Tanner Crab Appendix C

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Introduction

Subsequent to submission of the May 2021 Tanner crab report to the Crab Plan Team, additional analyses were completed using Model 21.15 as the base model. Model 21.15 had a number of parameters estimated at a bound. The model presented here, 21.23, builds on 21.15 by expanding the bounds on some of the parameters hitting a bound in 21.15 while fixing others to a value almost at the bound. This was an iterative process (documented below) that was repeated until the final version of Model 21.23 was able to converge with no estimated parameters at a bound. In most cases, the values chosen for parameters that were fixed at a bound can be justified.

Methods

Model 21.15 had 7 parameters, all related to selectivity, estimated at a bound:

Table 1. Parameters at a bound in Model 21.15.

name	value	test	description
pRb[1]	2.0E-08	at lower bound	scale factor for recruitment size distribution (ln-scale)
pS1[10]	140.00	at upper bound	ascending z-at-1 for SCF selectivity (males, pre-1997)
pS1[22]	180.00	at upper bound	size at 1 for RKF selectivity (males, pre-1997)
pS1[25]	140.00	at upper bound	size at 1 for RKF selectivity (females, pre-1997)
pS3[2]	8.7E-07	at lower bound	scaled increment for descending z-at-1 for SCF selectivity (males, 1997-2004)
pS3[3]	7.0E-08	at lower bound	scaled increment for descending z-at-1 for SCF selectivity (males, 2005+)
pDC2[3]	-10.00	at lower bound	ln-scale fishery capture offset for female bycatch in GF All

It was also noticed that the Dirichlet-multinomial scale parameter for female bycatch size compositions in the snow crab fishery had been incorrectly assigned. Consequently, Model 21.15 was re-run prior to adjusting any parameters with this correction made and fits to size compositions for bycatch in the snow crab, BBRKC, and groundfish fisheries were evaluated using the Dirichlet-multinomial likelihood with scale parameters estimated (the scale factors for the BBRKC size compositions had previously been estimated at their upper bounds, implying no adjustment of input sample sizes, so the multinomial likelihood had been used in 21.15 instead). After this run, pS1[24], the size-at-1 for male bycatch in the RKF (i.e., BBRKC fishery), was also found to be at its upper bound, as were the Dirichlet-multinomial scale parameters for female bycatch size compositions in the snow crab and BBRKC fisheries. In order to deal with these problematic parameters, the following steps were undertaken:

1. pS1[22], the size at 1 for RKF bycatch selectivity on males pre-1997 was fixed at its upper bound (179.9 mm CW)
2. pS1[24], the size at 1 for RKF bycatch selectivity on males 2005+ was fixed at its upper bound (179.9 mm CW)
3. pS1[25], the size at 1 for RKF bycatch selectivity on females pre-1997 was fixed at its upper bound (139.9 mm CW)
4. pS3[2], the scaled increment for the plateau before descending from z-at-1 for male bycatch selectivity in the snow crab fishery during 1997-2004 was fixed at its lower bound (0.001)
5. pS3[2], the scaled increment for the plateau before descending from z-at-1 for male bycatch selectivity in the snow crab fishery during 2005+, was fixed at its lower bound (0.001)

6. pLnDirMul[9], the ln-scale Dirichlet-multinomial scale parameter for female bycatch size compositions in the snow crab fishery was fixed at its upper bound (10)
7. pLnDirMul[11], the ln-scale Dirichlet-multinomial scale parameter for female bycatch size compositions in the BBRKC fishery was fixed at its upper bound (10)
8. pRb[1] was not changed

The results from this first round of iteration were that:

1. pRb[1] was again estimated at its lower bound
2. pS1[10], the size-at-1 on the ascending limb of the double normal selectivity function for male bycatch in the snow crab fishery before 1997, was estimated at its upper bound (140 mm CW)
3. pDC2[3], the ln-scale offset for female bycatch rates in the groundfish fisheries, was estimated at its lower bound (-10)

For the next iteration, the following changes were made:

1. pRb[1] was fixed near its lower bound (at 0.00995 on the ln-scale)
2. the upper bound on pS1[10] was expanded from 140 to 180
3. pDC2[3] was fixed near its lower bound (at -9.9 on the ln-scale)

The results from this second round were that two new parameters were found to be at a bound:

1. pS3[1], the scaled increment for the size at which the double normal selectivity function for male bycatch in the snow crab fishery prior to 1997 began to descend, was estimated at its lower bound
2. pS4[1], the descending width for the double normal selectivity function for male bycatch in the snow crab fishery prior to 1997, was estimated at its lower bound (1)

For the third iteration, pS3[1] was fixed at its lower bound (0.001) so the double normal selectivity function essentially had no plateau at 1. pS4[1] was re-estimated, with the result that it was again estimated at its lower bound (1). For the fourth (and final) iteration, pS4[1] was fixed near its lower bound (1.01). This fourth iteration resulted in no further parameters estimated at a bound.

To summarize, Model 21.23 differs from 21.15 in the following:

1. pRb[1]: fixed at 0.00995 on the ln-scale (1.01 on the arithmetic scale) near its lower bound (0 on the ln-scale)
2. pS1[10]: upper bound increased from 140 to 180 mm CW
3. pS1[22] and pS1[24] were both fixed at 179.9 mm CW near their upper bounds (180)
4. pS1[25] was fixed at 139.9 mmCW near its upper bound (140)
5. pS3[1], pS3[2] and pS3[3] were fixed at 0.001 near their lower bounds
6. pS4[1] was fixed at 1.01 near its lower bound
7. pLnDirMul[9] and pLnDirMul[11] were each fixed at 10 (on the ln-scale)

Results: comparison with Model 21.15

The differences between the two models were extremely small (Table 2, Figures 1-20), except for the difference in the objective function values for the converged models (Table 2) as well as the differences resulting from changes in bycatch selectivity on males in the snow crab fishery before 1997 (Figure 7). Although the overall objective function for 21.23 was larger than that for 21.15 by 240 likelihood units, this was due to

Table 2. Summary of model results. Units for average recruitment are millions of crab. Units for B100, Bmsy, current MMB, MSY, OFL, and projected MMB are 1,000's t. Max gradient for 21.23 was the result of using ADMB's new "hess_step" procedure to iteratively improve model convergence using the hessian matrix.

case	objective function	max gradient	avg recruitment	B100	Bmsy	current MMB	Fmsy	MSY	Fofl	OFL	projected MMB
21.15	6349.95	0.01683371	1409.54	124.67	43.63	72.21	1.20	20.70	0.99	23.87	36.80
21.23	6590.74	0	1409.28	124.20	43.47	71.97	1.22	20.68	1.00	23.87	36.56

using different likelihoods (the multinomial for 21.15 and the Dirichlet-multinomial for 21.23) to evaluate the fits to the bycatch size compositions in the BBRKC fishery so that the total likelihoods are not directly comparable. However, 21.23 has no estimated parameters at a bound and the maximum gradient at the converged solution is truly zero. In addition, the differences resulting from changes in bycatch selectivity on males in the snow crab fishery before 1997 (Figure 7) in fully-selected fishery capture rates (Figure 8) and estimated catch before 1990 (Figure 10) have little to no effect on other model results.

Figure Captions

Figures

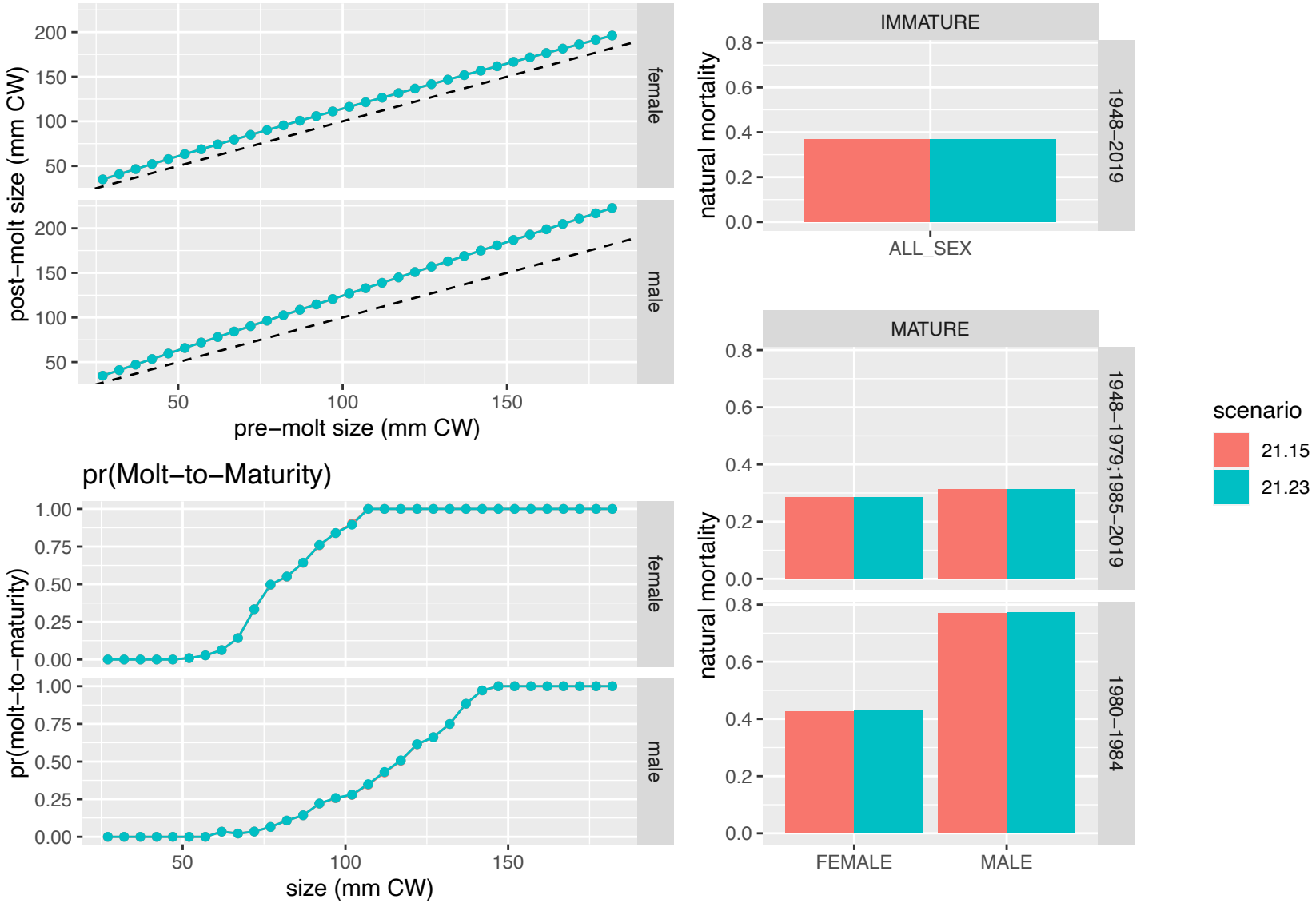

Figure 1. Estimated population processes.

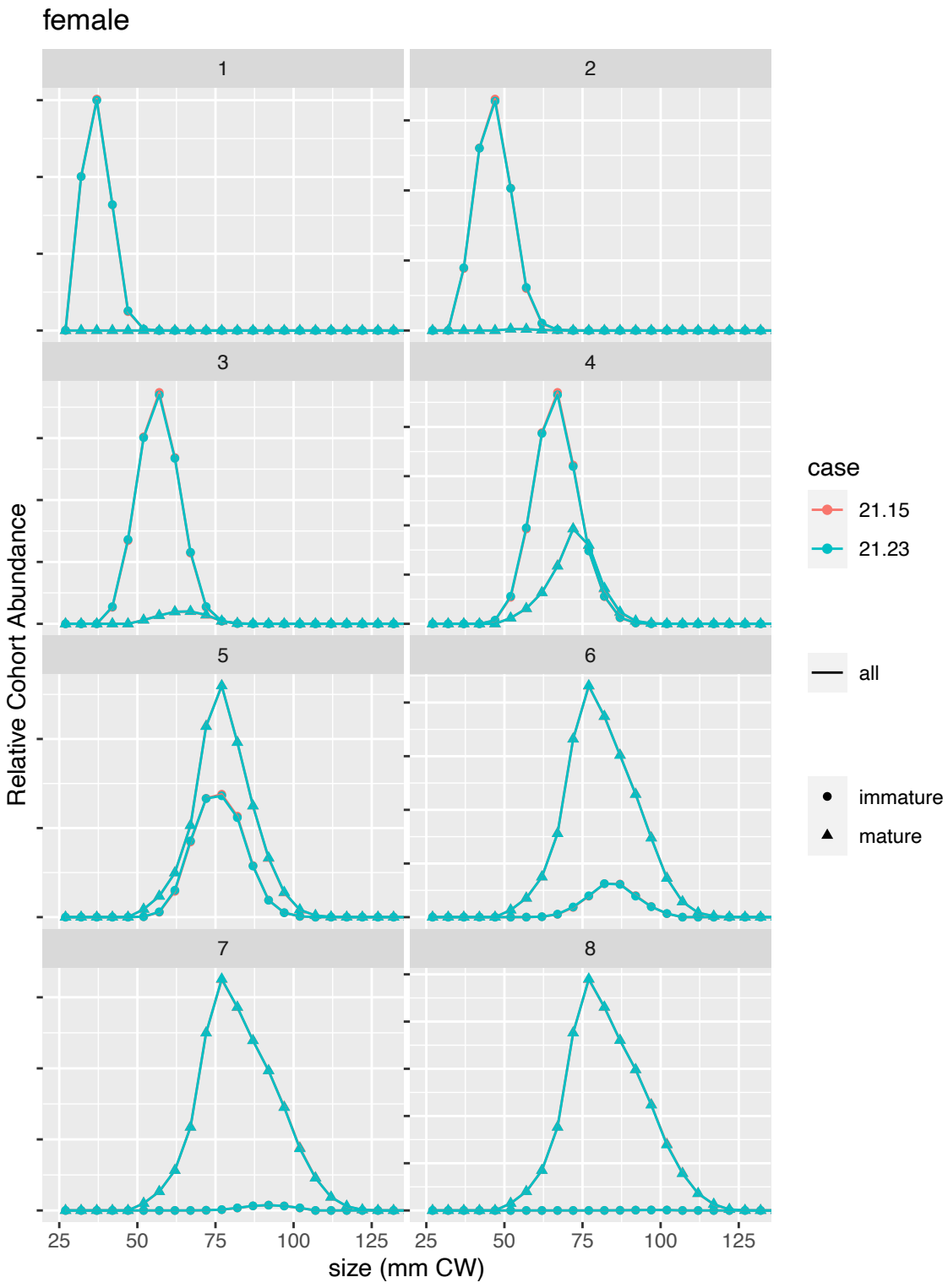

Figure 2. Estimated size progression of a cohort of female crab through time (years).

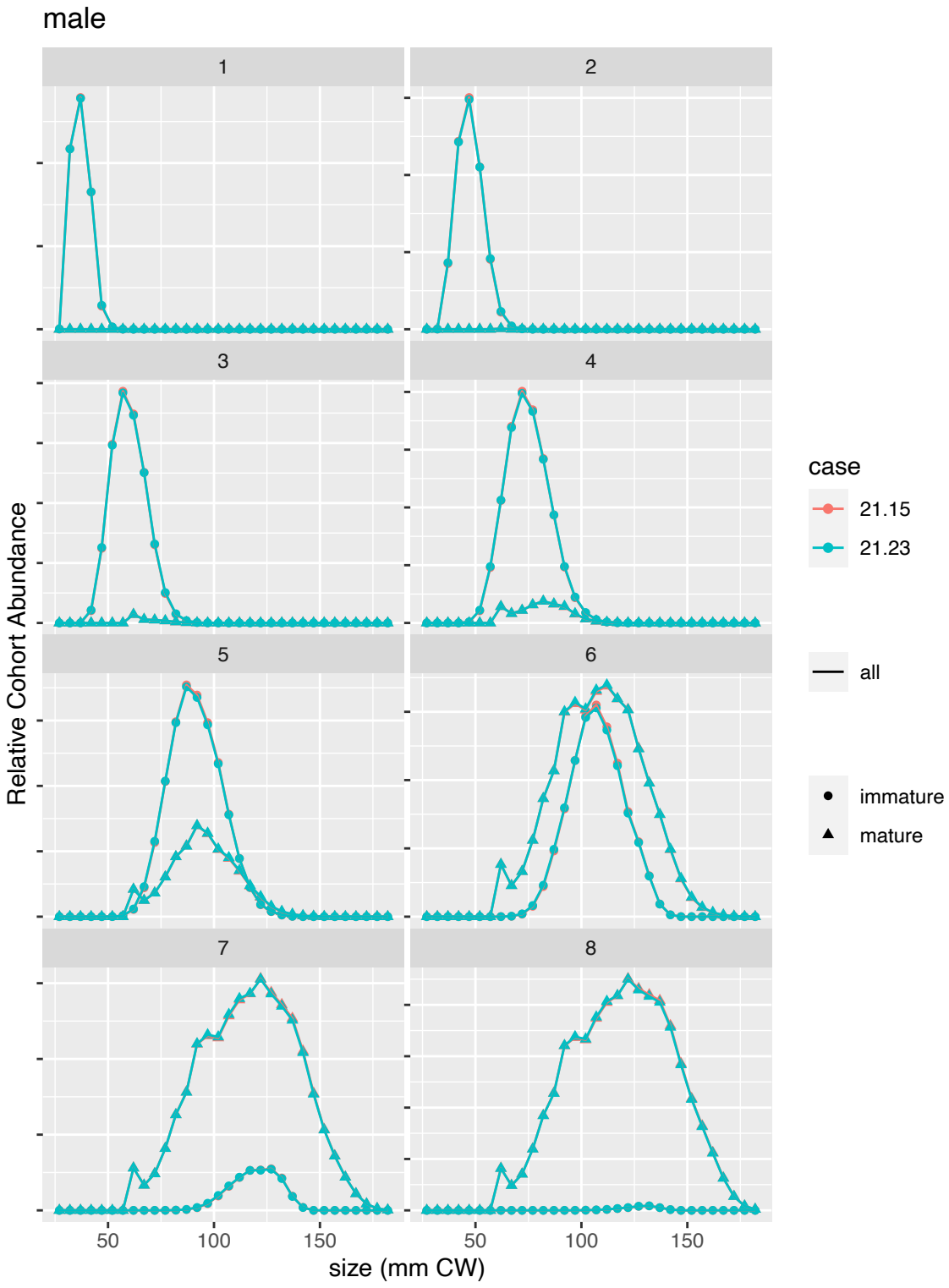

Figure 3. Estimated size progression of a cohort of male crab through time (years).

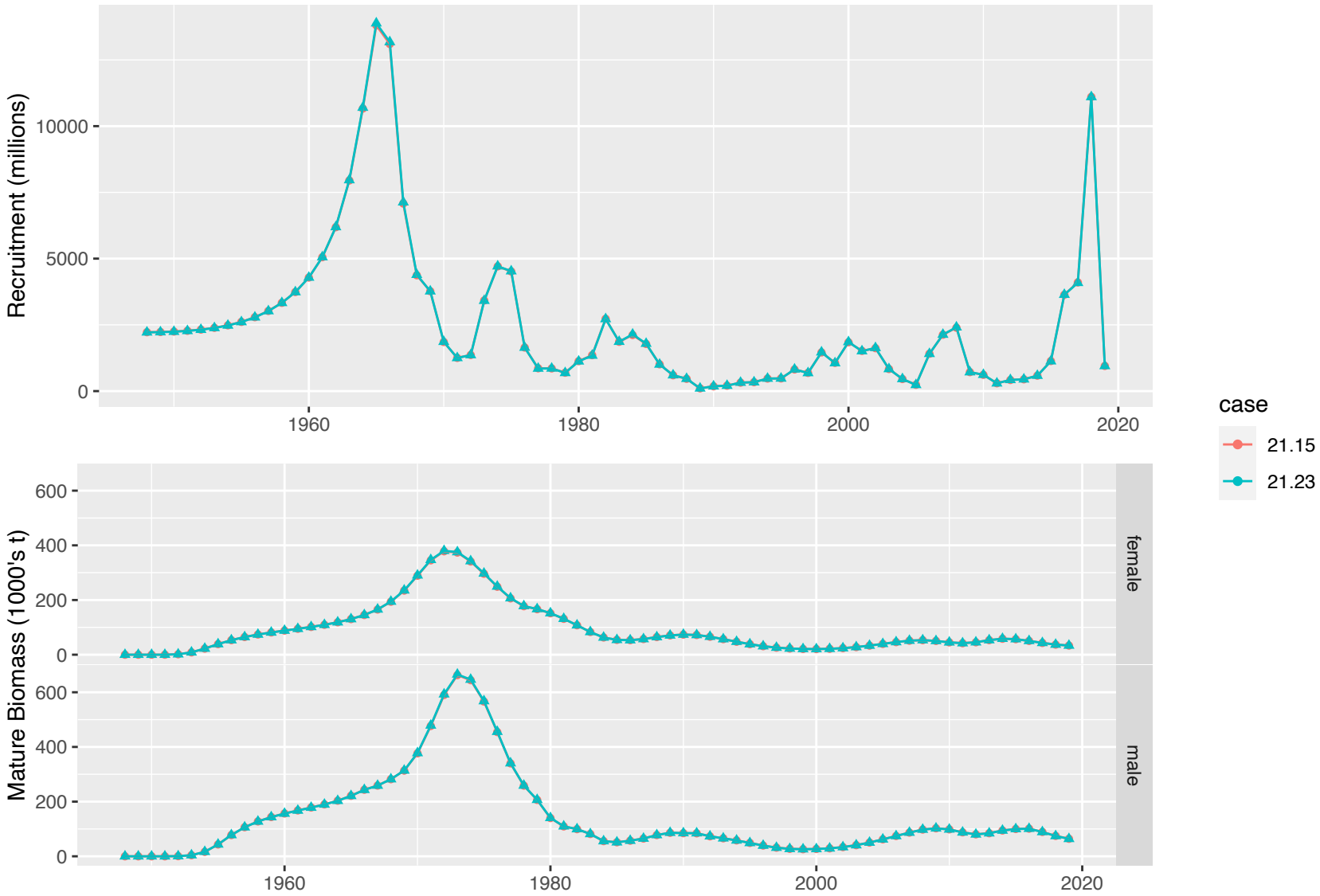

Figure 4. Estimated time series of recruitment and mature biomass.

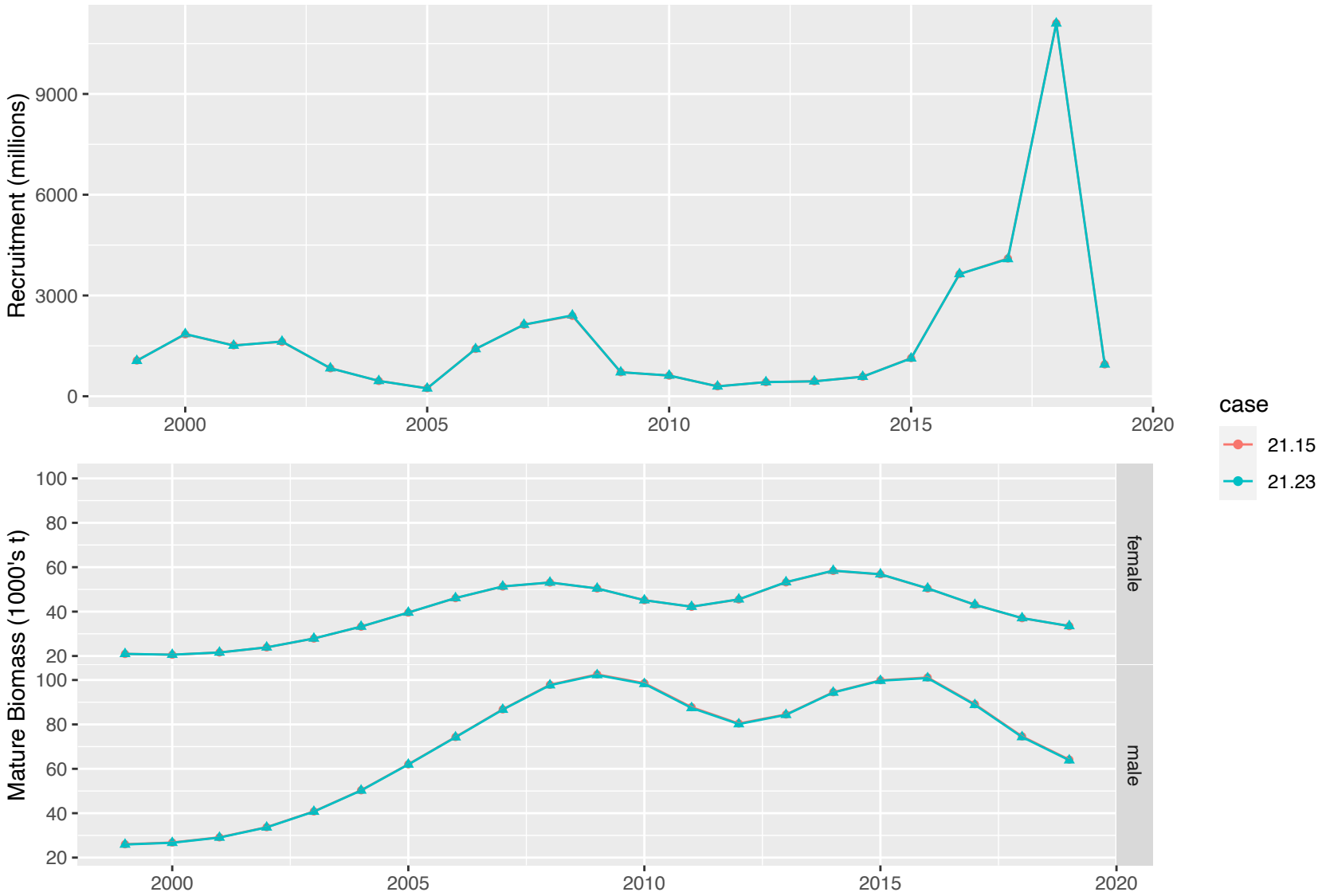

Figure 4a. Estimated time series of recruitment and mature biomass.

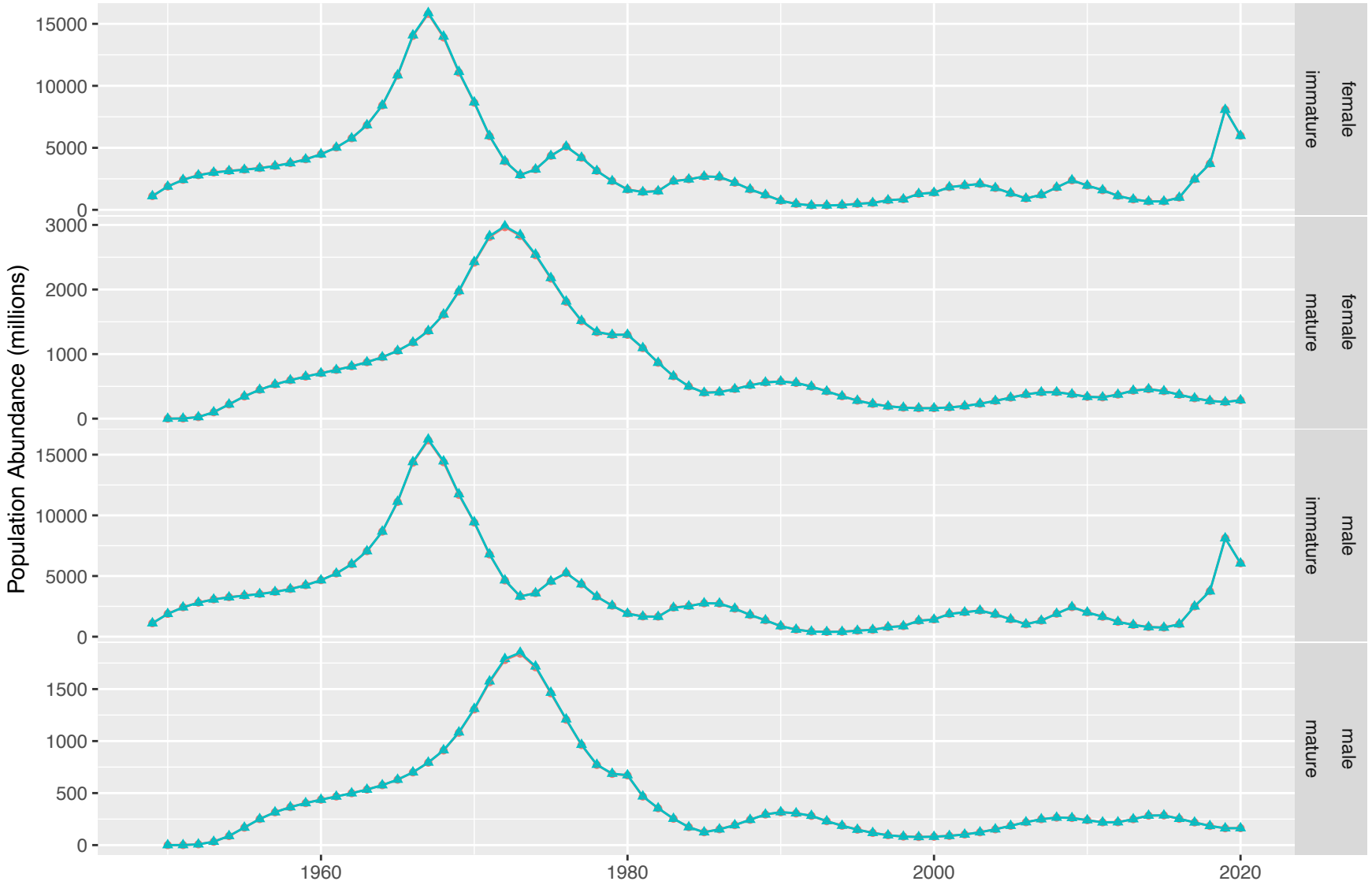

Figure 5. Estimated time series of population abundance.

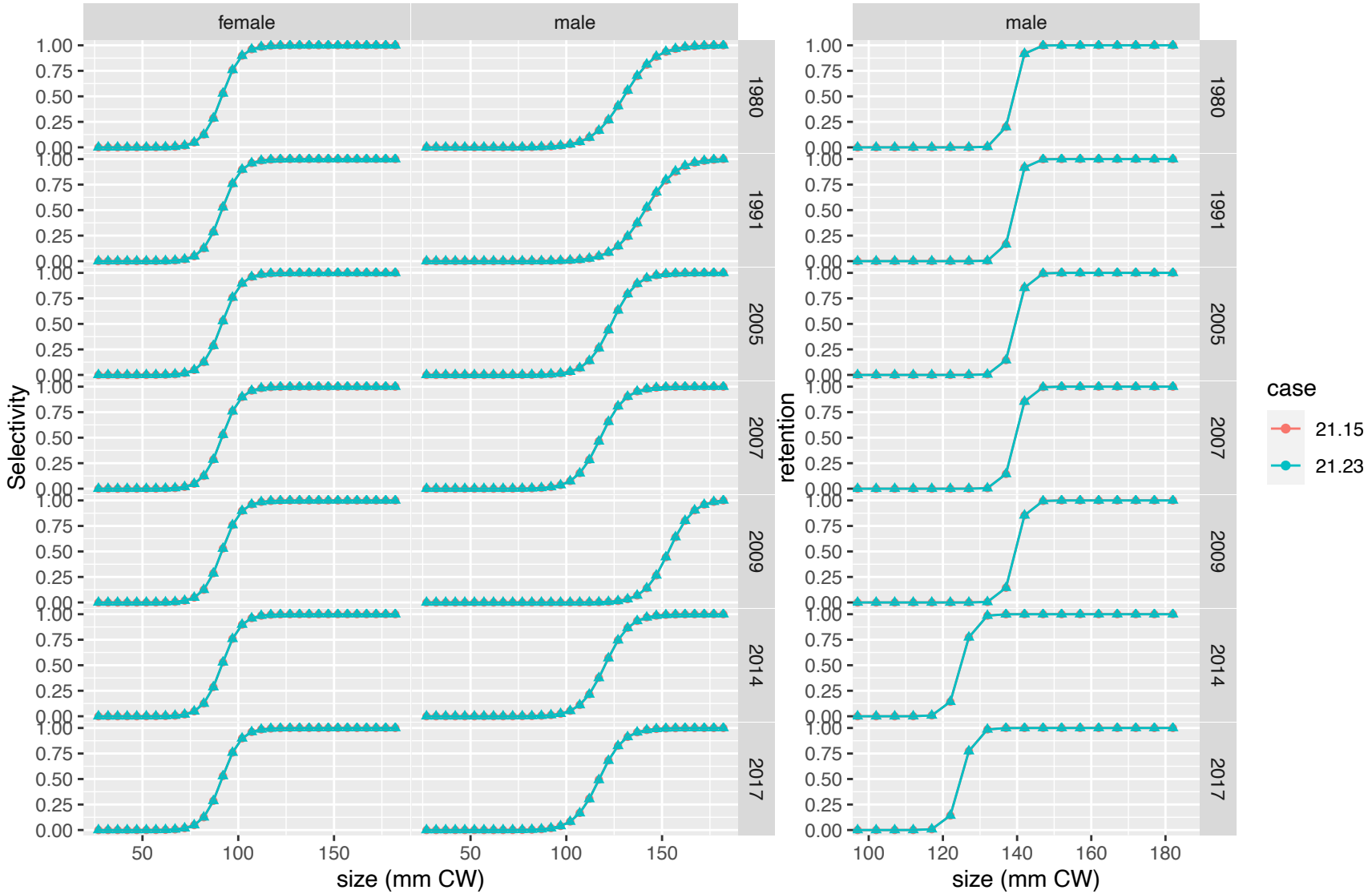

Figure 6. Estimated retention and total catch selectivity in the directed fishery ("TCF").

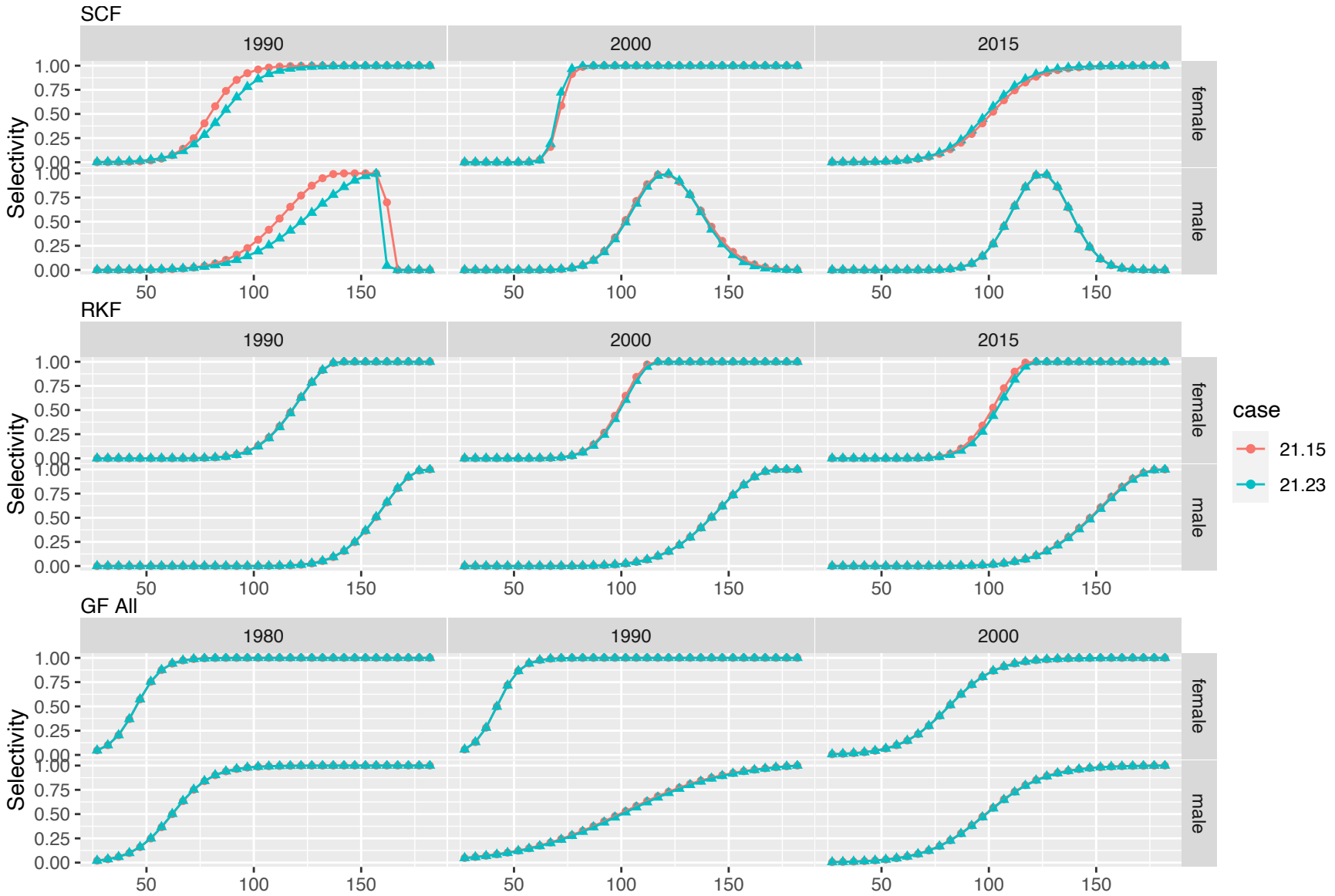

Figure 7. Estimated fishery selectivity in fisheries that take Tanner crab as bycatch: snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

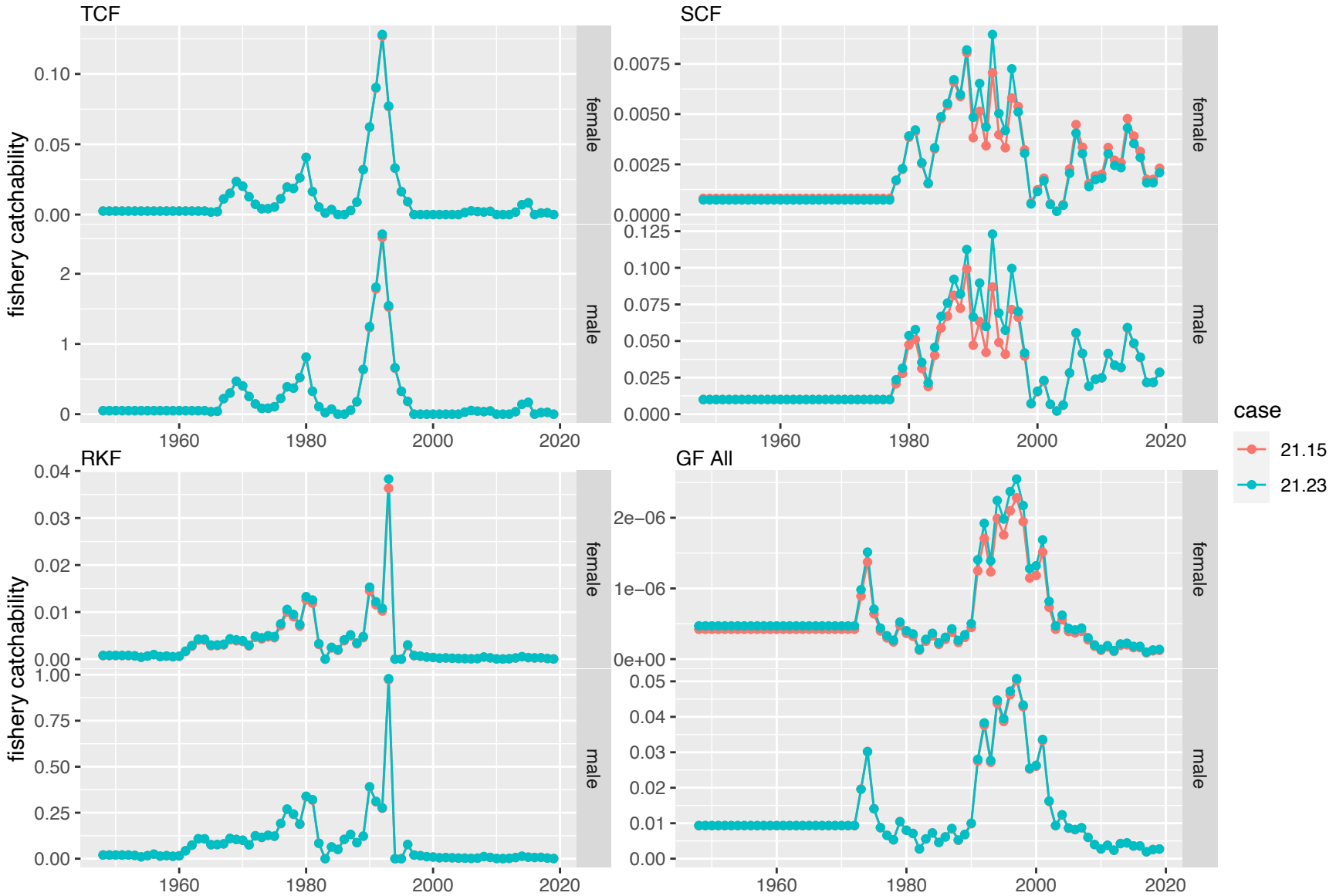

Figure 8. Estimated fishery capture rates in the directed fishery ("TCF") and other fisheries that take Tanner crab as bycatch: snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

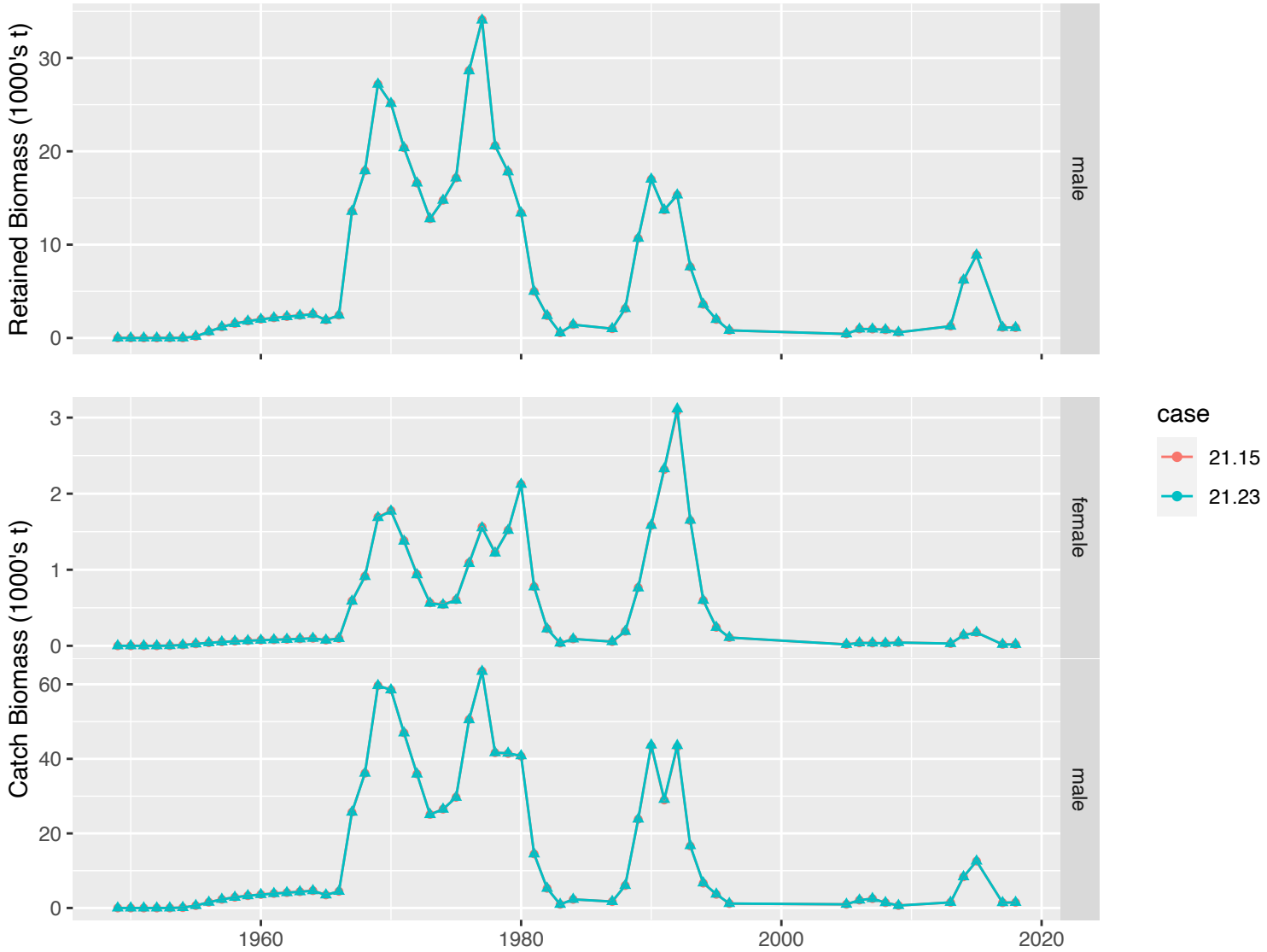

Figure 9. Model-estimated retained catch and total catch biomass in the directed fishery ("TCF").

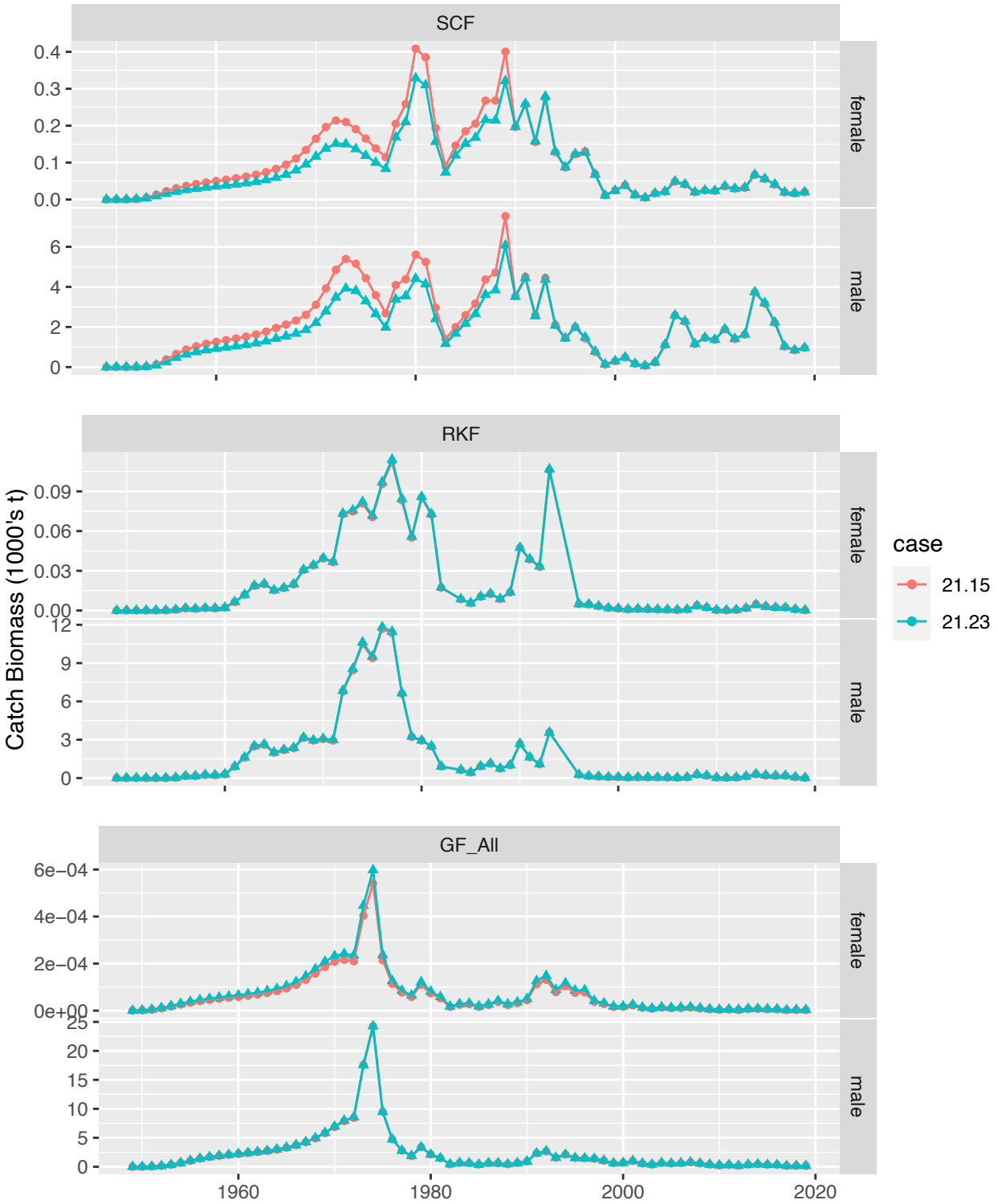

Figure 10. Model-estimated bycatch biomass in fisheries that take Tanner crab as bycatch: snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

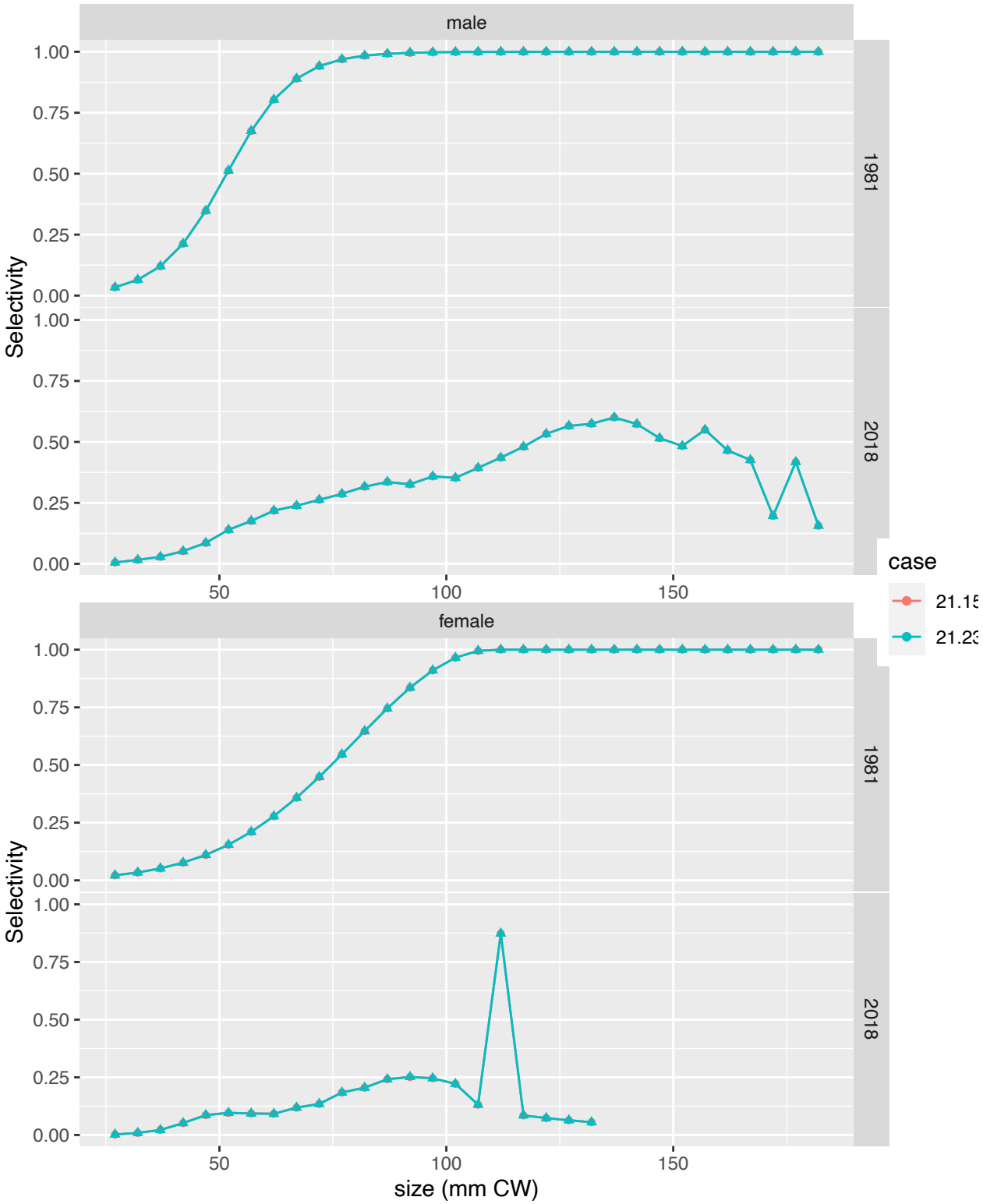

Figure 11. Estimated survey selectivity for the NMFS EBS Shelf Survey.

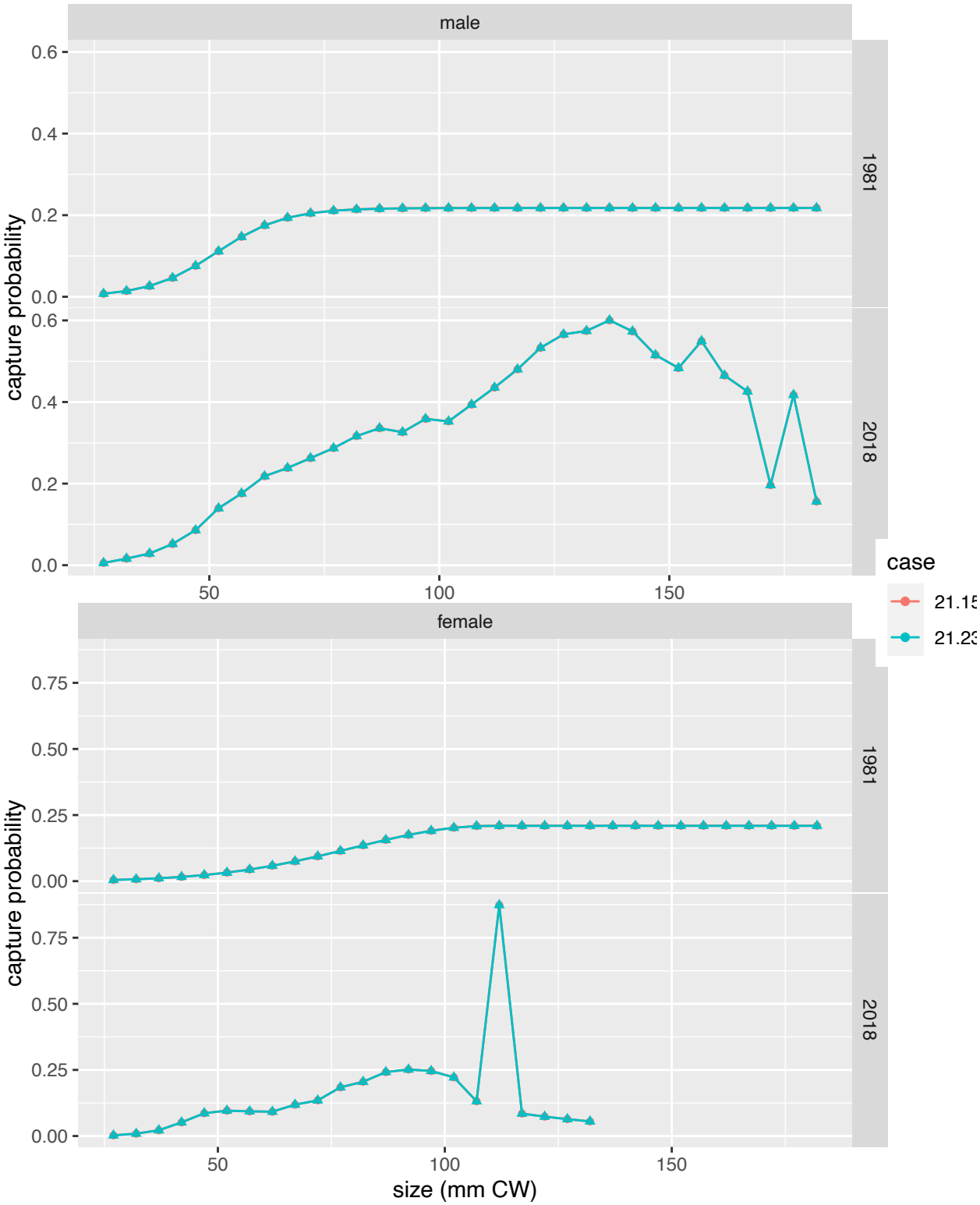

Figure 12. Estimated survey catchability for the NMFS EBS Shelf Survey.

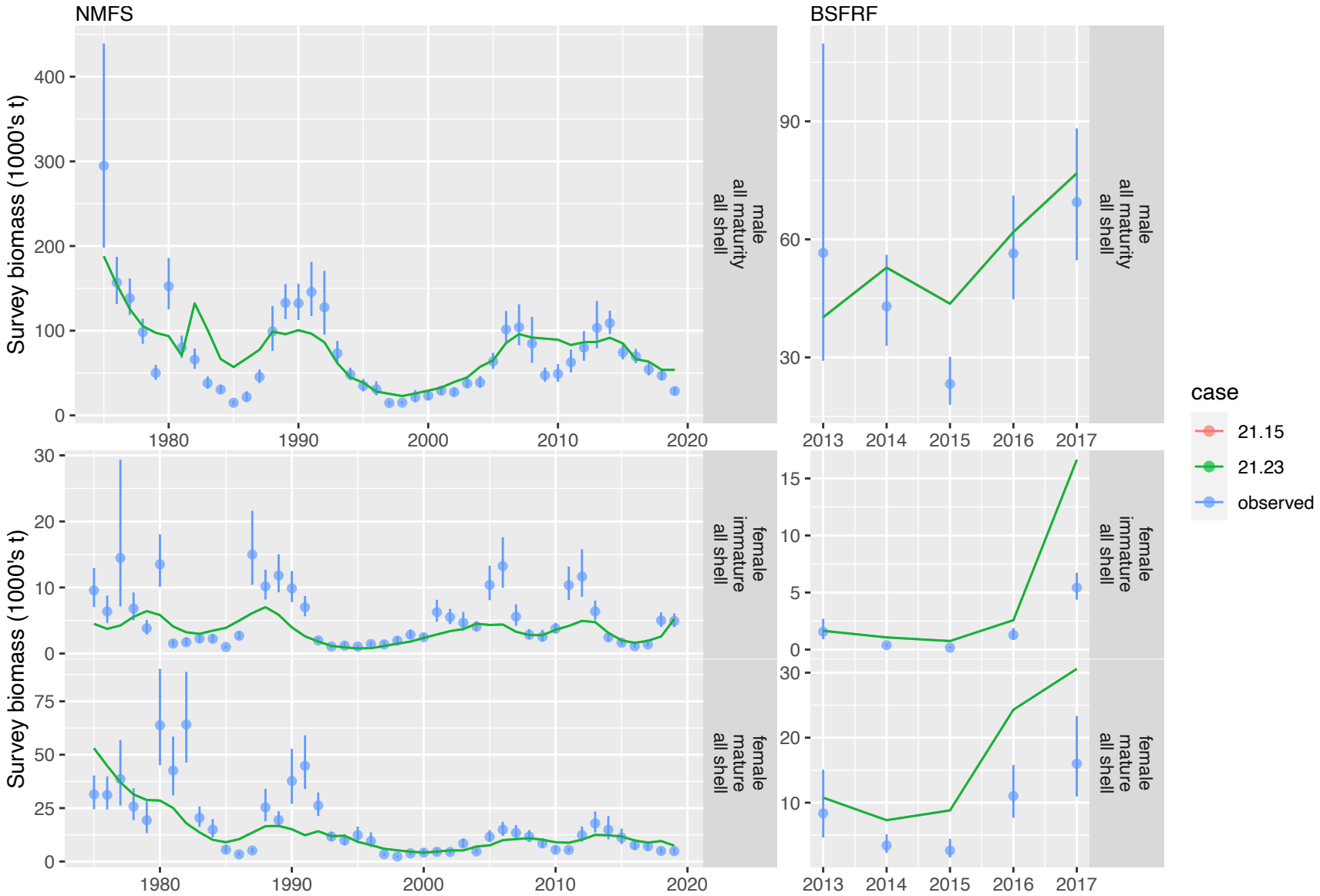

Figure 13. Fits to survey biomass time series from the NMFS EBS Shelf Survey and BSFRF side-by-side surveys.

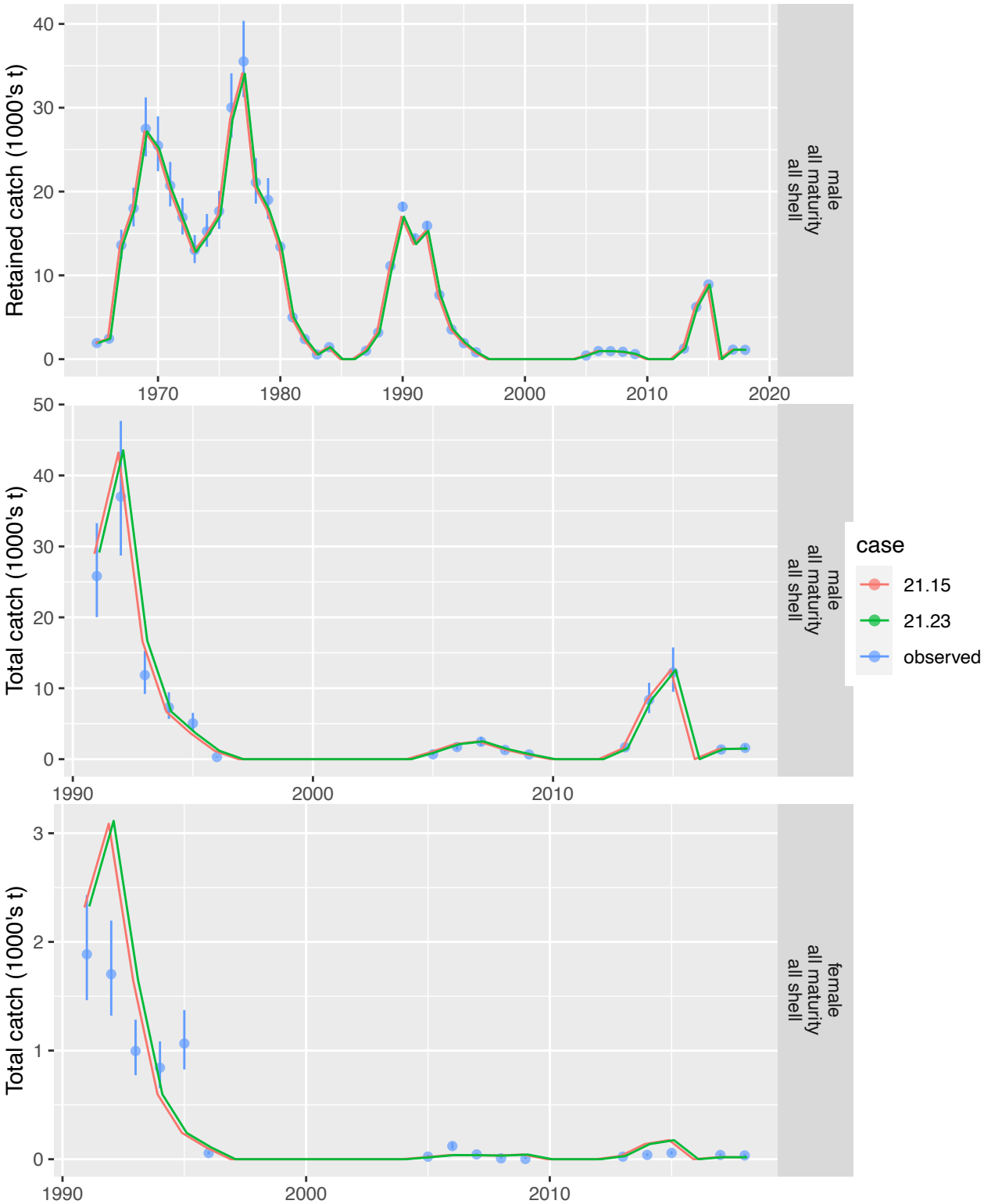

Figure 14. Fits to retained catch and total catch biomass time series in the directed fishery.

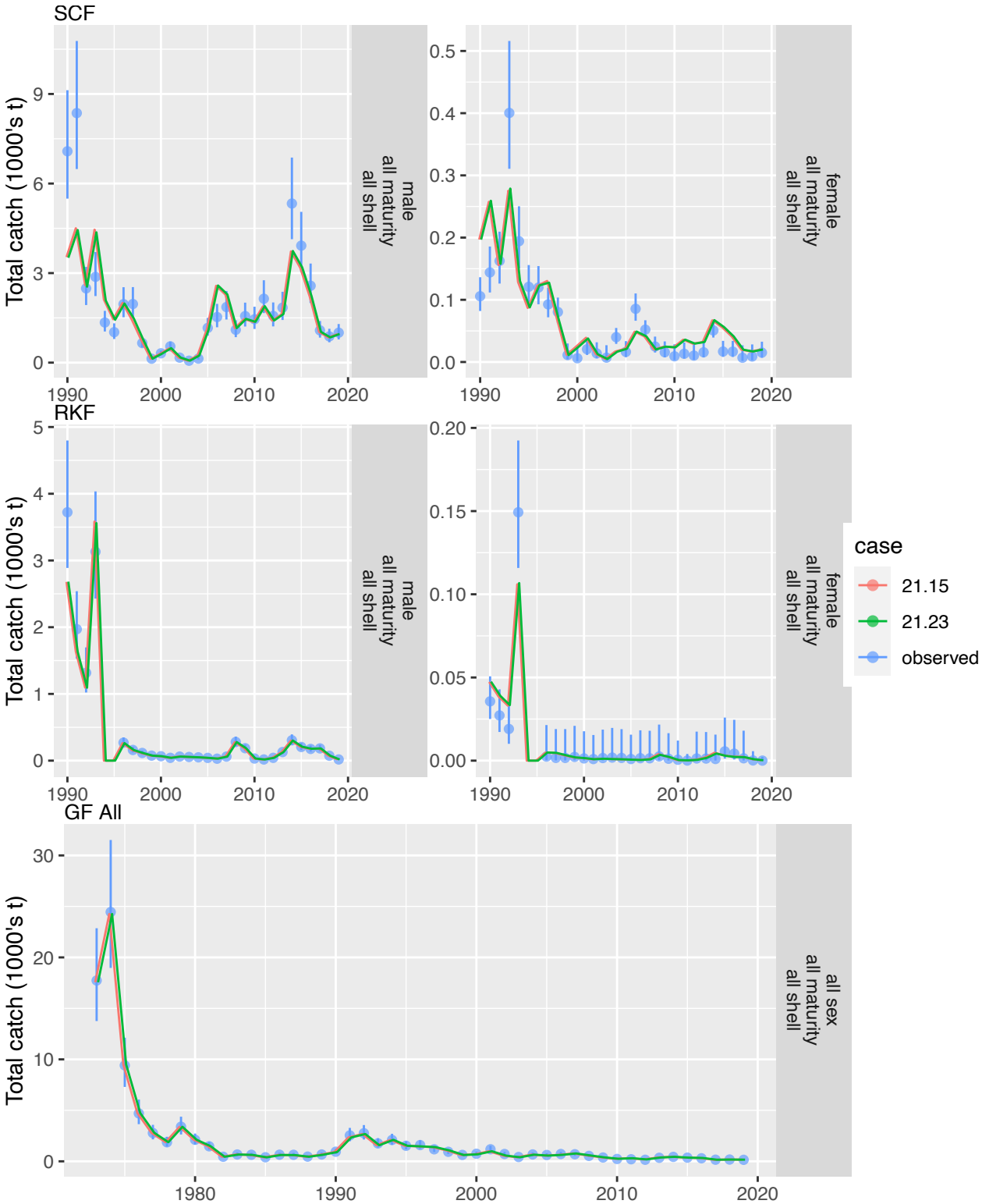

Figure 15. Fits to catch biomass time series for Tanner crab bycatch in the snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

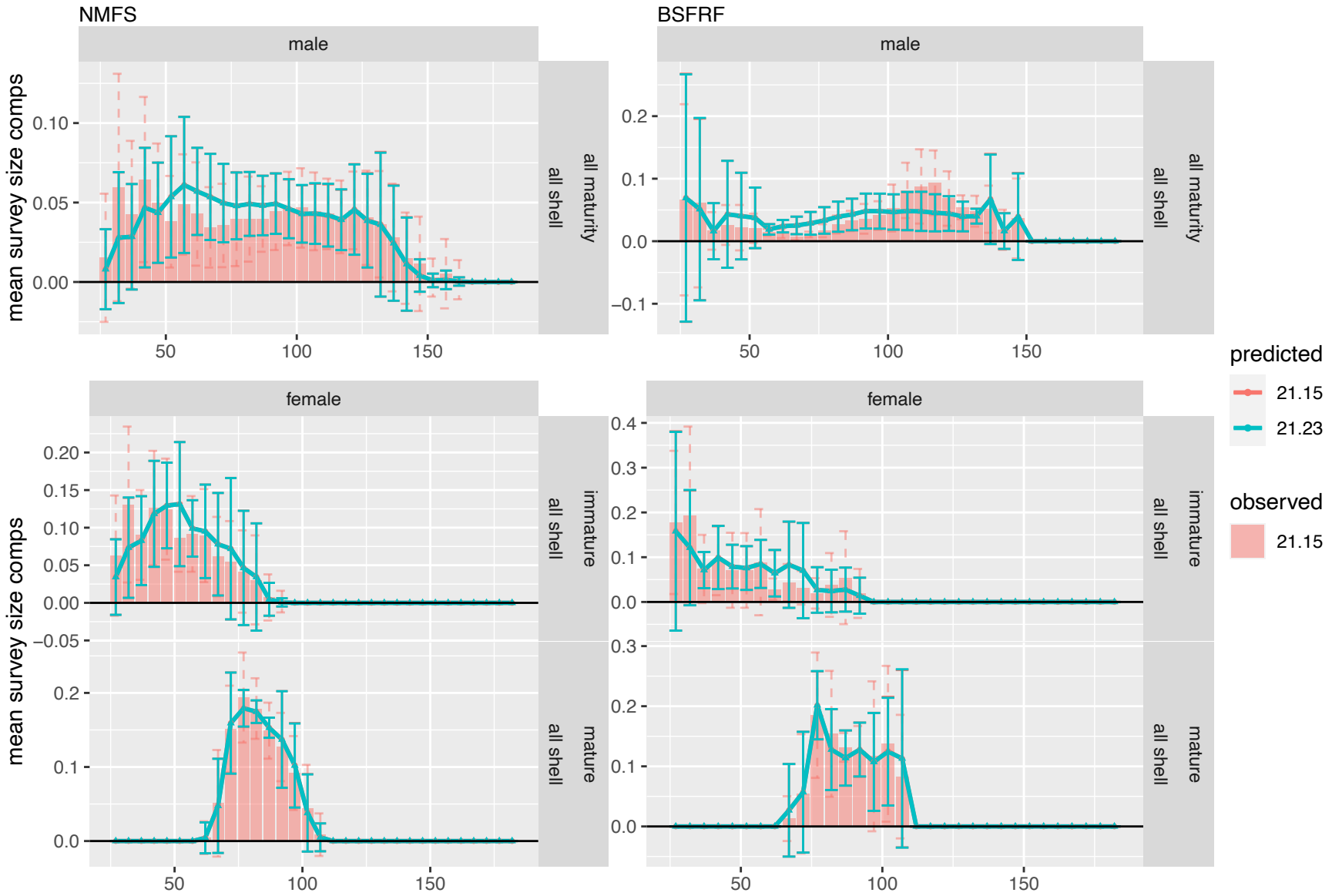

Figure 16. Fits to mean size compositions from the NMFS EBS Shelf Survey and BSFRF side-by-side surveys.

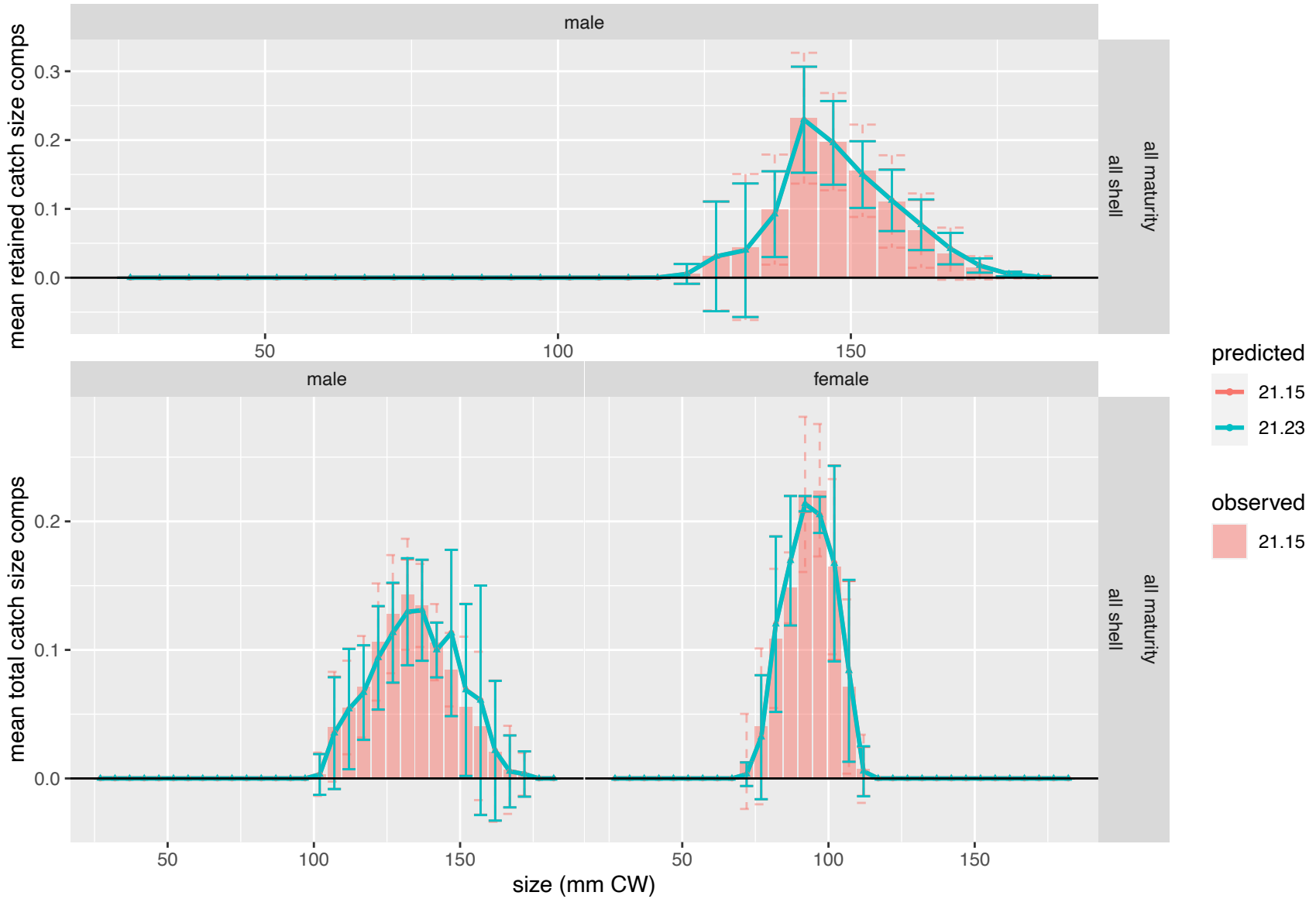

Figure 17. Fits to mean size compositions for retained catch and total catch size compositions in the directed fishery.

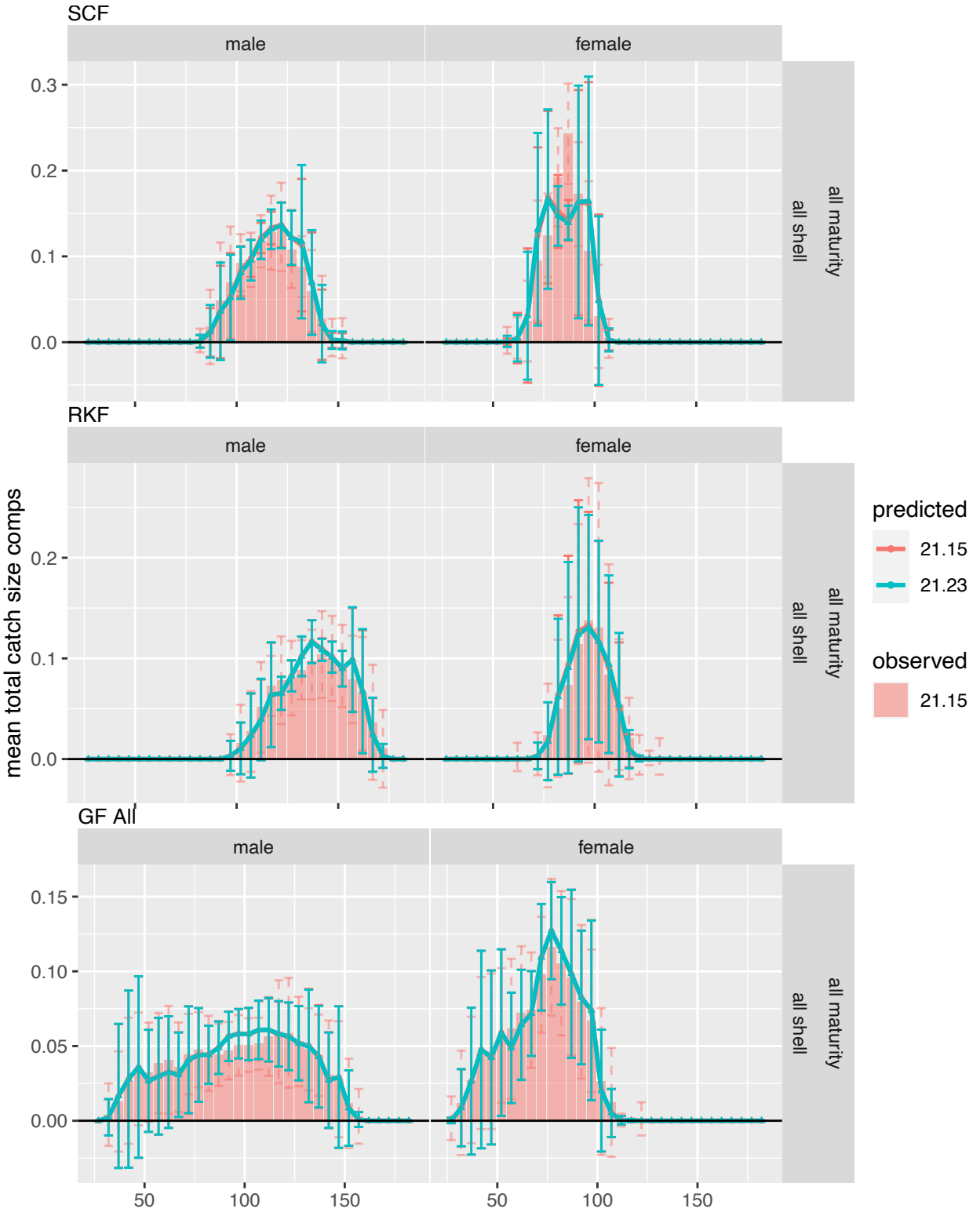

Figure 18. Fits to mean size compositions for Tanner crab bycatch in the snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

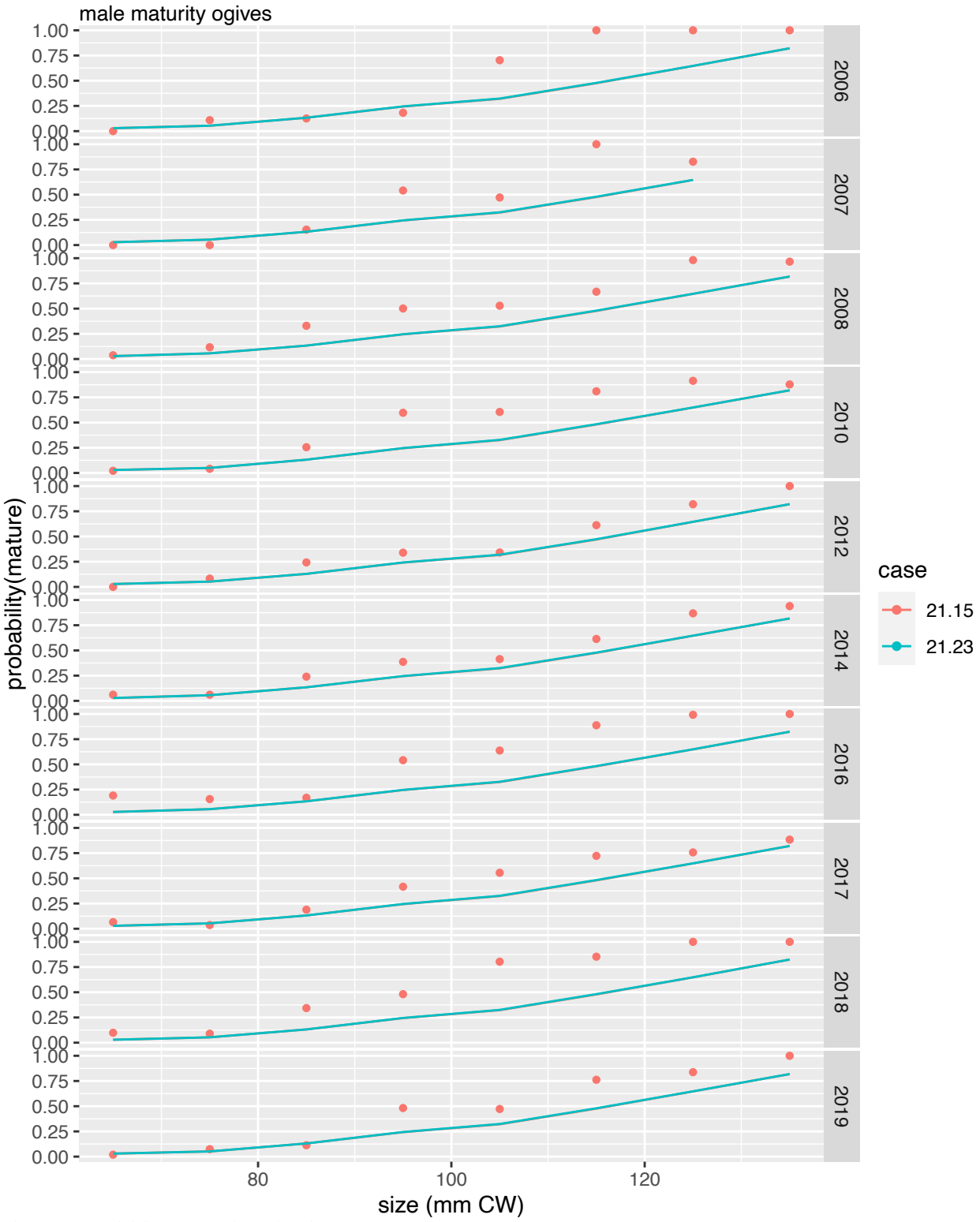

Figure 19. Model fits to maturity ogive data.

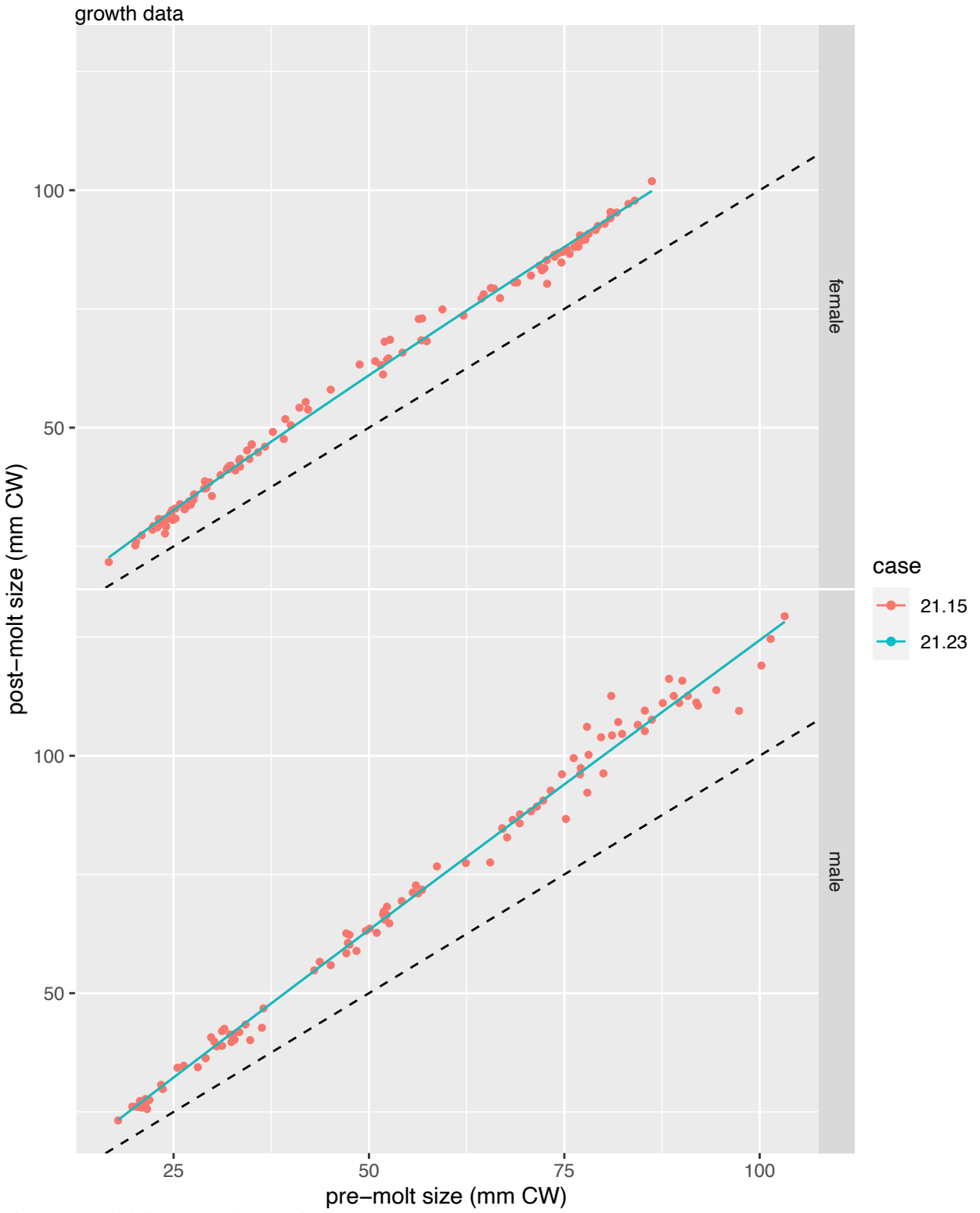

Figure 20. Model fits to maturity growth data.