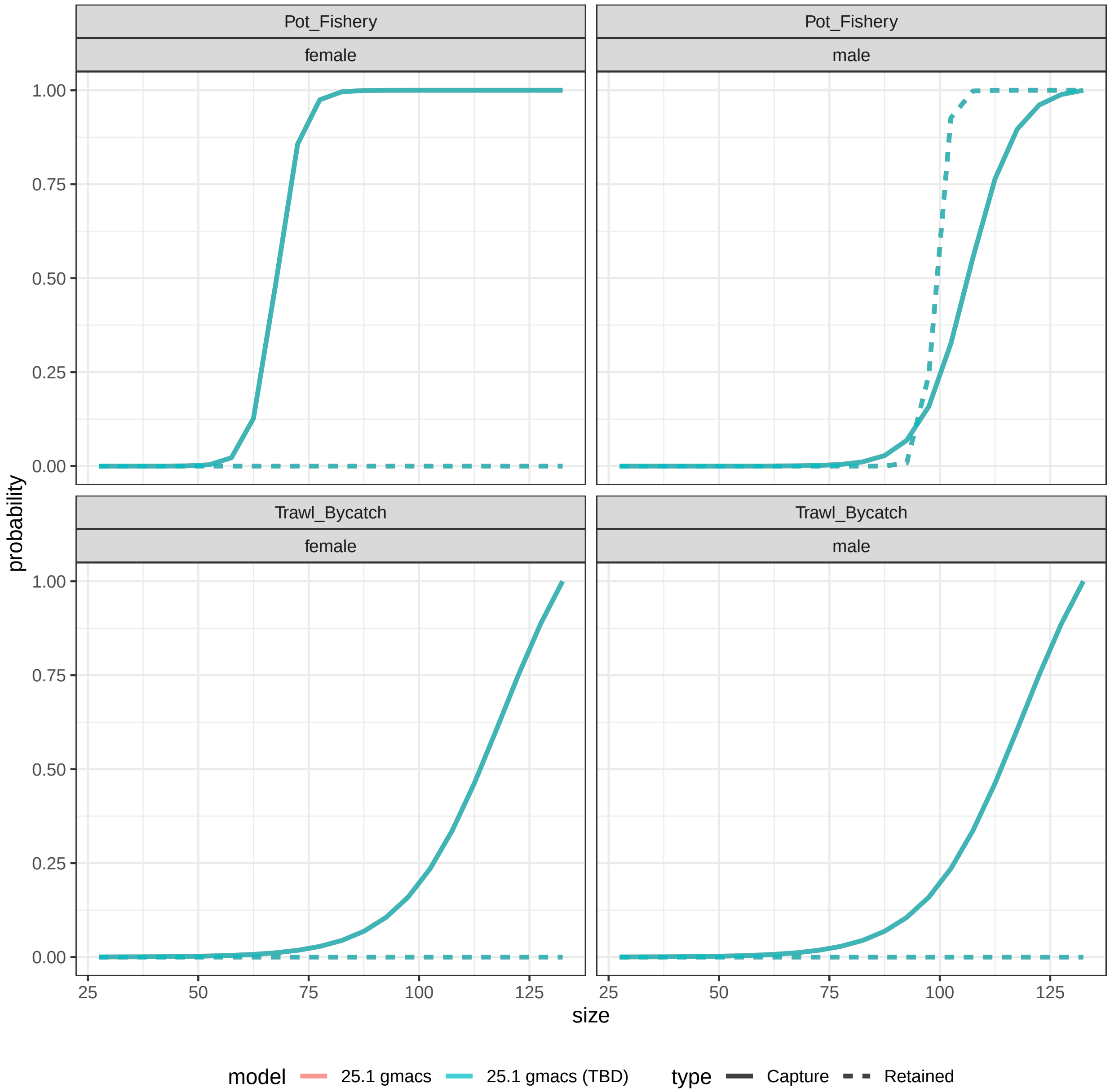

Figure 19: Estimated selectivities by fishing fleet and sex for capture and retained catches.

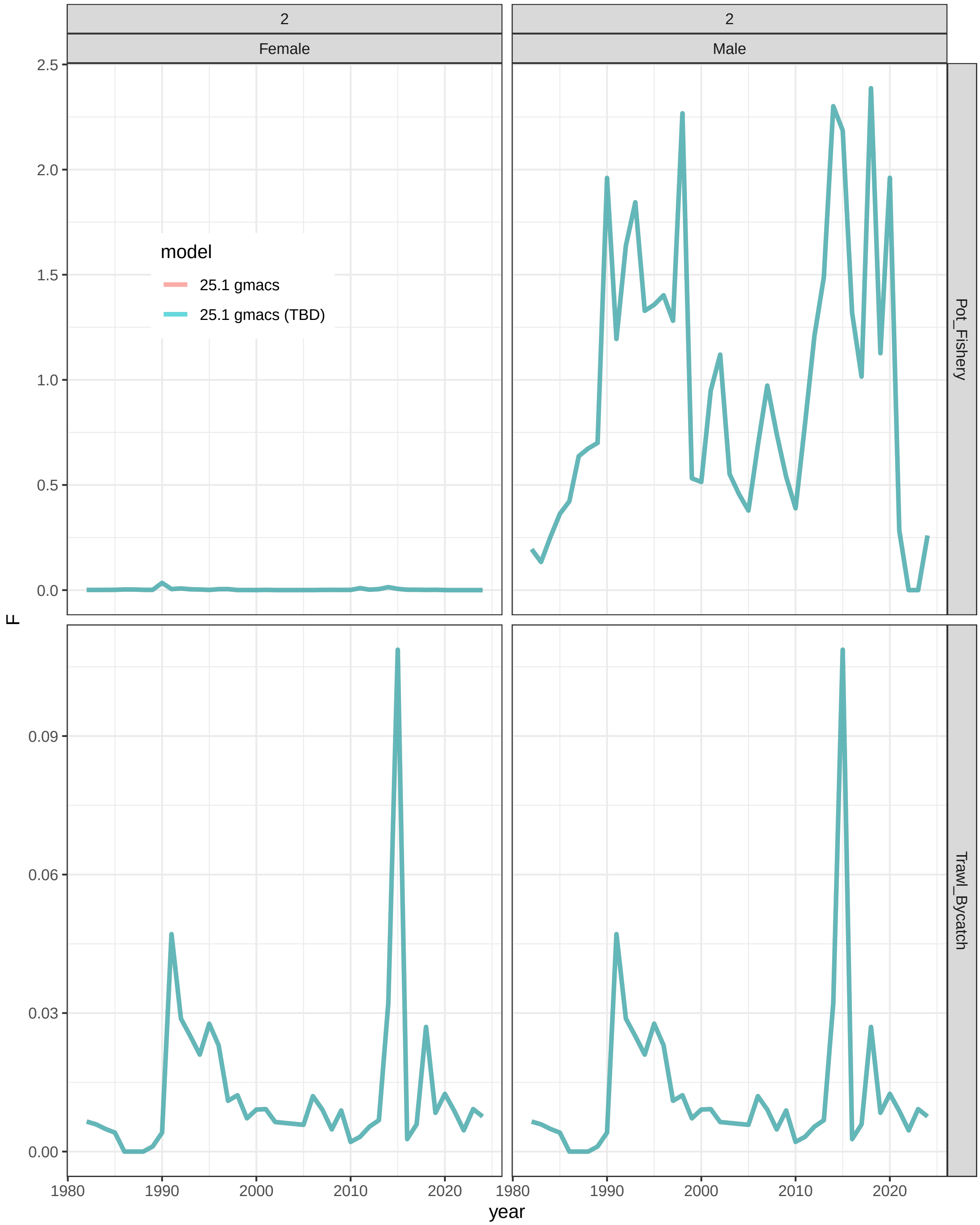

Figure 20: Estimated fishing mortalities for the directed and non-directed fisheries.

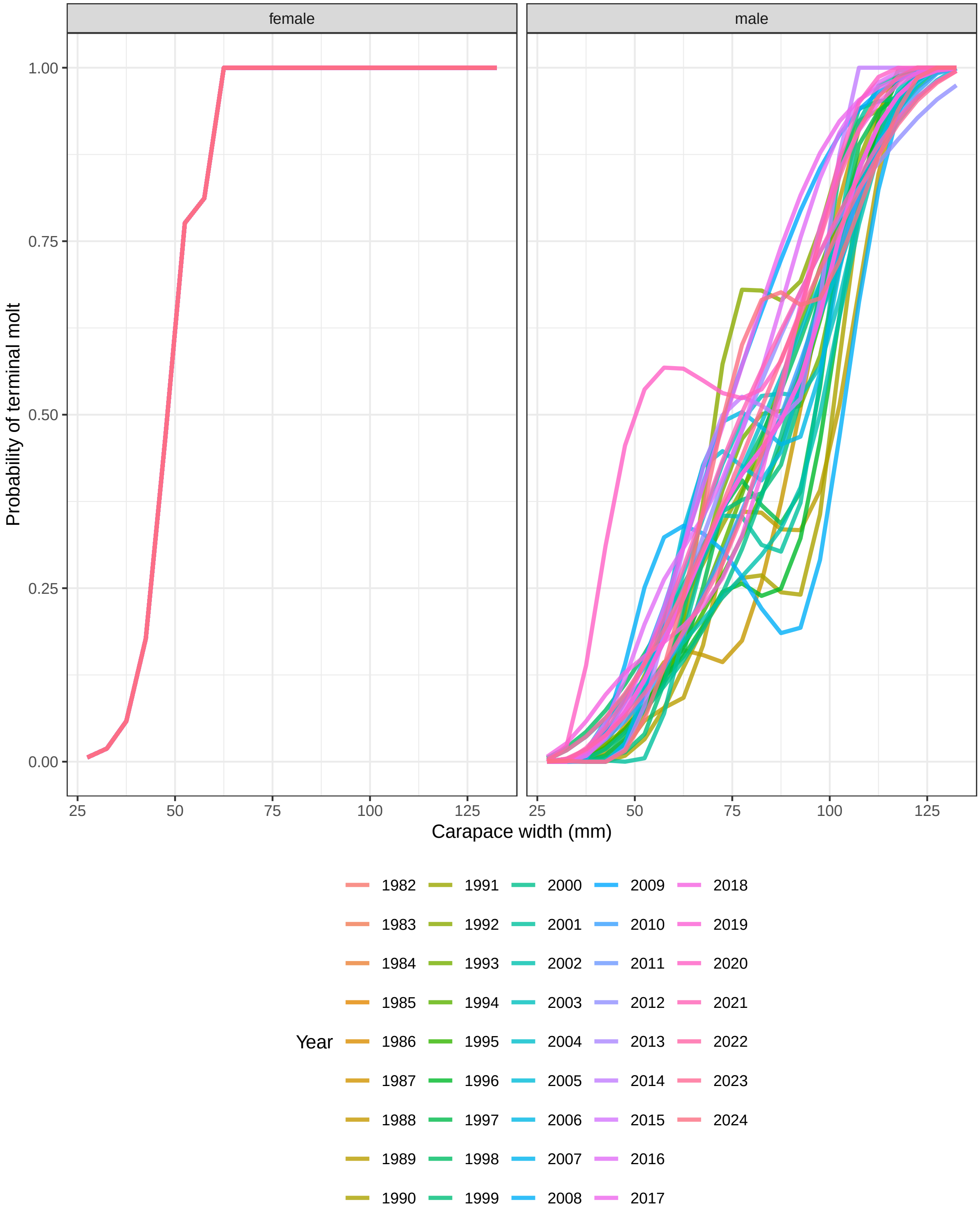

Figure 21: Estimated (black line) or specified (colored lines) probability(s) of maturing for male crab.

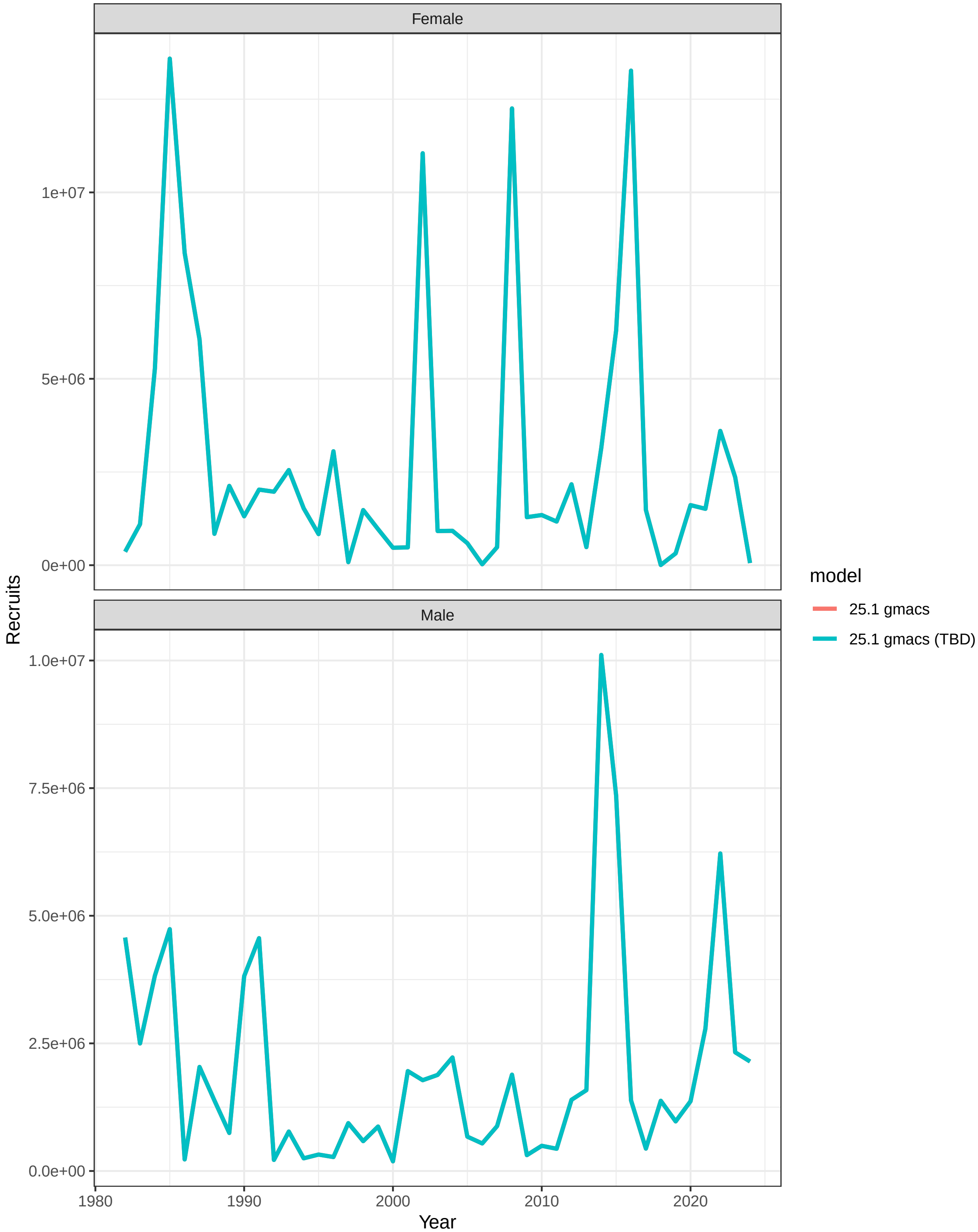

Figure 22: Estimated recruitment by sex (bottom) and proportions recruiting to length bin (top) by model.

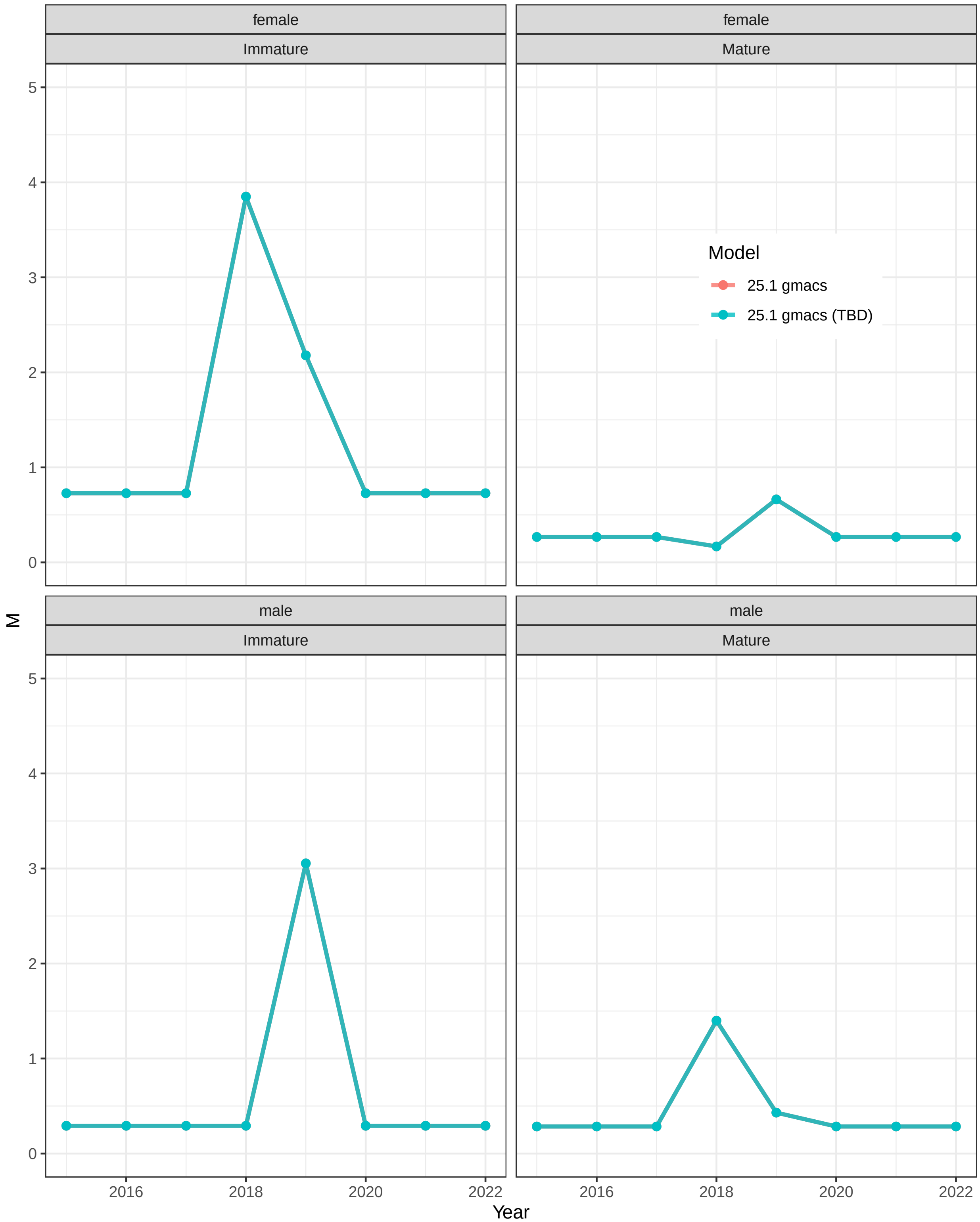

Figure 23: Estimated natural mortality by sex and maturity state. Natural mortality in all years previous to 2018 and after 2019 are equal to the estimated M in 2017.

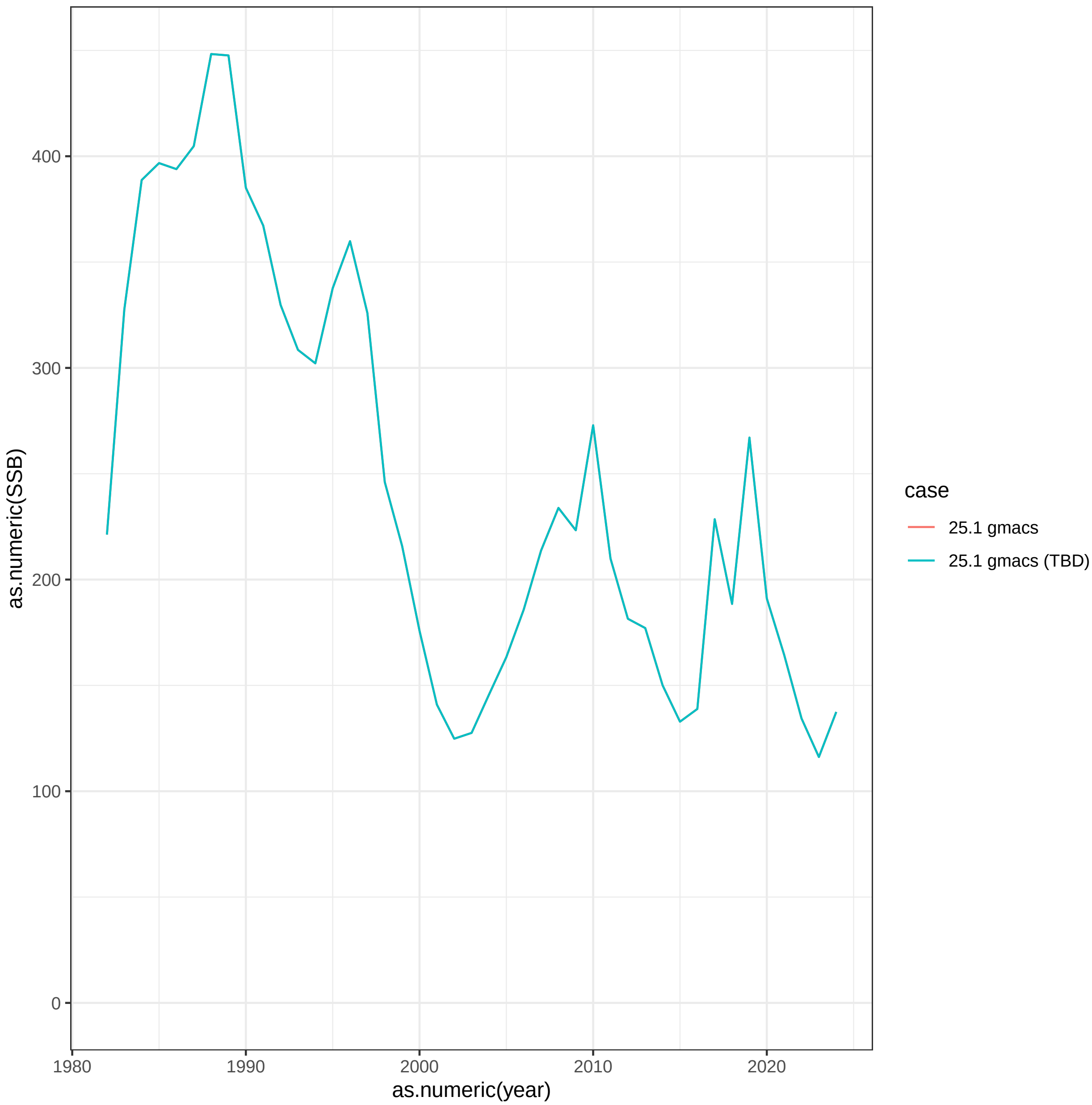

Figure 24: Model predicted mature male biomass at mating time in 1,000 tonnes. Dashed horizontal lines are half of the respective BMSY proxies based on B35% of a given management currency (i.e. MSST).