Tanner Crab Appendix B

William Stockhausen
NOAA/NMFS/AFSC
May 2021

Introduction

Subsequent to submission of the May 2021 Tanner crab report to the Crab Plan Team, additional analyses were completed using Model 21.13 as the base model. Model 21.13 had a number of parameters estimated at a bound. The model presented here, 21.22, builds on 21.13 by expanding the bounds on some of the parameters hitting a bound in 21.13 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 21.22 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 21.13 had 9 parameters, all related to selectivity, estimated at a bound:

Table 1. Parameters at a bound in Model 21.13.

name	value	test	description
pS1[4]	130	at upper bound	size at 1 for NMFS survey selectivity (females, 1982+)
pS1[10]	140	at upper bound	ascending z-at-1 for SCF selectivity (males, pre-1997)
pS1[20]	40	at lower bound	z50 for GF.AllGear selectivity (females, 1987-1996)
pS1[22]	180	at upper bound	size at 1 for RKF selectivity (males, pre-1997)
pS1[23]	179.998	at upper bound	size at 1 for RKF selectivity (males, 1997-2004)
pS1[24]	180	at upper bound	size at 1 for RKF selectivity (males, 2005+)
pS1[25]	139.999	at upper bound	size at 1 for RKF selectivity (females, pre-1997)
pS3[2]	0.000	at lower bound	scaled increment for descending z-at-1 for SCF selectivity (males, 1997-2004)
pS3[3]	0.000	at lower bound	scaled increment for descending z-at-1 for SCF selectivity (males, 2005+)

In order to deal with these problematic parameters, the following steps were undertaken:

1. pS1[4]: fixed at 129.9
2. pS1[10]: upper bound increased from 140 to 180 mm CW
3. pS1[20]: lower bound decreased from 40 to 25 mm CW
4. pS1[22], pS1[23], and pS1[24] were all fixed at 179.9
5. no changes were made to pS1[25], pS3[2], pS3[3]

The results from this first round of iteration were that:

1. pS3[2] was again estimated at its lower bound
2. pS3[3] was again estimated at its lower bound
3. pLnDirMul[9], the Dirichlet-multinomial scaling parameter for female bycatch size compositions in the snow crab fishery, was estimated at its upper bound
4. pLnDirMul[13], the Dirichlet-multinomial scaling parameter for bycatch size compositions in the groundfish fisheries, was estimated at its upper bound

For the next (and final) iteration, the two remaining (and two new) problematic parameters were all fixed to values near the indicated bound. Setting pS3[2] and pS3[3] to their lower bounds was equivalent to using double normal functions with no plateau at 1, while setting the Dirichlet-multinomial parameters to

their upper bounds was equivalent to reverting to multinomial likelihoods for the associated size compositions (but with different constants), with no adjustment of input sample sizes.

No parameters were estimated at bounds in the second iteration; this model was taken as Model 21.22. To summarize, Model 21.22 differs from 21.13 in the following:

1. pS1[4]: fixed at 129.9
2. pS1[10]: upper bound increased from 140 to 180 mm CW
3. pS1[20]: lower bound decreased from 40 to 25 mm CW
4. pS1[22], pS1[23], and pS1[24] were all fixed at 179.9
5. pS3[2] and pS3[3] were fixed at 0.001
6. pLnDirMul[9] and pLnDirMul[13] were each fixed at 10 (on the ln-scale)

Results: comparison with Model 21.13

On the whole, the differences between the two models were very small (Table 2, Figures 1-20). The overall likelihood for 21.22 was larger than that for 21.13 by 63 likelihood units. The largest

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 21.22 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
21.13	6089.74	0.06988745	359.13	107.91	37.77	74.12	0.95	16.85	0.95	23.80	39.15
21.22	6153.67	0	349.48	107.76	37.72	74.91	0.94	16.75	0.94	24.01	39.67

contributor to this was the difference in likelihood value for the fit to bycatch size compositions in the groundfish fisheries (~18 likelihood units), while combined likelihoods for fits to survey size compositions and survey biomass made up the remainder. However, 21.22 has no estimated parameters at a bound and the maximum gradient at the converged solution is truly zero.

Figure captions

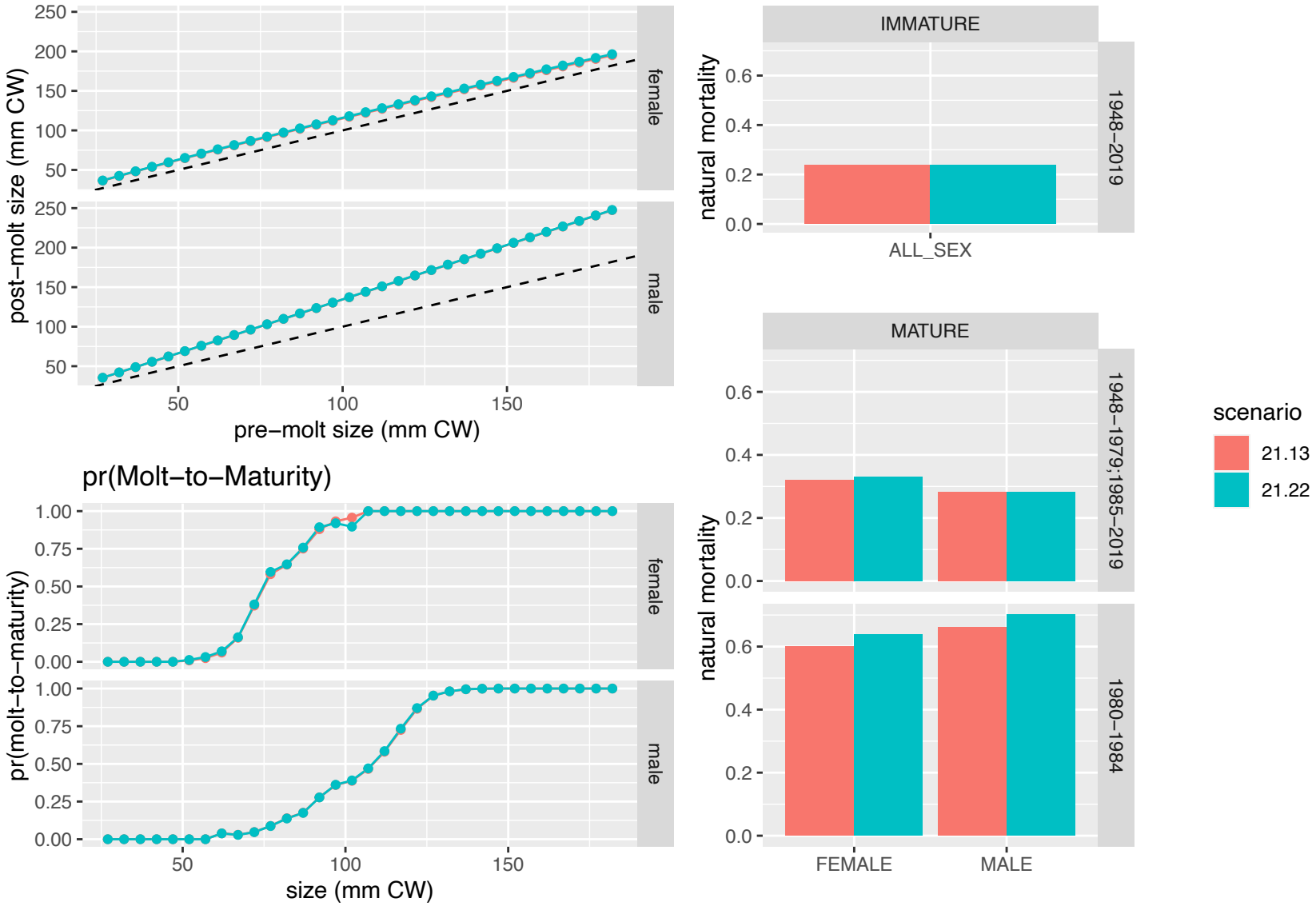

Figure 1. Estimated population processes.

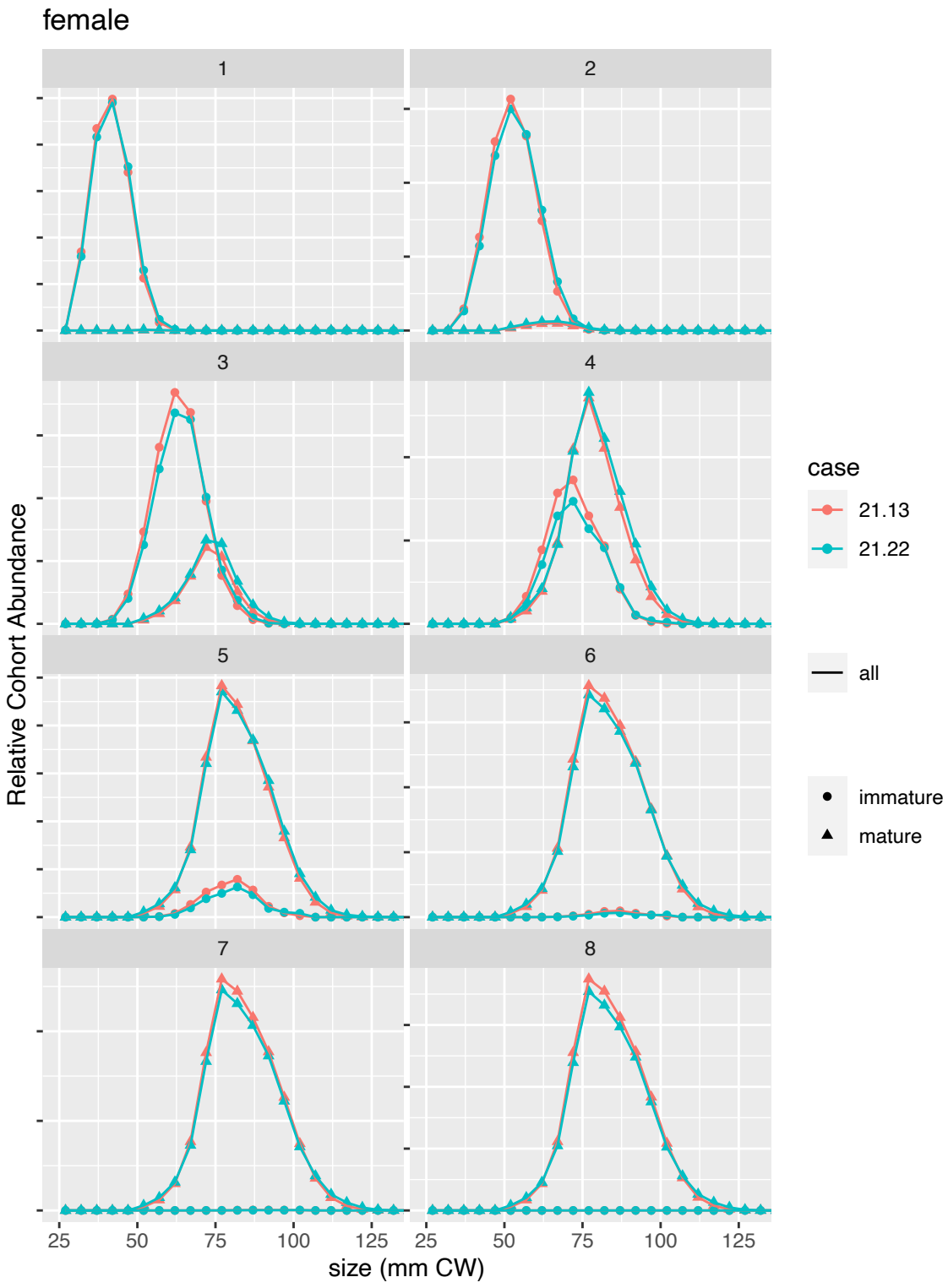

Figure 2. Estimated size progression of a cohort of female crab through time (years).

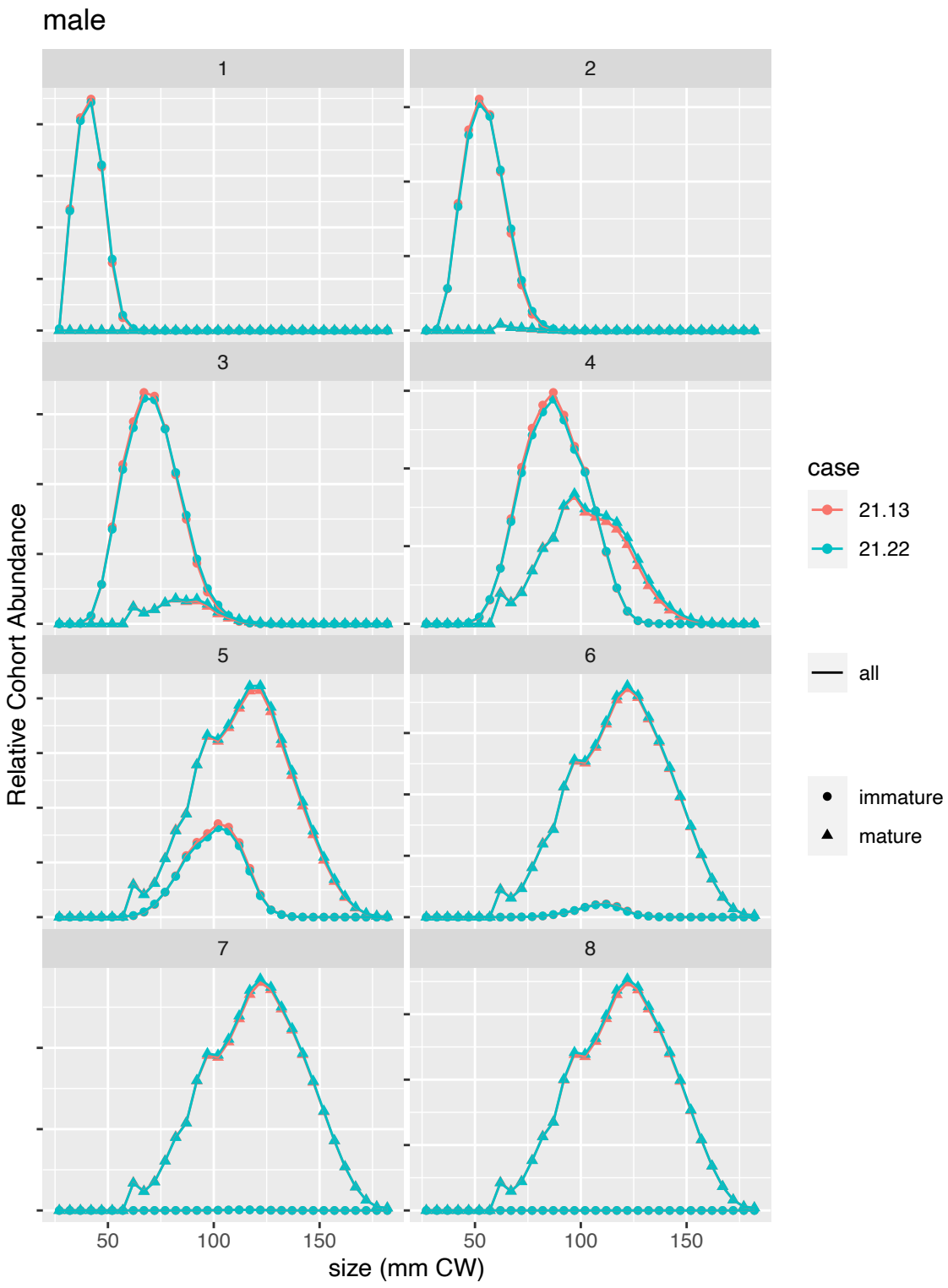

Figure 3. Estimated size progression of a cohort of male crab through time (years).

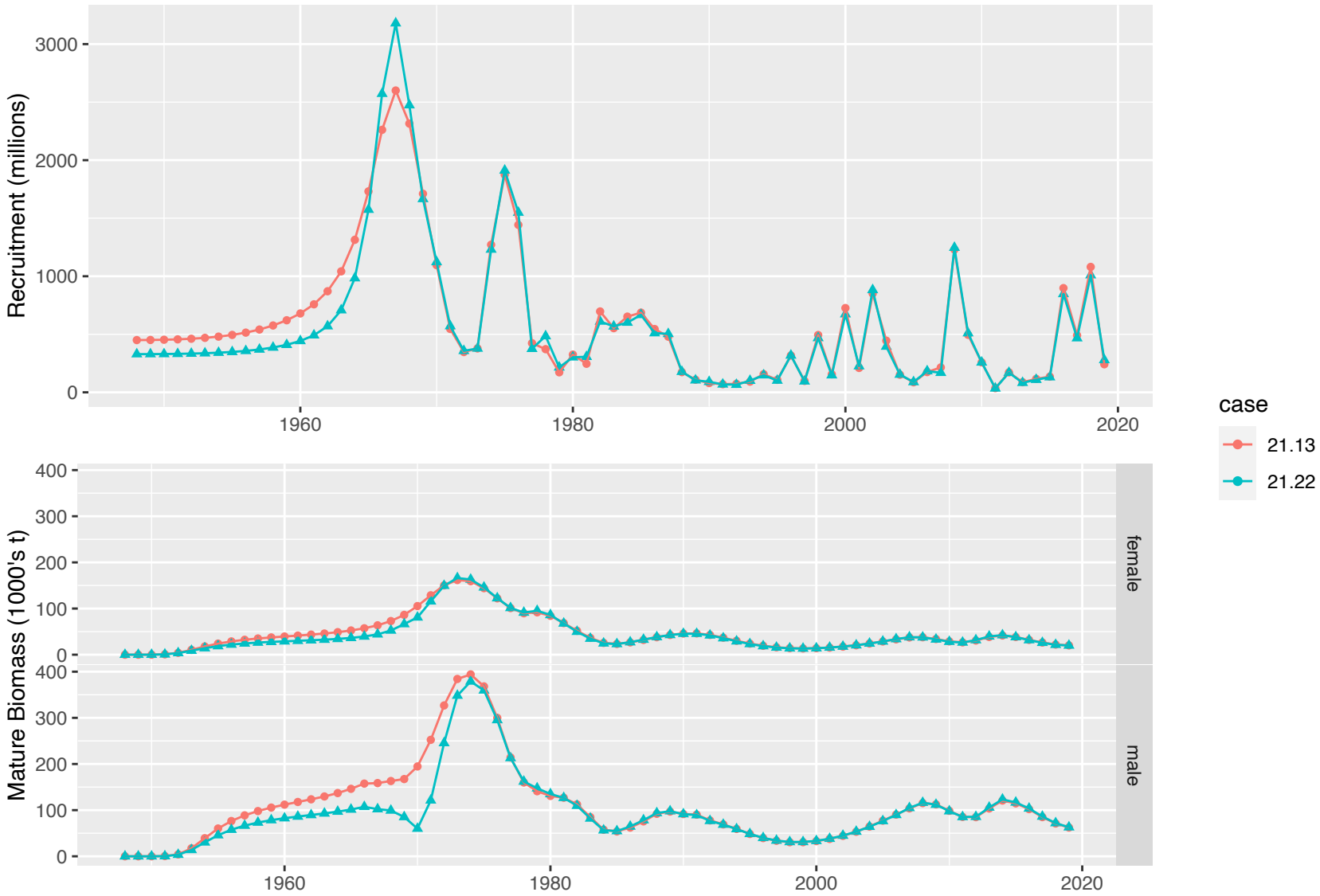

Figure 4. Estimated time series of recruitment and mature biomass.

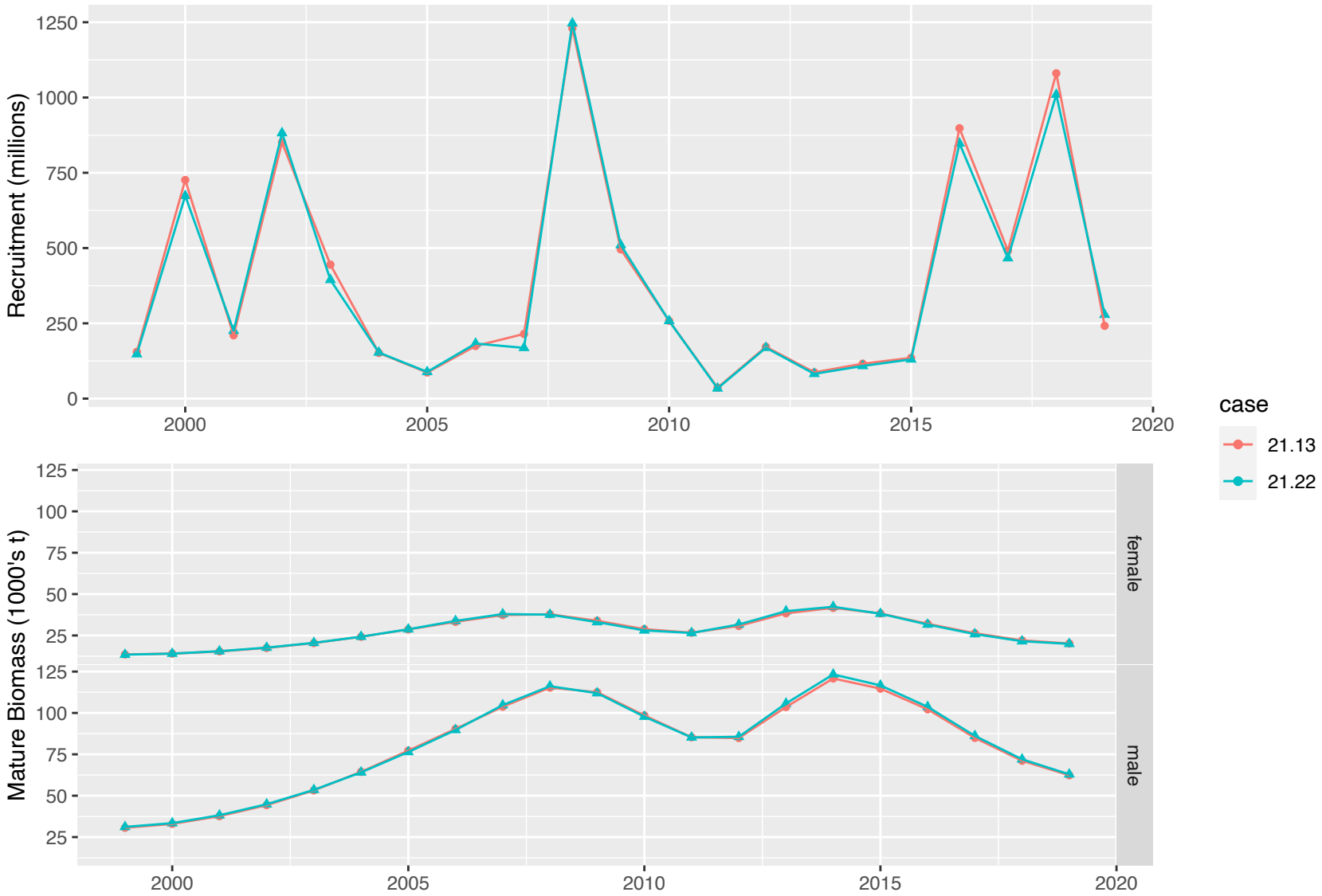

Figure 4a. Estimated time series of recruitment and mature biomass.

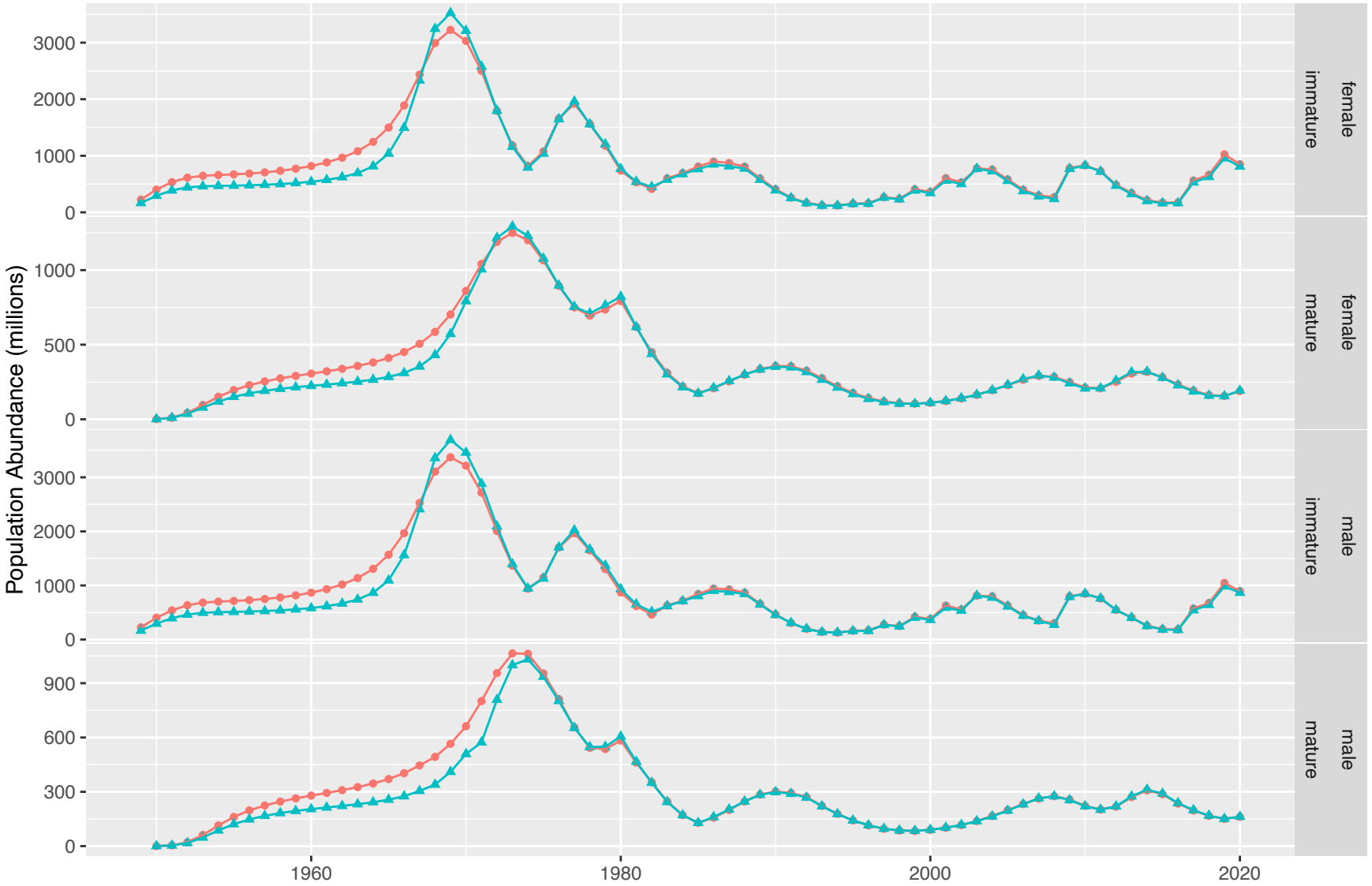

Figure 5. Estimated time series of population abundance.

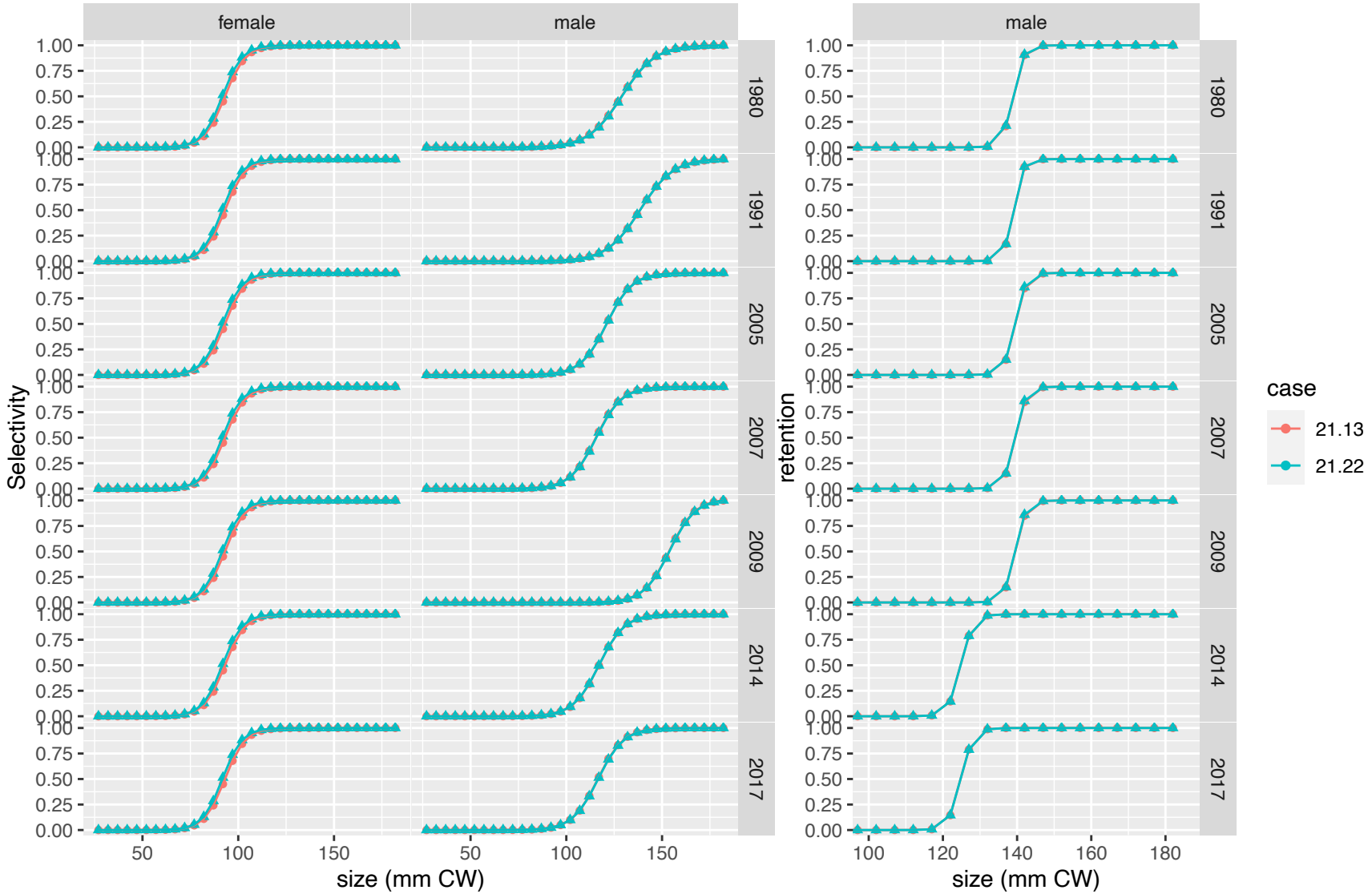

Figure 6. Estimated retention and total catch selectivity in the directed fishery ("TCF").

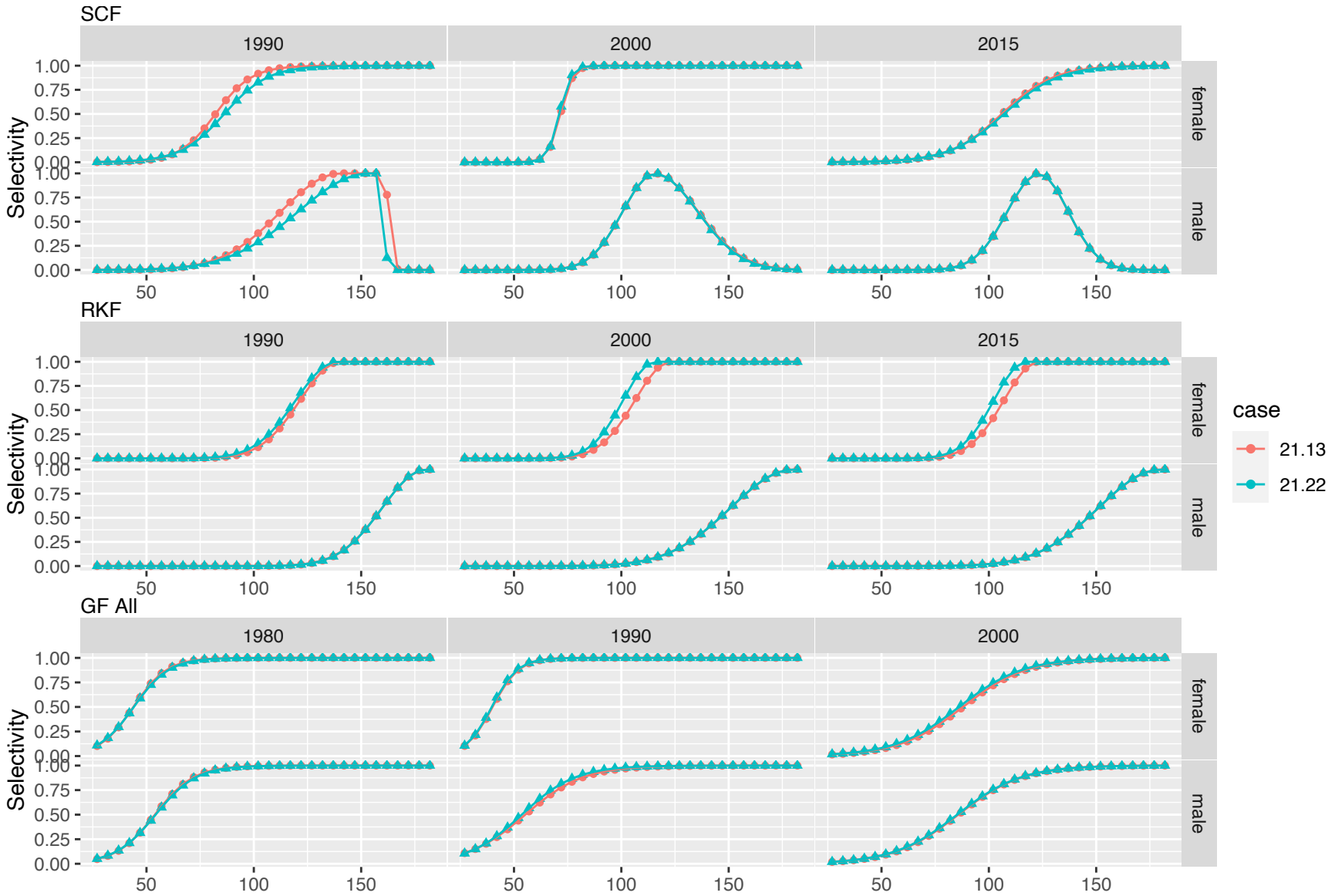

Figure 7. Estimated fishery selectivity in fisheries that take Tanner crab as bycatch: snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

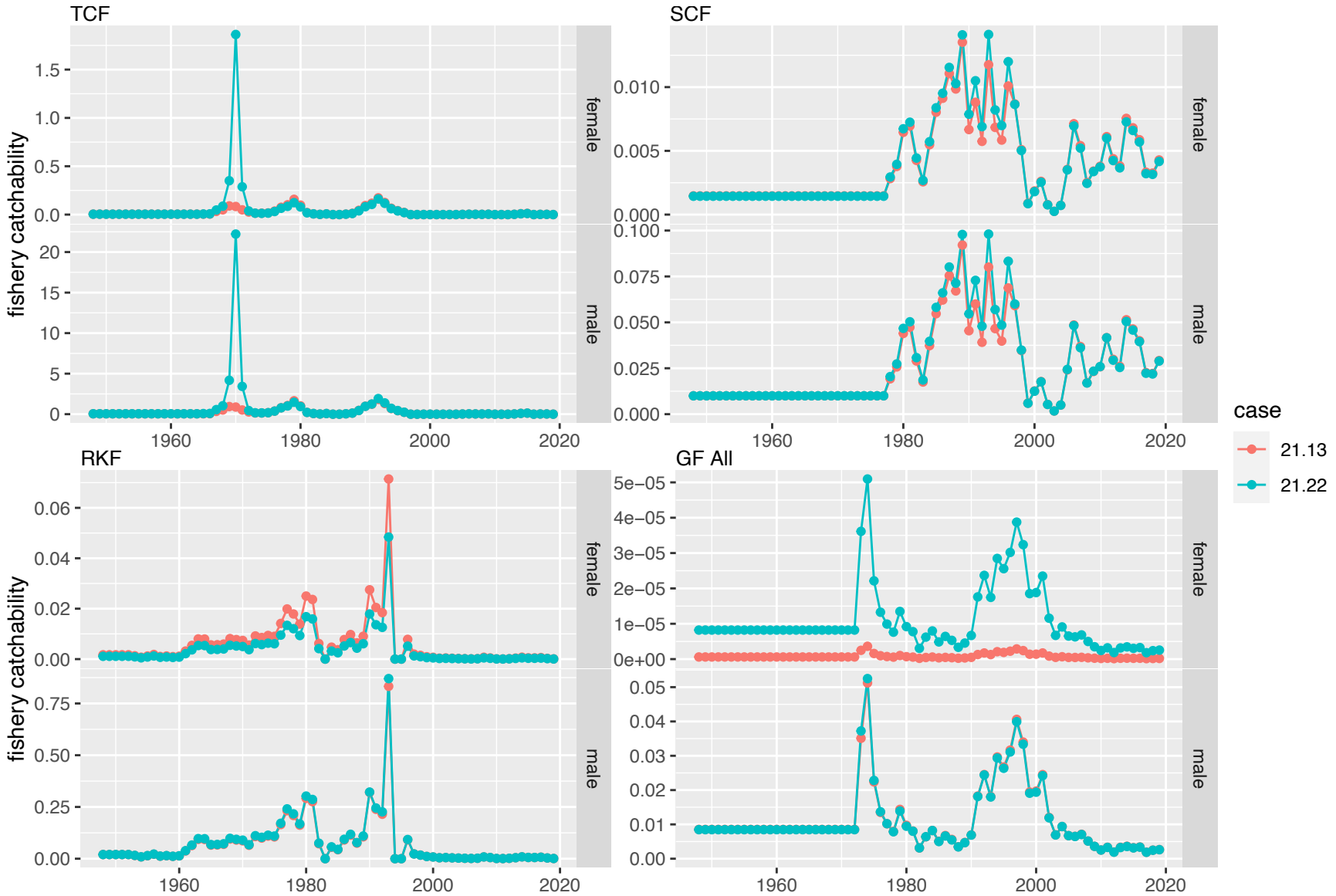

Figure 8. Estimated fishery capture rates in the directed fishery ("TCF") and other fisheries that take Tanner crab as bycatch: snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

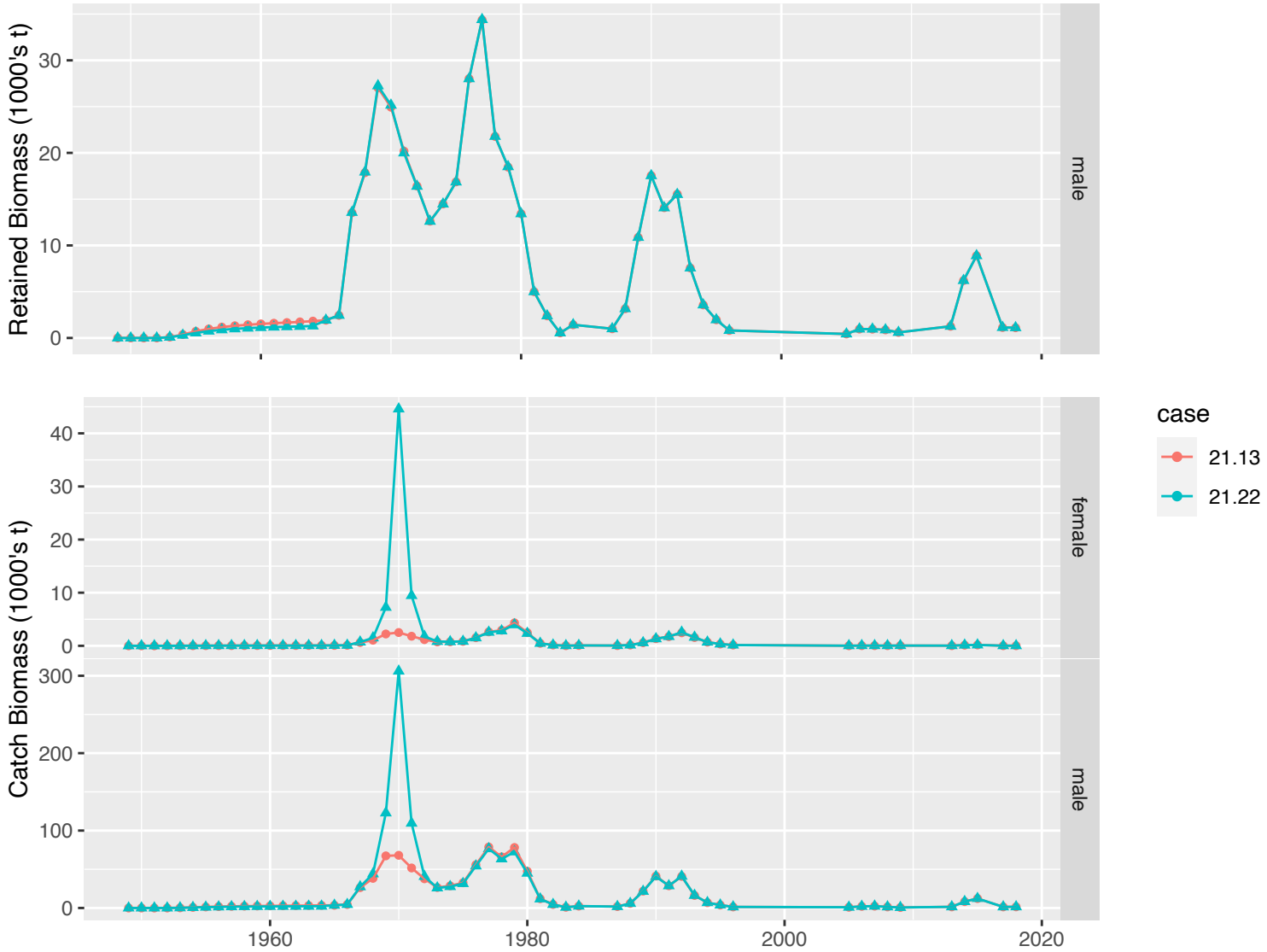

Figure 9. Model-estimated retained catch and total catch biomass in the directed fishery ("TCF").

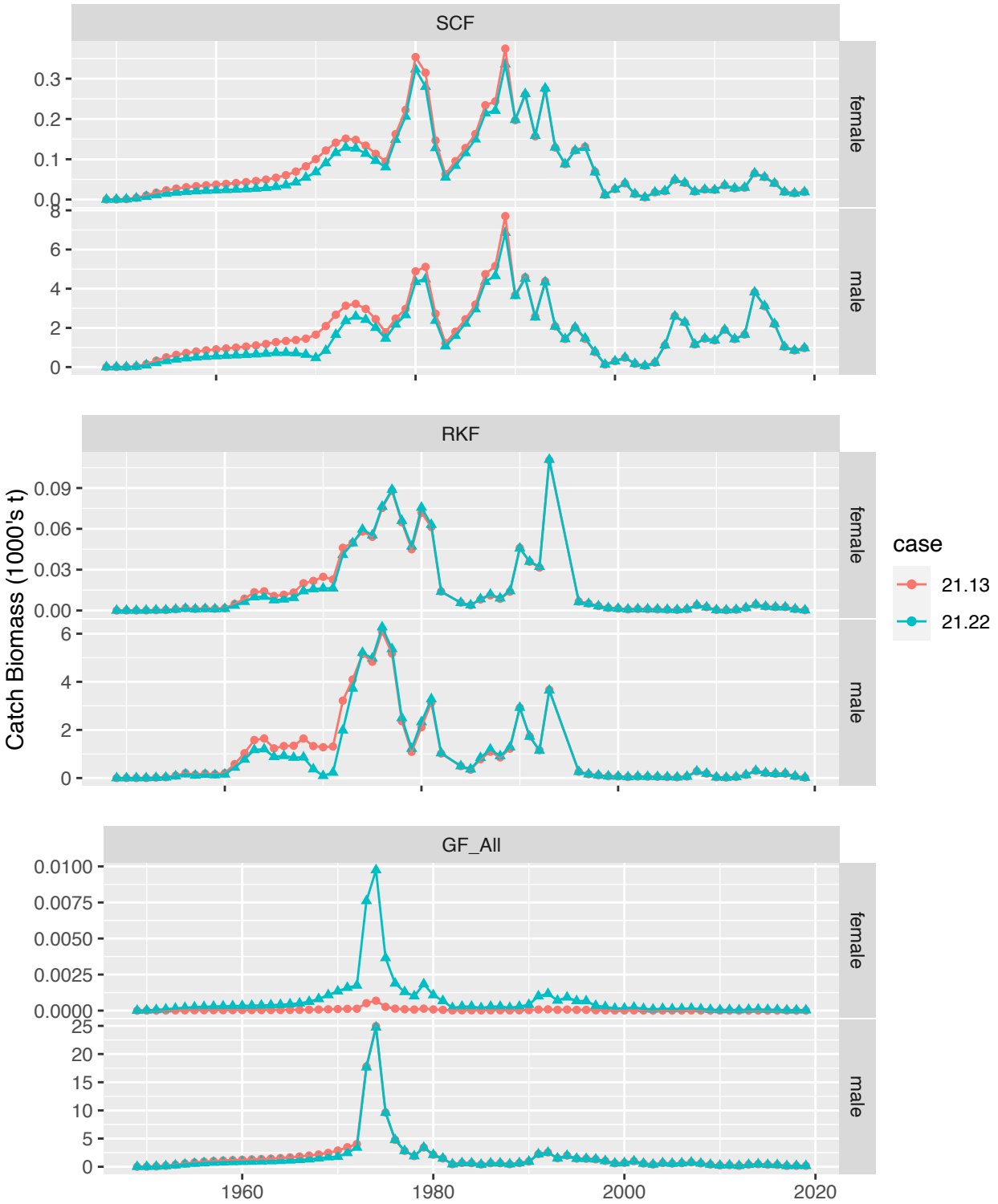

Figure 10. Model-estimated bycatch biomass in fisheries that take Tanner crab as bycatch: snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

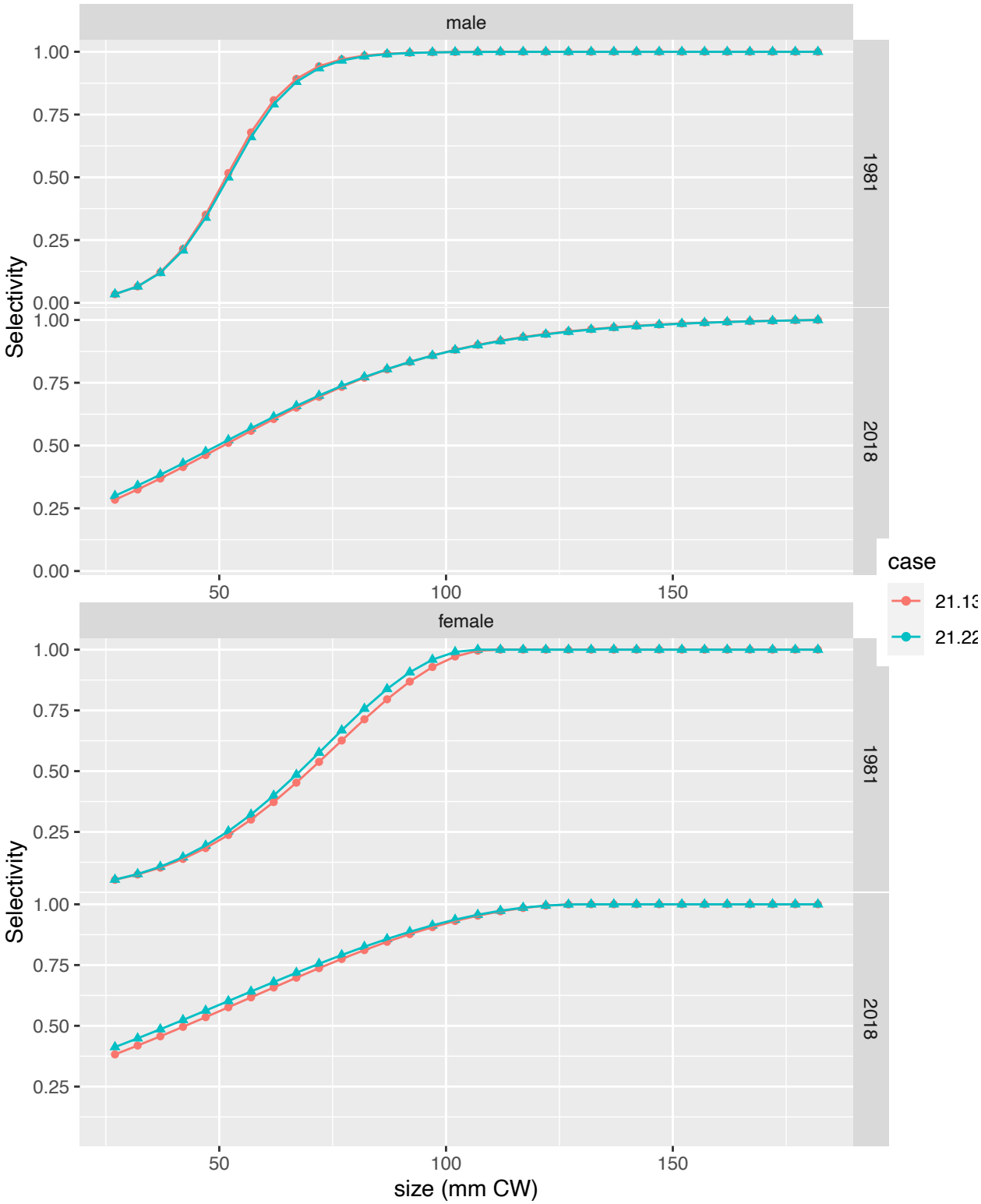

Figure 11. Estimated survey selectivity for the NMFS EBS Shelf Survey.

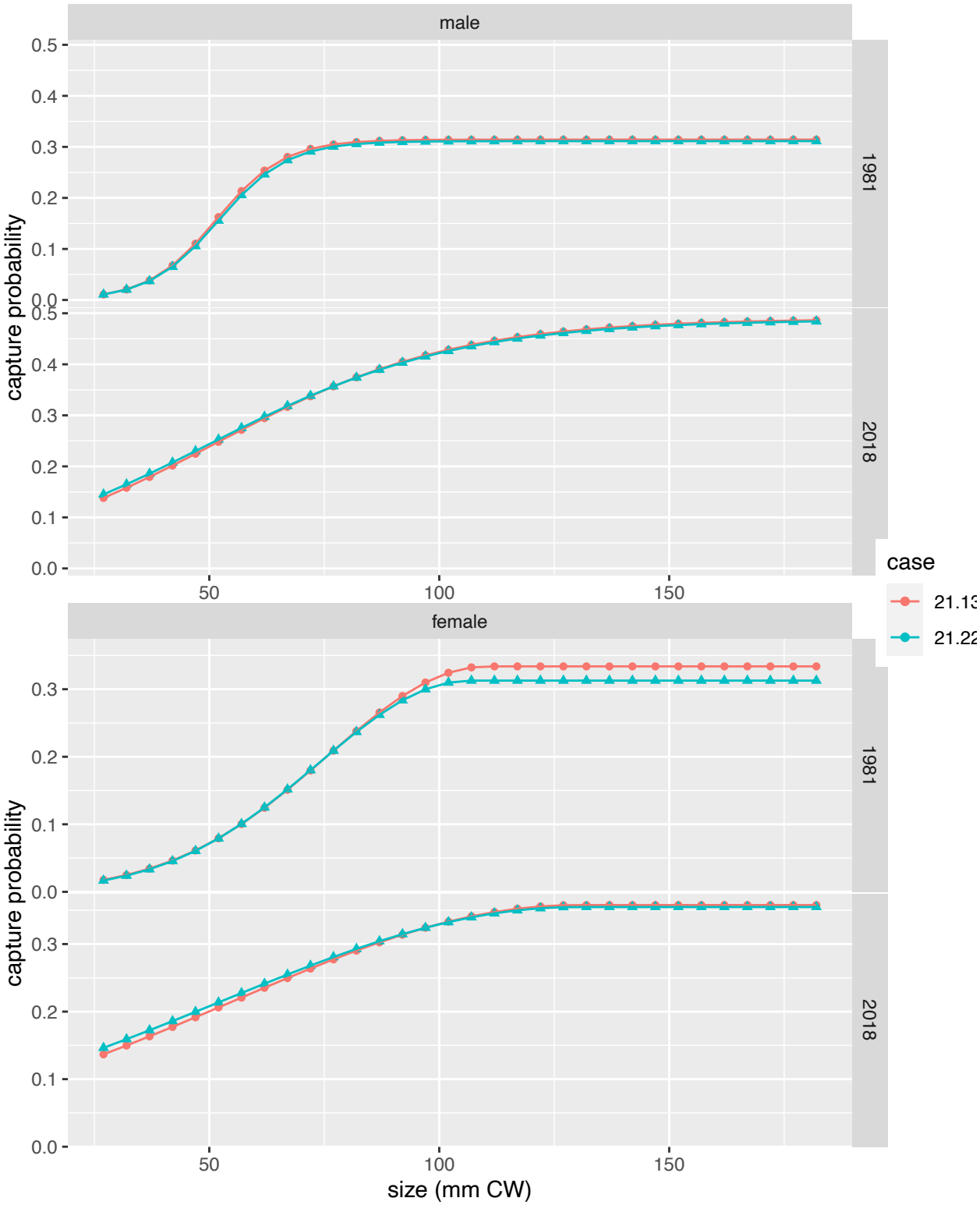

Figure 12. Estimated survey catchability for the NMFS EBS Shelf Survey.

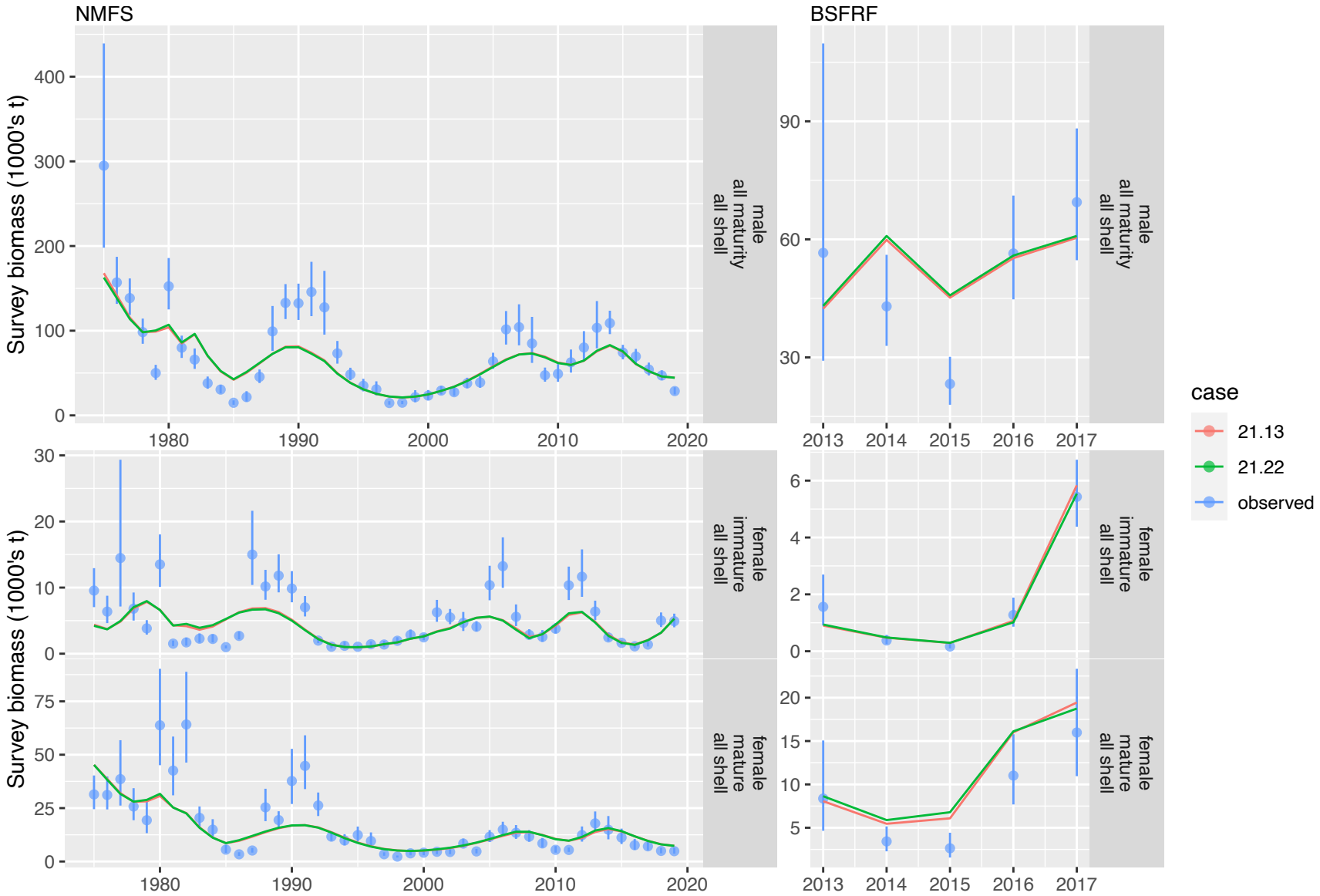

Figure 13. Fits to survey biomass time series from the NMFS EBS Shelf Survey and BSFRF side-by-side surveys.

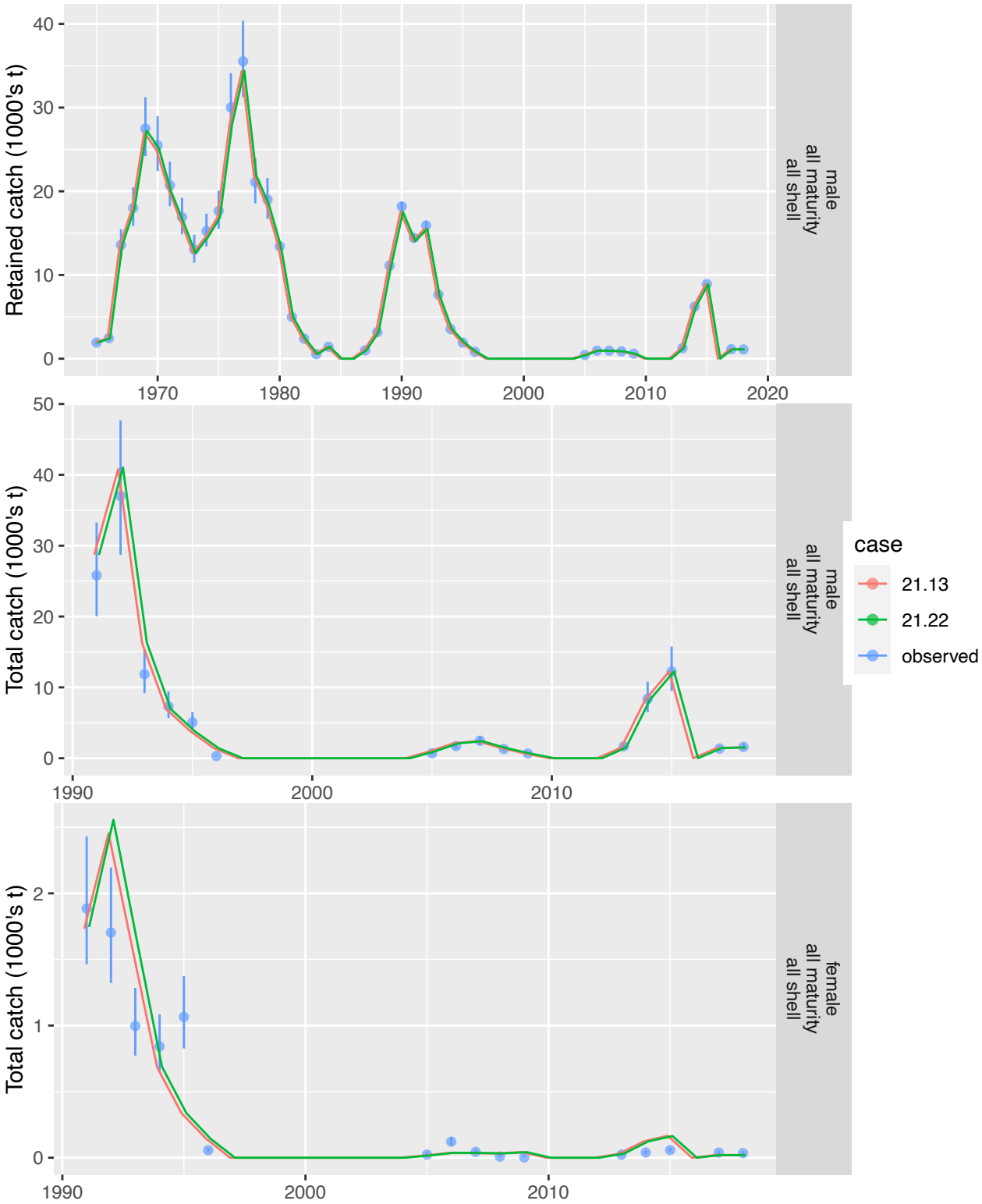

Figure 14. Fits to retained catch and total catch biomass time series in the directed fishery.

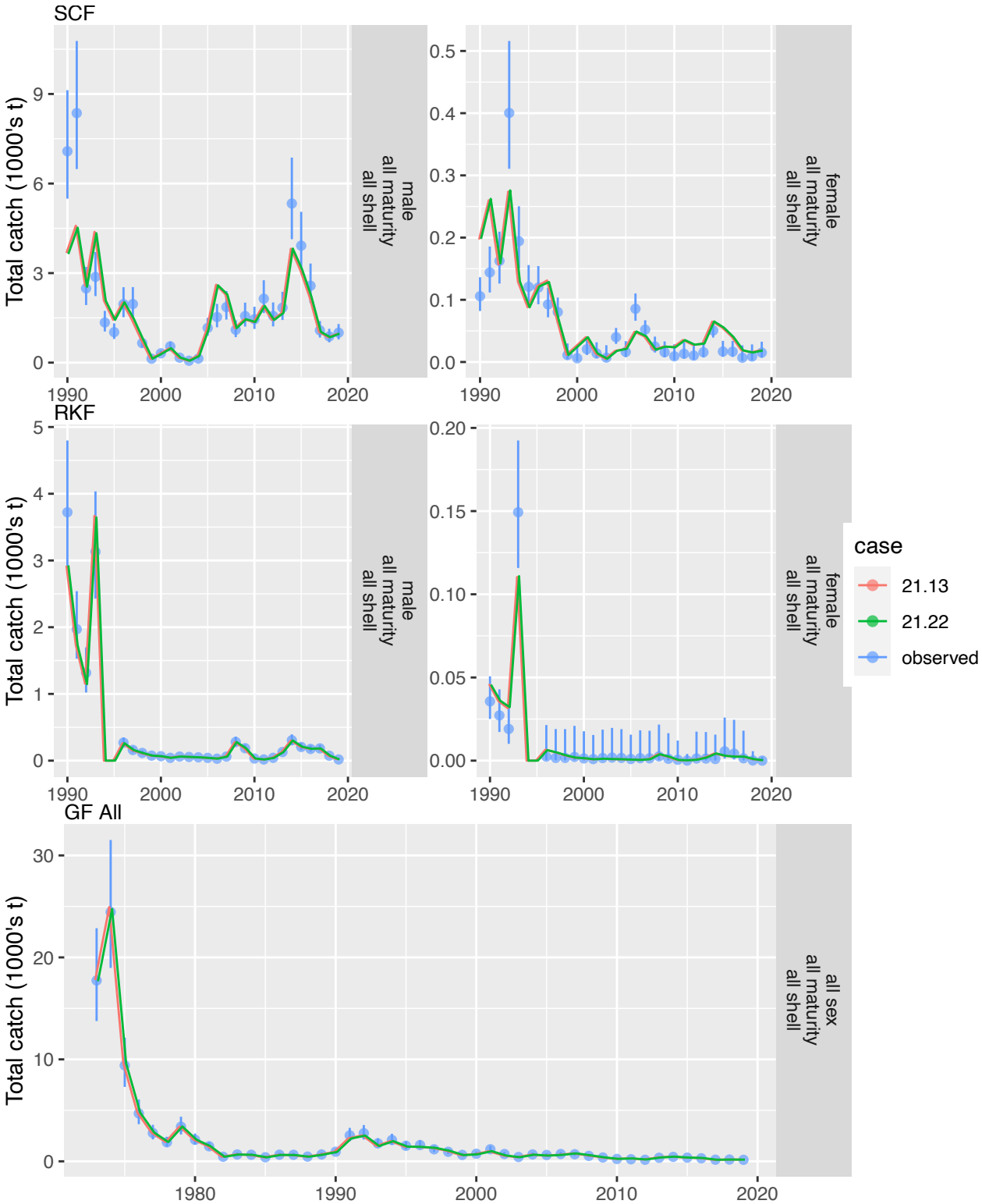

Figure 15. Fits to catch biomass time series for Tanner crab bycatch in the snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

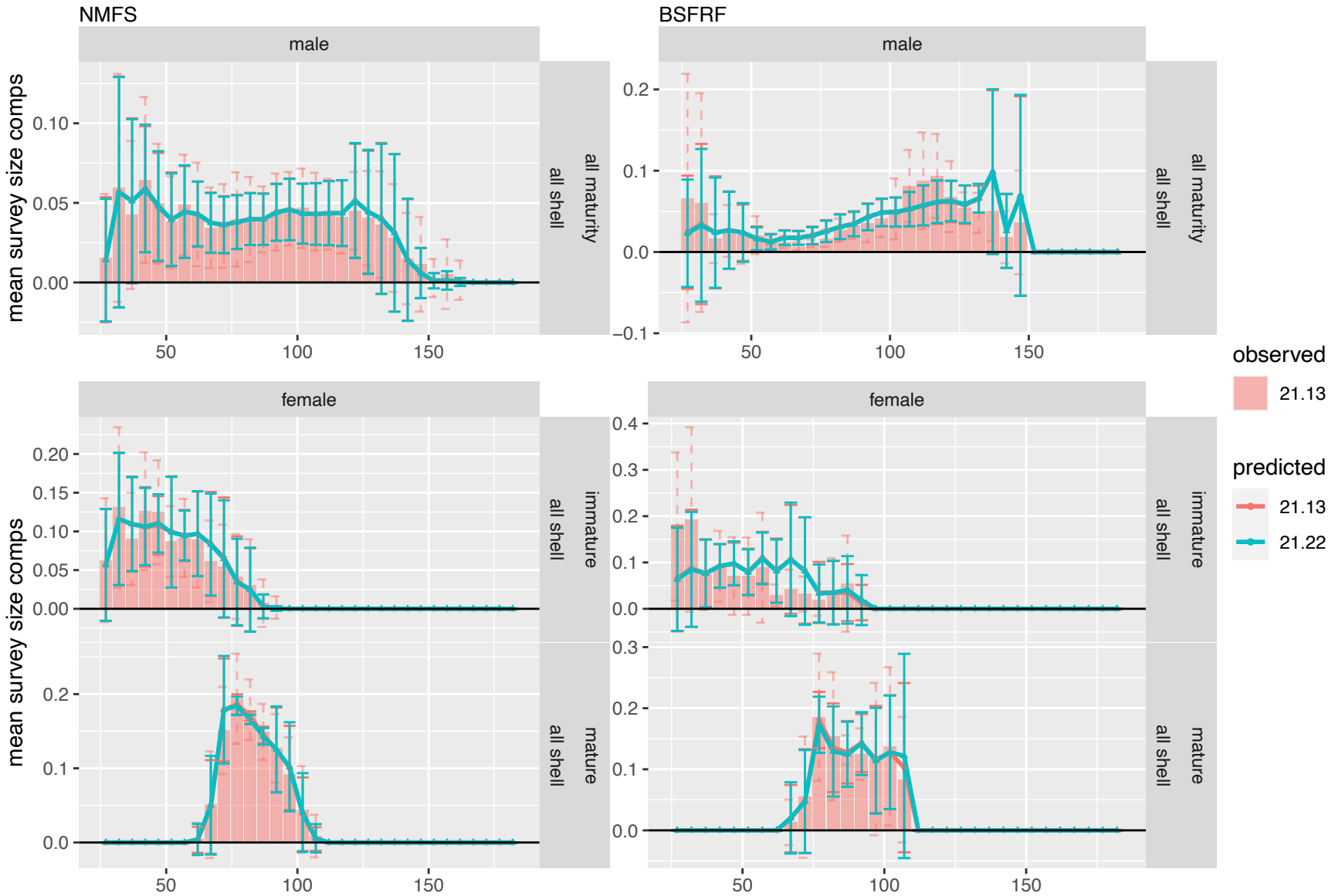

Figure 16. Fits to mean size compositions from the NMFS EBS Shelf Survey and BSFRF side-by-side surveys.

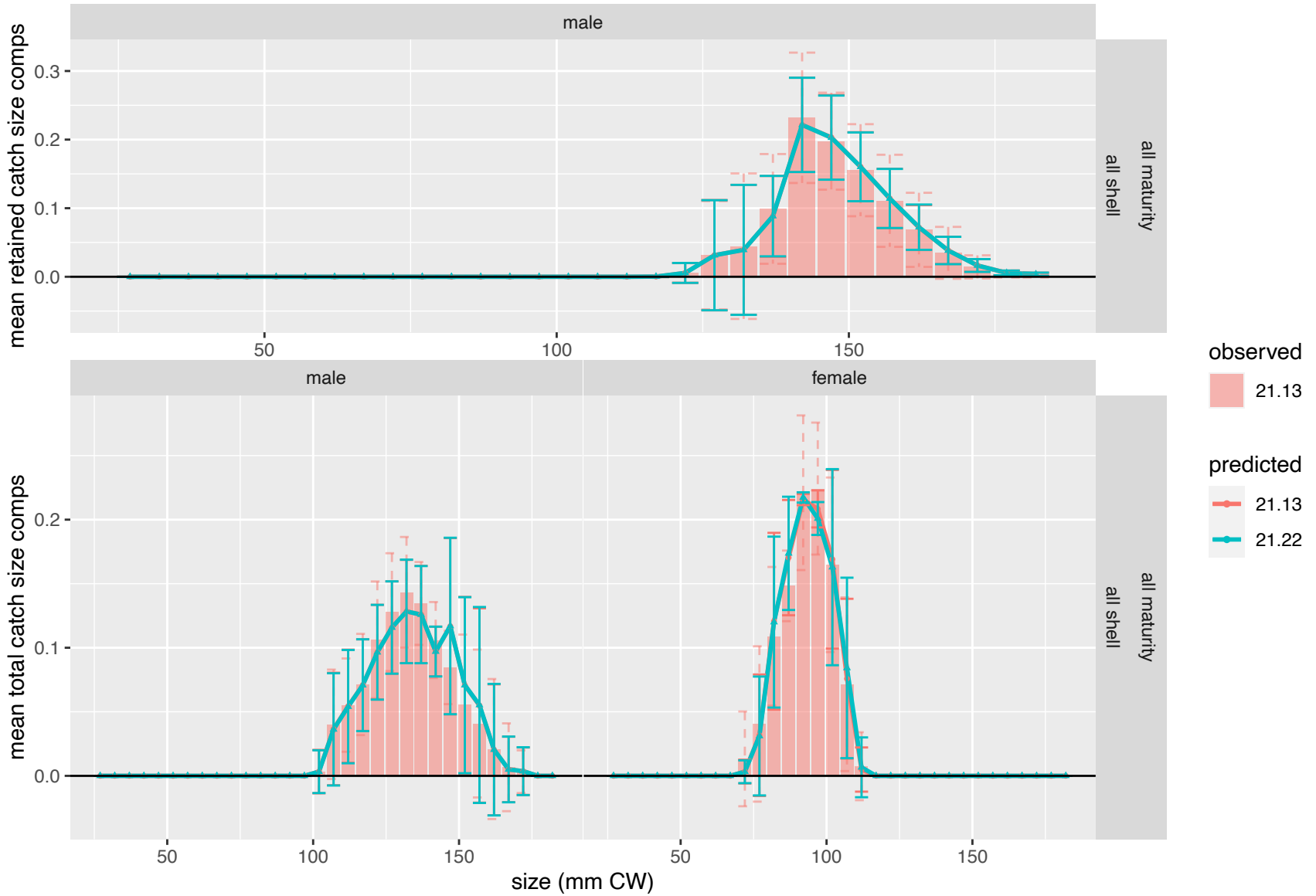

Figure 17. Fits to mean size compositions for retained catch and total catch size compositions in the directed fishery.

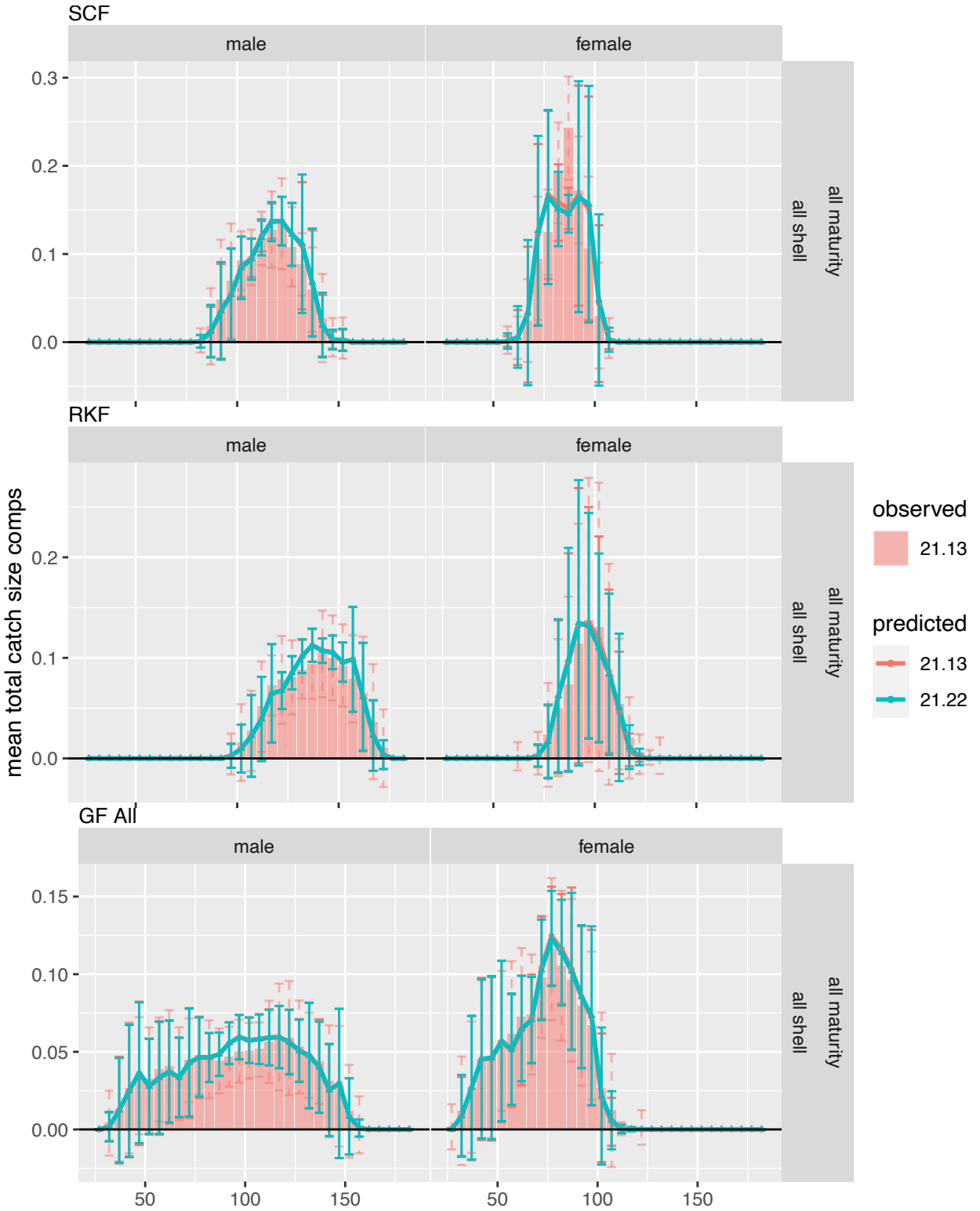

Figure 18. Fits to mean size compositions for Tanner crab bycatch in the snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

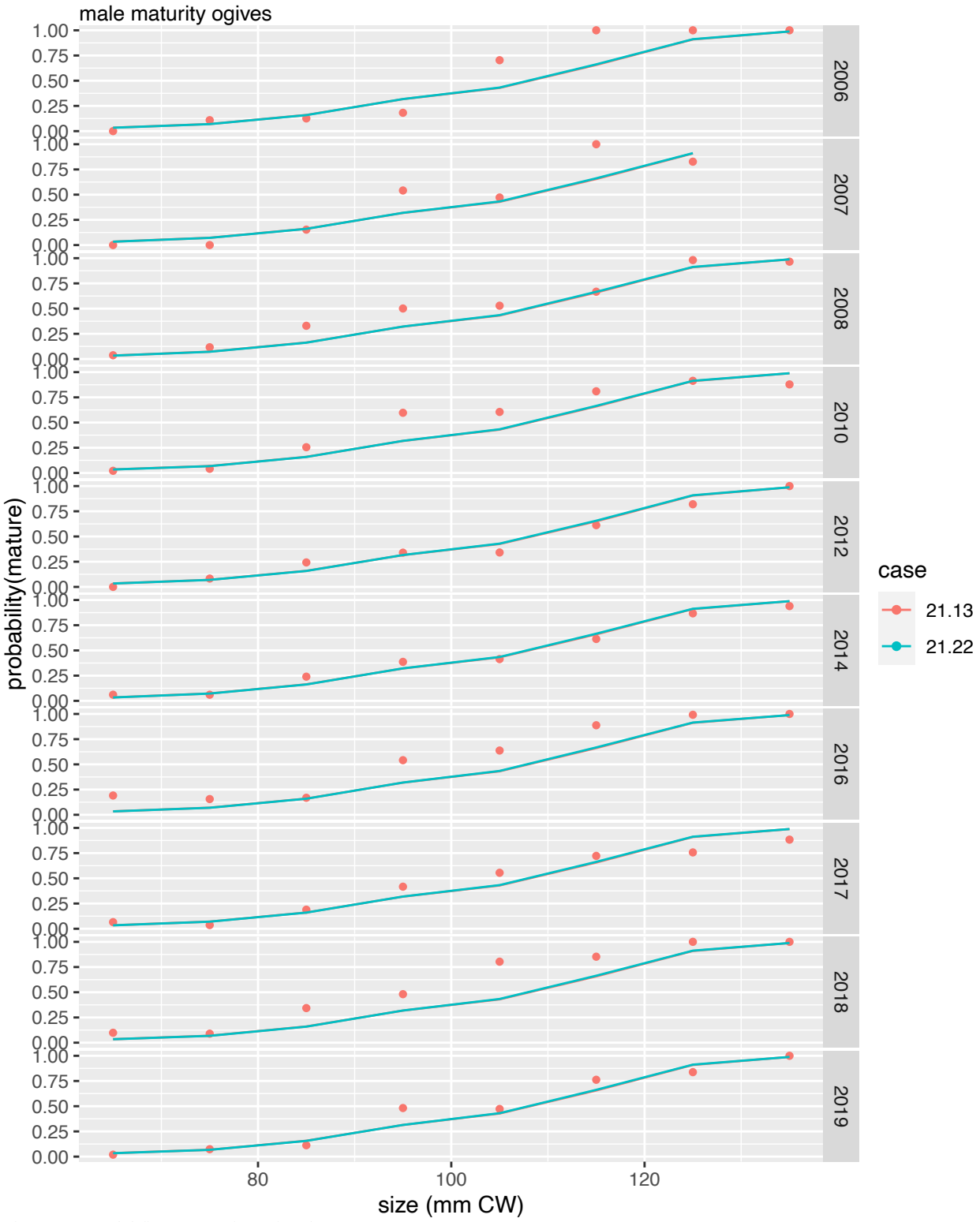

Figure 19. Model fits to maturity ogive data.

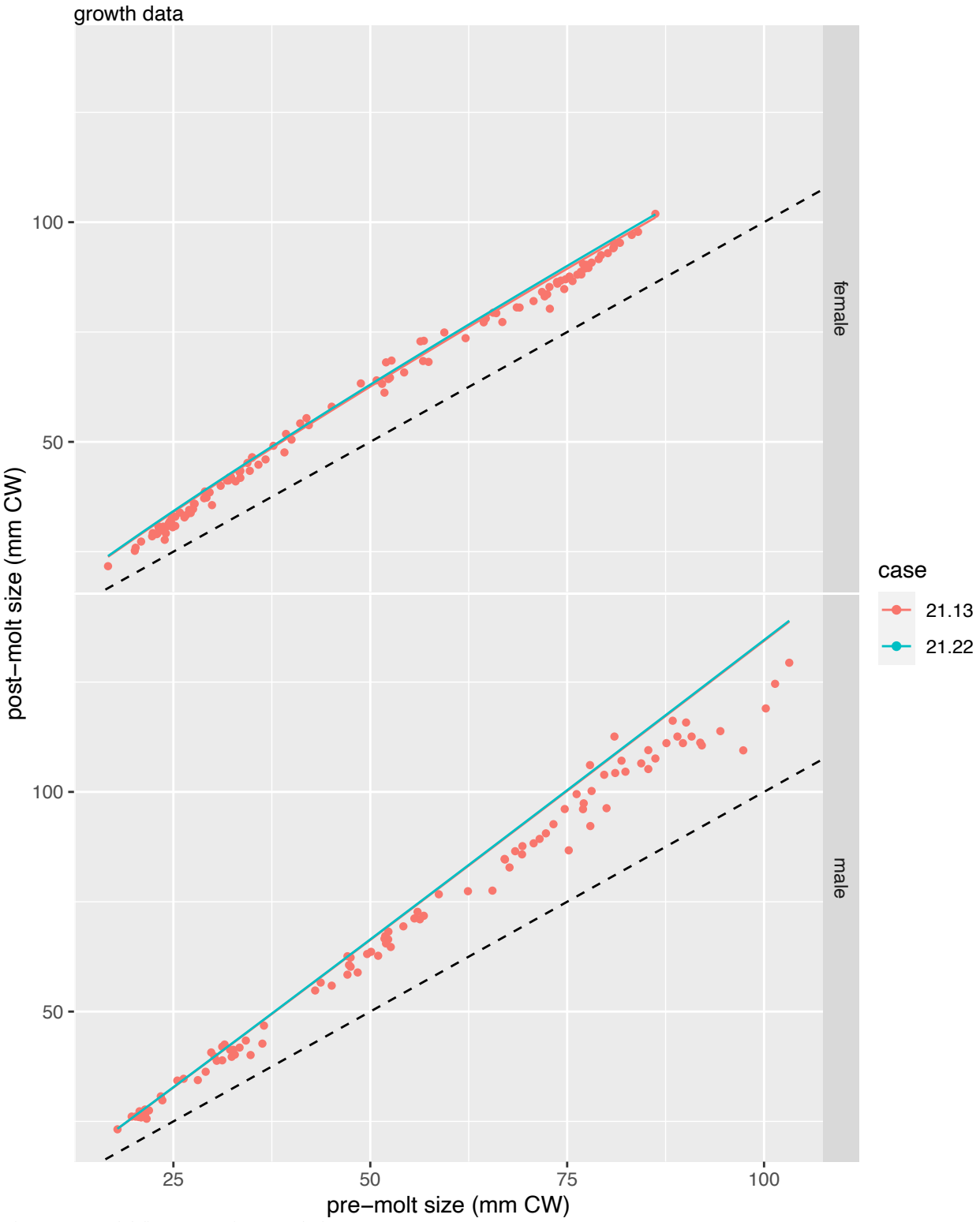

Figure 20. Model fits to maturity growth data.