Tanner Crab Appendix A

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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 21.04 as the base model. Model 21.04 had a number of parameters estimated at a bound. The model presented here, 21.21, builds on 21.04 by expanding the bounds on some of the parameters hitting a bound in 21.04 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 21.21 was able to converge with no estimated parameters at a bound. In all cases, the values chosen for parameters that were fixed at a bound could be justified.

Methods

Model 21.04 had 5 parameters, all related to selectivity, estimated at a bound:

Table 1. Parameters at a bound in Model 21.04.

name	value	test	description
pS1[4]	69	at upper bound	z50 for NMFS survey selectivity (females, 1982+)
pS1[23]	180	at upper bound	z95 for RKF selectivity (males, 1997-2004)
pS1[24]	180	at upper bound	z95 for RKF selectivity (males, 2005+)
pS2[4]	100	at upper bound	z95-z50 for NMFS survey selectivity (females, 1982+)
pS4[2]	0.10	at lower bound	descending slope for SCF selectivity (males, 1997-2004)

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

1. the selectivity function for the 1982+ NMFS survey for females was changed from an ascending logistic (parameterized with the size at 50% selected, *z50*, and the difference between *z95-z50*, where *z95* is the size at 95%-selected) to an ascending normal function (parameterized with size-at-1 and width). Bounds were placed on the size-at-1 parameter (the new pS1[4]) of 100 to 140 mm CW. After an initial run in which pS1[4] hit its upper bound, it was fixed at 139.9 mm CW. The width parameter (the new pS2[4]) was estimated within the bounds set for it (10 to 100 mm CW).
2. pS1[23], the z95 parameter for the 1997-2004 RKF bycatch selectivity function for males was fixed at 179.9 mm CW.
3. pS1[24], the z95 parameter for the 2005-present RKF bycatch selectivity for males was fixed at 179.9 mm CW.
4. the bounds on pS4[1], the descending slope of the double logistic function for SCF male bycatch selectivity was increased from 0.1-0.5 to 0.01-0.5.

The model run with these changes resulted in the z50 parameter (pS1[20]) for bycatch selectivity on females in the 1987-1996 groundfish fisheries being estimated at its upper bound (140 mm CW). This selectivity function was re-parameterized as an ascending normal curve, with the bounds for the size-at-1 parameter (pS1[20]) set to 100 to 140 mm CW and the bounds on the width parameter (pS2[20]) set to 10 to 100 mm CW. After a subsequent model run in which pS1[20] was estimated at its upper bound (140 mm CW), it was fixed at 139.9 mm CW.

No parameters were estimated at bounds in the next (and final) model run; this model was taken as Model 21.21. To summarize, Model 21.21 differs from 21.04 in the following:

1. the selectivity function for the 1982+ NMFS survey for females was changed from an ascending logistic to an ascending normal function (parameterized with size-at-1 and width).
    a. the z-at-1 parameter was fixed at 139.9 mm CW.
2. pS1[23], the z95 parameter for the 1997-2004 RKF bycatch selectivity function for males, was fixed at 179.9 mm CW.
3. pS1[24], the z95 parameter for the 2005-present RKF bycatch selectivity for males, was fixed at 179.9 mm CW.
4. the bounds on pS4[1], the descending slope of the double logistic function for SCF male bycatch selectivity, were increased.
5. the selectivity function for 1987-1996 GF bycatch of females was changed from ascending logistic to an ascending normal.
    a. pS1[20], the size-at-1 parameter was fixed at 139.9 mm CW.

The values at which the parameters were fixed in Model 21.04 were based on the maximum sizes for males (182.5 mm CW) and females (137.5 mm CW) in the model and the requirement that ascending asymptotic selectivity functions reach 1 prior to reaching those sizes.

Results: comparison with Model 21.04

On the whole, the differences between the two models are very small (Table 2, Figures 1-20). As expected, the overall likelihood for 21.21 is slightly

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 21.21 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
21.04	3165.74	0.00108333	424.93	115.23	40.33	73.90	1.12	18.39	1.06	24.11	38.40
21.21	3175.37	0	419.61	115.17	40.31	74.00	1.13	18.40	1.07	24.20	38.38

larger than that for 21.04 because the fixed parameters were set to values close, but not identical, to the imposed bounds. However, 21.21 has no estimated parameters at a bound and the maximum gradient at the converged solution is truly zero. The only differences worth noting are for male bycatch selectivity in the snow crab fishery during 1997-2004 (Fig. 7; 21.21 has a slightly wider descending limb), corresponding differences in fully-selected fishery capture rates (Fig. 8), changes in female selectivity and catchability curves for the NMFS survey after 1981 (Figures 11 and 12), and a slight decrease in fully-selected catchability for females in the pre-1982 NMFS survey (Figure 12). While the changes in female selectivity in the NMFS survey after 1981 appear to be fairly large (~10% at 100 mm CW, Figure 11), they are quite a bit smaller when fully-selected catchability is factored in (~1% at 100 mm CW, Figure 12).

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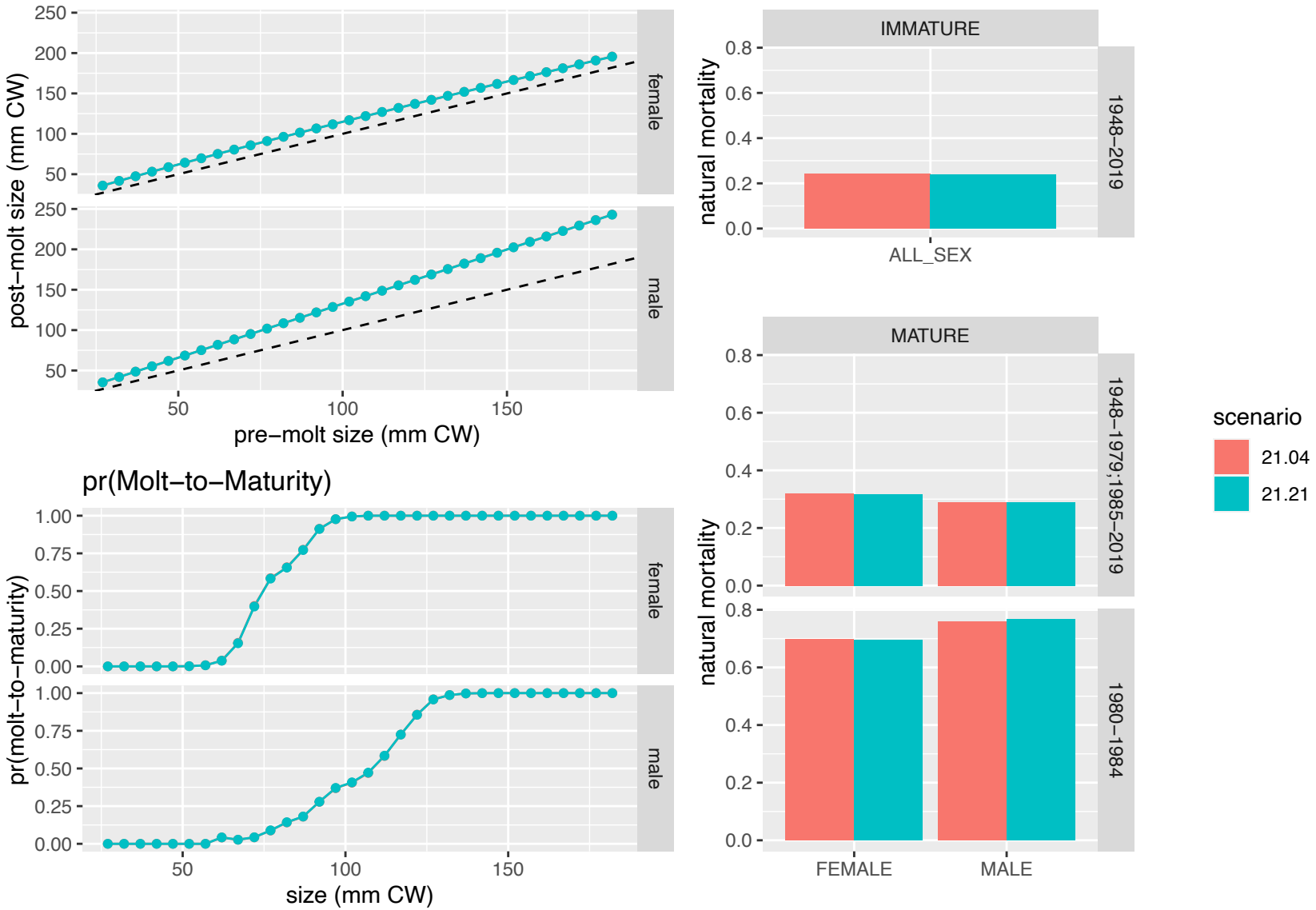


Figure 1. Estimated population processes.

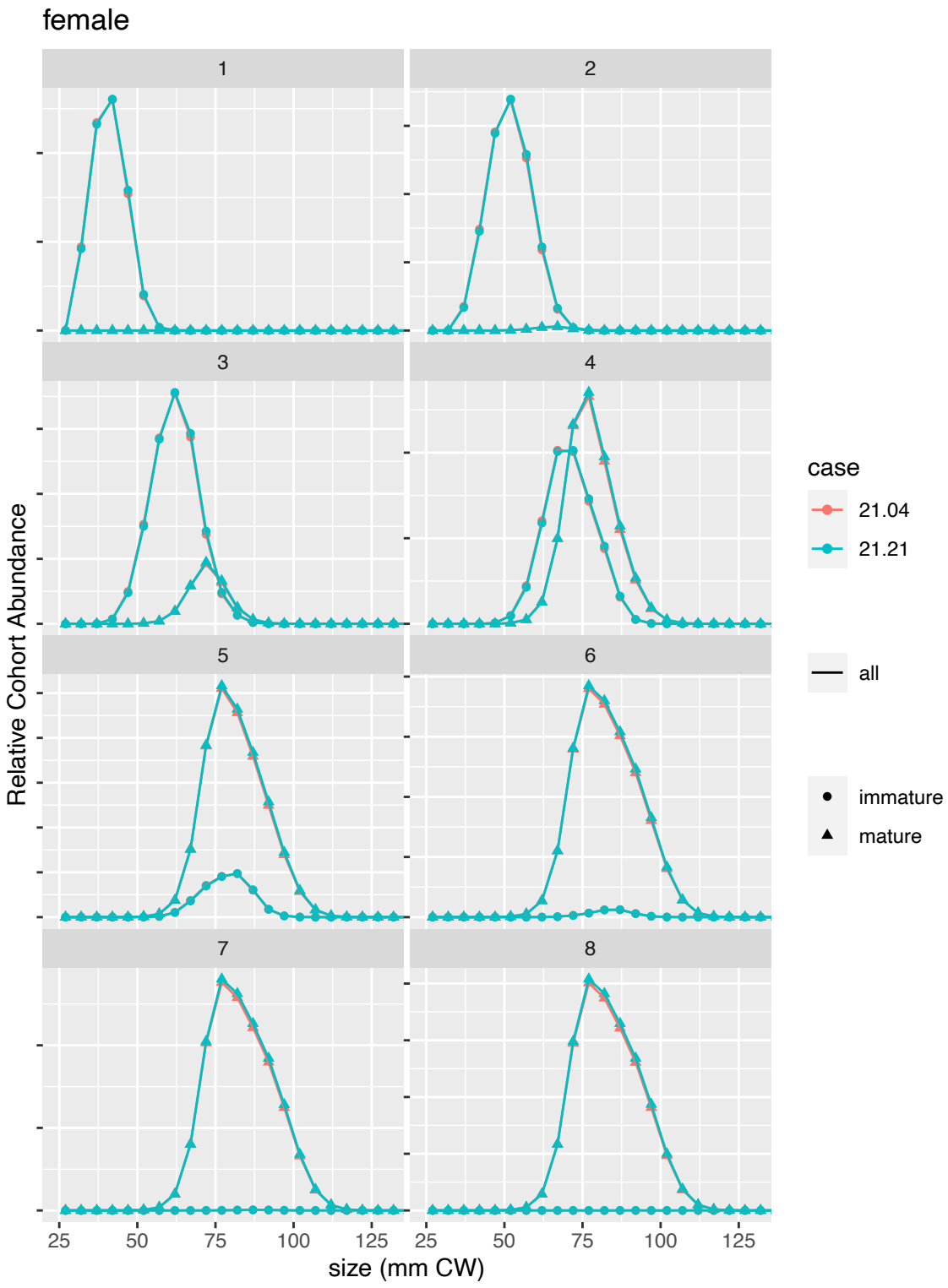


Figure 2. Estimated size progression of a cohort of female crab through time (years).

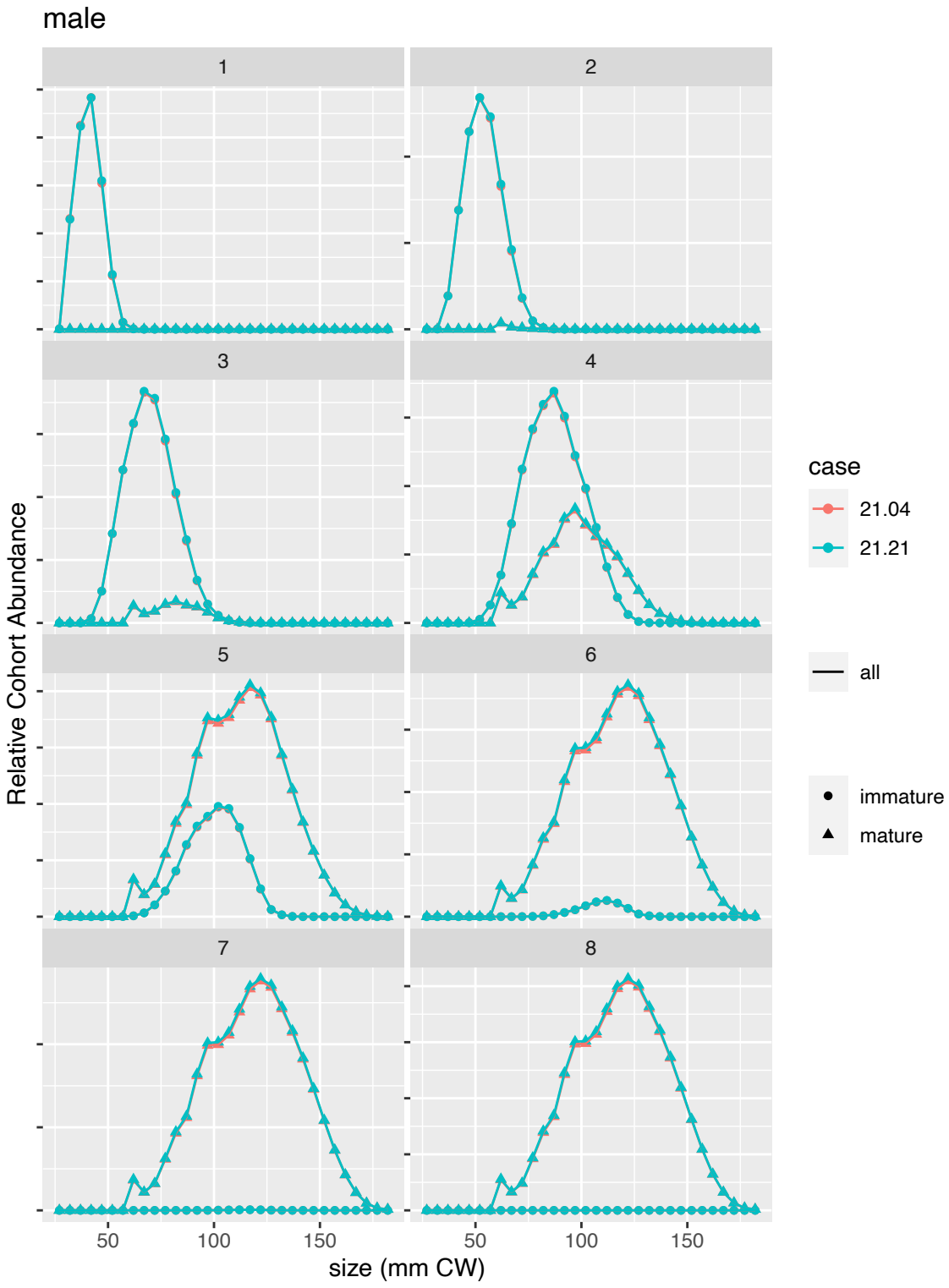


Figure 3. Estimated size progression of a cohort of male crab through time (years).

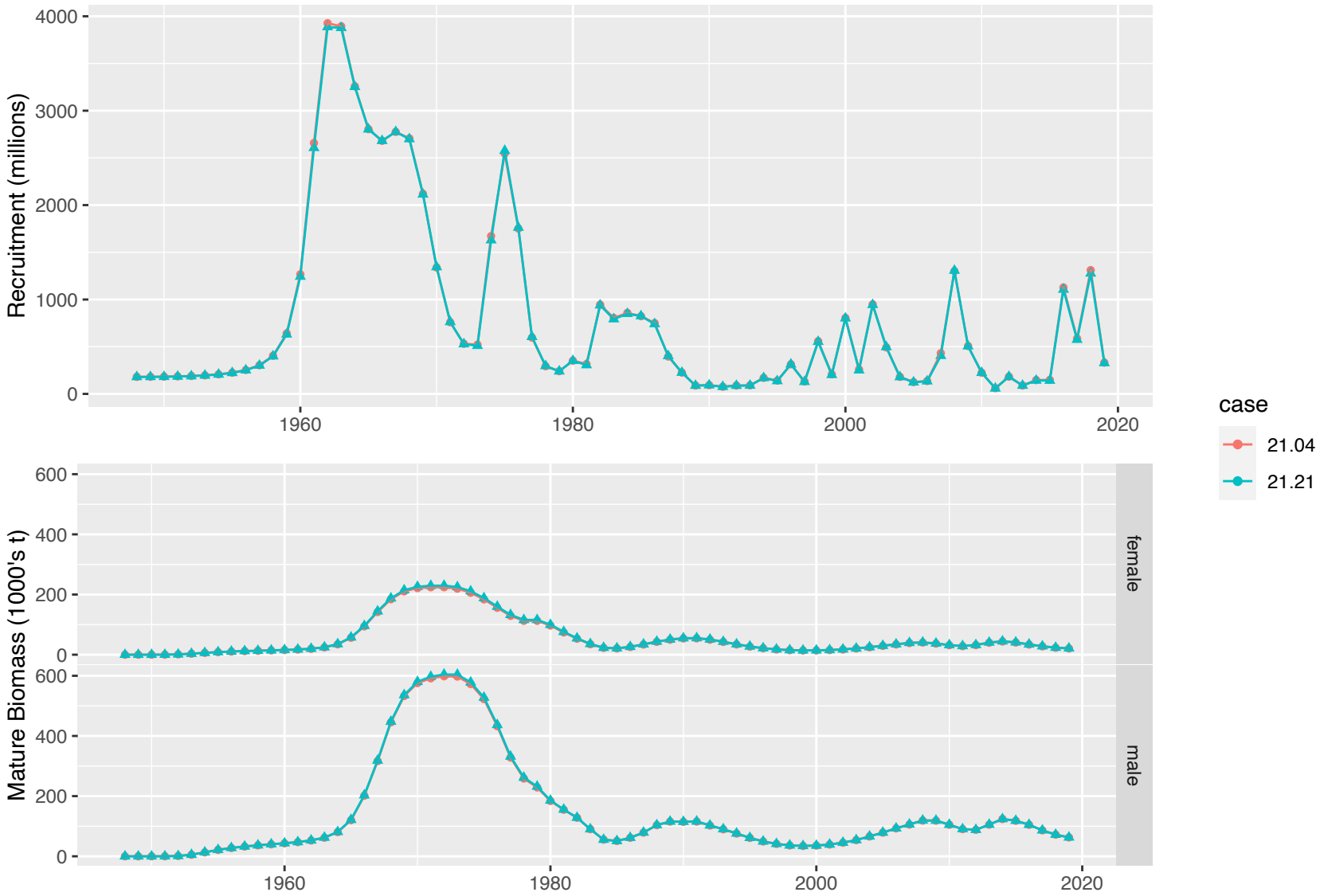


Figure 4. Estimated time series of recruitment and mature biomass.

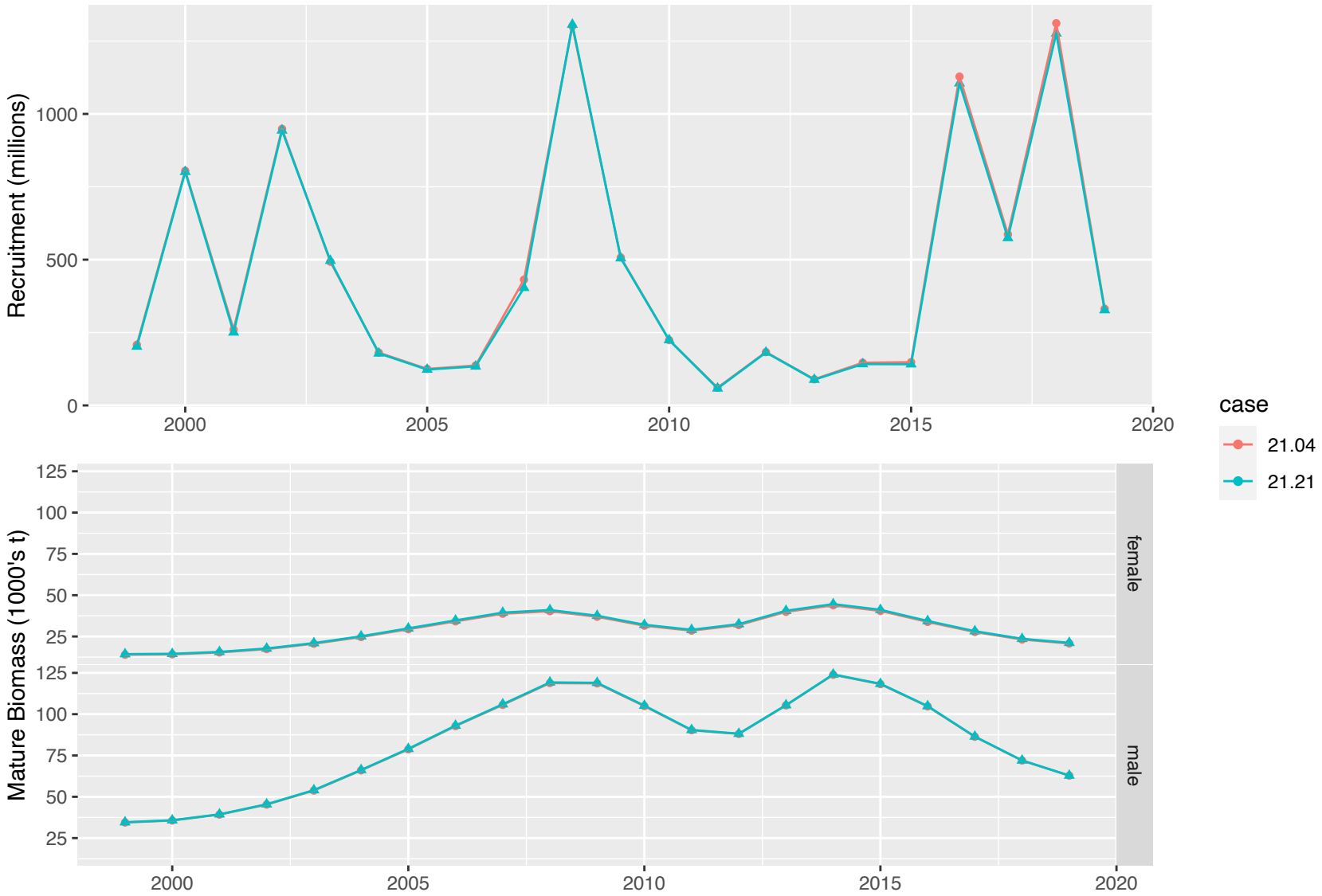


Figure 4a. Estimated time series of recruitment and mature biomass.

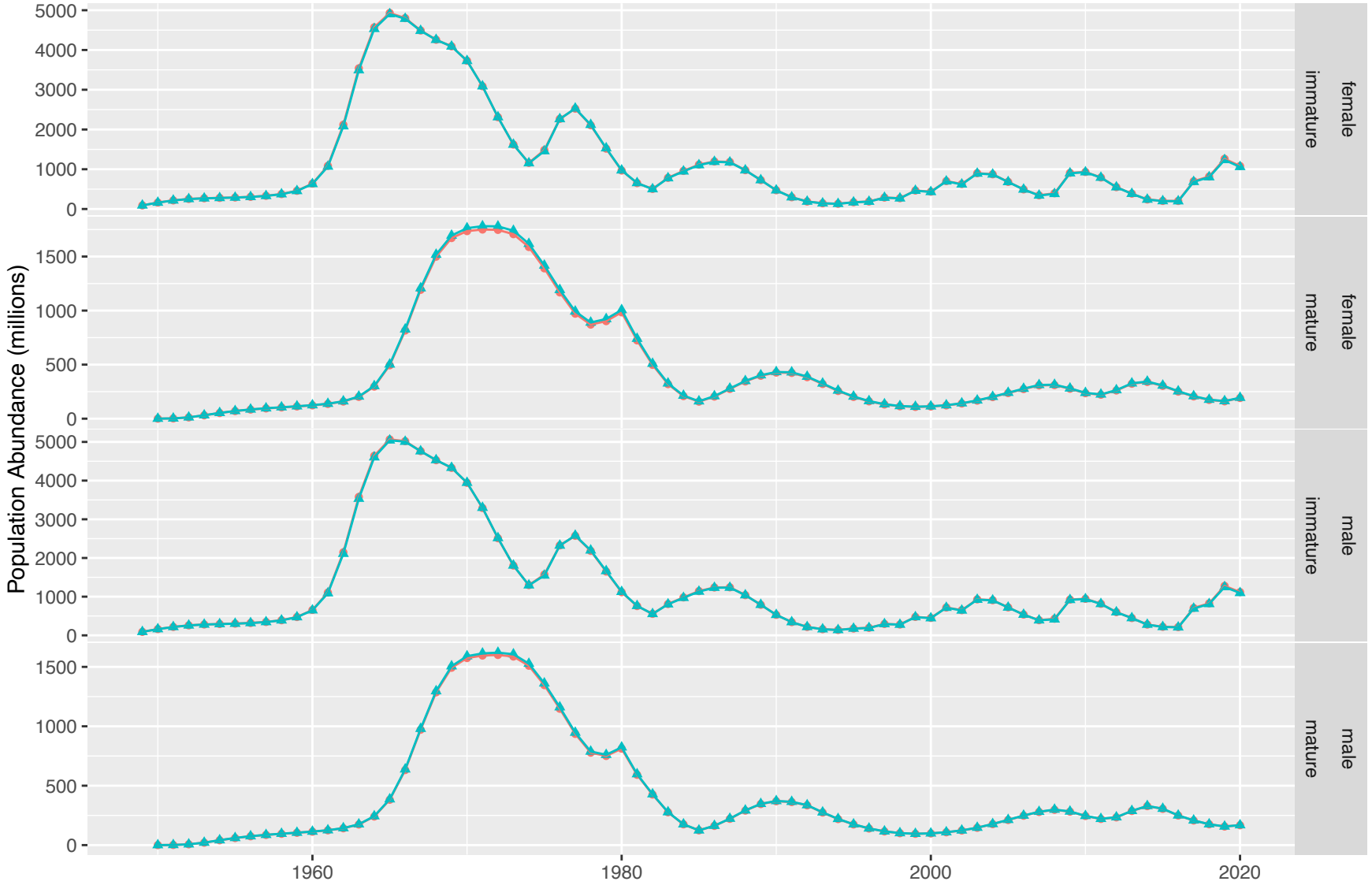


Figure 5. Estimated time series of population abundance.

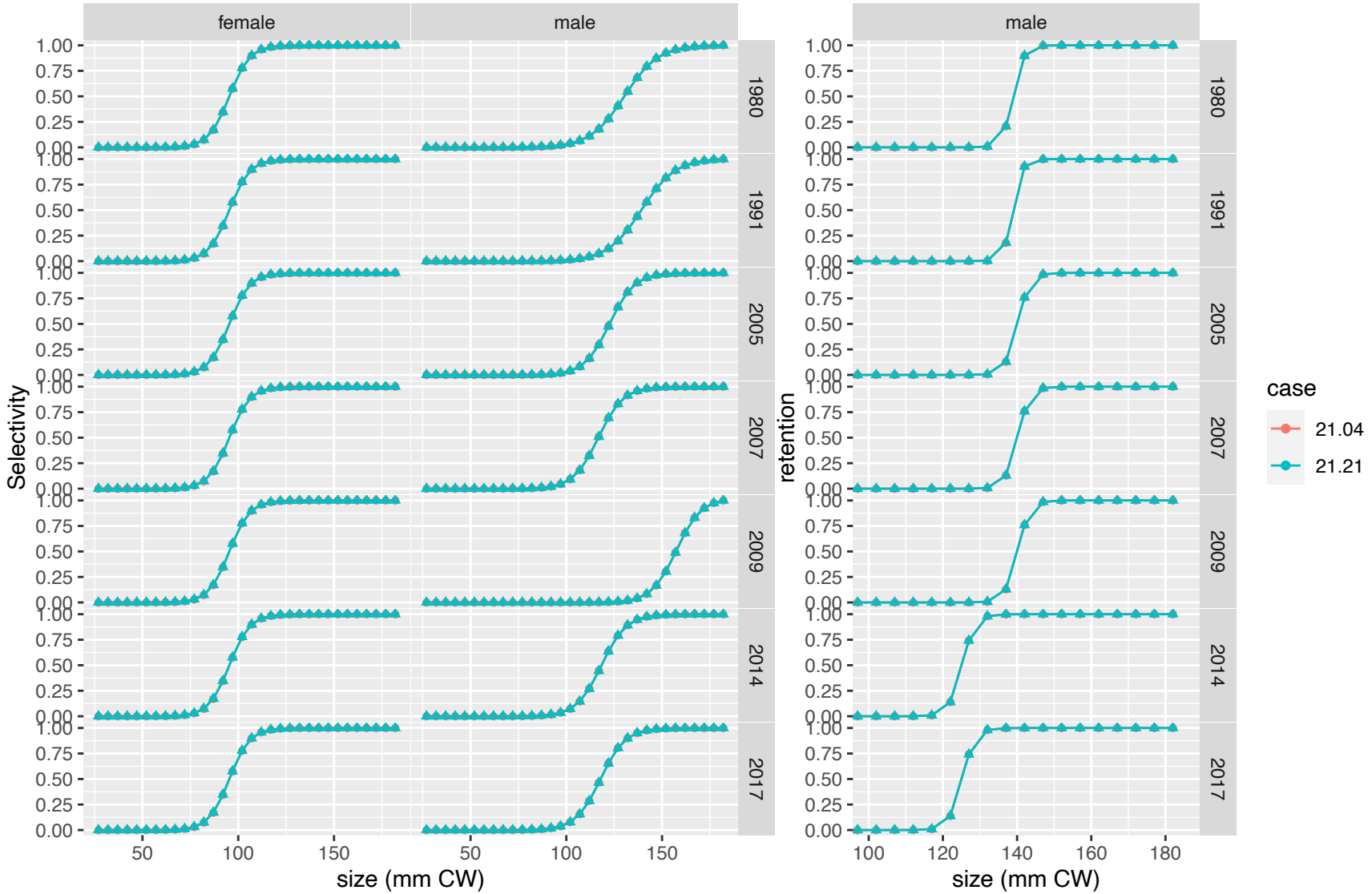


Figure 6. Estimated retention and total catch selectivity in the directed fishery ("TCF").

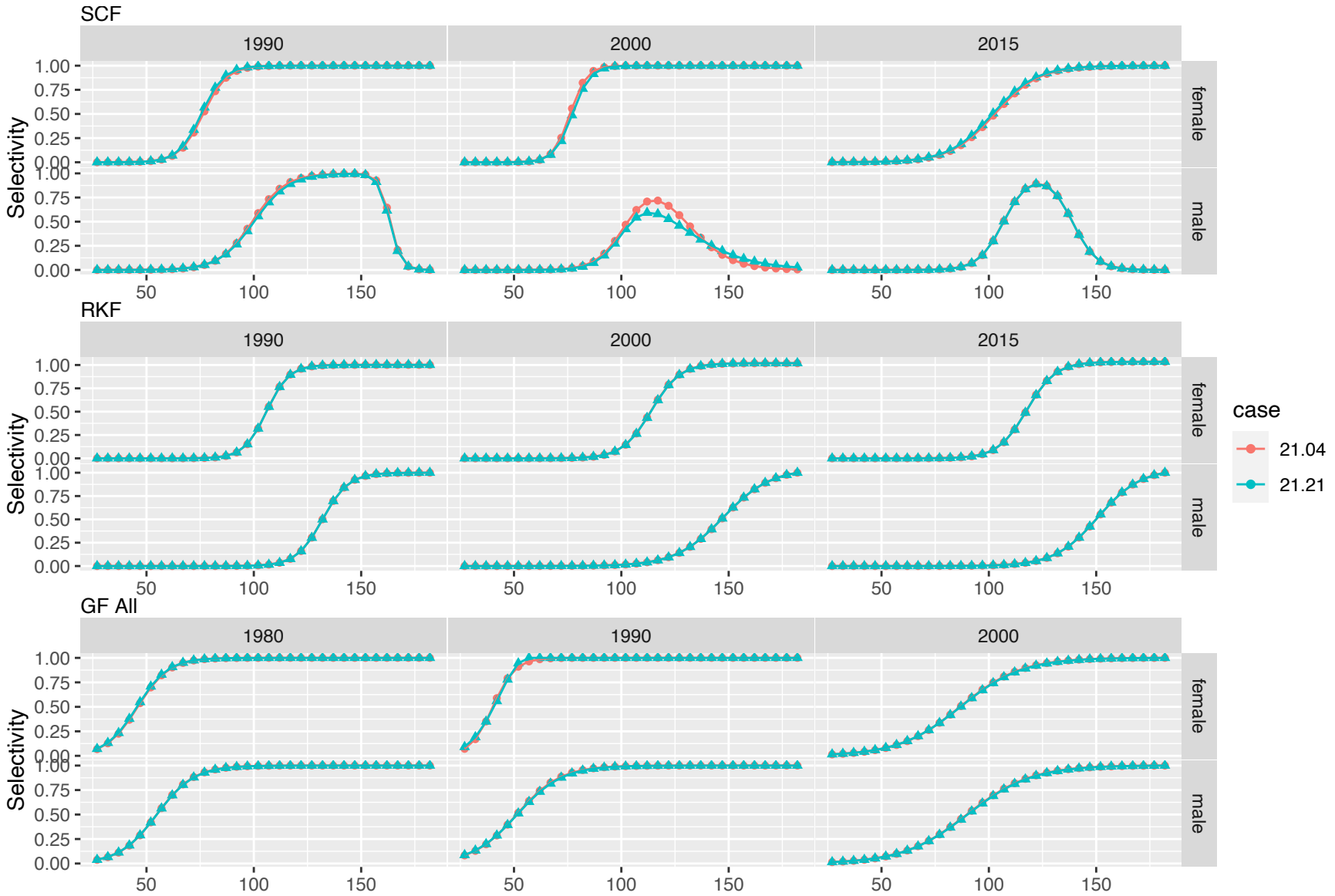


Figure 7. Estimated fishery selectivity in fisheries that take Tanner crab as bycatch: snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

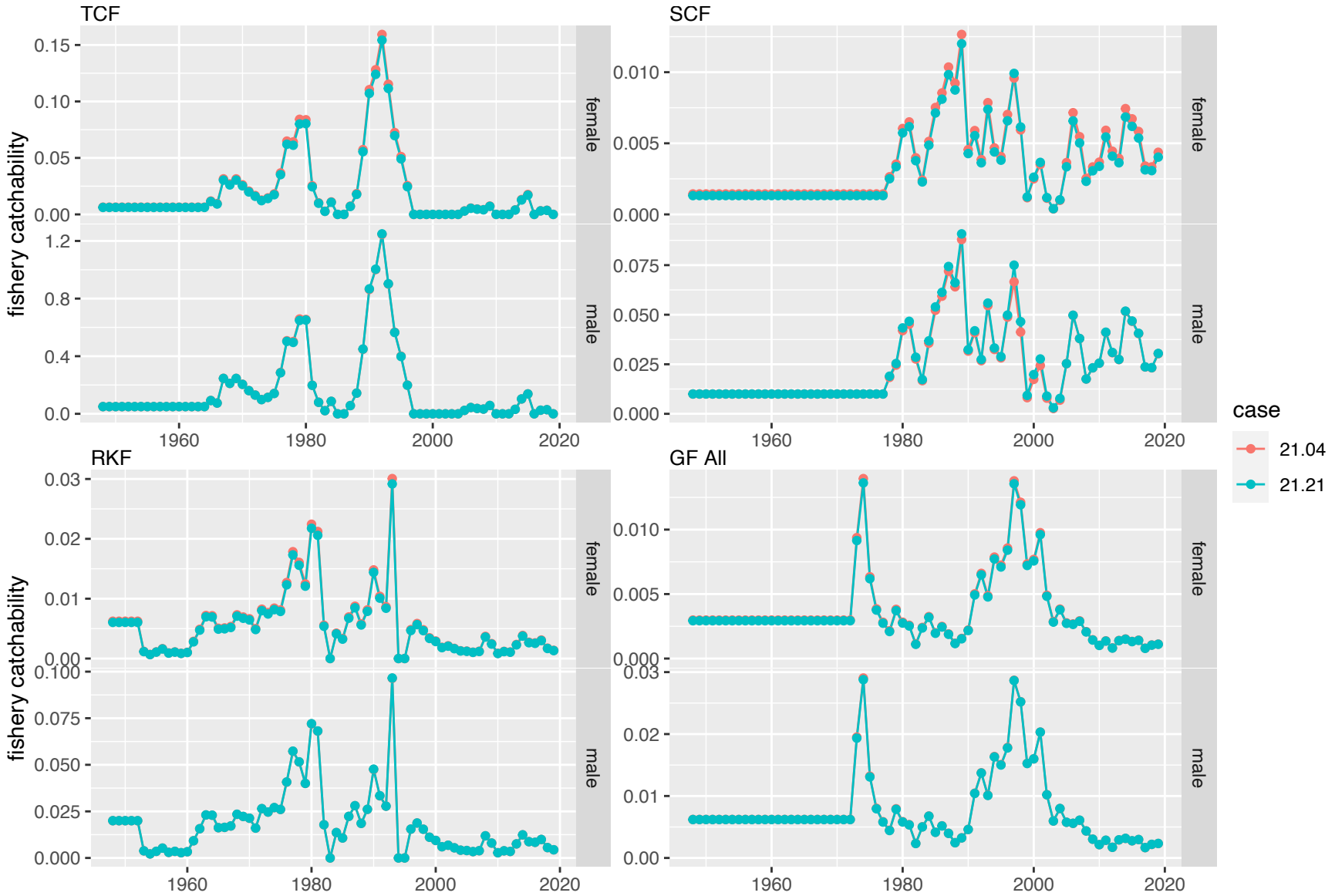


Figure 8. Estimated fishery capture rates in the directed fishery ("TCF") and other fisheries that take Tanner crab as bycatch: snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

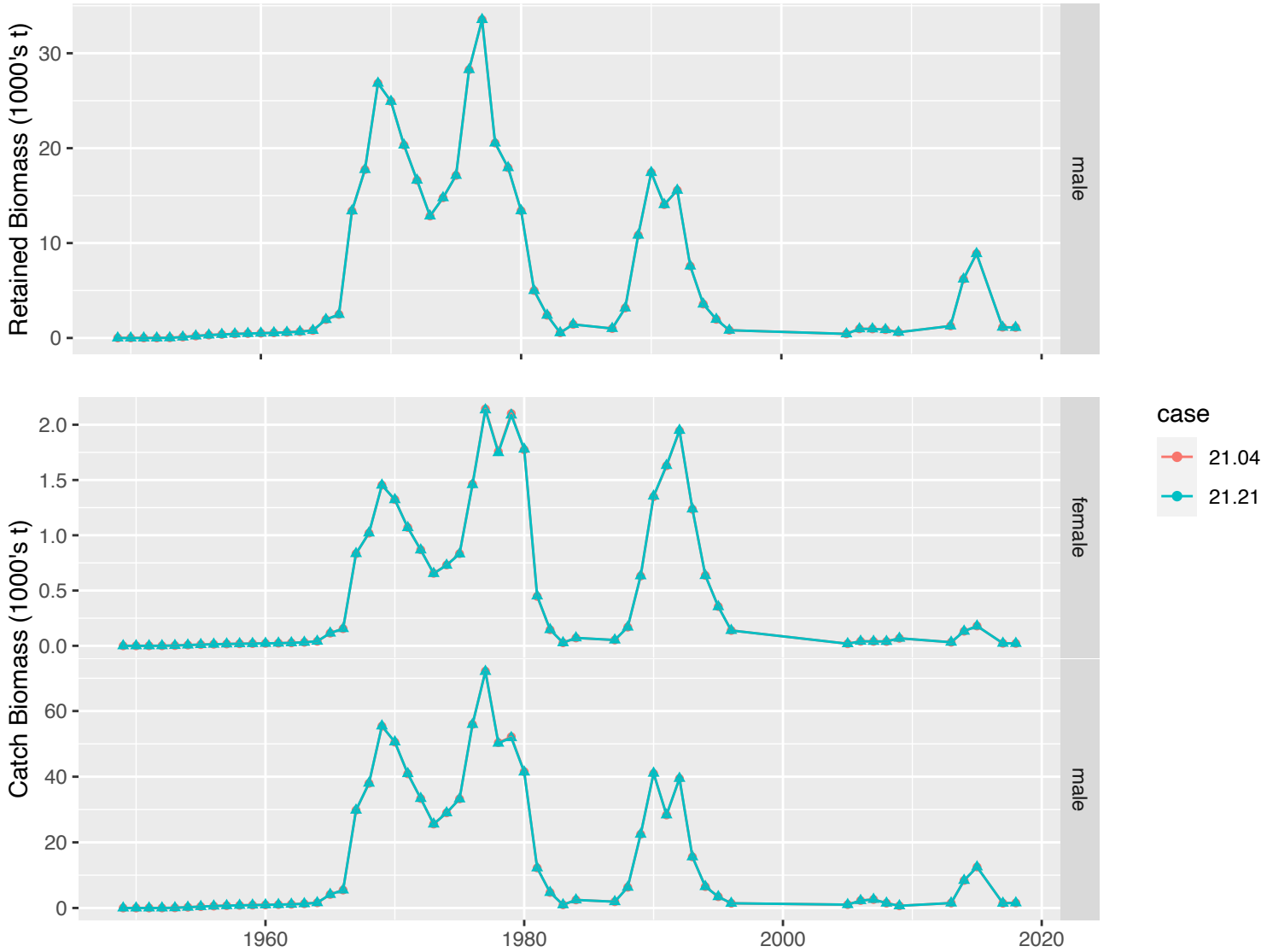


Figure 9. Model-estimated retained catch and total catch biomass in the directed fishery ("TCF").

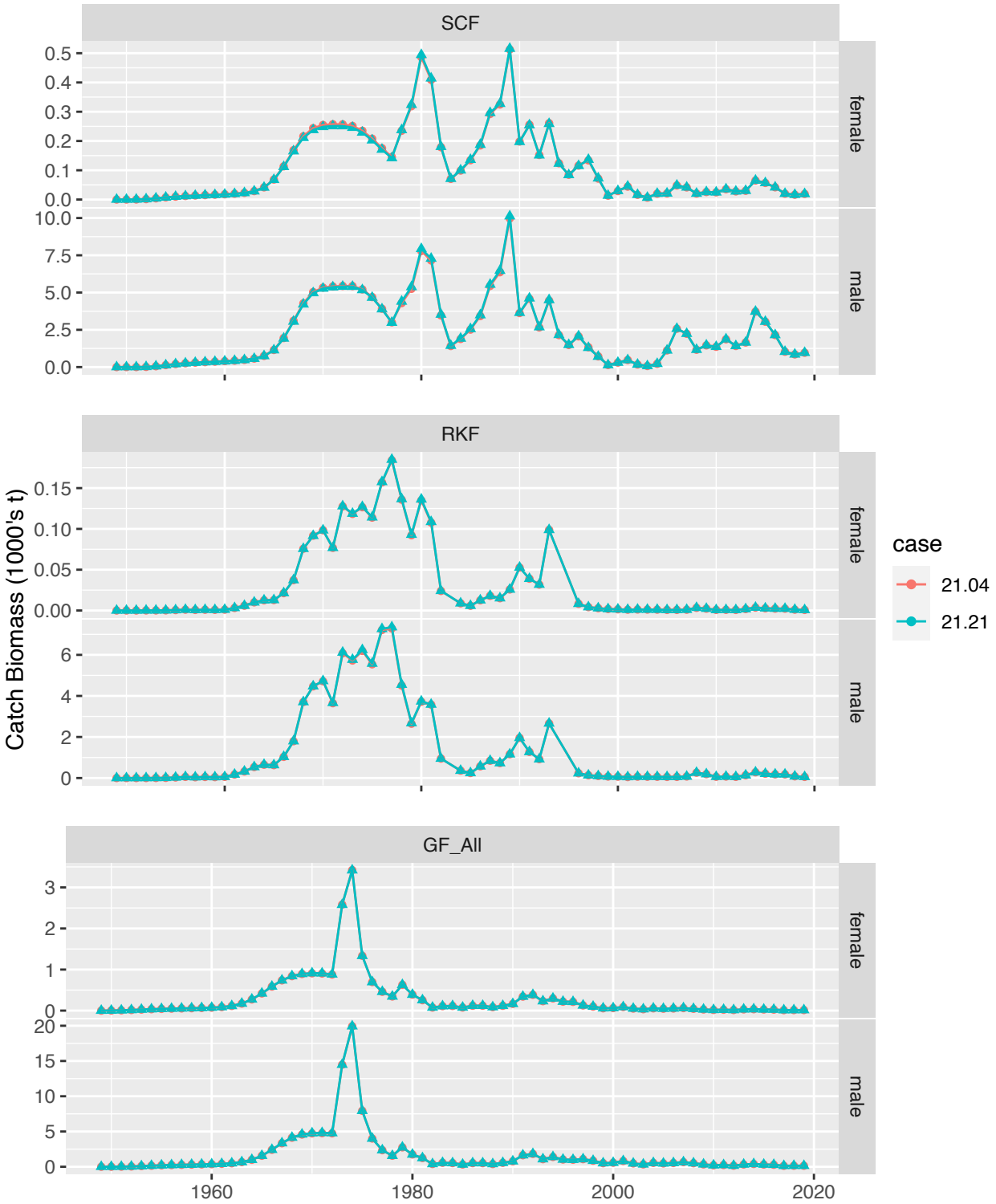


Figure 10. Model-estimated bycatch biomass in fisheries that take Tanner crab as bycatch: snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

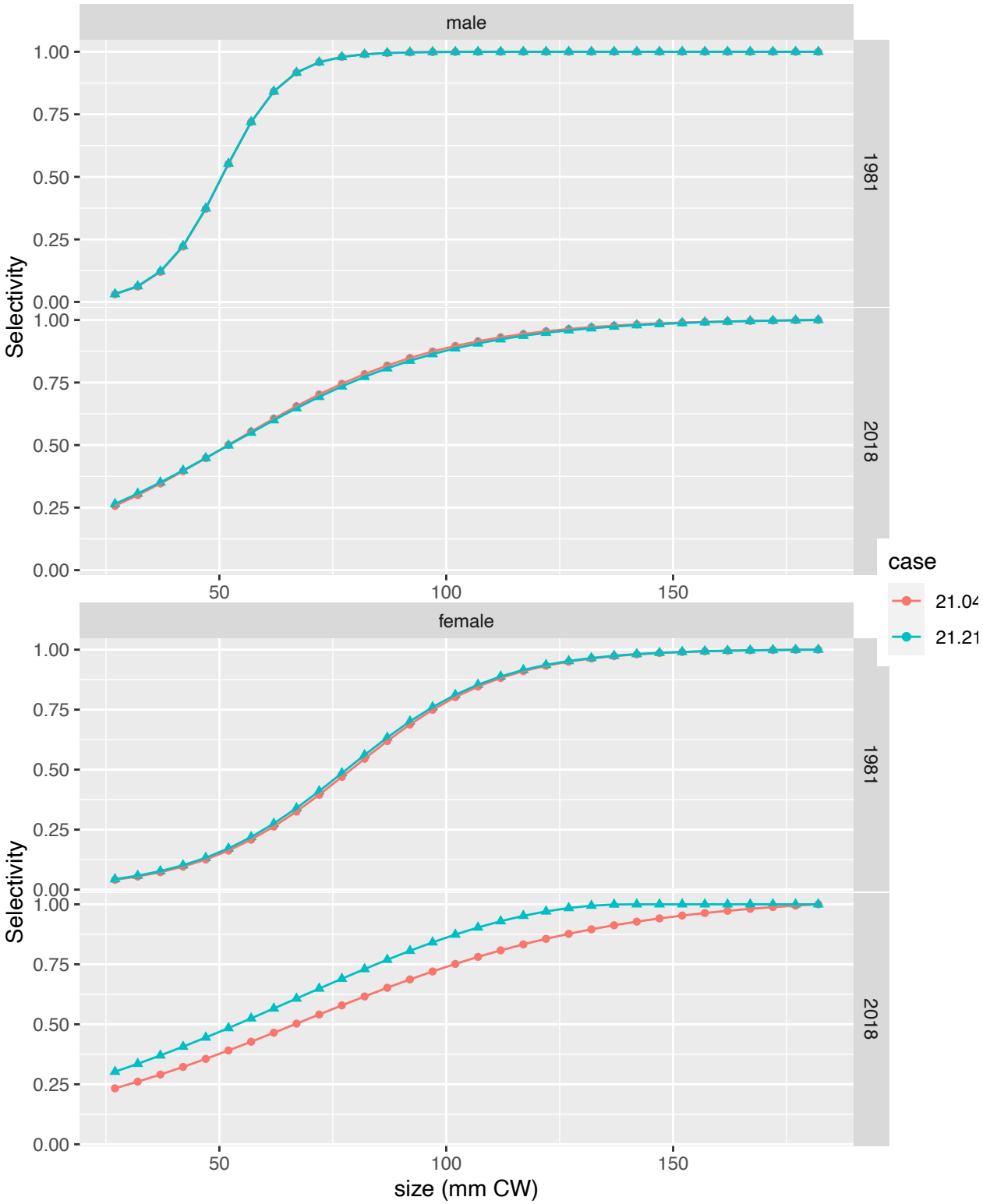


Figure 11. Estimated survey selectivity for the NMFS EBS Shelf Survey.

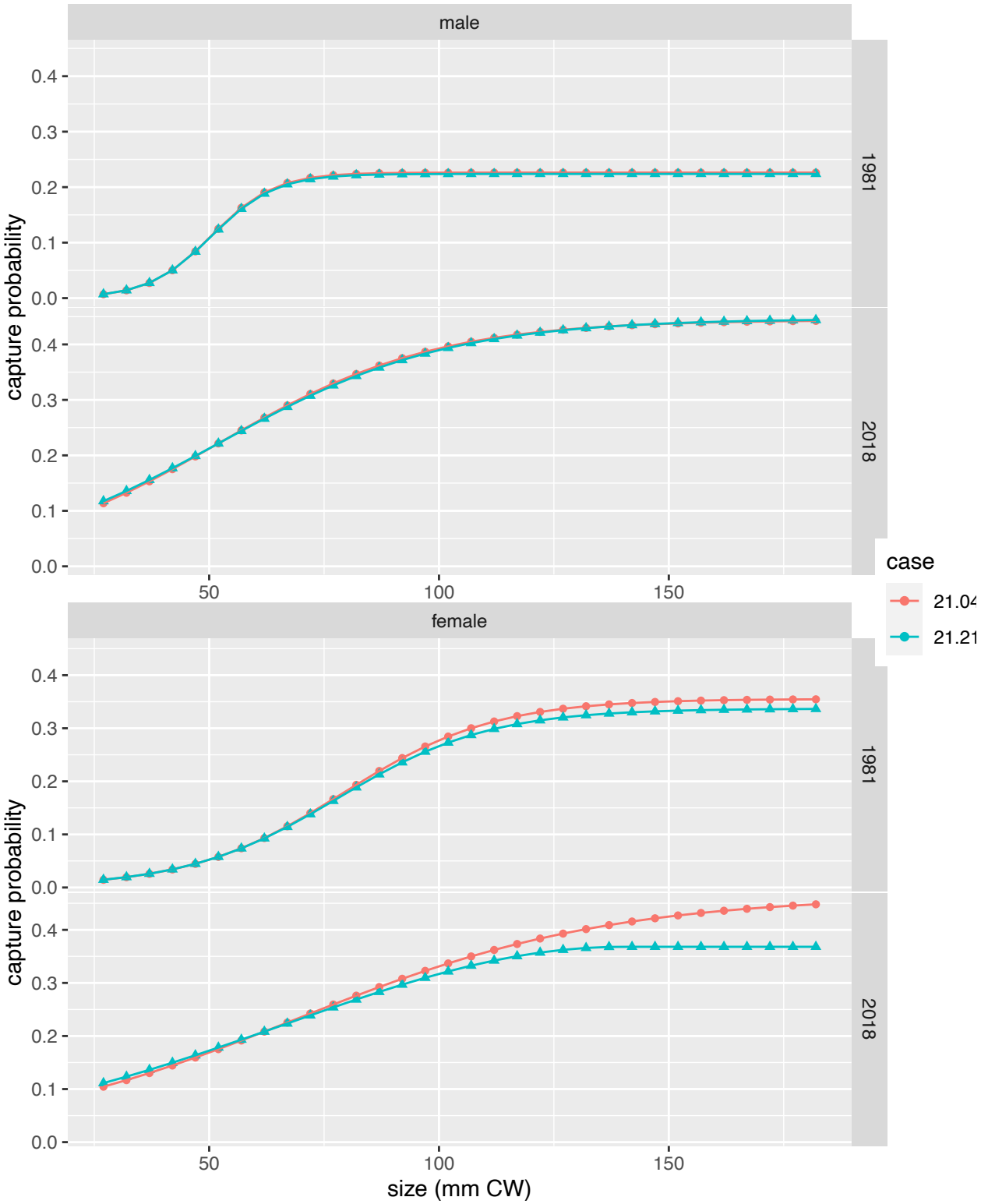


Figure 12. Estimated survey catchability for the NMFS EBS Shelf Survey.

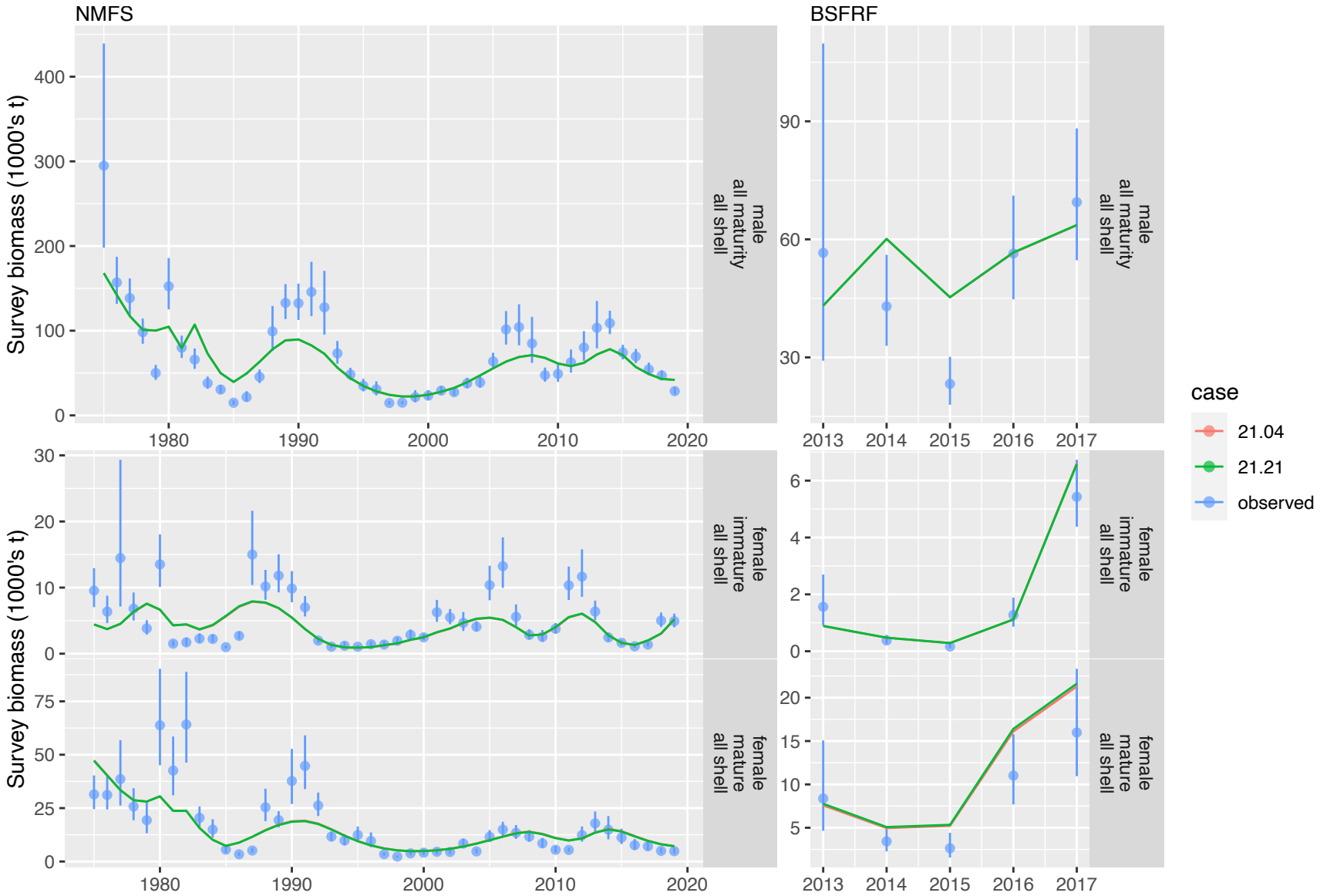


Figure 13. Fits to survey biomass time series from the NMFS EBS Shelf Survey and BSFRF side-by-side surveys.

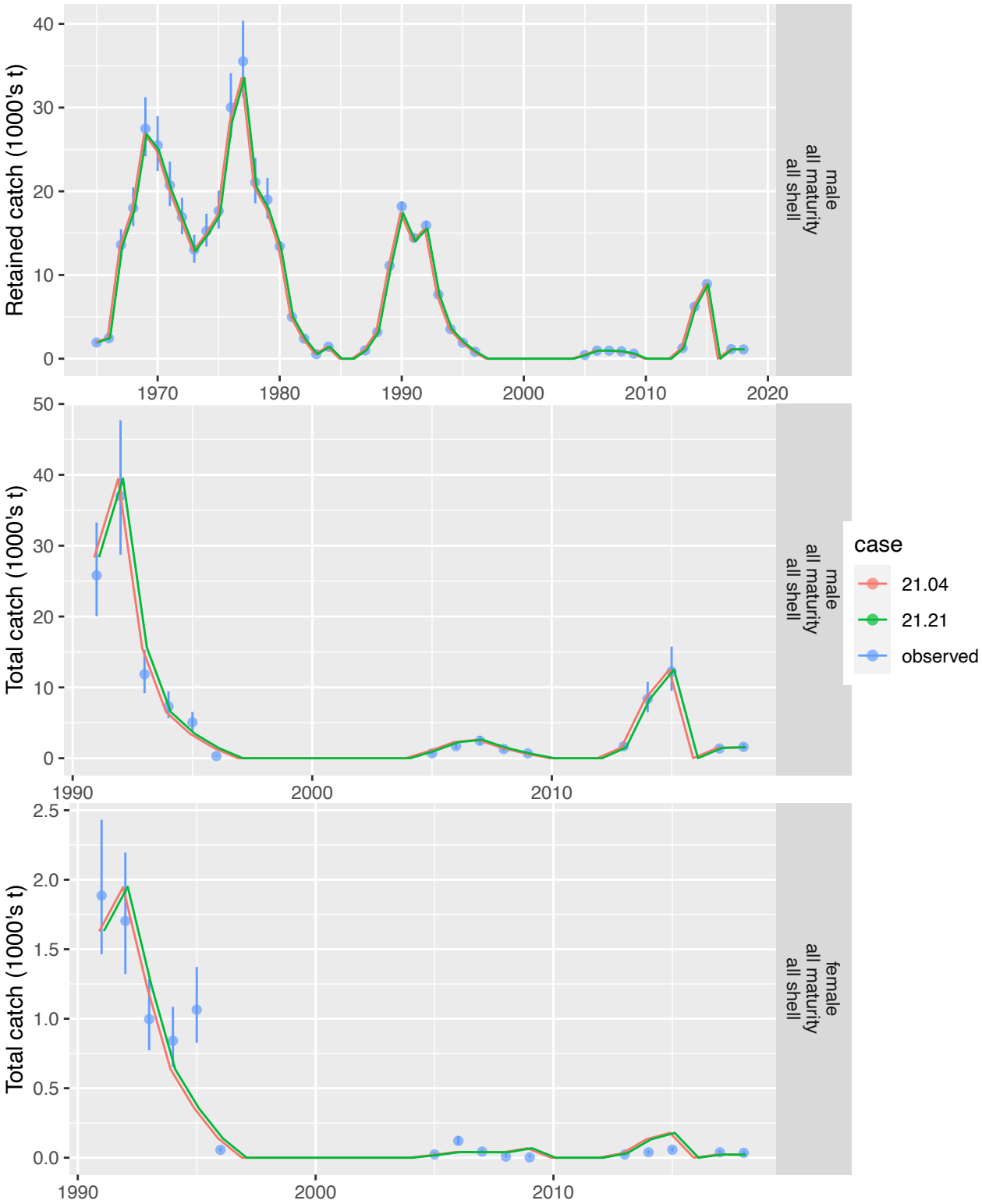
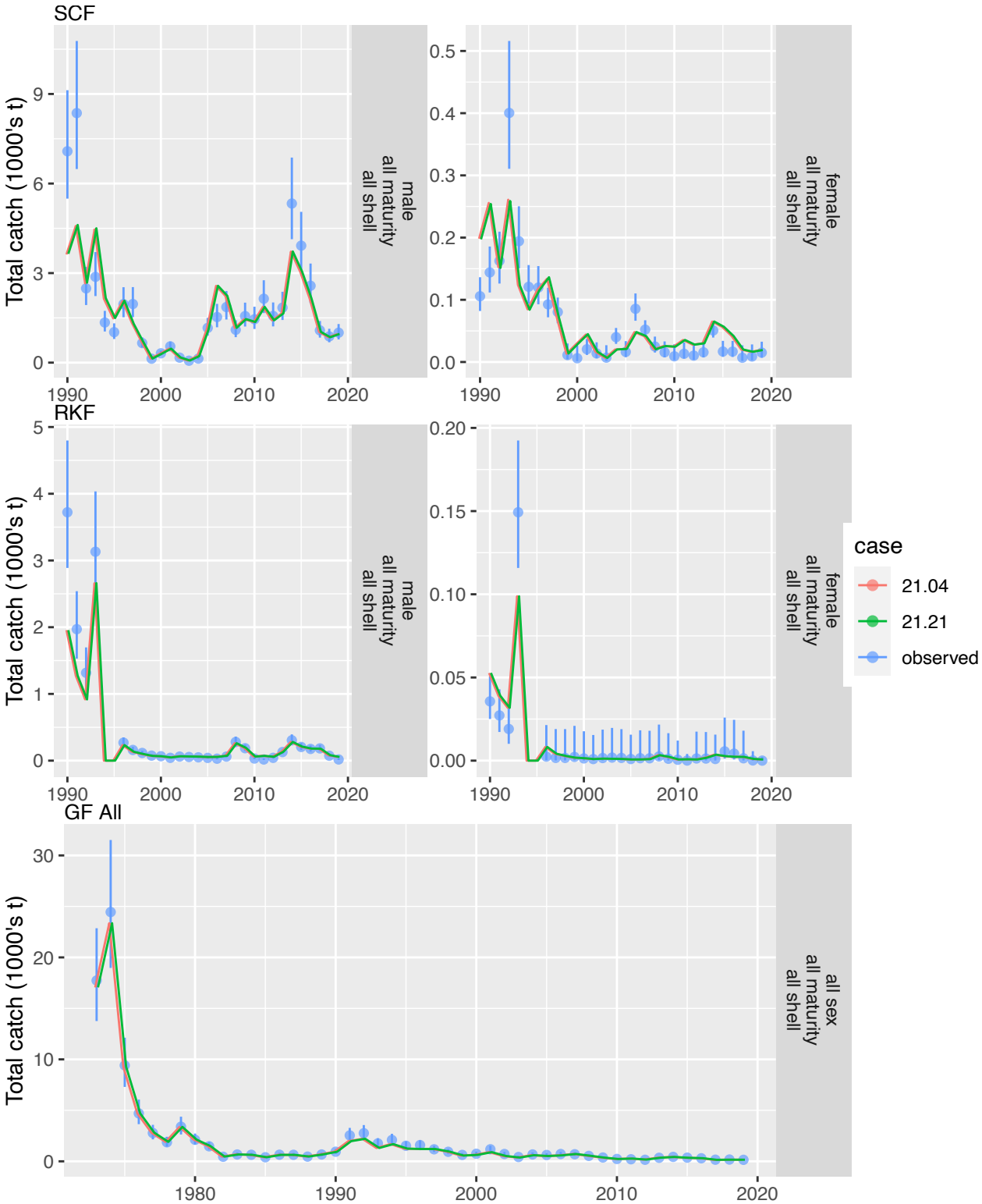


Figure 14. Fits to retained catch and total catch biomass time series in the directed fishery.



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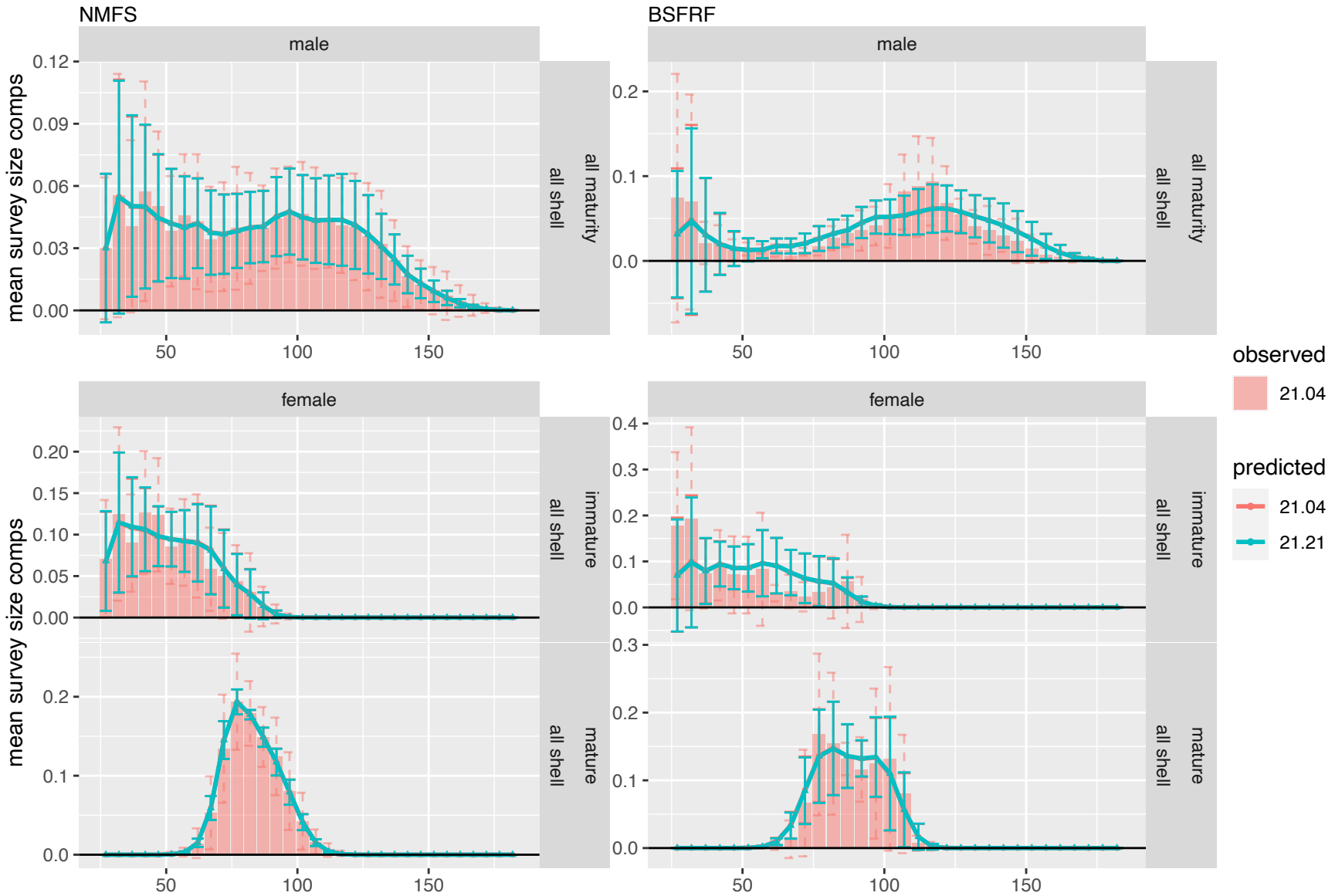

Figure 16. Fits to mean size compositions from the NMFS EBS Shelf Survey and BSFRF side-by-side surveys.

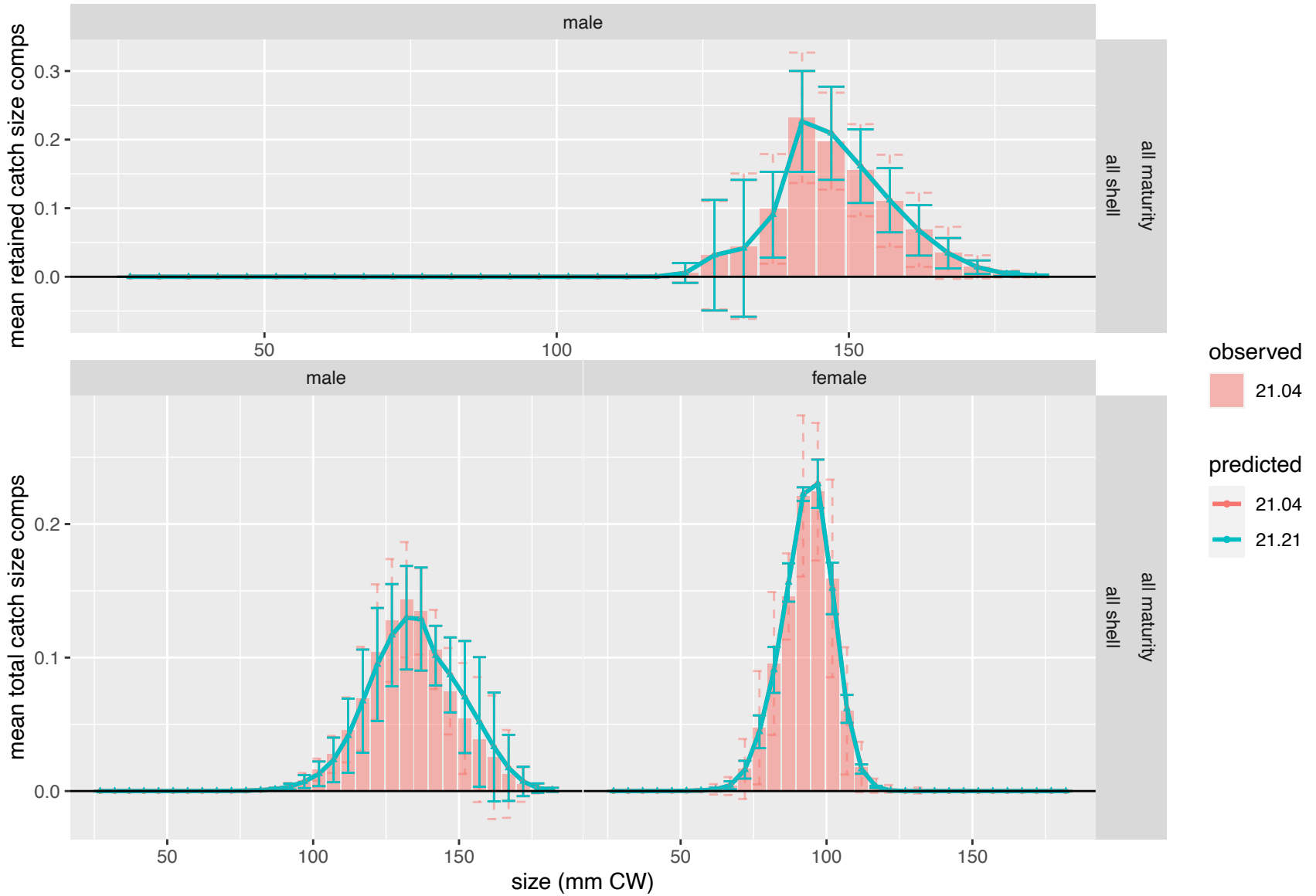

Figure 17. Fits to mean size compositions for retained catch and total catch size compositions in the directed fishery.

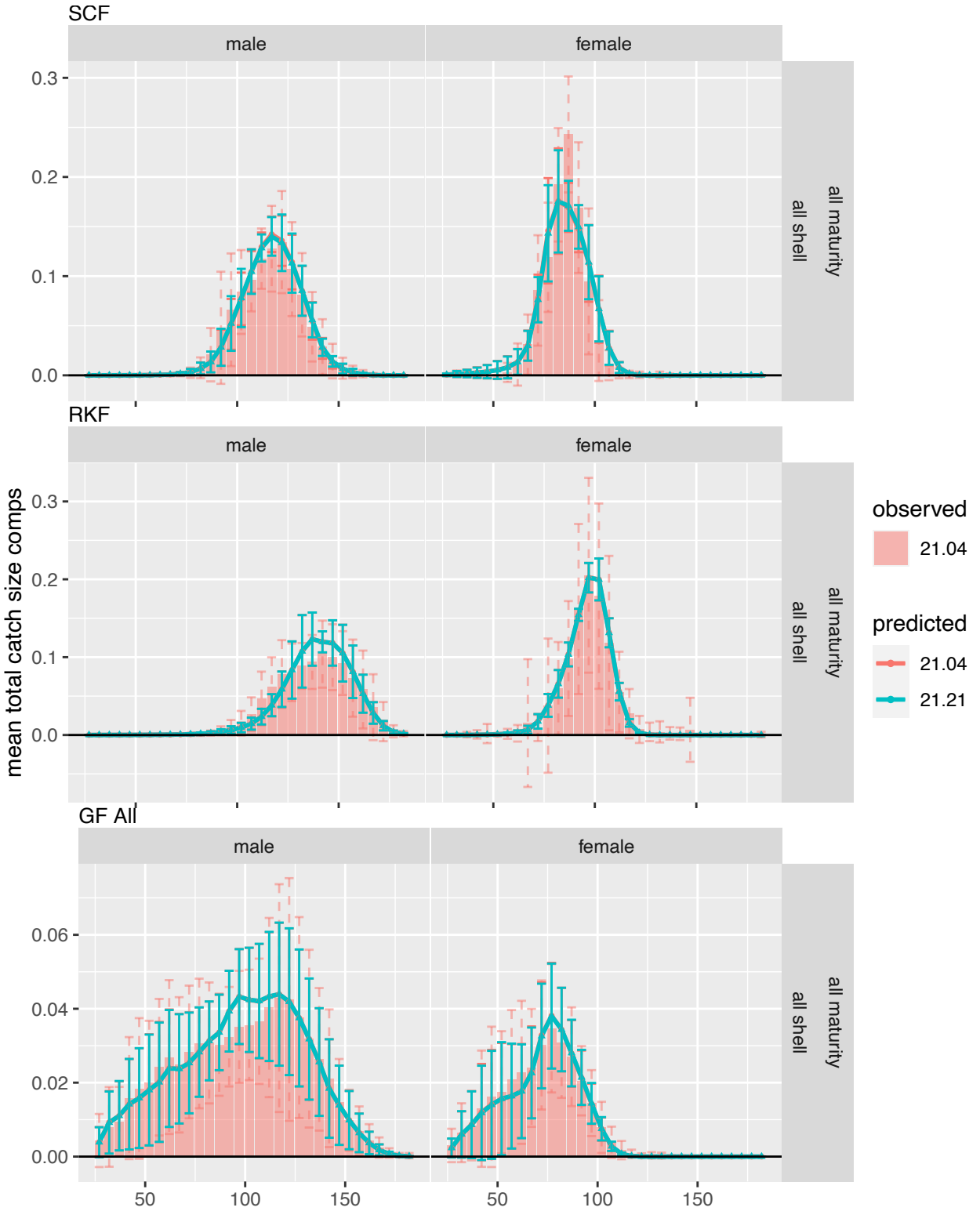

Figure 18. Fits to mean size compositions for Tanner crab bycatch in the snow crab ("SCF"), BBRKC ("RKF"), and groundfish fisheries ("GF All").

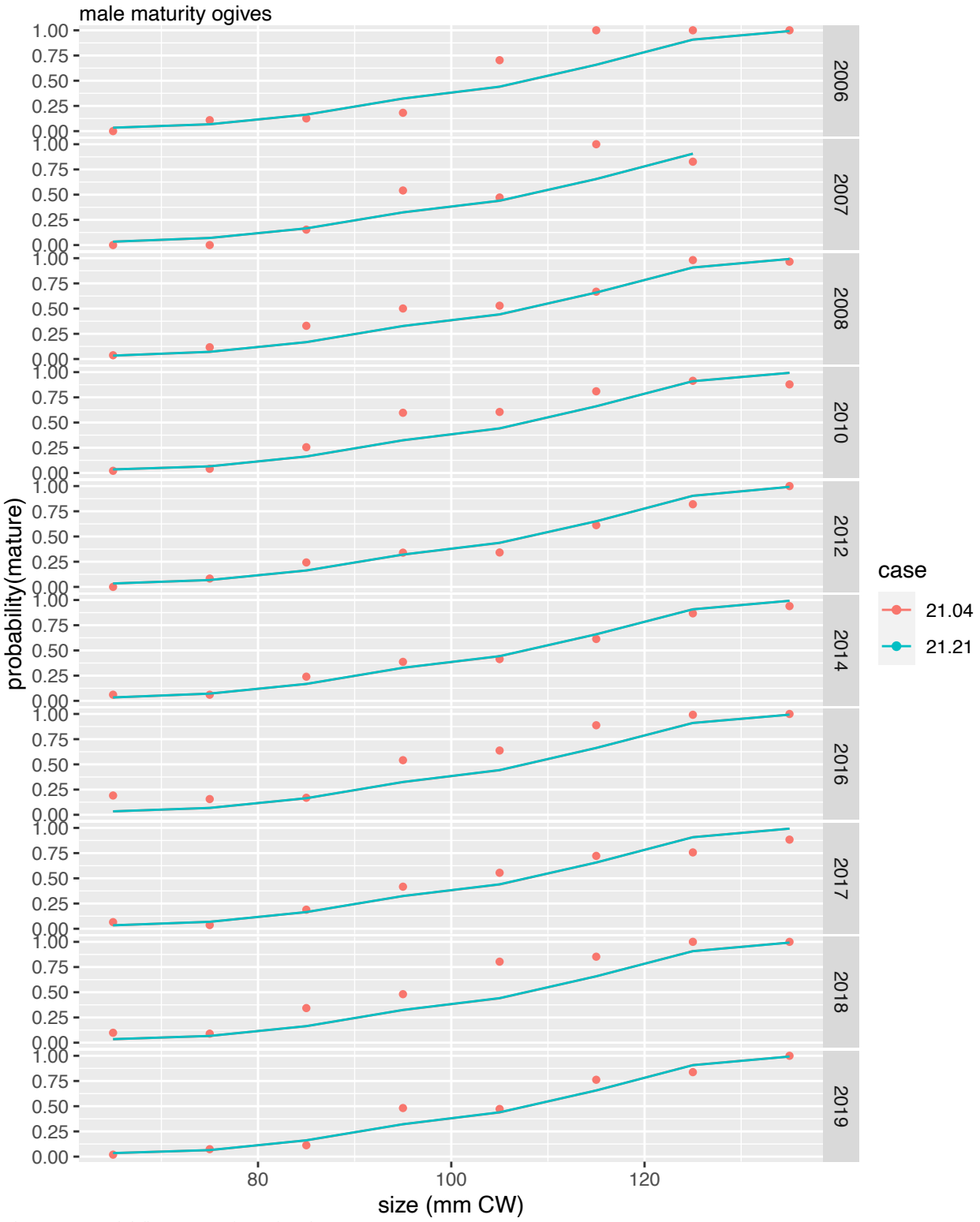

Figure 19. Model fits to maturity ogive data.

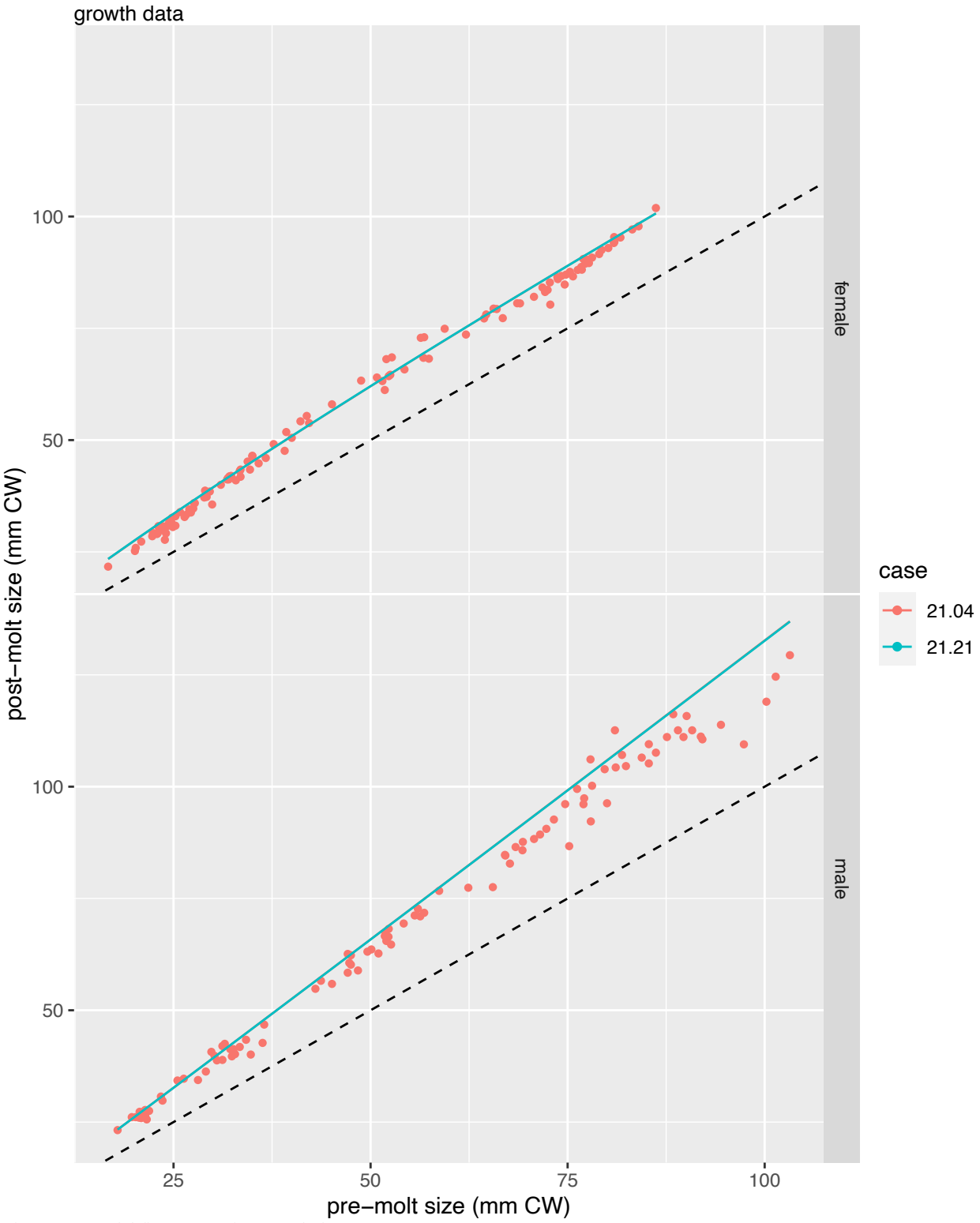

Figure 20. Model fits to maturity growth data.