Proposed Models for the 2024 Tanner Crab Assessment

William T. Stockhausen

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1 Introduction

The next assessment for Tanner crab will be reviewed by the Crab Plan Team (CPT) in September 2024 and the NPFMC's Science and Statistical Committee (SSC) in October 2024. The 2023/24 Tanner crab assessment model, referred to as "22.03b" using the SSC's model numbering protocol (Stockhausen 2023a), provides the base model for development and comparisons among the alternative Tier 3 models presented here. Of note, while 22.03b is based on the "bespoke" Tanner crab stock assessment modeling framework (TCSAM02, Stockhausen 2023b), several alternative models presented here are based on the GMACS modeling framework used in other crab assessments (e.g. Szuwalski 2023). These models represent the first time that GMACS models have been developed for Tanner crab and are responsive to the previous SSC comments "…support[ing] development of a parallel or simplified version of the Tanner crab assessment model in the GMACS platform."

This report is organized into the following sections: Responses to CPT and SSC Comments (Section 2), New Data and Analyses (Section 3), Assessment Model Descriptions (Section 4), TCSAM02 Proposed Model Results (Section 5), GMACS Proposed Model Results (Section 6), Summary (Section 8), and Acknowledgments (Section 9).

2 Responses to the most recent two set of SSC and CPT Comments

2.1 CPT Comments September 2023

2.1.1 CPT Comments (general)

The CPT recommends that all assessment authors document assumptions and simulate data under those assumptions to test the ability of the model to estimate key parameters in an unbiased manner. These simulations would be used to demonstrate precision and bias in estimated model parameters.

Response

May 2024: On the "to do" list.

2.1.2 CPT Comment

The CPT recommends that weighting factors be expressed as sigmas or CVs or effective sample sizes. The team requests all authors to follow the Guidelines for SAFE preparation and to follow the Terms of Reference as listed therein as applicable by individual assessment for both content and diagnostics.

Response

May 2024: These requests are generally followed, but the compressed time frame for SAFE preparation in the fall often precludes including analyses that require extended time frames e.g., MCMC evaluation).

2.1.3 CPT Comment

Authors should focus on displaying information on revised models as compared to last year's model rather than focusing on aspects of the assessment that have not changed from the previous year.

Response

May 2024: This is generally the case, except to highlight issues that remain unresolved from the previous assessment.

2.1.4 CPT Comment

The current approach for fitting length-composition data accounts for sampling error but ignores the fact that selectivity among size classes is not constant within years; a small change in the selectivity on small animals could lead to a very large change in the catch of such animals. Authors are encouraged to develop approaches for accounting for this source of process error. This issue is generic to assessments of crab and groundfish stocks.

Response

May 2024: Annual survey selectivity curves for the NMFS EBS shelf survey have been estimated using selectivity models derived from the BSFRF "side-by-side" selectivity studies. Several of the GMACS models presented in this report incorporate this source of variability.

2.1.5 CPT Comment

Authors are reminded that assessments should include the time series of stock estimates at the time of survey for at least the author's recommended model in that year.

Response

May 2024: This has generally been the case.

2.1.6 CPT Comment

Consider stepwise changes to data as individual model runs instead of changing multiple parameters at once so that changes in model performance may be attributed to specific data.

Response

May 2024: This has generally been the approach in presenting model results. the GMACS models presented in this report, however, represent enough of a "clean break" from the current assessment model that this incremental approach would have been extremely unwieldy (if not impossible) to implement.

2.1.7 CPT Comments (specific to assessment)

None.

2.2 SSC Comments October 2023

2.2.1 SSC Comments (general)

For the inclusion of trawl survey data, the SSC suggests crab assessment authors and the CPT be more explicit about best practices for which standard years are included for bottom trawl survey data. The SSC suggests that the years recommended by the Groundfish Plan Teams would be a good starting point, which specify using the following bottom trawl survey data years: - Aleutian Islands: 1991 - present (standard gear) - Eastern Bering Sea: 1982 - present (standard gear, grid, and design), 1987 - present for species that inhabit the northwest corner of the survey (which was added in 1987 for snow crab and walleye pollock)

Response

May 2024: As per every assessment since 2015, the current stock assessment model fits NMFS EBS bottom trawl survey biomass indices and size comps using crab-standardized stations starting in 1975. It estimates separate sex-specific parametric selectivity curves and fully-selected catchabilities for the 1975-1981 and gear-standardized 1982+ time periods. Alternative models such as the GMACS models considered in the May 2024 Tanner crab report have used only the 1982+ time period.

2.2.2 SSC Comment

Risk tables would be used to provide a more comprehensive, transparent, and defensible justification for CPT and SSC recommendations on ABC buffers.

Response

May 2024: a risk table will be included in the 2024 assessment.

2.2.3 SSC Comment

future BBRKC, Tanner and snow crab assessments routinely include a simple Tier 4 analysis that includes a smoothed time series of survey vulnerable biomass (legal size or smaller to accommodate discard mortality) using the REMA package and not adjusted for natural mortality. This model will provide a consistent alternative should the preferred Tier 3 approach fail in some way and also a point of comparison with Tier 3 and State methods used as a basis for TAC setting.

Response

May 2024: The SSC appears to have accepted the author's approach used in the 2023 assesssment. This will be repeated for 2024.

2.2.4 SSC Comment

include uncertainty intervals when showing time series of biomass/abundance estimated by the stock assessment models

Response

May 2024: This will be done for the 2024 assessment.

2.2.5 SSC Comment

The SSC suggests that the CPT and crab authors continue to evaluate whether VAST or similar approaches, when specified carefully for individual crab stocks (i.e., the choice of error distributions and number of knots) might provide more robust survey time-series

Response

May 2024: Previous reports have examined the use of VAST-derived time series for survey abundance/biomass and results from a GMACS model fitting to VAST-derived estimates are presented in the May 2024 Tanner crab report. Using the VAST estimates for the survey biomass time series results in poor model fits and model convergence issues.The VAST and design-based estimates are typically similar but differ mainly in the associated estimates of uncertainty. Thus, the ultimate effect of using the VAST estimates could be achieved heuristically simply by placing more emphasis on the survey indices relative to the fishery catch data than is currently done. However, the estimates themselves suggest that interannual changes in stock biomass much larger than the current model dynamics (constant M, constant probability of terminal molt, constant growth dynamics, constant survey selectivity and fully-selected catchability) can accommodate are credible and should be captured by the model. The introduction of more flexible, time-varying dynamics is the key to better fitting the survey indices (VAST or design-based), but to do so with regard to plausible mechanisms and drivers is an area of ongoing research.

2.3 SSC Comments (specific to assessment)

The SSC continues to support development of a parallel or simplified version of the Tanner crab assessment model in the GMACS platform, and the author's proposed development timeline in fall 2023.

Response

May 2024: Simplified versions of the Tanner crab assessment model using the GMACS framework are presented in the May 2024 Tanner crab report.

2.3.1 SSC Comment

The SSC appreciates the author's development of a simplified Tier 4 model for use as a backup in the event that extreme and insurmountable issues are encountered by the Tier 3 assessment model in the future. The SSC supports the structure of the Tier 4 model as presented, based on the estimate of vulnerable male crab biomass from the NMFS EBS bottom trawl survey and including the use of the coefficient of variation in projected biomass as a reasonable basis for defining the ABC buffer. With respect to the reference time period for calculating BMSY, the SSC concurs with the CPT recommendation to use the entire time series since 1982.

Response

May 2024: Results from this model will be updated for the 2024 assessment.

2.3.2 SSC Comment

Briefly summarize the history of the GOA Tanner crab fishery and stock dynamics, given the possible value of this information for the interpretation of BSAI Tanner crab stock dynamics.

Response

May 2024: Kally Spalinger (ADFG) and Nathaniel Nichols (ADFG) have provided the author with, respectively, data from the Kodiak Large Mesh Survey for Tanner crab and historical landings from GOA Tanner crab fisheries. A "history" has not yet been developed, but time series of abundance and landings are included in the May 2024 Tanner crab report. A preliminary comparison of survey abundnace trends suggests that recruitment in the GOA and EBS is correlated, but whether this is due to a direct linkage or simply environmental mediation is unknown.

2.3.3 SSC Comment

Consider directly incorporating annual molt to maturity data, as implemented in the EBS snow crab assessment, if sufficient data are available.

Response

May 2024: This suggestion is explored in several GMACS models presented in the May 2024 Tanner crab report.

2.3.4 SSC Comment

Consider using the Bering Sea Fisheries Research Foundation (BSFRF) survey data to inform selectivity and catchability, as implemented in the EBS snow crab assessment, as an alternative to fitting these data as a separate index.

Response

May 2024: The BSFRF data has been used to inform NMFS survey selectivity/catchability in several GMACS models presented in the May 2024 Tanner crab report.

2.3.5 SSC Comment

Explore what might be driving the residual pattern in the fit to the NMFS survey data.

Response

May 2024: Because recruitment is, too a large part, freely estimated, the residual patterns are presumably due to the constraints on the model dynamics imposed by 1) constant M and 2) constant growth dynamics, as well (possibly) as variability in weight-at-size.

2.3.6 SSC Comment

With respect to the spatial distribution of Tanner crab captured in the NMFS bottom trawl survey, the SSC appreciates the inclusion of Figures 38-42 which highlight both the large number of small male crab encountered in 2023 and the spatially expansive nature of that increase in CPUE. The SSC encourages exploration of differences in the spatial distribution of small male crab in the NMFS survey, to identify if the distribution of small crab encountered in 2003-2005 and 2008-2010, which successfully propagated to larger sizes, showed differences in habitat use compared with the cohort first observed in 2017-2019, which did not propagate to larger sizes.

Response

May 2024: This is an avenue for future research.

2.3.7 SSC Comment

Likewise, the SSC recommends that a comparison of environmental conditions experienced by small crabs during these periods may help to elucidate why some cohorts appear to propagate and others do not.

Response

May 2024: This is an avenue for future research.

2.3.8 SSC Comment

Fits to length composition data in the recent period remain a concern, exemplified by large negative residuals in length composition fits for the largest observed length bin in recent years and as a strong positive retrospective pattern in recruitment.

Response

May 2024: Large negative residuals in (male) size compositions continue to be a problem with this assessment. The residuals to the estimated mean post-molt size for large males are also (increasingly) negative with pre-molt size. This suggests that something else in the data is forcing male crab to grow to sizes inconsistent with the molt increment and size composition data. Potential sources for this include a biased size-weight regression used to convert abundance to biomass and biased probabilities of terminal molt and suggest avenues for future research.

2.4 CPT comments May 2023:

2.4.1 CPT Comments (specific to assessment)

The CPT commends the author for the large amount of exploration and work done on model runs and recommends that the author bring forward model 22.03b as the base model for specifications in the fall.

Response (9/23)

Done.

2.4.2 CPT Comment

The CPT encouraged the author to bring forward in September the Tier 4 option that was decided upon at the simpler modeling workshop. This involved using smoothing of the area-swept MMB estimates and applying F = M for OFL determination. There was discussion upon which set of years to use for setting status determination using this method, and CPT members suggested reviewing the last accepted Tier 4 model – i.e., before the Tier 3 model was accepted – for reasoning as to the years that were used for status determination at that time.

Response (9/23)

Done.

2.5 SSC comments June 2023:

2.5.1 SSC Comment (general)

The SSC highlights that the estimation of unrealistically high instantaneous fishing mortality rates appears to be an emergent property of several crab assessments…These estimates result in ABC recommendations that would remove virtually all legal sized crab from the population. The SSC encourages collaboration among assessment authors to identify the root causes of this common issue and potential solutions and suggests potentially using a hypothesis driven approach…a high priority topic for the crab modeling workshop planned for January 2024.

Response (9/23)

The root cause of ABC recommendations that would remove all legal-sized crab is the combination of an industry-preferred size larger than the average size at maturity, and an SPR-based harvest control rule. Mature males smaller than the industry-preferred size form a "pool" protected from exploitation. As the separation between industry-preferred size and average size of mature males increases, the more the biomass in this protected pool increases relative to unfished biomass and the less is needed in the vulnerable pool of large males to achieve 35% of unfished MMB. The consequence is that the F_{OFL} calculation results in higher and higher F's on industry-preferred males. For king crab, which do not undergo terminal molt, crab in the protected pool will eventually grow into the vulnerable pool–which somewhat reduces the estimated F's. For opilio and bairdi, because they undergo terminal molt, mature males under the industry-preferred size will never grow out of the protected pool of biomass–thus increasing the estimated F's over what they would be for species with similar population characteristics that did not undergo terminal molt.

2.5.2 SSC Comment

The SSC recommends that when "fallback" Tier 4 alternatives are provided, as recommended by the crab Simpler Modelling Workshop, plots that compare the OFLs predicted by the existing status quo Tier 3 model against the OFLs recommended by Tier 4 models for previous years be included.

Response (9/23)

The Tier 4 model does not estimate OFLs for "previous years", which would require developing a retrospective analysis capability. If this is a priority, it could be addressed in the future.

2.5.3 SSC Comment (general)

In addition, when estimating biomass for Tier 4 models, the SSC recommends that the authors base these on the whole time series or develop justification for a better time block that represents current fishing potential for the stock.

Response (9/23)

Results for B_{MSY} calculated using several alternative time blocks are presented.

2.5.4 SSC Comment (general)

The SSC also recommends that, for "fallback" Tier 4 models, the authors and CPT recommend an appropriate ABC buffer.

Response (9/23)

The author recommends using the cv for terminal year survey biomass from the random walk model as a basis for the ABC buffer. The final value could be based on a P*-like calculation or directly as a fractional buffer (i.e., $ABC = (1 - cv) \cdot OFL$).

2.5.5 SSC Comment (specific)

The SSC reiterates its support for transitioning this model, or a simplified version thereof, into the standardized GMACS platform. The SSC feels that transitioning this assessment into GMACS is a higher priority at this point than continued exploration of model alternatives (e.g. 23.02, 23.05) within the existing framework. The SSC further reiterates its recommendation from October 2022 that the GMACS implementation of the Tanner crab model could represent a simplified version of the current model structure, as a foundation upon which additional features may be explored and incorporated sequentially.

Response (9/23)

Transitioning the assessment to GMACS is the top priority for development in Fall, 2023.

2.5.6 SSC Comment(specific)

The SSC requests that a clear justification for the choice of Tier 4 fallback reference time period be provided in the September SAFE document, beyond simple precedent, and that several alternative time periods be considered (each with its own justification).

Response (9/23)

Several time blocks were considered for the Tier 4 averaging time period used to calculate B_{MSY}. Justification for using each is discussed.

2.5.7 SSC Comment (specific)

The SSC concurs with the CPT that continued exploration of constrained time-varying natural mortality may be appropriate, when paired with external estimation of growth and use of BSFRF data to inform priors on selectivity. This may represent a suitable balance in terms of the added complexity of time-varying natural mortality, against reductions in the complexity of growth and selectivity estimation. However, the SSC recommends that these explorations be conducted using a GMACS version of the assessment model, when successfully implemented.

Response (9/23)

Noted.

2.6 CPT comments September 2022:

2.6.1 CPT Comment (specific)

The author identified several avenues of research to be pursued in the coming year, including: transitioning to GMACS, completing the BSFRF/NMFS survey selectivity analysis, exploring time-varying natural mortality, investigating non-parametric approaches to selectivity, and a more thorough evaluation of a model that starts in 1982. The CPT was supportive of these pursuits.

Response (9/23)

Models that investigated time-varying M were presented at the May, 2023 CPT meeting. Completing the survey selectivity analysis awaits acquisition of the 2018 BSFRF survey data. Transitioning to GMACS will be top priority following the 2023 assessment; other areas for investigation will be lower priority.

2.6.2 CPT Comment (specific)

Show plots for jitter analyses that could demonstrate (or rule out) bimodality in management quantities (the author noted that the models presented converged to the MLE over 50% of the time in 800 jitter runs, but diagnostic plots were not presented).

Response (9/23)

A figure representing jitter diagnostics is presented for Model 22.03b.

2.6.3 CPT Comment (specific)

Provide a plot of the fits to male and female components separately when they are fit in an aggregated fashion (as in 22.03). Are the fits to either sex substantially degraded?

Response (9/23)

Although this is a reasonable idea, it is currently not possible to provide such a plot.

2.6.4 CPT Comment (specific)

Provide some discussion as to why there was an exceptionally small retrospective pattern in spite of the issues with recruitments that appear and then do not propagate through the population.

Response (9/23)

The small retrospective pattern was with respect to MMB, while the pattern for recruitment was much larger. The larger retrospective pattern for recruitment occurs exactly as a result of the apparent recruitment events disappearing (new data reduces the estimated size of recruitment in any particular year). The small retrospective pattern for MMB is a result of the estimated model dynamics that extend over many cohorts and "damp out" patterns seen in the small size classes in order to better fit patterns seen in the larger size classes. The model places much more emphasis on fitting large size classes better because it fits to survey and fishery *biomass* time series, not abundance time series.

2.6.5 CPT Comment (specific)

Continue to explore ways to eliminate the overestimates of large crab (the interplay between growth estimates and non-parametric selectivity might be a useful avenue to explore)

Response (9/23)

This suggestion will be explored as part of building a GMACS Tanner crab model.

2.7 SSC comments October 2022:

2.7.1 SSC Comment (general)

The SSC supports the CPT plans to discuss appropriate model start dates as well as reference periods for B_{MSY} (e.g., SMBKC and PIRKC) at their January 2023 meeting to provide guidance to stock assessment authors. The SSC recommends that the CPT explore a consistent approach across all EBS stocks to use trawl survey data after 1982 when gear and sampling designs were more standardized

Response (9/23)

See Section 2.9.1.

2.7.2 SSC Comment (general)

The SSC encourages crab authors to continue to move as much of the research and model development as possible to earlier in the year, as this would streamline reviews in the fall and facilitate the use of VAST models and inclusion of Northern Bering Sea (NBS) survey data into crab assessments.

Response (9/23)

Almost all Tanner crab model development occurs between October following the SSC meeting and the subsequent May CPT meeting.

2.7.3 SSC Comment (general)

The SSC encourages further considerations or ideas on potential cooperative pot surveys for different crab stocks.

Response (9/23)

This seems like a potential topic for the January CPT meeting.

2.7.4 SSC Comment (general/specific)

The SSC suggests that fitting a range of simpler models and data limited approaches, such as the Tier 4 calculation, can also provide insight into the differences between raw survey observations and integrated assessment model output…The SSC recommends a working group to address the use of simpler models for at least snow crab, Tanner crab and BBRKC.

Response (9/23)

The suggested working group was convened in March, 2023 at the AFSC. Methodology for and results from a "fallback" Tier 4 model for Tanner crab are presented.

2.7.5 SSC Comment (general)

The SSC recommends the formation of a working group to develop a framework for how to estimate the magnitude of unobserved mortality for crab stocks and how these estimations may be utilized in BSAI crab stock assessments.

Response (9/23)

The working group has been formed; meetings are scheduled for October.

2.7.6 SSC Comment (general)

The SSC recommends that all crab authors plot length compositions over years with the most recent year at the bottom of the plot.

Response (9/23)

Not yet addressed.

2.7.7 SSC Comment (specific)

The SSC highlights the following areas as highest priority for the Tanner crab assessment: 1) transition the Tanner assessment model to GMACS; 2) the investigation of model outputs that better inform State management, especially males of industry-preferred size to ensure proper scaling; 3) The SSC suggests fitting a range of simpler models or data limited approaches;

Response (9/23)

For 1), transition to GMACS will be given the highest priority following the October SSC meeting. For 2), State management occurs on a two-area basis while the assessment model is area-aggregated (a "fleets-as-areas" model incorporating area-specific considerations was previously investigated but fitting the area-specific data was problematic). The correct scaling of (area-aggregated) industry-preferred male abundance in the assessment model depends on correctly estimating survey selectivity and catchability, growth, terminal molt, and natural mortality simultaneously, but this remains problematic due to parameter confounding among these processes. For 3), a Tier 4 model was developed and results are presented in this assessment.

2.7.8 SSC Comment (specific)

The SSC recommends that the CPT review the assessment frequency (see also Stock Prioritization section) for Tanner crab and provide the SSC their recommendation.

Response (9/23)

An issue for the CPT, but noted here.

2.8 CPT comments May 2022:

2.8.1 CPT Comment (specific)

Four models are requested by the CPT for the September CPT meeting: 1) Model 22.01: Base model from last year updated with new data; 2) Model 22.03: updated bycatch estimates for the groundfish fisheries, and fitting to fishery aggregate biomass; 3) modified model 22.06a: Initial size composition in 1982 with a smoothing weight of 0.1, and initial composition parameters estimated on a logit scale, but also including the features of model 22.03; and 4) modified model 22.06a as described above plus bootstrap estimates of input sample sizes.

Response (9/22)

All requested models were implemented and results are provided in this assessment. The latter two models were numbered as 22.07 and 22.08 because they differ from models presented in May.

2.8.2 CPT Comment (specific)

The CPT also encourages Buck to continue exploring alternative approaches to incorporating the BSFRF survey data in the assessment, attempting to model the ADF&G management areas as separate fisheries, and to continue making progress on a GMACS implementation for Tanner crab.

Response (9/23)

These continue to be areas of active investigation. Implementing a Tanner crab model in GMACS will be given the highest priority following the 2023 assessment.

2.9 SSC comments June 2022:

2.9.1 SSC Comment (general)

The SSC suggests that the CPT develop guidelines for when to change model start dates. Both BBRKC and Tanner crab assessment authors proposed changes to model start dates with similar, but not identical rationales. While changing start dates may lead to improved model fits to available data and allow for reduced model complexity in terms of removing time blocks for natural mortality or other parameters, there is a potential to lose historical context or the ability to better understand what might have caused model difficulties or demographic changes (e.g., increased mortality events). Thus, the overall goal of these guidelines would be to ensure a full discussion and consistent criteria be applied for proposed changes across stocks into the future. The SSC recommends that these guidelines for start date changes should consider data availability, model complexity, impacts to estimates of the average level and variation in recruitment, loss of historical context and perspective on natural mortality changes and how this would impact short and long-term projections for stock dynamics.

Response (9/23)

The CPT discussed developing general and consistent guidelines on changing model start date at its January 2023 meeting. The issues discussed were very stock-specific and the CPT was unable to make any firm recommendations on general guidelines.

2.9.2 SSC Comment (specific)

Even though the estimation of input sample sizes did not perform as expected (it produced even higher sample sizes than default values in the base model), the SSC supports the CPT recommendation to revisit this approach with the revised start date (1982).

Response (9/22)

Model 22.08 addresses this request, but results remained problematic. The author notes that multinomial likelihoods were used in fitting this model and that it should be reconsidered using the Dirichlet-multinomial likelihood.

2.9.3 SSC Comment (specific)

The SSC commends the authors for proposing two models (22.01 and 22.03) with no parameters hitting bounds and the remaining models having only two or three parameters at bounds (depending on smoothing). The SSC recommends continued efforts to examine and address the remaining parameters that are still estimated at their bounds.

Response (9/22)

The author appreciates the SSC comment and notes that remaining parameters at bounds involve limits on selectivity-related parameters reflecting knife-edge like selectivity patterns (e.g., retention functions) or full selected sizes that would go beyond observed sizes in the data. Implementation of a well-behaved bounding function is an area of active (although incomplete) research.

2.9.4 SSC Comment (specific)

The SSC supports CPT recommendations to continue exploring alternative approaches to incorporating the BSFRF survey data in the assessment, attempting to model the ADF&G management areas as separate fisheries, and to continue making progress on a GMACS implementation for Tanner crab. However, the SSC recognizes that there may be benefits of waiting until additional improvements in GMACS occur, specifically the adoption of a GMACS model for snow crab.

Response (9/22)

GMACS models for snow crab have now been adopted, so development of a GMACS version of the Tanner crab model is underway. The SSC's other recommendations are appreciated and the author notes that these are active areas of research.

2.9.5 SSC Comment (specific)

The SSC also suggests that the CPT develop guidelines for changing model start dates. Both BBRKC and Tanner crab assessments proposed changes to their starting dates with similar rationales. Please refer to the General Comments for Crab Assessment Authors section above for a more detailed SSC recommendation.

Response (9/22)

See Section 2.9.1.

2.10 CPT comments January 2022

2.11 SSC comments February 2022

2.11.1 SSC Comment (general)

The SSC supports the CPT general recommendations that all stock assessments include results from the currently accepted model with new data (base model) so that changes in model performance can be assessed. Values for management-related quantities for all models that may be recommended by the CPT or SSC should also be available.

Response (9/23)

The author's preferred model, 22.03b (and the only Tier 3 model evaluated for this assessment) is essentially identical to the model from last year's assessment (22.03). Consequently, results are compared between 22.03b with data updated for 2023 and results for 22.03 from last year's assessment.

2.11.2 SSC Comment (general)

The SSC supports the CPT's proposed changes to the terms of reference for SAFE chapters for BSAI crab stocks, including efforts to clarify and standardize summary tables that include management performance, status, and catch specifications. Specifically, summary tables in the main body of a SAFE chapter for a given stock will provide information for each model run. In addition, the SSC recommends that the executive summary of the SAFE chapter will provide information for the author recommended model only and the BSAI Crab SAFE Introduction Chapter will provide information for the CPT recommended model, specifying if that differs from the author-recommended model. The SSC references its recommendation from December 2021 that assessment authors do not change recommendations in documents between the Plan Team and the SSC meetings and that deliberations and disagreements over assessment and other recommendations be documented in the Plan Team minutes. This ensures that changes between author recommendations and Plan Team recommendations are clearly documented and easily tracked.

Response (9/22)

Noted.

2.11.3 SSC Comment (general)

The SSC also appreciates the CPT's discussion regarding efforts to develop a standardized table and figure output for all SAFE chapters and encourages coordination with Groundfish Plan Teams to, as much as reasonably possible, strive for consistency, standardization, and reproducible documentation across all stocks.

Response (9/22)

Standardization with other stocks will probably remain an issue until the assessment is converted to GMACS. Candidate formats for standardized tables and figures have been developed that GMACS models could implement, if found useful.

3 New Data and Analyses

3.1 BSFRF/NMFS 2018 Cooperative EBS Trawl Survey Selectivity Study Data

BSFRF and NMFS conducted a series of cooperative side-by-side (SBS) trawl studies from 2013 to 2018 to better understand the size-specific selectivity of the NMFS 83-112 bottom trawl gear used in the annual AFSC Eastern Bering Sea shelf bottom trawl survey (NMFS EBS survey) for BBRKC and Tanner crab. The studies consisted of paired-tow hauls conducted at a subset of the standard NMFS EBS survey stations. At each SBS station, the NMFS vessel towed its 83-112 bottom trawl gear as per EBS survey standards (e.g., typically 30-minutes at 1-2 kts; (R. R. Lauth and Conner 2019)) while a BSFRF-chartered vessel towed a nephrops bottom trawl along a parallel path for 5 minutes displaced approximately 1 km from the NMFS tow path. The BSFRF nephrops gear is assumed to have caught all crab within its tow path on each haul (Somerton et al. 2013), thus providing an absolute estimate of local size-specific abundance of crab for comparison with the catch by the NMFS gear and allowing estimation of the size-specific catchability of the NMFS gear on a per-haul basis. The haul-level catch can also be scaled up by gear type to provide absolute (BSFRF) and relative (NMFS) estimates of size-specific abundance/biomass across the area surveyed each study year. Catch data for the BSFRF gear from the 2013-2017 studies was provided to the author in 2018, from which annual estimates of absolute abundance/biomass and size compositions were calculated using standard design-based methods and first incorporated into the Tanner crab assessment in 2018 (Stockhausen 2018). In December, Scott Goodman (BSFRF, NRC) provided an updated dataset for the BSFRF haul-level catch data that included results from the 2018 study and some minor "cleaning" of the 2013-2017 dataset. This dataset was used to inform the selectivity study reported here (Section 3.1), the results of which are used in several of the GMACS models presented in this report (Section 4.4). These data were also used to update the BSFRF catch biomass and size composition data used in the assessment in the alternative TCSAM02 models discussed herein (Section 4.2).

Standard design-based methods (Wakabayashi et al. 1985) were used to expand the haul-level catch data to survey-wide estimates of sex-specific Tanner crab stock abundance, biomass, and size compositions within the SBS study areas, which were smaller than the complete EBS shelf survey area and varied with study year (moving progressively westward from within Bristol Bay in 2013 to the middle and outer shelf in 2018; Figure 1). The minor "cleaning" of the original 2013-2017 dataset had minimal impact on the estimates of expanded stock biomass, with only small differences in 2017 evident for male and mature female stock biomass estimates (Figure 2) and size compositions (Figures 3 and 4).

3.2 Empirical Availability for the SBS Studies

The indices and size compositions from the BSFRF SBS studies discussed in the previous section provide information on Tanner crab stock abundance and composition in addition to that provided by the NMFS EBS bottom trawl survey but, while the NMFS surveys cover the entire EBS Tanner crab stock area, the BSFRF surveys only cover parts of the stock area. To be fit in the assessment model, the "availability" of the stock to the BSFRF survey gear needs to be determined in order to scale the predicted population size from the stock area to the area covered by the survey. The availability of the population in a given area, $A_x(z)$, is a sex-specific function of crab size because Tanner crab of different sexes and sizes typically have different spatial distributions. Because the NMFS surveys cover the entire stock area, the availability in area a in year y can be estimated from the ratio of the size compositions in area a to those from the total area derived from the NMFS survey in year y as:

$$A_x(z) = \frac{N_x^a(z)}{N_x^t(z)} \tag{1}$$

where a and t denote the SBS study area and the full survey area, respectively. For the 2013-2018 SBS studies, this resulted in the "raw" availability curves shown in Figures 5 and 6 (similar curves for the 2013-2017 dataset are almost identical).

The availability curves used in the assessment model are "smoothed" estimates of the raw results. For the 2013-2017 dataset, the raw results were fit by sex with generalized additive models (GAMs) using the *mgcv* package from R (Wood et al. 2016; R Core Team 2022) with a normal error distribution and log link using the model

$$log(A_{y,z}) = s(z, by = y) \tag{2}$$

where SBS survey year (y) was treated as a "by" variable. The 2013-2018 dataset was also fit on a sex-specific basis, but the GAMs were fit assuming a binomial error distribution with a logistic link

$$\frac{log(A_{y,z})}{log(1 - A_{y,z})} = c_y + s(z, by = y) \tag{3}$$

and weighted by $N_x^t(z)$. The estimated smooth curves from both datasets are compared in Figures 7 and 8. The resulting curves are quite similar to each other except at the largest crab sizes where there is little support from the raw estimates.

3.3 Empirical probability of terminal molt

Undergoing the terminal molt to functional maturity is one of the key biological processes Tanner (and snow) crab undergo. Consequently, it is a very important process to capture accurately in the assessment model. In the current assessment model framework (TCSAM02), the estimated probability of terminal molt is a function of *pre-molt* size: thus, whether an immature crab undergoes terminal molt is determined before it grows (i.e., molts). This process is not observed directly and estimating the probability of undergoing terminal molt is an emergent property of the assessment based on predicting the post-molt size distributions of immature and mature new shell crab resulting from maturation followed by growth. In GMACS, in contrast, the estimated probability of terminal molt is based on the *postmolt* size: thus, whether an immature crab molted to maturity is determined after growth occurs.

An empirical estimate for the probability of an individual crab *having undergone* terminal molt as a function of its postmolt size, $prTM(z)$, is given by the size-specific ratio of the abundance of new shell mature crab to all new shell crab:

$$prTM(z) = \frac{N_M(z)}{N_M(z) + N_I(z)} \tag{4}$$

where z is postmolt size (i.e., carapace width), N_M is the number of new shell mature crab, and N_I is the number of new shell immature crab. This estimate is independent of survey catchability if catchability is the same for immature and mature crab of the same size. This estimate is reasonably straightforward from survey data for female Tanner crab because maturity is easily determined morphologically. It is less straightforward for male Tanner crab because maturity must be determined statistically through a size-specific discriminant analysis of chela height-to-carapace width (CH-CW) ratios. However, once the analysis determines the fraction of new shell mature males relative to all new shell males (i.e., those that underwent molting), the estimate is the same.

For females, annual estimates of the empirical probability of having undergone terminal molt were obtained from NMFS EBS shelf bottom trawl survey data using Equation 4 with design-based estimates of new shell mature and immature mature crab calculated by 5-mm CW size bin (Figure 9). For males, while carapace width measurements were taken on all sampled males, chela heights were only taken during surveys conducted in 1990-2012, 2014, and 2016-2023 (and the 2020 survey was not conducted). Thus, annual estimates are unavailable for some years in the 1982-2023 time period. For years when chela heights were taken, Jon Richar (AFSC) estimated annual maturity ogives for males from distributions of CH-CW ratios by 10-mm CW size bin (see Richar and Foy 2022). These were linearly interpolated to 5-mm CW size bins for use in GMACS models (Figure 10). Sex-specific mean curves (black lines in Figures 9 and 10) were obtained by simple averaging over time and used as estimates for both sexes for 2020 when the survey was not conducted and for males for years when chela height measurements were unavailable.

3.4 VAST biomass indices

Jon Richar (AFSC) provided new model-based biomass time series to the author for Tanner crab from the NMFS EBS bottom trawl survey for 1982-2023 using the Vector-Autoregressive Spatio-Temporal (VAST) R package (R Core Team (2022)). Time series were provided for all males (maturity undetermined), immature females, and mature females. These VAST-based indices provide an alternative to the design-based survey indices that have been used in past assessments. While using VAST does not eliminate the need to correct for survey catchability when fitting the survey indices in an assessment model, its use typically results in increased precision in the estimates of survey biomass over that of standard design-based calculations. A number of groundfish assessments incorporate VAST indices into their assessment frameworks. However, previous attempts to fit VAST-based indices in the Tanner crab assessment using the TCSAM02 framework have not been satisfactory (e.g., Stockhausen 2023c) and incorporating VAST-based indices into the assessment has remained an issue for further research.

For Tanner crab, the model-based survey biomass indices using VAST have smaller cv's than those from standard design-based methods, while the estimated mean values are typically very similar (Figures 11 and 12, Table 1).

3.5 Empirical NMFS Survey Catchability Functions

Empirical estimates for sex/size-specific catchability of Tanner crab in the NMFS EBS shelf bottom trawl survey were developed from the paired-haul selectivity analysis for Tanner crab conducted using the BSFRF and NMFS side-by-side (SBS) studies conducted during 2013-2018 (Stockhausen, in prep.). In that analysis, smooth functions of size, depth, temperature, and sediment characteristics were fit to the ratio of size-specific abundance caught by the NMFS gear to that caught by the BSFRF gear on a paired-haul basis. The resulting functions allow one to predict the vulnerability of Tanner crab, $V_{h,x}(z, e_{1,h}, e_{2,h}, ...)$ to the NMFS gear on a sex- and size-specific (x and

z, respectively) basis for a given haul h given values for the haul-associated environmental variables ($e_{1,h}, e_{2,h}, ...$) that were found to be informative in the analysis. Annual sex- and size-specific catchabilities for the NMFS survey (i.e., across all hauls conducted in a given survey year) were then estimated as a weighted average over hauls as (dropping the "x" notation):

$$c(z) = \frac{\sum_h w_{h,z} \cdot V_h(z, e_{1,h}, e_{2,h}, ...)}{\sum_h w_{h,z}} \tag{5}$$

where the weights $w_{h,z}$ were set to:

$$w_{h,z} = \frac{N_{h,z}}{\sigma_{h,z}} \tag{6}$$

where $N_{h,z}$ is the observed abundance-at-size of crab on haul h in size bin z and $\sigma_{h,z}$ is the standard error of $V_{h,x}(z, e_{1,h}, e_{2,h}, ...)$. The size-specific weighted standard deviations from the estimated annual catchability curve were used as estimates of the associated size-specific uncertainty. The overall mean sex/size-specific catchability curves for the 1982-2023 survey time period were also calculated.

The annual estimates for males and females exhibit shapes that are approximately logistic in nature, but with some suggestion of a descending trend at large size (Figures 13 and 14), although this may be an artifact of smaller sample sizes. In addition, the curves for males exhibit a slight "wiggle" between 80 and 120 mm CW whereas the curves for females do not. Values at full selection were consistently smaller for females than males (Figure 15), with values from the mean catchability curves of 0.1628003 and 0.4178859 respectively.

For use in the GMACS model runs (Section 4.4), the annual and mean catchability curves were extended from the largest sizes for which estimates existed to the largest size bin in the model using the estimate from the largest "observed" size bin.

3.6 GOA Tanner crab trends

Following the 2023 Tanner crab stock assessment, the SSC requested that the author "Briefly summarize the history of the GOA Tanner crab fishery and stock dynamics, given the possible value of this information for the interpretation of BSAI Tanner crab stock dynamics." Kally Spalinger (ADFG) provided the author with data for Tanner crab abundance from ADFG's Large-Mesh Bottom Trawl Survey of Crab and Groundfish in Kodiak, Chignik, the South Peninsula, and the Eastern Aleutian Management Districts for 1988-2023 on a per-haul basis. Nathaniel Nichols (ADFG) provided the author with Tanner crab harvest data from seven Tanner crab fisheries in the GOA. This report provides only a preliminary response to the SSC request: a more detailed review of the GOA Tanner crab fisheries and stock dynamics is in preparation but its completion is regarded (without further direction) as a lower priority relative to GMACS model development.

3.6.1 Kodiak Large-Mesh Bottom Trawl Survey Results

Estimates of total survey abundance in the Kodiak District (i.e., expanded to the survey area but uncorrected for gear selectivity/catchability) from 1988-2023 were obtained from Table 4 in Spalinger and Silva (2024) for juvenile females, mature females, total females, males <70 mm CW, males 70-91 mm CW, males 92-114 mm CW, males >114 mm CW, recruit males, postrecruit males, mature males, legal males, total males, and total crab.

Time series estimates of total NMFS EBS survey abundance from 1988-2023 for immature females and mature females are compared from the two areas are compared in Figure 16. Time series estimates for different size classes of males from the two areas are compared in Figure 17. Starting in 2000, the time series for immature females and males < 70 mm CW show a strong degree of synchrony between the two areas whereas the other population categories exhibit much less. Cross-correlation of the time series between the Kodiak District and the EBS (Figures 18, 19, and 20) indicates that the time series for immature females and males < 70 mm CW are significantly correlated between the areas at zero time lag, whereas the other population categories are not significantly correlated between the two areas. This raises the intriguing possibility that recruitment may be correlated across the two areas. One possible mechanism for correlated recruitment across the two areas would be the existence of large scale environmental forcing that affected hatching/settlement/early benthic juvenile success. Another possible mechanism is that the two areas are demographically linked: given the dominant current flow along the Alaska Peninsula and through the Aleutian passes, recruitment in the Bering Sea could be augmented by export of larvae from the Kodiak stock. Of course, these are simply highly speculative suggestions at this point.

3.6.2 Historical catch comparisons

Trends in Tanner crab harvests from the Chignik, Kodiak, South Peninsula, Yakutat, and Southeast Alaska Districts are illustrated in Figures 21-23. The Chignik, Kodiak, and South Peninsula Districts are part of ADFG's Registration Area J, also to referred to as the Western Region, of which the EBS management areas are also in. Harvest statistics were also provided for the Cook Inlet and Prince William Sound areas but are not shown in the figure because these were available for only one year (2020) since 1994 in either area. The trends are generally punctuated by high variability and relatively short-lived booms followed by small harvests or closures for several years. There appears to be little coherence between catch levels in the EBS and GOA areas, although there seems to be some coherence between catch levels in Chignik, Kodiak, and the Alaska Peninsula since 2000 (Figure 23). Harvests in the Southeast District appear to be the most stable among the GOA areas, at least since 2000 when the data provided by ADFG starts.

4 Assessment Model Descriptions

4.1 The 2023/24 Assessment Model

The 2023/24 Tanner crab assessment model (Stockhausen 2023a), referred to as "22.03b" using the SSC's model numbering protocol, is an integrated assessment model based on a stage/size-structured population dynamics model that incorporates sex, shell condition, and maturity as different categories into which the overall stock is divided on a size-specific basis. The model is fit to indices of stock biomass from the NMFS EBS shelf survey and BSFRF side-by-side (SBS) selectivity studies, retained catch, total catch (retained catch + discarded bycatch), size compositions, molt increment data, and male maturity data. Parameters are estimated by minimizing a quasi-Bayesian/negative log-likelihood objective function, with priors and/or penalties placed on a number of parameters (Stockhausen 2023a). The model uses the TCSAM02 modeling framework, which is similar to the more generic GMACS modeling framework, but was developed specifically for *Chionoecetes* crab (the reader is referred to (Stockhausen 2023b) and the GitHub repository for specific details on TCSAM02). Tables 2-6 summarize specific details of 22.03b. In total, the model estimated 354 parameters describing population processes (recruitment, natural mortality, growth, and maturation), fishing mortality from four fisheries, and indices from two surveys (Figure 25).

The model tracks size-specific abundance by sex, maturity state (immature, mature), and shell condition (new shell, old shell). Most biological processes are sex-specific (Tables 2 and 3). Immature crab molt and grow on an annual basis in the spring based on an estimated growth transition matrix. Immature crab may also undergo a terminal molt to maturity, at which point growth stops. The sex-specific probability of undergoing terminal molt depends on pre-molt size (in contrast to GMACS, where it depends on post-molt size). Natural mortality is modeled as sex/maturity-state-dependent. Natural mortality rates are estimated in two time blocks, but estimated growth and the probability of undergoing terminal molt apply to the entire model time period (Figure 25). Sex-specific weight-at-size is determined outside the model and used to convert numbers to biomass. The model starts in 1948 and builds up the population size structure over time through estimates of annual recruitment. Annual recruitment is estimated as ln-scale deviations from longterm means separately for two time blocks, an initial start-up period (1948-1974) and the remainder of the model period. No stock-recruit relationship is assumed.

Fishing mortality in the directed Tanner crab fishery includes retained catch of legal-sized males and discard mortality on all other crab (males and females) caught (Table 4). Discard mortality (with assumed rates by gear type: crab pot gear: 0.321; groundfish pot gear: 0.321; trawl gear: 0.800) is also accounted for on bycatch of Tanner crab caught in the snow crab fishery, the Bristol Bay red king crab (BBRKC) fishery, and the (combined) groundfish fisheries. Time series of annual ln-scale deviations from mean fully-selected capture rates are estimated for males while ln-scale offsets are estimated for females. Capture selectivity curves are sex-specific and estimated in several fishery-specific time blocks for the bycatch fisheries; for the directed fishery, year-specific curves are estimated for males. Estimated selectivity curves are ascending logistic or ascending normal for all fleets and both sexes, except for male bycatch in the snow crab fishery–which is modeled using a double normal, dome-shaped curve. Size-specific retention curves (ascending logistic) are estimated for the directed fishery for three time blocks (Figure 25), chosen based on changes in fishing practices and fishery management. Maximum retention is fixed at 100% based on previous assessment results (Stockhausen 2023a).

Survey selectivity for the NMFS EBS bottom trawl survey is modeled using sex-specific parametric functions (ascending normal curves) in two time blocks (pre/post a gear change and survey standardization in 1982; Table 5). Sex-specific fully-selected survey catchabilities are estimated for the same time blocks. The BSFRF survey gear is assumed to catch all crab within its sweep (i.e., selectivity is constant across size and catchability is 1); sex/size-specific curves describing the annual availability of crab to the BSFRF survey gear are estimated outside the model (Section 3.2) and used to predict BSFRF survey indices and size compositions.

An incidental amount of Tanner crab may be legally retained in the snow crab and BBRKC fisheries when the Tanner crab fishery is open, but this has always been a small fraction of the total retained catch; for the purposes of the assessment, any incidentally-retained catch is added to that from the directed fishery. Annual retained catch biomass in the directed fishery since 1965 is fit using a lognormal error distribution with assumed variances based on perceived data quality (Table 6, Figure 25). Total catch biomass (aggregated over both sexes) from crab (starting in the early 1990s) or groundfish (starting in the early 1970s) fisheries observer data is also fit using lognormal error distributions and assumed variances based on perceived data quality (Figure 25). Retained catch and total catch size compositions are fit using multinomial error distributions with "extended" sex-specific size compositions; effective sample sizes are fixed to input sample sizes, which are scaled relative to the maximum sample size for retained catch.

The NMFS EBS shelf survey provides the primary fishery-independent relative biomass index and associated size composition data (annually, 1975-2023; with the exception of 2020; Figure 25). Design-based annual biomass indices are fit using lognormal error distributions separately for males, immature females, and mature females (Table 6). Size compositions are fit by the same categories assuming multinomial error distributions; sample sizes are fixed to input values, which are scaled relative to the overall mean number of crab sampled annually in the survey, which is assigned a value of 200. Data from BSFRF "side-by-side" (SBS) selectivity study surveys (2013-2017) are assumed to provide absolute indices of biomass (limited spatially and temporally by the study areas/years), as well as size composition data. BSFRF size compositions are fit using Dirichlet multinomial distributions with estimated sample sizes; input sample sizes are determined similarly to those for the NMFS survey.

Growth data from observed individual molting events is fit assuming a gamma error distribution for predicted molt increment size. Male maturity ogives, based on observed chela height-carapace width distributions from the NMFS EBS survey, are fit using multinomial error distributions; sample sizes are fixed to input values, which are based on the number of chela height measurements determining each annual ogive.

4.2 TCSAM02 Proposed Models

Two new models, 24.01 and 24.02, based on the TCSAM02 modeling framework are examined in this report. Both models are identical in structure to 22.03b, the 2023/24 assessment model, and differ from it only in that both models substitute biomass indices and size composition data based on the 2013-2018 BSFRF SBS survey dataset for those based on the 2013-2017 dataset and use the associated empirical availability functions. Model 24.01 does not include the 2018 data from the 2013-2018 dataset and is regarded as a "bridging" model from 22.03b to 24.01 to allow examination of any effects of the switch from the 2013-2017 dataset without introducing the additional effects of the 2018 data. **Model 24.02 is proposed as an alternative to 22.03b**.

4.3 GMACS Model Descriptions

Initial model construction for a GMACS Tanner crab assessment model was motivated by the SSC recommendation that "the GMACS implementation of the Tanner crab model could represent a simplified version of the current model structure, as a foundation upon which additional features may be explored and incorporated sequentially." All GMACS models presented here are considered simplified versions of the current TCSAM02 assessment model structure. The author looks forward to discussions with the CPT and SSC regarding model choices and further refinements.

Population categories in all GMACS models discussed in this report consisted of two sexes, two maturity states (immature and mature, or terminally molted), and 32 5-mm CW size bins (27-182 mm CW). All models started in 1982 to avoid issues with prior gear changes in the NMFS EBS bottom trawl survey (Figure 26). The model year, which started on July 1 as per convention, was divided into three seasons of lengths 0.62, 0.01, and 0.37 yr to match the assessment as closely as possible. Natural mortality occurred across all three seasons, the NMFS survey occurred at the start of the year, fishing mortality was included as a continuous process in season 2, while growth and recruitment occurred in season 3. This configuration is similar to that used in the current assessment model, other than model start time and modeling fishing mortality as a continuous process in season 2 (it is modeled as an instantaneous process in the assessment model). However, unlike the current assessment model, all estimated processes were modeled without time blocks as a simplifying assumption.

The biological processes represented in GMACS are similar to those in the assessment model (Table 7). To simplify model development, several processes were estimated outside the models, then fixed within a GMACS model (although possibly varied between models). Sex-specific growth transition matrices were based on previously-developed relationships for mean postmolt size as a function of pre-molt size determined by fitting molt increment data outside the model (Stockhausen 2023c). Sex-specific probabilities of maturing/terminal molt as functions of postmolt size were determined outside the model as outlined in Section 3.3. Natural mortality was estimated for immature crab, mature males, and mature females. The initial population structure (sex-specific immature and mature abundance by size class in sex/maturity-specific size ranges) was estimated using 85 parameters. A small penalty on adjacent size classes was applied to obtain smoothly-varying estimates across size bins. Ln-scale mean recruitment and annual deviations were estimated, with the sex ratio at recruitment fixed to 1:1.

Six sources of fishing mortality were included in the model: the directed Tanner crab fishery (identified in tables and figures as "TCF"), the snow crab fishery ("SCF"), the Bristol Bay red king crab fishery ("BBRKC" or "RKF"), a "combined-gear" groundfish fishery ("GFA"), a trawl-gear groundfish fishery ("GFT"), and a fixed-gear groundfish fishery ("GFF") (Tables 8 and 9). The groundfish fisheries were divided into 3 "fleets" based on information regarding catch by gear type: all gear combined (GFA: 1982-1989), trawl gear (GFT: 1990-present), and fixed gear (GFF: 1990-present). The trawl and fixed gear size compositions exhibit substantial differences from each other on an annual basis, indicating gear-specific selectivity patterns (catch biomass estimates provided by AKRO before 1990 are not distinguished by gear type), motivating the disaggregation by gear type for these fleets (bycatch data in the groundfish fisheries are treated as a single combined-gear fleet in the current assessment model). Capture selectivity and retention in the directed and bycatch fisheries were represented by ascending logistic functions, with the value in the largest size bin normalized to 1 and parameters estimated by sex and fleet. Ln-scale fully-selected mean capture rates and annual deviations were estimated for male crab and as offsets to the male estimates for female crab. Annual effort data (total potlifts) were used to estimate capture rates in the snow crab and BBRKC fisheries prior to the start of observer data in 1990.

The NMFS EBS bottom trawl survey is the only survey explicitly included in the model; data from three population categories are represented as separate "fleets": all males ("NMFSAM"), immature females ("NMFSIF"), and mature females ("NMFSMF")(Table 10). Survey catchability is sex-specific (the NMFIF and NMFSMF fleets share the same selectivity function and fully-selected catchability coefficient) and selectivity is estimated using ascending logistic functions.

The models were fit to retained catch biomass and size compositions from the directed Tanner crab fishery, total catch biomass and size compositions in the directed fishery and fisheries that take Tanner crab as bycatch (the snow crab fishery, the BBRKC fishery, and groundfish fisheries distinguished by gear type), and survey biomass and size composition indices from the NMFS EBS bottom trawl survey (Figure 26 and Table 11). All biomass time series were fit assuming lognormal error distributions: values for cv's for fishery data were assumed based on perceived data quality while those for survey data were estimated using standard design-based or model-based (i.e., VAST) calculations. The total catch biomass time series were fit by sex for the crab fisheries; this was not possible for the groundfish fisheries (expanded bycatch estimates are not sex-specific) and these data were fit on a combined-sex basis. For the "base" GMACS model, G24.02, all fishery size composition data were fit assuming multinomial error distributions using "extended" size compositions (i.e., normalized across sex) for the groundfish fisheries. The biomass indices and size compositions from the NMFS "fleets" were fit separately by fleet/population category: NMFSAM/all males, NMFSIF/immature females, and NMFSAM/mature females.

4.4 GMACS Proposed Models

Seven GMACS model configurations are considered in this report (Table 12). The base model, G24.02, was described in the previous section. G24.02a is a modification of G24.02 that changes how the crab fishery size composition data are fit from "extended" mode (i.e., the proportions are normalized across both sexes) to "normal" mode (i.e., the proportions are normalized within each sex separately). The remaining five models build on G24.02a. G24.03 fixes sex-specific NMFS survey selectivity (including fully-selected catchability) to the mean curves estimated from the SBS selectivity studies, rather than estimating sex-specific ascending logistic curves and fully-selected catchability coefficients. G24.04 builds on G23.03 by replacing the mean curves from the SBS selectivity analysis with the annual estimates from the analysis (Section 3.5). G24.05 builds on G24.03 by replacing the mean values used to describe the sex/size-specific probability of having undergone terminal molt with the annual estimates from that analysis (Section 3.3). G24.06 combines the time-varying aspects of G24.04 and G24.05 by including the time-varying estimates for both NMFS survey selectivity and the probability of having undergone terminal molt in a single model. Finally, G24.07 is identical to G24.06 except that it replaces the design-based estimates for male, immature female, and mature female biomass indices from the NMFS EBS trawl survey with VAST-based estimates.

5 Model Results: TCSAM02 Models

Results from the TCSAM02 models 24.01 and 24.02 are compared with those from the 2023/24 assessment model, 22.03b. The only differences between 24.01 and 22.03b is that 24.01 updates the BSFRF SBS biomass indices and size compositions based on the 2013-2017 dataset, along with the associated estimated availability curves, with those from the 2013-2018 dataset (Sections 3.1 and Section 3.5). Model 24.01 is simply a bridging model between the two that includes the 2013-2018 dataset, but only using 2013-2017. Parameter estimation for both new models converged successfully, with small final maximum gradients and invertible hessians (allowing parameter uncertainty to be estimated; Table A). The total objective function value decreased substantially (3142.77 to 3021.33 likelihood units) from 22.03b to 24.01 (the increase from 24.01 to 24.02 includes the additional 2018 BSFRF SBS data). However, the differences are primarily due to differences in the components of the objective function related to the BSFRF data, rendering direct inference on model fits based on the total objective function value invalid. The estimated sample size parameters associated with the Dirichlet multinomial likelihoods used to fit the BSFRF size compositions hit their upper bounds for both 24.01 and 24.02 (i.e., the effective sample size were no smaller than the input sample sizes; Table 13), suggesting that these can be fixed to their upper limits or that simple multinomial likelihoods are appropriate for fitting this data. Only relatively small changes in estimated parameter values occurred (Tables 14-26).

Individual components to the overall objective function value for the models are compared in Tables 27-30 while the difference in values relative to 22.03b are presented in Tables 31-34. The largest differences are that the new models fit the BSFRF SBS size compositions much better than 22.03b.

Table A. Summary convergence diagnostics. Diagnostics for 22.03 are from the 2022 assessment.

model configuration	number of parameters	no. of param.s at bounds	objective function value	max gradient	invertible for std. devs?
22.03b	354	0	3142.77	8.13E-05	yes
24.01	354	2	3021.33	3.96E-02	yes
24.02	354	2	3086.21	1.08E-02	yes

5.1 Estimated Fishery-related Quantities

All estimated fishery-related quantities are essentially identical for all three TCSAM02 models. Graphs of time series of estimated fully-selected F (total catch capture rates, not necessarily mortality) in the directed fishery are shown in Figure 27, while the associated selectivity functions are illustrated in Figures 28-30. The estimates of size-selective retention of males captured in the directed fishery are presented in Figure 31. Graphs of time series of estimated fully-selected F (again, total catch capture rates, not mortality) and the associated selectivity functions for the bycatch fisheries are shown in Figures 32-34.

5.2 Estimated Survey-related Quantities

Graphs of estimated sex-specific survey catchability and the associated selectivity functions for the NMFS EBS survey are shown in Figure 35. Assumed survey availability curves for the BSFRF side-by-side catchability studies are illustrated in Figure 36. These were not estimated; they were determined outside the model (see Section 3.2). The BSFRF nephrops bottom trawl gear is assumed to be non-size-selective (i.e., selectivity=1 at all sizes) and catch all crab in its swept-area path (i.e., the fully-selected catchability coefficient $q = 1$).

5.3 Estimated Population-related Quantities

5.3.1 Molting probabilities, growth, and other schedules depending on parameter estimates

Immature crab are assumed to molt annually. The estimated sex/size-specific probability of undergoing the molt to maturity (terminal molt) is shown in Figure 37, together with estimated mean molt increments (as a function of pre-molt size) and natural mortality rates. The cohort progressions (growth and development) resulting from these schedules are illustrated in Figures 38 and 39.

5.3.2 Estimated population-related time series

Estimated time series for recruitment and MMB are shown in Figures 40 and 41. Time series of abundance by sex and maturity state are illustrated in Figure 42, while time series of biomass by sex and maturity state are illustrated in Figure 43.

5.4 Estimated Fishing Mortality versus Estimated Spawning Stock Biomass

Estimated total fishing mortality (retained + discards) is plotted against spawning stock biomass (MMB) for the previous assessment (22.03b) and preferred (24.01, 24.02) models in Figure 44.

5.5 Fits to Fishery Catch Data

Fits to the observed and model-predicted fishery catch biomass data are presented in Figures 45-49. for the previous assessment (22.03b) and preferred (24.01, 24.02) models. Residuals to the fits and summary statistics are also shown on each figure. Graphs of fits to observed catches from the directed fishery are presented in Figures 45-46 for retained catch and total catch. Fits to bycatch data from the snow crab fishery are shown in Figure 47. Fits to bycatch data from the BBRKC fishery are shown in Figure 48. Fits to bycatch data from the groundfish fisheries are shown in Figure 49.

5.6 Fits to Survey Indices and Related Data

5.6.1 Graphs of model fits to survey biomass and numbers

Model fits to survey biomass time series from the NMFS EBS shelf survey and the BSFRF SBS surveys are shown for the base and preferred models in Figure 50. Residuals to the fits and summary fit statistics are shown in Figures 51-54.

Model fits to the survey abundance time series for both the NMFS EBS shelf survey and the BSFRF SBS surveys are shown for the base and preferred models in Figure 55. Residuals to the fits and summary fit statistics are shown in Figures 56-59. Note that the fits to survey abundance are not included in the model objective function but serve as independent diagnostics of model fit.

5.6.2 Graphs of model fits to other data

Model fits to molt increment growth data, as well as residual patterns and summary fit statistics, are illustrated in Figure 60. Model fits to maturity ogive data from the NMFS EBS shelf survey are presented in Figure 61, while Pearson's residuals to the fits are shown in Figure 62.

5.7 Fits to Fishery Size Compositions

Fits to the observed and model-predicted fishery catch proportions by size class, as well as the resulting patterns of residuals, are presented in Figures 63-97 for the previous assessment (22.03b) and preferred (24.01, 24.02) models. Both models fit the total catch size composition data from the directed and bycatch fisheries by normalizing it across sexes and fitting the resulting proportions jointly. Graphs for the directed fishery are given in Figures 63-73. Graphs for the snow crab fishery are given in Figures 76-81. Graphs for the BBRKC fishery are given in Figures 84-89. Graphs for the groundfish fisheries are given in Figures 92-97.

5.8 Fits to Survey Size Compositions

Fits to the observed and model-predicted survey proportions by size class/sex/maturity state, as well as the resulting patterns of residuals, from the NMFS EBS shelf survey and the BSFRF SBS survey are presented in Figures 100-119 for the previous assessment (22.03b) and alternative (24.01, 24.02) models.

5.9 Marginal Distributions for Fits to Compositional Data

Marginal distributions for fits to the compositional data from the fisheries are shown in Figures 121-124. Marginal distributions for fits to the compositional data from the surveys are shown in Figure 125.

6 Model Results: GMACS Models

This section provides a summary of results for GMACS Tanner crab models G24.02, G24.02a, G24.03, G24.04, G24.05, G24.06 and G24.07.

6.1 Model convergence

Parameter jittering was used to improve confidence that the "best" results for each model were associated with the model's maximum likelihood estimate (MLE). Each model was run 400 times, with the initial values for estimated parameters randomly selected with an uncertainty factor of 0.1. Model convergence was judged on the basis of a small final maximum gradient and successful estimation of parameter uncertainty information (Table B). Based on these criteria, all of the 7 models converged successfully. The optimization process was fairly robust for five of the seven models, with greater than 10% of the jitter runs achieving essentially the same solution. However, this was not the case for models 24.02a an 24.07, both of which had less than 4 out of 400 runs end near the "best" run in terms of the final value for the model's objective function.

All of the models exhibited at least one parameter estimated at bound in the "best" model run Table 35. The largest number occurred in model G24.02a, with four. The mean for the ascending logistic function used to describe fishery selectivity for male bycatch in the BBRKC ("RKF") fishery was estimated at its upper bound in all seven models. All parameter values are listed in Tables 36-53.

Table B. Summary convergence diagnostics for the GMACS models

model configuration	number of parameters	no. of jitter runs	no. converged to MLE	no. of param.s at bounds	objective function value	max gradient	invertible for std. devs?
G24.02	445	400	55	2	13904.46	1.52E-03	yes
G24.02a	445	400	1	4	14158.37	1.24E-03	yes
G24.03	441	400	65	1	14502	8.42E-03	yes
G24.04	441	400	64	1	14540	1.56E-02	yes
G24.05	441	400	79	1	14365	6.34E-03	yes
G24.06	441	400	82	1	14420	3.42E-03	yes
G24.07	441	400	3	2	16139	9.48E-04	yes

6.2 Fits to fishery catch data

Fits to retained catch were excellent for all models (Figures 126 and 127), as expected. Fits to total catch biomass in the crab fisheries were also very good for the directed fishery ("TCF") and the snow crab fishery ("SCF") for all models and all years, although there were some differences between predicted and observed values in the early 1990's (Figures 128, 129, and 130). However, fits to total catch biomass in the BBRKC fishery ("RKF") exhibited some extremely large differences for models 24.07 for females and 24.02a for males. All seven models substantially over-predict total catch biomass for males in the BBRKC fishery in 2007. In contrast, fits to Tanner crab bycatch in the groundfish fisheries are very good across all three fleets for all models, although the fits for 24.07 to the catch by trawl gear ("GFT") diverge from the observations as one goes back in time from 1997 (Figures 131 and 132).

6.3 Fits to relative biomass indices

Fits to the NMFS survey biomass indices are relatively poor (or worse) and broadly correlated across all three population categories (males, immature females, mature females) for all models (Figures 133 and 134). Model G24.07, fitting to VAST-based indices, exhibited the worst performance due to the smaller CVs associated with those time series.

6.4 Fits to size compositions

Predicted retained catch size compositions (Figure 135) are very similar across all years and models while observed compositions vary annually in both shape and location, reflecting changes in harvest strategies and industry-preferred crab size, spatial shifts in fishing effort (including spatial closures), and changes in the underlying population size structure and spatial pattern. This inflexibility in the predicted size compositions is directly related to the use of retention (and selectivity) functions for the directed fishery whose estimated parameters do not vary with time in the models considered here.

Comparison of fits to the sex-specific total catch size compositions from the crab fisheries (Figures 136-147) is somewhat complicated by the fact that G24.02 appends the female size compositions to the male size compositions in to create an "extended" composition (on an annual basis) that is normalized across both sexes and a single (annual) likelihood value calculated whereas the remaining models fit the size compositions separately by sex. One advantage to this approach is that it retains information about the sex ratio when abundance or biomass indices are aggregated across sex, as in G24.02 for both crab and groundfish fishery data or the remaining models for groundfish data only. Fits to the crab fishery total catch size compositions for G24.02 are thus presented in figures separately from those from the other models. Because sample sizes for males are typically much larger than those for females, the observed proportions in the crab fishery data associated with females at all sizes are much smaller than those for males in G24.02. Consequently, poor fits to the female portion of the extended size crab fishery compositions are typically downweighted in the overall likelihood relative to those in the non-extended fits while those for males are not. Because the catch biomass data from the groundfish fisheries is not sex-specific, fitting the groundfish bycatch size compositions using the "extended" approach is necessary to retain information regarding the size composition of bycatch in the groundfish fisheries.

The predicted size compositions for males in the directed fishery are very similar across all seven models (Figures 136 and 138). The models somewhat overpredict the proportion of small males and underpredict the proportion of large males from compositions in the early 1990s while the opposite is true for compositions from 2015/16 on. For females, Model G24.02 tended to underestimate proportions in the directed fishery across all size bins prior to 2008/09 and overestimated them afterward (Figure 137). In contrast, the other models fit the female size compositions fairly well (Figure 139).

On the whole, predicted size compositions for males in the snow crab fishery were very similar across all seven models (Figures 140 and 142). As with the directed fishery, fits to size compositions for females were poor for G24.02 (Figure 141) while the other models predicted the female size compositions in similar fashion and fit them fairly well (Figure 143), with the exceptions of the final two years of data when sample sizes were very small.

Predicted size compositions for males in the BBRKC fishery were very similar across all seven models (Figures 144 and 146), but the fits in many years were poor (e.g., 1990, 2009). Fits to size compositions for females were again poor for G24.02 (Figure 145). The predicted female size compositions from G24.07 were substantially different from the remaining models (Figure 147; overall, G24.07 fit the data poorly while the models fit the data well in a few years (e.g., 2008) but rather poorly in most (although better than 24.07 in all years).

Model G24.07 predicted substantially different size compositions for male Tanner crab taken in the combined gear groundfish fisheries in 1987-1989 relative to the other models (Figure 148), although none of the fits to the data in these years were very good. The predicted size compositions for females taken in the combined gear groundfish fisheries were more similar across models (Figure 149) and the fits (with the exceptions of 1982-1984) were marginally better than for males. The predicted size compositions for males taken in the fixed gear groundfish fisheries were remarkably similar across models (Figure 150), while the fits were good in most years (1992 and 1993 being exceptions). The predicted size compositions for females differed somewhat more across models, specially during 1991-1995 (Figure 151). On the whole, predicted size compositions for males taken in the trawl gear groundfish fisheries (Figure 152) were similar across models in most years, but showed more differences across models in 1994, 1995, 2003 and 2004. The associated fits to the observed size compositions ranged from reasonably good (e.g., 2014, 2015) to relatively poor (e.g., 1995, 1997). Similar observations hold for the predicted female size compositions in the fixed gear groundfish fisheries (Figure 153), although the years in which good (2014, 2019) and bad (1992, 1995) fits occur differ.

Given the differences in how NMFS survey selectivities are modeled among the various GMACS models, the predicted size compositions for the NMFS survey are surprisingly similar (Figures 154-156). In general, all fit the observed size compositions reasonably well for immature and mature females (Figures 154 and 155). Visually, the poorest fits occur when proportions in one or two size bins dominate the composition (e.g., mature females, 1982 and 1986) or where observed modes well fit in one year do not propagate to the next in the observed composition but do so in the predicted values (e.g., immature females, 2001-2004). Fits to male size compositions (Figure 155) are a mix of good (e.g., 1997, 2007, 2023) and poor (e.g., 1982, 1985, 1992) fits.

6.5 Estimated population quantities

All seven models estimated generally similar patterns for annual recruitment (Figure 157), although overall levels differed substantially, with G24.02a exhibiting the lowest and G24.02 the highest. Similar observations hold for estimated mature male biomass (MMB; Figure 158), although G24.07 exhibited the lowest overall level rather than G24.02a.

Estimates across the seven models for initial numbers by population category and size class (Figure 159) differ primarily in scale. One difference is that the numbers in the two smallest size classes for immature males estimated in G24.07 follow a different pattern (decreasing from a high value in the first size bin) from that exhibited by the other models (increasing from a low value in the first size bin). **The results for mature males highlight a structural issue with the GMACS framework that needs to be corrected: the numbers in the smallest size bin for mature males should be zero for all models.** They are not because GMACS hardwires this population category/size bin as a (necessary) reference class for the parameters that determine the initial size structure. The reference size bin, however, needs to user-determined: in the case of Tanner crab, there should be no mature males in the 25-30 mm CW size class. This issue, however, only affects model results until the first generation of crab dies out.

Estimates across the seven models for final numbers by population category and size class (Figure 160) also differ primarily in scale. None of the models predict mature males in the smallest size bin, so the structural error in the initial size structure is indeed only a transient issue and (for Tanner crab) has no impact on results after the first 15-20 years.

Estimated time series for abundance aggregated by immature category (Figure 161) generally reflect differences in recruitment across the models, with G24.02 consistently estimating the highest levels of abundance for immature crab and G24.02a the lowest levels. The patterns across models are less consistent for mature crab. G24.07 exhibits some abrupt changes in mature female abundance (e.g., late 1980s, mid-1990s) not seen in the other models nor particularly reflected in the estimated time series for mature males. G24.02 consistently estimated the highest abundance for mature males across time, but this was not the case for mature females. Conversely, G24.02a consistently estimated the lowest abundance for mature females across time, but this was not the case for males. Similar patterns are generally evident in the estimates for biomass aggregated by population category, as well (Figure 161).

Estimated rates for natural mortality (Figure 163) were fairly consistent across the models for mature males, but this was not the case for immature crab or mature females. Estimated rates for immature crab hit their lower bound (0.1 yr^{-1}) in G24.02a and were lower than 0.2 yr^{1-} for G24.03 and G24.04 but higher (and roughly similar) for the remaining models. Estimated rates for mature females were generally higher across the models compared with the other population categories, with the estimate from G24.07 being the exception (it was similar to its estimates for M on immature crab). For the other models, the estimated rates for mature females grouped by model pairs: highest for G24.02 and G24.02a, intermediate for G24.03 and G24.04, and lowest (but still above 0.3 yr^{-1}) for G24.05 and G24.06.

6.6 Selectivity in the fisheries

Estimated logistic selectivity curves for males in the directed fishery (Figure 164) have generally similar widths across the models, with G24.07 estimating the furthest left-shifted (relatively higher selection at smaller sizes) and G24.02a the furthest right-shifted (relatively lower selection at smaller sizes). The estimated logistic retention curves are essentially identical for all models, with very narrow widths and inflection points very close to 144 mm CW. The industry-preferred minimum size has changed over time from 145 mm CW to 125 mm CW, so this would suggest that the models underestimated the retention of males less than 145 mm CW (as is the case; Figure 135). Estimated selectivity for females in the directed fishery was similar across all models except G24.02, which was shifted 30 mm to larger sizes.

Estimated logistic capture selectivity for male Tanner crab in the snow crab were essentially identical across models, as was the case for the BBRKC fishery, with full selection at smaller sizes in the snow crab fishery (Figure 165). For females, selectivity in the snow crab fishery was shifted 35 mm to the right in G24.02 from the curves estimated in the remaining models (inflection points ~79 mm CW). G24.07 was the "odd man out" for female selectivity in the BBRKC fishery, shifted to an inflection point at 63 mm CW roughly ~50 mm to the left of the inflection points estimated in the other models. Additionally, unlike the other models, the width of the female selectivity curve for G24.07 was estimated at its lower bound.

The estimated logistic selectivity curves in the groundfish fisheries were fairly similar by sex and fishery, except for those estimated for G24.07 in the combined-gear fishery (Figure 166). These were both substantially right-shifted relative to the estimated curves for the other models.

6.7 Fishing mortality

Estimated retained catch fishing mortality (Figure 167) was essentially identical across all seven models, with the exception of G24.02a in 2006, which estimated a smaller value compared with the other models. All seven models exhibited an anomalous "spike" in estimated total catch fishing mortality (i.e., retained catch plus all discard mortality; Figure 168) in 2019 associated with over-estimated bycatch in the BBRKC fishery; G24.07 estimated three additional "spikes" while 24.02a estimated one additional spike.

Estimated fully-selected fishing mortality rates on males in the directed fishery (Figure 169) are extremely high (> 1) in the 1989-1991 time period for all seven models, reflecting the large reported retained and total catches during this time. Estimated rates are highest for G24.02a and lowest for G4.02. Rates show similar patterns for females, but the rates are highest for G24.02 and lowest for G24.07. Rates for fully-selected fishing mortality on males in the snow crab fishery also peak in 1989-1991 across all models, but at much lower values (< 0.15) than the levels in the directed fishery (Figure 170). Rates were lowest for G24.02a across the entire model time period but no model consistently exhibited the highest rates. Similar to results for the directed fishery, rates for females were highest for G24.02a. Estimates of fully-selected fishing mortality in the BBRKC fishery exhibited worrisome "spikes" of unreasonable magnitude for G24.07 and G24.02a (Figure 171). Additionally, all of the models exhibited an unreasonable spike in 2019, the last year for which observed data were included. These spikes account for the poor fits to total catch biomass in the BBRKC fishery (Figure 128) but may indicate problems with model specification.

Estimates of fully-selected fishing mortality in the groundfish fisheries vary in absolute level but exhibit substantially similar variability across time for all seven models (Figures 172-174). For the combined-gear fisheries, G24.07 exhibits an overall downward trend from 1982 to 1990 where the other models exhibit upward trends, but the variability superimposed on these trends is similar across all the model (Figure 172). For the trawl gear fisheries, both the trends and interannual variability are similar for males (Figure 172). Fishing mortality on females appears to be identically zero across all models for the trawl gear fishery; this is due to the precision (to 0.0001) to which results are reported in the model output. A similar issue occurs with fishing mortality for females in the fixed gear fisheries and is responsible for the quantization evident in Figure 174. As with the other groundfish fisheries, the trends and interannual variability are also similar across models for fishing mortality on males by the fixed gear fisheries, mainly differeing by overall level.

For the crab fisheries, the annual ln-scale fishing mortality deviations for males and offset deviations for females exhibit a few very large estimates related to bycatch in the BBRKC ("RKF") fishery for G24.02a and G24.07 (Figure 175), as well as across all models for 2019. These are the source for the spikes in fully-selected fishing mortality in the BBRKC fishery just discussed.

For the groundfish fisheries, the mean ln-scale fishing mortality offsets for females vary much more widely across models than either the mean ln-scale estimates or the annual deviations for males (Figure 176). Otherwise, the only standout differences are the annual ln-scale deviations are always more extreme from G24.07 (higher or lower) than the annual median for the combined groundfish fleets ("GFA").

6.8 Survey selectivity

Survey selectivity curves are estimated only in models G24.02 and G24.02a (Figures 177 and 178, which show combined catchability/selectivity), while mean or annual curves estimated outside the model (as discussed in Section 3.5) are used in the remaining models. The estimated sex-specific curves are logistic and apply to the entire model time period. The inflection point of the curve estimated in G24.02 for males is beyond the largest size class in the model; combined with the estimate for fully-selected catchability (fixed at 0.5 based on TCSAM02 model results), the resulting curve is smaller than the empirical curves used in models G24.03-24.07 except for the largest size bins (Figure 177). The curve for 24.02a, on the other hand, runs through the middle of the (blue) mean empirical selectivity curve. Fully-selected catchability for both G24.02 and G24.02a are is roughly the same as that implied by the mean empirical curve. The results for females are different (178). For females, the combined catchability/selectivity curve from G24_02a is larger than the empirical selectivity curve across all size bins while the curve for G24.02 is smaller than the empirical mean until ~90 mm CW, beyond which it is larger. The fully-selected catchability from the mean empirical curve is smaller than that for both 24.02 and 24.02a.

6.9 Summary

The seven models considered here represent a "first cut" at developing a GMACS model for Tanner crab. Emphasis was placed on constructing the "simplest" models capable of representing the population and fishery dynamics. In particular, no estimated parameters other than fully-selected fishing mortality rates varied in time, whereas parameters reflecting natural mortality and fishery selectivity are estimated within multiple time blocks in the current assessment model. Parameters that varied across time in some of the models (i.e., the probability of terminal molt and NMFS survey selectivity) were estimated outside those models and fixed inside them. Based on the models' relatively poor abilities to follow the variability manifested in the observed time series for NMFS survey biomass, this simplified approach to including temporal variability in a model was not sufficient. It is reasonably clear, and this is true to a lesser extent of the current stock assessment model as well, that at least one of the time-invariant biological processes (e.g., natural mortality, growth) needs to vary temporally in order to better capture the 3-5 year variability seen in the survey data. It is unclear, however, how this should be implemented.

Other considerations for next steps include: 1) alternative fishery selectivity curves; 2) adding time blocks for fishery selectivity; and 3) combining or eliminating fishery datasets. With regard to 1), male selectivity in the snow crab fishery is dome-shaped in the current assessment model (and pretty well supported by the data) but logistic in the GMACS models considered here. With regard to 2), important changes in the prosecution of both crab and groundfish fisheries have occurred since 1982 (e.g., rationalization of the crab fisheries) that should be better captured by at least estimating appropriate selectivity curves by relevant time blocks. With regard to 3), combining the small amounts of recent bycatch in the BBRKC and groundfish fisheries into a combined bycatch fleet might improve the overall stability of the models by eliminating the need to fit to multiple small sources of fishing mortality.

7 Comparisons between TCSAM02 and GMACS models

Results from the GMCAS models are compared with the proposed TCSAM02 model 24.02 in this section on a rather qualitative basis, because the computer code to provide a more detailed, quantitative comparison has not been developed yet. The GMACS model G24.06 is highlighted in the plots because it incorporates the most information regarding the temporal variability of processes affecting stock dynamics (the terminal molt to maturity) and observations (survey selectivity).

Fits to the NMFS survey biomass indices (Figures 179 and 180) show fairly good agreement among the models, but none track the full dynamic range of the design-based indices (the VAST-based indices that are fit by G24.07 are not shown, but they follow similar patterns). In particular, the models substantially underpredict the high biomasses in the late 1980's-early 1990's. The GMACS model G24.07 fits the survey biomass time series much more poorly than the other models, based on standardized residuals that include the uncertainty in the observed data, because it was fit to the VAST-based indices that have smaller cv's (Figures 181-183). This model provides slightly better fits than the TCSAM02 model, as well as the other GMACS models, when judged from the perspective of statistics that do not include the uncertainty associated with the observations (i.e., the MAD, MARE, and RMSE statistics included in the figures), but this is to be expected because the smaller VAST cv's place more weight on fitting the survey observations than do the design-based cv's. From this perspective, the TCSAM02 model 24.02 and the other GMACS models perform similarly, with none of the models standing out across all statistics and data types.

When comparing the models across predictions of of various stock trends (recruitment, MMB, abundnce, Figures 184-186), GMACS models G24.02 and G24.02a stand out as outliers in terms of overall scale (G24.02 higher than the rest, G24.02a lower than the rest). For the remainder, the largest differences between the TCSAM02 model and the GMACS models occur principally for mature males (either MMB or abundance) in the 1980s. These differences reflect: 1) the startup of the GMACS models, which are initialized in 1982 and 2) the estimated "high mortality" period included in the TCSAM02 model from 1980-1984 to better follow the drops in survey biomass from 1975-1986 for mature males and females (see Figures 179 and 180).

8 Summary

The author recommends TCSAM02 model 24.02, which incorporates biomass indices and size compositions from the complete (2013-2018) collaborative BSFRF/NMFS SBS Tanner crab selectivity study, as the principal Tier 3 model for the 2024/25 Tanner crab assessment.

As previously noted, initial model construction for a GMACS Tanner crab assessment model was motivated by the SSC recommendation that "the GMACS implementation of the Tanner crab model could represent a simplified version of the current model structure, as a foundation upon which additional features may be explored and incorporated sequentially." All GMACS models presented here are considered simplified versions of the current TCSAM02 assessment model structure. The issue of the "spikes" in estimated fishing mortality from bycatch in the BBRKC fishery needs to be resolved before any of these models could be used for management. Assuming that this could be done in time for the September assessment, the author proposes to include GMACS model G24.06 (updated with data for 2023/24) as an alternative model for consideration in September, recognizing that no information has been provided in this report regarding GMACS-based management quantities, retrospective patterns, or projections.

In regards to further development of the GMACS models, it would be worthwhile to consider adding the features currently included in the TCSAM02 model: 1) time-varying selectivity to describe changes in fishing practices in the directed fishery (e.g., spatial shifts due to area closures, changes in industry-preferred minimum crab size) and 2) dome-shaped selectivity for males in the snow crab fishery. It will also be worthwhile (in the longer term) to explore modeling time-varying mortality and/or growth (either changes in molt increment or weight-at-size) as solutions to the lack of dynamic range exhibited by both the TCSAM02 and GMACS models reviewed here.

The author looks forward to discussions with the CPT and SSC regarding model choices for the September assessment and further refinements to address on a longer timescale.

9 Acknowledgments

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Tables

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Table 1. Comparison of model-based (VAST) and design-based biomass indices for Tanner crab in the NMFS EBS bottom trawl survey.

	immature female				mature female				undetermined male			
	design		VAST		design		VAST		design		VAST	
year	est	cv	est	cv	est	cv	est	cv	est	cv	est	cv
1975	9.55	0.241	9.74	0.107	31.42	0.196	41.79	0.100	294.88	0.318	298.25	0.089
1976	6.37	0.253	5.82	0.092	31.16	0.193	37.17	0.078	157.02	0.138	195.13	0.083
1977	14.47	0.596	6.72	0.122	38.57	0.309	41.03	0.089	138.50	0.121	177.53	0.082
1978	6.81	0.243	8.17	0.127	25.75	0.227	27.66	0.090	98.30	0.118	115.42	0.078
1979	2.66	0.287	4.15	0.099	10.45	0.328	20.33	0.123	51.42	0.165	58.29	0.076
1980	13.51	0.229	15.21	0.121	63.78	0.276	55.63	0.114	152.48	0.155	154.30	0.078
1981	1.52	0.210	1.41	0.102	42.58	0.252	36.95	0.121	79.92	0.128	85.37	0.080
1982	1.71	0.270	1.50	0.118	64.14	0.258	50.80	0.092	65.85	0.143	71.29	0.069
1983	2.27	0.237	2.18	0.092	20.43	0.183	22.04	0.081	37.98	0.148	36.39	0.065
1984	2.23	0.212	1.98	0.084	14.91	0.224	14.70	0.087	30.50	0.128	30.63	0.067
1985	0.99	0.178	0.93	0.073	5.55	0.263	5.62	0.099	14.90	0.135	15.79	0.080
1986	2.69	0.170	2.52	0.074	3.37	0.197	3.50	0.073	21.59	0.221	16.89	0.063
1987	14.99	0.291	12.22	0.099	5.14	0.164	5.88	0.073	45.50	0.137	45.34	0.069
1988	10.17	0.173	9.40	0.074	25.37	0.233	22.40	0.072	99.21	0.208	82.96	0.069
1989	11.81	0.190	9.74	0.072	19.40	0.151	21.41	0.059	132.80	0.121	129.17	0.069
1990	9.86	0.187	8.92	0.069	37.69	0.267	34.54	0.066	132.42	0.126	143.62	0.065
1991	7.01	0.171	6.58	0.072	44.76	0.219	40.74	0.073	145.79	0.172	142.15	0.063
1992	1.98	0.169	2.00	0.078	26.23	0.164	26.34	0.062	127.58	0.230	106.95	0.071
1993	1.06	0.186	1.09	0.094	11.64	0.144	13.39	0.066	73.27	0.142	77.60	0.067
1994	1.20	0.325	1.02	0.108	9.85	0.206	9.92	0.071	48.33	0.119	52.51	0.066
1995	1.05	0.155	1.10	0.082	12.40	0.219	11.34	0.077	34.98	0.165	34.06	0.071
1996	1.43	0.208	1.42	0.083	9.58	0.280	8.26	0.081	30.76	0.211	28.83	0.078
1997	1.39	0.266	1.28	0.092	3.40	0.185	3.96	0.073	14.63	0.110	16.67	0.069
1998	1.96	0.191	1.81	0.074	2.28	0.158	2.63	0.080	15.00	0.099	16.63	0.062
1999	2.85	0.195	2.92	0.076	3.83	0.216	4.21	0.078	21.53	0.255	20.03	0.079
2000	2.47	0.153	2.52	0.071	4.13	0.282	4.10	0.089	23.33	0.197	24.36	0.086
2001	6.27	0.206	5.87	0.074	4.56	0.225	4.64	0.080	29.25	0.130	31.59	0.072
2002	5.49	0.164	5.71	0.079	4.47	0.202	5.07	0.085	27.41	0.130	30.57	0.076
2003	4.66	0.240	4.04	0.080	8.40	0.191	9.85	0.093	37.80	0.127	42.76	0.076
2004	4.08	0.147	4.12	0.067	4.73	0.173	5.29	0.078	38.87	0.138	41.26	0.064
2005	10.37	0.196	10.01	0.088	11.58	0.188	13.03	0.124	63.74	0.116	66.67	0.060
2006	13.24	0.225	11.52	0.077	14.94	0.172	15.52	0.069	101.53	0.152	100.67	0.064
2007	5.58	0.229	5.10	0.076	13.44	0.188	14.60	0.076	104.18	0.181	96.03	0.063
2008	2.84	0.208	2.54	0.082	11.66	0.182	12.94	0.092	84.90	0.249	75.30	0.064
2009	2.54	0.272	2.40	0.081	8.48	0.206	8.87	0.084	47.41	0.137	50.30	0.066
2010	3.77	0.163	3.47	0.065	5.47	0.219	5.98	0.087	49.00	0.166	49.04	0.067
2011	10.34	0.190	8.63	0.068	5.41	0.144	6.27	0.070	62.66	0.170	60.96	0.062
2012	11.65	0.240	10.17	0.089	12.36	0.224	11.11	0.063	80.11	0.170	74.14	0.067
2013	6.37	0.181	6.01	0.070	17.85	0.215	15.26	0.067	103.37	0.211	86.89	0.074
2014	2.45	0.207	2.30	0.069	14.86	0.286	13.03	0.075	108.91	0.099	115.78	0.062
2015	1.65	0.172	1.71	0.087	11.21	0.250	10.09	0.090	74.23	0.090	81.17	0.056
2016	1.12	0.215	1.00	0.104	7.63	0.256	6.85	0.081	69.62	0.094	75.89	0.058
2017	1.38	0.185	1.51	0.099	7.11	0.230	6.60	0.083	54.20	0.109	59.43	0.062

(continued)

	immature female				mature female				undetermined male			
	design		VAST		design		VAST		design		VAST	
year	est	cv	est	cv	est	cv	est	cv	est	cv	est	cv
2018	5.02	0.171	4.75	0.073	4.97	0.203	5.17	0.084	47.08	0.095	52.28	0.060
2019	4.92	0.164	4.69	0.067	4.85	0.218	4.80	0.081	28.67	0.116	31.02	0.058
2021	3.34	0.134	3.52	0.056	8.55	0.151	9.29	0.064	31.56	0.109	33.23	0.060
2022	2.69	0.201	2.42	0.074	6.67	0.203	6.87	0.071	29.63	0.111	31.30	0.059
2023	9.26	0.165	8.89	0.066	7.33	0.225	7.05	0.064	34.52	0.082	37.93	0.053

Table 2. Biological processes included in 22.03b, the 2023 assessment model.

process	time blocks	22.03b description
Population rates and quantities		
Population built from annual recruitment		
Recruitment	1949-1974	ln-scale mean + annual devs constrained as AR1 process
	1975+	ln-scale mean + annual devs
	1949+	sigma-R fixed, sex ratio fixed at 1:1
Growth	1949+	sex-specific
		mean post-molt size: power function of pre-molt size
		post-molt size: gamma distribution conditioned on pre-molt size
Maturity	1949+	sex-specific
		size-specific probability of terminal molt
		logit-scale parameterization
Natural mortalty	1949-1979,	estimated sex/maturity state-specific multipliers on base rate
	1985+	priors on multipliers based on uncertainty in max age
	1980-1984	estimated "enhanced mortality" period multipliers

Table 3. Description of modeled fishery processes and time blocks for the directed Tanner crab (TCF) and snow crab (SCF) fisheries included in 22.03b, the 2023 assessment model.

Fishery/process	time blocks	22.03b description
TCF	directed Tanner crab fishery	
capture rates	pre-1965	male nominal rate
	1965+	male ln-scale mean + annual devs
	1949+	ln-scale female offset
male selectivity	1949-1990	ascending logistic
	1991-1996	annually-varying ascending logistic
	2005+	annually-varying ascending logistic
female selectivity	1949+	ascending logistic
male retention	1949-1990; 1991-1996; 2005-2009; 2013+	ascending logistic
% retained	pre-1988	fixed at 100%
	1991-1996	fixed at 100%
	2005-2009	fixed at 100%
	2013+	fixed at 100%
SCF	bycatch in snow crab fishery	
capture rates	pre-1978	nominal rate on males
	1979-1991	extrapolated from effort
	1992+	male ln-scale mean + annual devs
	1949+	ln-scale female offset
male selectivity	1949-1996	dome-shaped (double normal)
		--plateau width fixed to 0
		--descending limb width fixed to 1
	1997-2004	dome-shaped (double normal)
	2005+	dome-shaped (double normal)
female selectivity	1949-1996	ascending logistic
	1997-2004	ascending logistic
	2005+	ascending logistic

Table 4. Description of modeled fishery processes and time blocks for the BBRKC (RKF) and groundfish (GTF) fisheries included in 22.03b, the 2023 assessment model.

Fishery/process	time blocks	22.03b description
RKF	bycatch in BBRKC fishery	
capture rates	pre-1952	nominal rate on males
	1953-1991	extrapolated from effort
	1992+	male ln-scale mean + annual devs
	1949+	ln-scale female offset
male selectivity	1949-1996	ascending normal, asymptote fixed
	1997-2004	ascending normal, asymptote fixed
	2005+	ascending normal, asymptote fixed
female selectivity	1949-1996	ascending normal, asymptote fixed
	1997-2004	ascending normal
	2005+	ascending normal
GTF	bycatch in groundfish fisheries	
capture rates	pre-1973	male ln-scale mean from 1973+
	1973+	male ln-scale mean + annual devs
	1973+	ln-scale female offset
male selectivity	1949-1986	ascending logistic
	1987-1996	ascending logistic
	1997+	ascending logistic
female selectivity	1949-1986	ascending logistic
	1987-1996	ascending logistic
	1997+	ascending logistic

Table 5. Description of modeled survey processes and time blocks for the annual NMFS EBS shelf trawl survey and the BSFRF side-by-side catchability study surveys included in 22.03b, the 2023 assessment model.

Survey/process	time blocks	22.03b description
NMFS EBS trawl survey		
male survey q	1975-1981	ln-scale
	1982+	ln-scale w/ prior based on Somerton's underbag experiment
female survey q	1975-1981	ln-scale
	1982+	ln-scale w/ prior based on Somerton's underbag experiment
male selectivity	1975-1981	ascending normal, fixed fully-selected size at 180
	1982+	ascending normal, fixed fully-selected size at 180
female selectivity	1975-1981	ascending normal, fixed fully-selected size at 130
	1982+	ascending normal, fixed fully-selected size at 130
BSFRF SBS trawl surveys		
male catchability	2013-2017	fixed at 1 for all sizes
male availability	2013-2017	empirically-determined outside the model
female catchability	2013-2017	fixed at 1 for all sizes
female availability	2013-2017	empirically-determined outside the model

Table 6. Description of likelihood components in 22.03b, the 2023 assessment model. TCF: directed Tanner crab fishery; SCF: snow crab fishery; RKF: BBRKC fishery; GF All: groundfish fisheries. NMFS M and F surveys: NMFS EBS shelf trawl survey, distinguished by sex (M: males-only; F: females-only); BSFRF M and F surveys: BSFRF side-by-side (SBS) catchability study surveys, ditinguished by sex (M: males-only; F: females-only). Separate likelihood components are used for the male and female survey biomass indices: female survey biomass is fit separately by maturity state whereas total male biomass is fit. Consequently, the models treat them as separate data sets.

Model	Component	Type	included in optimization	Fits	Likelihood distribution
22.03b	TCF: retained catch	biomass	yes	males only	lognormal
		size comp.s	yes	males only	multinomial
	TCF: total catch	biomass	yes	total	lognormal
		size comp.s	yes	by sex (extended)	multinomial
	SCF: total catch	biomass	yes	total	lognormal
		size comp.s	yes	by sex (extended)	multinomial
	RKF: total catch	biomass	yes	total	lognormal
		size comp.s	yes	by sex (extended)	multinomial
	GF All: total catch	abundance	yes	total	lognormal
		biomass	yes	total	lognormal
		size comp.s	yes	by sex	multinomial
	NMFS "M" survey (males only, no maturity)	biomass	yes	males only	lognormal
		size comp.s	yes	males only	multinomial
	NMFS "F" survey (females only, w/ maturity)	biomass	yes	by maturity classification	lognormal
		size comp.s	yes	by maturity classification	multinomial
	BSFRF "M" survey (males only, no maturity)	biomass	yes	males only	lognormal
		size comp.s	yes	males only	D-M
	BSFRF "F" survey (females only, w/ maturity)	biomass	yes	by maturity classification	lognormal
		size comp.s	yes	by maturity classification	D-M
	growth data	EBS only	yes	by sex	gamma
	male maturity ogive data	EBS only	yes	males only	binomial

Table 7. Biological processes included in G24.02, the base GMACS model.

process	time blocks	G24.02 description
Population rates and quantities		
initial population stru	1982	estimated with smoothing penalties
Recruitment	1982+	ln-scale mean + annual devs
Growth	1982+	sex-specific, determined outside model mean post-molt size: power function of pre-molt size post-molt size: gamma distribution conditioned on pre-molt size
Maturity	1982+	sex-specific probability of terminal molt depends on postmolt size determined outside model
Natural mortalty	1982+	estimated sex/maturity state-specific offsets from base rate on mature males

Table 8. Description of modeled fishery processes and time blocks for the directed and bycatch crab fisheries included in G24.02, the base GMACS model.

Fishery/process	time blocks	G24.02 description
TCF	directed Tanner crab fishery	
capture rates	1982+	male ln-scale mean + annual devs
	1982+	ln-scale female offsets (mean+annual devs)
male selectivity	1982+	ascending logistic
female selectivity	1982+	ascending logistic
male retention	1982+	ascending logistic
% retained	1982+	fixed at 100%
SCF	bycatch in snow crab fishery	
capture rates	1982-1989	extrapolated from effort
	1990+	male ln-scale mean + annual devs
	1990+	ln-scale female offsets (mean+annual devs)
male selectivity	1982+	ascending logistic
female selectivity	1982+	ascending logistic
RKF	bycatch in BBRKC fishery	
capture rates	1982-1989	extrapolated from effort
	1990+	male ln-scale mean + annual devs
	1990+	ln-scale female offsets (mean+annual devs)
male selectivity	1982+	ascending logistic
female selectivity	1949-1996	ascending logistic

Table 9. Description of modeled fishery processes and time blocks for the groundfish fisheries included in G24.02, the base GMACS model.

Fishery/process	time blocks	G24.02 description
GFA	combined-gear bycatch in groundfish fisheries	
capture rates	1982-1990	male ln-scale mean + annual devs
	1982-1990	ln-scale female offsets (mean+annual devs)
male selectivity	1982-1990	ascending logistic
female selectivity	1982-1990	ascending logistic
GFT	trawl-specific bycatch in groundfish fisheries	
capture rates	1991+	male ln-scale mean + annual devs
	1991+	ln-scale female offsets (mean+annual devs)
male selectivity	1991+	ascending logistic
female selectivity	1991+	ascending logistic
GFF	fixed gear-specific bycatch in groundfish fisheries	
capture rates	1991+	male ln-scale mean + annual devs
	1991+	ln-scale female offsets (mean+annual devs)
male selectivity	1991+	ascending logistic
female selectivity	1991+	ascending logistic

Table 10. Description of modeled survey processes and time blocks for the annual NMFS EBS shelf trawl survey included in G24.02, the base GMACS model.

Survey/process	time blocks	22.03b description
NMFS EBS trawl survey		
male survey q	1982+	ln-scale w/ prior based on Somerton's underbag experiment
female survey q	1982+	ln-scale w/ prior based on Somerton's underbag experiment
male selectivity	1982+	ascending logistic
female selectivity	1982+	ascending logistic

Table 11. Description of likelihood components included in G24.02, the base GMACS model. TCF: directed Tanner crab fishery; SCF: snow crab fishery; RKF: BBRKC fishery; GFA: combined-gear groundfish fisheries (1982-1990); GFT: trawl gear groundfish fisheries (1991-present); GFF: fixed-gear groundfish fisheries (1991-present).NMFSAM, NMFSIF, and NMFSMF surveys: NMFS EBS shelf trawl survey, distinguished by ",”sex/maturity category (AM: all males; IF: immature females; MF: mature females); Separate likelihood components are used for the male and female survey biomass indices: female survey biomass is fit separately by maturity state whereas total male biomass is fit.

Model	Component	Type	included in optimization	Fits	Likelihood distribution
G24.02	TCF: retained catch	biomass	yes	males only	lognormal
		size comp.s	yes	males only	multinomial
	TCF: total catch	biomass	yes	combined sex	lognormal
		size comp.s	yes	by sex (extended)	multinomial
	SCF: total catch	biomass	yes	combined sex	lognormal
		size comp.s	yes	by sex (extended)	multinomial
	RKF: total catch	biomass	yes	combined sex	lognormal
		size comp.s	yes	by sex (extended)	multinomial
	GFA (combined gear): total catch	biomass	yes	combined sex	lognormal
		size comp.s	yes	by sex (extended)	multinomial
	GFT (trawl gear): total catch	biomass	yes	combined sex	lognormal
		size comp.s	yes	by sex (extended)	multinomial
	GFF (fixed gear): total catch	biomass	yes	combined sex	lognormal
		size comp.s	yes	by sex (extended)	multinomial
	NMFS "M" survey (males only, comb. maturity)	biomass	yes	design-based indices	lognormal
		size comp.s	yes	design-based indices	multinomial
	NMFS "IF" survey (immature females)	biomass	yes	design-based indices	lognormal
		size comp.s	yes	design-based indices	multinomial
	NMFS "MF" survey (mature females)	biomass	yes	design-based indices	lognormal
		size comp.s	yes	design-based indices	multinomial
	growth data	EBS only	no	--	--
	male maturity ogive data	EBS only	no	--	--

Table 12. Additional GMACS models.

model configuration	parent(s)	number of estimated parameters	changes to parent model
G24.02	--	445	--
G24.02a	G24.02	445	fits to crab fishery catch data are sex-specific, not combined sex
G24.03	G24.02a	441	NMFS survey selectivities fixed to mean empirical selectivities
G24.04	G24.03	441	NMFS survey selectivities fixed to year-specific empirical selectivities
G24.05	G24.03	441	probability of terminal molt fixed to year-specific estimates
G24.06	G24.04, G24.05	441	probability of terminal molt fixed to year-specific estimates, NMFS survey selectivities fixed to year-specific empirical selectivities
G24.07	G24.06	441	fits to VAST survey biomass indices

Table 13. TCSAM02 models parameters at bounds.

		name	label	22.03b	24.01	24.02
likelihood	Dirichlet-Multinomial	pLnDirMul[1]	ln(theta) parameter for BSFRF SBS M	–	1	1
		pLnDirMul[2]	ln(theta) parameter for BSFRF SBS F	–	1	1

Table 14. TCSAM02 models final values for non-vector parameters related to recruitment, initial abundance, natural mortality, and growth. Parameters with values whose standard error is NA are fixed, not estimated.

				22.03b		24.01		24.02
process	name	label	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
recruitment	pLnR[1]	historical recruitment period	6.862	0.59	6.964	0.59	6.989	0.59
	pLnR[2]	current recruitment period	5.901	0.071	5.998	0.070	6.007	0.066
	pRa[1]	fixed value	2.233	0.031	2.193	0.032	2.183	0.032
	pRb[1]	fixed value	1.351	0.077	1.306	0.083	1.325	0.084
	pRCV[1]	full model period	-0.7000	NA	-0.7000	NA	-0.7000	NA
	pRX[1]	full model period	0.000	NA	0.000	NA	0.000	NA
natural mortality	pDM1[1]	multiplier for immature crab	1.029	0.047	1.062	0.046	1.095	0.046
	pDM1[2]	multiplier for mature males	1.349	0.038	1.373	0.037	1.379	0.037
	pDM1[3]	multiplier for mature females	1.341	0.038	1.345	0.038	1.365	0.037
	pDM2[1]	1980-1984 multiplier for mature males	2.345	0.24	2.393	0.25	2.369	0.25
	pDM2[2]	1980-1984 multiplier for mature females	1.966	0.17	1.988	0.17	1.964	0.17
	pM[1]	base ln-scale M	-1.470	NA	-1.470	NA	-1.470	NA
growth	pGrA[1]	males	32.33	0.25	32.16	0.23	32.18	0.23
	pGrA[2]	females	33.69	0.31	33.51	0.29	33.48	0.29
	pGrB[1]	males	166.0	0.73	165.7	0.71	165.9	0.71
	pGrB[2]	females	114.9	0.61	115.0	0.59	115.1	0.59
	pGrBeta[1]	both sexes	0.8166	0.099	0.7588	0.090	0.7726	0.092

Table 15. TCSAM02 models final values for annual recruitment "devs" in the "historical" period up to 1975. Index begins in 1948.

		22.03b		24.01		24.02
index	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
1	-0.4961	1.8	-0.4968	1.8	-0.4900	1.8
2	-0.4953	1.6	-0.4961	1.6	-0.4893	1.6
3	-0.4935	1.5	-0.4944	1.5	-0.4875	1.5
4	-0.4903	1.4	-0.4913	1.4	-0.4845	1.4
5	-0.4852	1.3	-0.4864	1.3	-0.4797	1.3
6	-0.4778	1.2	-0.4791	1.2	-0.4726	1.2
7	-0.4671	1.1	-0.4688	1.1	-0.4624	1.1
8	-0.4523	0.97	-0.4542	0.97	-0.4481	0.97
9	-0.4319	0.90	-0.4341	0.89	-0.4284	0.90
10	-0.4045	0.84	-0.4069	0.84	-0.4016	0.84
11	-0.3680	0.81	-0.3704	0.81	-0.3658	0.81
12	-0.3199	0.80	-0.3220	0.80	-0.3181	0.80
13	-0.2563	0.82	-0.2572	0.82	-0.2544	0.82
14	-0.1707	0.86	-0.1690	0.86	-0.1678	0.86
15	-0.05195	0.90	-0.04515	0.90	-0.04616	0.90
16	0.1205	0.94	0.1369	0.94	0.1326	0.94
17	0.3872	0.93	0.4200	0.93	0.4113	0.93
18	0.8028	0.88	0.8572	0.87	0.8436	0.87
19	1.362	0.78	1.424	0.77	1.407	0.77
20	1.678	0.67	1.669	0.66	1.658	0.66
21	1.200	0.68	1.115	0.68	1.119	0.69
22	0.6397	0.68	0.5799	0.68	0.5864	0.68
23	0.3565	0.66	0.3315	0.66	0.3271	0.66
24	-0.07634	0.66	-0.1171	0.66	-0.1320	0.66
25	-0.4516	0.66	-0.4615	0.66	-0.4759	0.66
26	-0.1578	0.70	-0.08221	0.68	-0.07984	0.69

Table 16. TCSAM02 models final values for annual recruitment “devs” in the “current” period from 1975. The index begins in 1975.

	22.03b		24.01		24.02	
index	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
1	1.363	0.31	1.400	0.30	1.396	0.31
2	1.978	0.19	1.995	0.19	1.999	0.20
3	1.630	0.22	1.607	0.23	1.591	0.23
4	0.6179	0.42	0.5149	0.45	0.5178	0.45
5	-0.1172	0.53	-0.07090	0.51	-0.09390	0.52
6	-0.1723	0.41	-0.1649	0.41	-0.1690	0.41
7	-0.001938	0.29	0.03211	0.28	0.02807	0.29
8	-0.1593	0.28	-0.1301	0.28	-0.1358	0.29
9	1.069	0.12	1.100	0.12	1.108	0.12
10	0.7746	0.17	0.7840	0.17	0.7864	0.17
11	0.9094	0.16	0.8722	0.17	0.8903	0.17
12	0.9429	0.15	0.9426	0.15	0.9576	0.15
13	0.7695	0.17	0.7510	0.17	0.7671	0.17
14	0.3943	0.20	0.2959	0.21	0.2967	0.21
15	-0.3706	0.26	-0.3905	0.25	-0.3893	0.26
16	-1.083	0.35	-1.116	0.35	-1.112	0.35
17	-1.366	0.32	-1.402	0.33	-1.400	0.33
18	-1.297	0.26	-1.292	0.26	-1.287	0.26
19	-1.293	0.26	-1.265	0.26	-1.274	0.26
20	-1.118	0.24	-1.112	0.25	-1.114	0.25
21	-0.6249	0.18	-0.6013	0.18	-0.6024	0.18
22	-0.8545	0.23	-0.8366	0.24	-0.8397	0.24
23	0.06910	0.12	0.06034	0.12	0.05832	0.12
24	-0.9424	0.25	-0.9362	0.25	-0.9452	0.25
25	0.6167	0.099	0.6350	0.098	0.6321	0.099
26	-0.5172	0.28	-0.5445	0.29	-0.5548	0.29
27	1.003	0.10	0.9962	0.10	0.9940	0.10
28	-0.2241	0.29	-0.1964	0.29	-0.2102	0.29
29	1.099	0.11	1.083	0.11	1.083	0.11
30	0.5298	0.15	0.4474	0.16	0.4374	0.16
31	-0.6041	0.28	-0.6248	0.28	-0.6338	0.28
32	-1.068	0.36	-1.116	0.37	-1.124	0.37
33	-0.5162	0.26	-0.5219	0.27	-0.5266	0.27
34	-0.06014	0.27	0.07073	0.26	0.05773	0.26
35	1.394	0.095	1.367	0.10	1.362	0.10
36	0.3749	0.20	0.3139	0.20	0.2867	0.20
37	-0.3674	0.20	-0.3930	0.21	-0.4138	0.21
38	-1.665	0.38	-1.602	0.38	-1.624	0.38
39	-0.7416	0.16	-0.6890	0.15	-0.7136	0.15
40	-1.291	0.22	-1.433	0.24	-1.461	0.24
41	-1.129	0.20	-1.282	0.21	-1.318	0.21
42	-1.006	0.21	-0.6434	0.14	-0.6574	0.14
43	0.7964	0.080	0.7946	0.077	0.7470	0.074
44	-0.1233	0.19	-0.1661	0.19	0.1921	0.13
45	0.3454	0.13	0.3427	0.13	0.2242	0.14
46	-1.587	0.57	-1.521	0.57	-1.495	0.57

(continued)

		22.03b		24.01		24.02
index	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
47	0.7880	0.14	0.8344	0.14	0.8620	0.14
48	1.469	0.15	1.486	0.15	1.496	0.15
49	1.365	0.23	1.325	0.23	1.325	0.23

Table 17. TCSAM02 models final values for parameters related to the probability of terminal molt. Index corresponds to 5-mm size bin starting at 50 mm CW for females and 60 mm CW for males.

			22.03b		24.01		24.02
label	index	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
females 50-105 mmCW (entire model period)	1	-5.425	1.2	-5.376	1.2	-5.307	1.2
	2	-4.159	0.57	-4.130	0.57	-4.088	0.56
	3	-2.931	0.25	-2.921	0.25	-2.901	0.25
	4	-1.711	0.15	-1.705	0.15	-1.695	0.15
	5	-0.5840	0.091	-0.5744	0.091	-0.5656	0.090
	6	0.2544	0.091	0.2596	0.090	0.2720	0.090
	7	0.5724	0.10	0.5765	0.10	0.5885	0.10
	8	1.063	0.14	1.066	0.13	1.076	0.14
	9	1.949	0.23	1.974	0.23	1.981	0.23
	10	2.904	0.44	2.981	0.45	2.973	0.45
	11	3.922	1.0	4.063	1.0	4.033	1.0
males 60-150 mmCW (entire model period)	1	-2.988	0.21	-2.933	0.20	-2.938	0.20
	2	-3.561	0.30	-3.581	0.30	-3.573	0.30
	3	-3.016	0.25	-3.033	0.25	-3.016	0.25
	4	-2.139	0.13	-2.143	0.13	-2.150	0.13
	5	-1.342	0.11	-1.339	0.11	-1.350	0.11
	6	-1.236	0.10	-1.244	0.10	-1.246	0.10
	7	-0.7567	0.096	-0.7746	0.095	-0.7773	0.095
	8	-0.2357	0.086	-0.2308	0.085	-0.2316	0.085
	9	-0.2080	0.088	-0.2109	0.087	-0.2148	0.087
	10	0.1413	0.089	0.1568	0.088	0.1491	0.088
	11	0.5439	0.094	0.5587	0.093	0.5446	0.093
	12	1.020	0.12	0.9955	0.11	0.9986	0.11
	13	1.620	0.14	1.593	0.14	1.596	0.14
	14	2.640	0.26	2.610	0.26	2.616	0.26
	15	3.129	0.28	3.100	0.28	3.103	0.28
	16	3.715	0.49	3.702	0.49	3.697	0.49
	17	4.786	1.1	4.779	1.1	4.771	1.1

Table 18. TCSAM02 models final values for non-vector parameters related to fisheries, surveys, and the Dirichlet-Multinomial likelihood. Parameters with values whose standard error is NA are fixed, not estimated.

				22.03b		24.01		24.02
process	name	label	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
fisheries	pDC2[1]	TCF: female offset	-2.757	0.21	-2.788	0.21	-2.767	0.21
	pDC2[2]	SCF: female offset	-2.682	0.34	-2.703	0.34	-2.691	0.34
	pDC2[3]	GTF: female offset	-1.045	0.097	-1.077	0.099	-1.067	0.097
	pDC2[4]	RKF: female offset	-2.399	0.84	-2.404	0.85	-2.389	0.85
	pHM[1]	handling mortality for pot fisheries	0.3210	NA	0.3210	NA	0.3210	NA
	pHM[2]	handling mortality for groundfish trawl fisheries	0.8000	NA	0.8000	NA	0.8000	NA
	pLgtRet[1]	TCF: logit-scale max retention (pre-1997)	14.90	NA	14.90	NA	14.90	NA
	pLgtRet[2]	TCF: logit-scale max retention (2005-2009)	14.90	NA	14.90	NA	14.90	NA
	pLgtRet[3]	TCF: logit-scale max retention (2013+)	14.90	NA	14.90	NA	14.90	NA
	pLnC[1]	TCF: base capture rate, pre-1965 (=0.05)	-2.996	NA	-2.996	NA	-2.996	NA
	pLnC[2]	TCF: base capture rate, 1965+	-1.501	0.12	-1.495	0.12	-1.474	0.12
	pLnC[3]	SCF: base capture rate, pre-1978 (=0.01)	-4.605	NA	-4.605	NA	-4.605	NA
	pLnC[4]	SCF: base capture rate, 1992+	-3.752	0.071	-3.760	0.070	-3.725	0.068
	pLnC[5]	DUMMY CAPTURE RATE	-4.181	NA	-4.181	NA	-4.181	NA
	pLnC[6]	GTF: base capture rate, ALL YEARS	-5.008	0.060	-5.010	0.061	-4.983	0.059
	pLnC[7]	RKF: base capture rate, pre-1953 (=0.02)	-3.912	NA	-3.912	NA	-3.912	NA
	pLnC[8]	RKF: base capture rate, 1992+	-4.750	0.11	-4.731	0.11	-4.703	0.11
surveys	pQ[1]	NMFS trawl survey: males, 1975-1981	-0.7497	0.11	-0.7621	0.11	-0.7357	0.11
	pQ[2]	NMFS trawl survey: males, 1982+	-0.7258	0.052	-0.7202	0.051	-0.6839	0.049
	pQ[3]	NMFS trawl survey: females, 1975-1981	-1.155	0.14	-1.178	0.14	-1.131	0.13
	pQ[4]	NMFS trawl survey: females, 1982+	-1.391	0.076	-1.400	0.075	-1.343	0.072
	pQ[5]	BSFRF SBS	0.000	NA	0.000	NA	0.000	NA
Dirichlet-Multinomial	pLnDirMul[1]	ln(theta) parameter for BSFRF SBS M	0.9312	0.25	11.00	0.43	11.00	0.21
	pLnDirMul[2]	ln(theta) parameter for BSFRF SBS F	2.523	0.24	11.00	0.083	11.00	0.064

Table 19. TCSAM02 models final values for fishing mortality "devs" for the directed fishery. The index starts in 1965 (or 1982 for models 22.07 and 22.08) and does not include years when the fishery was completely closed.

	22.03b		24.01		24.02	
index	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
1	-1.302	0.88	-1.302	0.88	-1.328	0.89
2	-1.093	0.73	-1.092	0.73	-1.117	0.73
3	0.7475	0.66	0.7513	0.67	0.7258	0.67
4	1.323	0.64	1.329	0.65	1.304	0.65
5	2.471	0.89	2.487	0.91	2.460	0.91
6	4.127	0.76	4.146	0.75	4.128	0.75
7	4.631	0.79	4.612	0.84	4.597	0.85
8	2.075	1.2	2.030	1.3	2.009	1.3
9	0.08760	0.35	0.06128	0.35	0.04754	0.35
10	-0.2471	0.21	-0.2695	0.22	-0.2812	0.22
11	-0.1150	0.18	-0.1315	0.18	-0.1433	0.18
12	0.6381	0.18	0.6250	0.18	0.6142	0.18
13	1.373	0.20	1.353	0.21	1.351	0.21
14	1.597	0.28	1.559	0.28	1.576	0.28
15	2.014	0.35	1.949	0.34	1.981	0.34
16	1.819	0.26	1.812	0.26	1.828	0.26
17	0.2080	0.15	0.2305	0.15	0.2257	0.15
18	-0.9157	0.13	-0.9112	0.13	-0.9158	0.13
19	-2.341	0.13	-2.343	0.13	-2.345	0.13
20	-1.027	0.14	-1.021	0.14	-1.022	0.14
21	-1.381	0.12	-1.379	0.13	-1.381	0.13
22	-0.4222	0.12	-0.4119	0.12	-0.4181	0.13
23	0.7617	0.13	0.7603	0.13	0.7546	0.13
24	1.518	0.13	1.522	0.13	1.520	0.13
25	1.828	0.16	1.854	0.16	1.851	0.16
26	2.157	0.17	2.173	0.17	2.176	0.17
27	1.711	0.17	1.718	0.17	1.723	0.17
28	0.9555	0.17	0.9550	0.18	0.9673	0.18
29	0.3663	0.17	0.3490	0.17	0.3662	0.17
30	0.2977	0.22	0.2809	0.22	0.2975	0.22
31	-2.362	0.13	-2.351	0.13	-2.353	0.13
32	-1.744	0.13	-1.725	0.13	-1.726	0.13
33	-1.921	0.12	-1.910	0.13	-1.910	0.13
34	-2.079	0.12	-2.056	0.13	-2.057	0.13
35	-2.104	0.15	-2.080	0.15	-2.083	0.15
36	-1.953	0.13	-1.922	0.13	-1.918	0.13
37	-0.6772	0.12	-0.6452	0.13	-0.6372	0.13
38	-0.3711	0.12	-0.3602	0.12	-0.3443	0.12
39	-2.076	0.12	-2.081	0.12	-2.057	0.12
40	-1.917	0.12	-1.925	0.12	-1.897	0.12
41	-2.119	0.13	-2.113	0.13	-2.083	0.13
42	-2.448	0.13	-2.440	0.13	-2.410	0.13
43	-2.090	0.13	-2.088	0.13	-2.075	0.13

Table 20. TCSAM02 models final values for fishing mortality "devs" for the snow crab fishery. The indices start in 1990.

		22.03b		24.01		24.02
index	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
1	1.500	0.20	1.504	0.20	1.490	0.20
2	1.748	0.20	1.754	0.20	1.740	0.20
3	0.7377	0.19	0.7416	0.19	0.7315	0.19
4	1.121	0.18	1.124	0.18	1.118	0.18
5	0.5481	0.18	0.5492	0.18	0.5468	0.18
6	0.4713	0.19	0.4707	0.19	0.4710	0.19
7	1.312	0.20	1.314	0.20	1.316	0.20
8	1.082	0.21	1.075	0.21	1.075	0.21
9	0.1489	0.20	0.1433	0.20	0.1431	0.20
10	-1.460	0.21	-1.466	0.21	-1.466	0.21
11	-0.7120	0.21	-0.7162	0.21	-0.7189	0.21
12	-0.2581	0.21	-0.2593	0.21	-0.2627	0.21
13	-1.543	0.21	-1.544	0.21	-1.548	0.21
14	-2.660	0.24	-2.660	0.24	-2.665	0.24
15	-1.971	0.19	-1.974	0.19	-1.978	0.19
16	-0.009352	0.20	-0.005060	0.20	-0.01081	0.20
17	0.1356	0.19	0.1342	0.19	0.1291	0.19
18	0.1713	0.19	0.1757	0.19	0.1703	0.19
19	-0.4576	0.20	-0.4533	0.20	-0.4572	0.20
20	-0.07353	0.20	-0.07573	0.20	-0.07750	0.20
21	0.02648	0.20	0.02327	0.20	0.02331	0.20
22	0.5734	0.20	0.5764	0.20	0.5765	0.20
23	0.2741	0.20	0.2870	0.20	0.2851	0.20
24	0.2001	0.20	0.2210	0.20	0.2178	0.20
25	1.038	0.19	1.044	0.19	1.042	0.19
26	0.8372	0.19	0.8333	0.19	0.8381	0.19
27	0.6638	0.20	0.6524	0.20	0.6636	0.20
28	0.04276	0.20	0.02917	0.20	0.04338	0.20
29	0.04770	0.20	0.03689	0.20	0.05333	0.20
30	0.3588	0.20	0.3575	0.20	0.3760	0.20
31	-1.622	0.21	-1.621	0.21	-1.602	0.21
32	-2.272	0.23	-2.274	0.23	-2.263	0.23

Table 21. TCSAM02 models final values for fishing mortality "devs" for the BBRKC fishery. The indices start in 1990.

	22.03b		24.01		24.02	
index	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
1	3.773	0.23	3.767	0.23	3.757	0.23
2	3.451	0.24	3.458	0.24	3.449	0.24
3	3.243	0.25	3.242	0.25	3.237	0.25
4	4.164	0.23	4.155	0.23	4.151	0.23
5	2.205	0.24	2.184	0.24	2.194	0.24
6	0.9511	0.26	0.9331	0.26	0.9397	0.26
7	0.7002	0.26	0.6840	0.26	0.6889	0.26
8	0.2824	0.27	0.2699	0.27	0.2722	0.27
9	0.06274	0.28	0.05158	0.28	0.05064	0.28
10	-0.5299	0.34	-0.5360	0.34	-0.5399	0.34
11	-0.3393	0.28	-0.3424	0.28	-0.3473	0.28
12	-0.6368	0.29	-0.6373	0.29	-0.6438	0.29
13	-0.9578	0.30	-0.9590	0.30	-0.9654	0.30
14	-1.319	0.33	-1.313	0.33	-1.322	0.33
15	-1.817	0.43	-1.808	0.43	-1.816	0.43
16	-1.271	0.26	-1.265	0.26	-1.273	0.26
17	0.1124	0.22	0.1249	0.22	0.1174	0.22
18	-0.3592	0.22	-0.3512	0.22	-0.3567	0.22
19	-2.025	0.41	-2.023	0.41	-2.026	0.41
20	-2.468	0.69	-2.465	0.69	-2.466	0.69
21	-1.431	0.32	-1.421	0.32	-1.423	0.32
22	-0.3982	0.23	-0.3739	0.23	-0.3787	0.23
23	0.2625	0.22	0.2895	0.22	0.2866	0.22
24	-0.1473	0.22	-0.1374	0.22	-0.1332	0.22
25	-0.1820	0.22	-0.1856	0.22	-0.1755	0.22
26	0.03261	0.22	0.02380	0.22	0.03678	0.22
27	-0.6683	0.25	-0.6769	0.25	-0.6613	0.25
28	-1.897	0.68	-1.900	0.68	-1.883	0.68
29	-2.793	1.3	-2.788	1.3	-2.769	1.3

Table 22. TCSAM02 models final values for fishing mortality "devs" vectors for the groundfish fisheries. Indices start in 1973.

	22.03b		24.01		24.02	
index	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
1	1.495	0.23	1.466	0.23	1.456	0.23
2	1.829	0.21	1.804	0.21	1.794	0.21
3	0.9887	0.21	0.9672	0.21	0.9572	0.21
4	0.4594	0.21	0.4388	0.21	0.4307	0.21
5	0.1311	0.21	0.1090	0.21	0.1040	0.21
6	-0.1531	0.21	-0.1768	0.21	-0.1792	0.21
7	0.4365	0.21	0.4101	0.21	0.4102	0.21
8	0.07031	0.21	0.04836	0.21	0.04922	0.21
9	-0.1028	0.20	-0.1201	0.20	-0.1197	0.20
10	-1.036	0.20	-1.050	0.20	-1.049	0.20
11	-0.3013	0.20	-0.3083	0.20	-0.3085	0.20
12	-0.02304	0.21	-0.02362	0.21	-0.02506	0.21
13	-0.5094	0.20	-0.5122	0.20	-0.5149	0.20
14	-0.2439	0.20	-0.2503	0.20	-0.2553	0.20
15	-0.3566	0.20	-0.3610	0.20	-0.3686	0.20
16	-0.8523	0.20	-0.8586	0.20	-0.8682	0.20
17	-0.5638	0.20	-0.5700	0.20	-0.5810	0.20
18	-0.1902	0.20	-0.1950	0.20	-0.2062	0.20
19	0.6432	0.15	0.6373	0.15	0.6263	0.15
20	0.9007	0.15	0.8939	0.15	0.8861	0.15
21	0.6129	0.15	0.6051	0.15	0.6009	0.15
22	1.046	0.15	1.037	0.15	1.036	0.15
23	0.9548	0.15	0.9453	0.15	0.9471	0.15
24	1.130	0.15	1.120	0.15	1.124	0.15
25	1.583	0.15	1.589	0.15	1.594	0.15
26	1.445	0.15	1.452	0.15	1.457	0.15
27	0.9188	0.15	0.9274	0.15	0.9307	0.15
28	0.9573	0.15	0.9677	0.15	0.9697	0.15
29	1.180	0.15	1.193	0.15	1.194	0.15
30	0.4750	0.15	0.4885	0.15	0.4891	0.15
31	-0.06963	0.15	-0.05509	0.15	-0.05514	0.15
32	0.2206	0.15	0.2367	0.15	0.2363	0.15
33	-0.1107	0.15	-0.09373	0.15	-0.09434	0.15
34	-0.1376	0.15	-0.1210	0.15	-0.1216	0.15
35	-0.04778	0.15	-0.03054	0.15	-0.03100	0.15
36	-0.3839	0.15	-0.3694	0.15	-0.3689	0.15
37	-0.7573	0.14	-0.7450	0.15	-0.7425	0.14
38	-1.095	0.14	-1.081	0.14	-1.076	0.14
39	-0.7880	0.14	-0.7679	0.14	-0.7625	0.14
40	-1.269	0.15	-1.243	0.15	-1.238	0.15
41	-0.7032	0.15	-0.6783	0.15	-0.6740	0.15
42	-0.6180	0.15	-0.6023	0.15	-0.5956	0.15
43	-0.7509	0.14	-0.7441	0.14	-0.7325	0.14
44	-0.6526	0.14	-0.6523	0.14	-0.6365	0.14
45	-1.218	0.14	-1.217	0.14	-1.198	0.14
46	-0.9073	0.14	-0.9024	0.14	-0.8871	0.14

(continued)

		22.03b		24.01		24.02
index	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
47	-0.7780	0.15	-0.7683	0.15	-0.7520	0.15
48	-0.8471	0.15	-0.8366	0.15	-0.8259	0.15
49	-0.8609	0.15	-0.8553	0.15	-0.8574	0.15
50	-1.150	0.15	-1.149	0.15	-1.167	0.15

Table 23. TCSAM02 models final values for the "pS1" parameters related to selectivity functions. Parameters with values whose standard error is NA are fixed, not estimated.

				22.03b		24.01		24.02
	name	label	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
selectivity	pS1[1]	size at 1 for NMFS survey selectivity (males, pre-1982)	179.0	NA	179.0	NA	179.0	NA
	pS1[10]	ascending z-at-1 for SCF selectivity (males, pre-1997)	160.1	2.8	160.2	2.5	160.2	2.6
	pS1[11]	ascending z-at-1 for SCF selectivity (males, 1997-2004)	119.3	6.9	119.6	6.8	119.6	6.8
	pS1[12]	ascending z-at-1 for SCF selectivity (males, 2005+)	125.0	1.3	125.1	1.3	125.1	1.3
	pS1[13]	ascending z50 for SCF selectivity (females, pre-1997)	81.08	7.1	81.29	7.1	81.42	7.0
	pS1[14]	ascending z50 for SCF selectivity (females, 1997-2004)	72.69	4.4	72.80	4.4	72.87	4.3
	pS1[15]	ascending z50 for SCF selectivity (females, 2005+)	101.6	8.8	101.3	8.7	101.0	8.6
	pS1[16]	z50 for GF.AllGear selectivity (males, pre-1987)	61.28	3.5	62.86	3.6	62.91	3.5
	pS1[17]	z50 for GF.AllGear selectivity (males, 1987-1996)	72.57	6.9	74.53	6.9	74.62	6.8
	pS1[18]	z50 for GF.AllGear selectivity (males, 1997+)	98.51	2.6	99.78	2.5	99.64	2.5
	pS1[19]	z50 for GF.AllGear selectivity (females, pre-1987)	43.48	1.8	44.21	1.9	44.67	1.9
	pS1[2]	size at 1 for NMFS survey selectivity (males, 1982+)	179.0	NA	179.0	NA	179.0	NA
	pS1[20]	z50 for GF.AllGear selectivity (females, 1987-1996)	40.25	2.2	40.78	2.3	41.37	2.4
	pS1[21]	z50 for GF.AllGear selectivity (females, 1997+)	87.48	3.2	87.72	3.2	87.48	3.1
	pS1[22]	size at 1 for RKF selectivity (males, pre-1997)	179.9	NA	179.9	NA	179.9	NA
	pS1[23]	size at 1 for RKF selectivity (males, 1997-2004)	179.9	NA	179.9	NA	179.9	NA
	pS1[24]	size at 1 for RKF selectivity (males, 2005+)	179.9	NA	179.9	NA	179.9	NA
	pS1[25]	size at 1 for RKF selectivity (females, pre-1997)	139.9	NA	139.9	NA	139.9	NA
	pS1[26]	size at 1 for RKF selectivity (females, 1997-2004)	137.1	40.	137.3	40.	136.9	39.
	pS1[27]	size at 1 for RKF selectivity (females, 2005+)	135.2	23.	135.5	22.	135.2	22.
	pS1[28]	z50 for TCF retention (2005-2009)	137.6	0.28	137.6	0.28	137.6	0.28
	pS1[29]	z50 for TCF retention (2013+)	125.1	0.81	125.2	0.81	125.2	0.81
	pS1[3]	size at 1 for NMFS survey selectivity (females, pre-1982)	129.9	NA	129.9	NA	129.9	NA
	pS1[4]	size at 1 for NMFS survey selectivity (females, 1982+)	129.9	NA	129.9	NA	129.9	NA
	pS1[5]	z50 for TCF retention (pre-1991)	139.0	0.67	139.0	0.67	139.0	0.69
	pS1[6]	z50 for TCF retention (1991-1996)	138.6	1.2	138.5	1.2	138.4	1.4
	pS1[7]	DUMMY VALUE	4.500	NA	4.500	NA	4.500	NA
	pS1[8]	ln(z50) for TCF selectivity (males)	4.839	0.0062	4.841	0.0061	4.841	0.0061
	pS1[9]	z50 for TCF selectivity (females)	92.89	2.3	93.03	2.3	93.03	2.3

Table 24. TCSAM02 models final values for the “pS2” parameters related to selectivity functions. Parameters with values whose standard error is NA are fixed, not estimated.

			22.03b		24.01		24.02	
	name	label	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
selectivity	pS2[1]	width for NMFS survey selectivity (males, pre-1982)	65.69	2.5	64.22	2.3	63.92	2.2
	pS2[10]	ascending width for SCF selectivity (males, pre-1997)	32.62	1.6	32.44	1.5	32.35	1.5
	pS2[11]	ascending width for SCF selectivity (males, 1997-2004)	15.90	3.5	15.92	3.5	15.94	3.5
	pS2[12]	ascending width for SCF selectivity (males, 2005+)	14.54	0.70	14.53	0.69	14.52	0.69
	pS2[13]	slope for SCF selectivity (females, pre-1997)	0.1345	0.067	0.1347	0.066	0.1357	0.065
	pS2[14]	slope for SCF selectivity (females, 1997-2004)	0.3180	0.24	0.3167	0.24	0.3167	0.23
	pS2[15]	slope for SCF selectivity (females, 2005+)	0.09552	0.023	0.09725	0.023	0.09852	0.024
	pS2[16]	slope for GF.AllGear selectivity (males, pre-1987)	0.08671	0.011	0.08500	0.010	0.08596	0.010
	pS2[17]	slope for GF.AllGear selectivity (males, 1987-1996)	0.04363	0.0069	0.04379	0.0066	0.04451	0.0066
	pS2[18]	slope for GF.AllGear selectivity (males, 1997+)	0.05839	0.0024	0.05880	0.0024	0.05934	0.0023
	pS2[19]	slope for GF.AllGear selectivity (females, pre-1987)	0.1356	0.020	0.1349	0.019	0.1342	0.019
	pS2[2]	width for NMFS survey selectivity (males, 1982+)	90.17	3.0	86.10	2.5	84.75	2.4
	pS2[20]	slope for GF.AllGear selectivity (females, 1987-1996)	0.1649	0.054	0.1625	0.052	0.1563	0.050
	pS2[21]	slope for GF.AllGear selectivity (females, 1997+)	0.06409	0.0042	0.06534	0.0041	0.06659	0.0041
	pS2[22]	width for RKF selectivity (males, pre-1997)	19.87	0.80	19.79	0.79	19.80	0.79
	pS2[23]	width for RKF selectivity (males, 1997-2004)	27.79	2.1	27.66	2.1	27.68	2.1
	pS2[24]	width for RKF selectivity (males, 2005+)	27.34	0.97	27.13	0.95	27.18	0.95
	pS2[25]	width for RKF selectivity (males, pre-1997)	17.99	2.4	17.89	2.3	17.88	2.3
	pS2[26]	width for RKF selectivity (males, 1997-2004)	19.09	15.	19.04	15.	18.93	15.
	pS2[27]	width for RKF selectivity (males, 2005+)	18.05	7.9	18.00	7.8	17.93	7.8
	pS2[28]	slope for TCF retention (2005-2009)	1.990	NA	1.990	NA	1.990	NA
	pS2[29]	slope for TCF retention (2013+)	0.3345	0.070	0.3311	0.069	0.3315	0.069
	pS2[3]	width for NMFS survey selectivity (females, pre-1982)	41.58	2.3	40.80	2.1	40.35	2.1
	pS2[4]	width for NMFS survey selectivity (females, 1982+)	84.76	7.4	78.32	5.8	74.59	4.9
	pS2[5]	slope for TCF retention (pre-1991)	0.7107	0.19	0.7153	0.19	0.7268	0.20
	pS2[6]	slope for TCF retention (1997+)	1.003	0.73	1.012	0.77	1.064	0.99
	pS2[7]	slope for TCF selectivity (males, pre-1997)	0.1216	0.0067	0.1220	0.0066	0.1224	0.0066
	pS2[8]	slope for TCF selectivity (males, 1997+)	0.1718	0.0074	0.1713	0.0072	0.1718	0.0073
	pS2[9]	slope for TCF selectivity (females)	0.1935	0.025	0.1936	0.025	0.1948	0.025

Table 25. TCSAM02 models final values for the “pS3” and “pS4” parameters related to selectivity functions. Parameters with values whose standard error is NA are fixed, not estimated.

			22.03b		24.01		24.02	
	name	label	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
selectivity	pS3[1]	scaled increment for descending z-at-1 for SCF selectivity (males, pre-1997)	0.001000	NA	0.001000	NA	0.001000	NA
	pS3[2]	scaled increment for descending z-at-1 for SCF selectivity (males, 1997-2004)	0.001000	NA	0.001000	NA	0.001000	NA
	pS3[3]	scaled increment for descending z-at-1 for SCF selectivity (males, 2005+)	0.001000	NA	0.001000	NA	0.001000	NA
	pS4[1]	descending width for SCF selectivity (males, pre-1997)	1.100	NA	1.100	NA	1.100	NA
	pS4[2]	descending width for SCF selectivity (males, 1997-2004)	19.93	9.3	19.95	9.4	19.88	9.3
	pS4[3]	descending width for SCF selectivity (males, 2005+)	13.26	1.3	13.32	1.4	13.30	1.4

Table 26. TCSAM02 models final values for the devs parameters related to selectivity in the directed fishery. Parameters with values whose standard error is NA are fixed, not estimated.

	22.03b		24.01		24.02	
index	estimate	std. dev.	estimate	std. dev.	estimate	std. dev.
1	0.1072	0.014	0.1076	0.014	0.1073	0.014
2	0.08506	0.014	0.08534	0.014	0.08519	0.014
3	0.1236	0.013	0.1230	0.013	0.1226	0.013
4	0.1242	0.018	0.1235	0.018	0.1234	0.018
5	0.09926	0.021	0.09789	0.021	0.09800	0.021
6	0.2029	0.021	0.2011	0.021	0.2008	0.020
7	-0.02991	0.014	-0.02998	0.014	-0.03060	0.014
8	-0.01494	0.013	-0.01345	0.013	-0.01426	0.013
9	-0.08091	0.013	-0.08122	0.013	-0.08165	0.013
10	0.03598	0.011	0.03612	0.011	0.03552	0.011
11	0.1523	0.011	0.1513	0.011	0.1510	0.011
12	-0.009697	0.014	-0.009904	0.014	-0.01033	0.014
13	-0.06388	0.012	-0.06233	0.012	-0.06271	0.012
14	-0.09887	0.014	-0.09746	0.013	-0.09773	0.013
15	-0.06597	0.015	-0.06574	0.015	-0.06589	0.015
16	-0.1108	0.014	-0.1115	0.014	-0.1114	0.014
17	-0.1649	0.016	-0.1647	0.016	-0.1643	0.016
18	-0.1523	0.014	-0.1517	0.014	-0.1499	0.014
19	-0.1383	0.013	-0.1378	0.013	-0.1349	0.013

Table 27. Objective function data component values for TCSAM02 models 22.03b, 24.01, 24.02. Table 1 of 3. Abbreviations: n.at.z: size composition data; M: males only; F: females only; NMFS: NMFS EBS shelf survey; SBS BSFRF: BSFRF side-by-side catchability study survey; TCF: directed Tanner crab fishery; SCF: snow crab fishery; RKF: BBRKC fishery; GF All: combined groundfish fisheries. Components not included in the objective function are indicated by "–".

category	fleet	catch type	data type	sex	22.03b	24.01	24.02
surveys data	NMFS M	index catch	abundance	female	–	–	–
				male	–	–	–
			biomass	female	–	–	–
				male	79.29	80.40	82.73
			n.at.z	male	415.48	416.70	417.35
	NMFS F		abundance	female	–	–	–
				male	–	–	–
			biomass	female	165.61	168.44	167.06
				male	–	–	–
			n.at.z	female	299.20	300.54	303.56
	SBS BSFRF M		abundance	female	–	–	–
				male	–	–	–
			biomass	female	–	–	–
				male	-0.81	-1.13	-3.33
			n.at.z	male	290.59	245.67	280.82
	SBS BSFRF F		abundance	female	–	–	–
				male	–	–	–
			biomass	female	-0.19	1.74	2.02
				male	–	–	–

Table 28. Objective function data component values for TCSAM02 models 22.03b, 24.01, 24.02. Table 2 of 3. Abbreviations: n.at.z: size composition data; M: males only; F: females only; NMFS: NMFS EBS shelf survey; SBS BSFRF: BSFRF side-by-side catchability study survey; TCF: directed Tanner crab fishery; SCF: snow crab fishery; RKF: BBRKC fishery; GF All: combined groundfish fisheries. Components not included in the objective function are indicated by "–".

category	fleet	catch type	data type	sex	22.03b	24.01	24.02
surveys data	SBS BSFRF F	index catch	n.at.z	female	232.90	148.45	172.67
fisheries data	TCF	retained catch	abundance	female	–	–	–
				male	–	–	–
			biomass	female	–	–	–
				male	-147.65	-147.55	-147.33
			n.at.z	male	66.94	65.86	66.66
		total catch	abundance	all sexes	–	–	–
			biomass	all sexes	4.79	4.58	4.58
			n.at.z	female	91.38	91.95	91.80
				male	93.48	90.37	91.14
	SCF		abundance	all sexes	–	–	–
			biomass	all sexes	-52.25	-52.26	-52.23
			n.at.z	female	52.39	52.39	52.37
				male	80.30	80.31	80.39
	GF All		abundance	all sexes	-39.43	-39.41	-39.43
			biomass	all sexes	-70.21	-70.17	-70.25
			n.at.z	female	224.62	225.67	226.38
				male	307.29	310.97	311.04
	RKF		abundance	all sexes	–	–	–

Table 29. Objective function data component values for TCSAM02 models 22.03b, 24.01, 24.02. Table 3 of 3. Abbreviations: n.at.z: size composition data; M: males only; F: females only; NMFS: NMFS EBS shelf survey; SBS BSFRF: BSFRF side-by-side catchability study survey; TCF: directed Tanner crab fishery; SCF: snow crab fishery; RKF: BBRKC fishery; GF All: combined groundfish fisheries. Components not included in the objective function are indicated by "–".

category	fleet	catch type	data type	sex	22.03b	24.01	24.02
fisheries data	RKF	total catch	biomass	all sexes	-37.08	-37.05	-37.00
			n.at.z	female	6.88	6.89	6.87
				male	31.47	31.61	31.64
growth data			EBS molt increment data	female	246.16	242.71	243.16
				male	280.00	277.19	278.37
maturity ogive data	NMFS M		EBS mature male ratios	male	255.63	255.91	256.02

Table 30. Objective function non-data component values for TCSAM02 models 22.03b, 24.01, 24.02. Table 1 of 1. Abbreviations: devsSumSq: sum of squared annual deviations ("devs"); pDevsLnC: fishery capture probablity devs; pDevsLnR: recruitment devs; pDevsM: natural mortality devs; pDevsS1: selectivity deviations; pDM1: natural mortality multiplier; pQ: survey catchability. Components not included in the objective function are indicated by "–".

category	type	element	22.03b	24.01	24.02
penalties	devsSumSq	pDevsLnC	0.000	0.000	0.000
		pDevsLnR	0.000	0.000	0.000
		pDevsS1	0.000	0.000	0.000
	maturity	smoothness	2.090	2.244	2.217
priors	natural mortality	pDM1	41.676	46.027	50.914
	recruitment	pDevsLnR	115.363	115.217	115.354
	surveys	pQ	106.871	107.057	100.670

Table 31. Differences in objective function data component values between TCSAM02 models 24.01, 24.02 and 22.03b. Negative values indicate better fits. Table 1 of 3. Abbreviations: n.at.z: size composition data; M: males only; F: females only; NMFS: NMFS EBS shelf survey; SBS BSFRF: BSFRF side-by-side catchability study survey; TCF: directed Tanner crab fishery; SCF: snow crab fishery; RKF: BBRKC fishery; GF All: combined groundfish fisheries.

category	fleet	catch type	data type	sex	24.01	24.02
surveys data	NMFS M	index catch	abundance	female	0.000	0.000
surveys data	NMFS M	index catch	abundance	male	0.000	0.000
surveys data	NMFS M	index catch	biomass	female	0.000	0.000
surveys data	NMFS M	index catch	biomass	male	1.112	3.446
surveys data	NMFS M	index catch	n.at.z	male	1.224	1.871
surveys data	NMFS F	index catch	abundance	female	0.000	0.000
surveys data	NMFS F	index catch	abundance	male	0.000	0.000
surveys data	NMFS F	index catch	biomass	female	2.824	1.446
surveys data	NMFS F	index catch	biomass	male	0.000	0.000
surveys data	NMFS F	index catch	n.at.z	female	1.345	4.361
surveys data	SBS BSFRF M	index catch	abundance	female	0.000	0.000
surveys data	SBS BSFRF M	index catch	abundance	male	0.000	0.000
surveys data	SBS BSFRF M	index catch	biomass	female	0.000	0.000
surveys data	SBS BSFRF M	index catch	biomass	male	-0.314	-2.516
surveys data	SBS BSFRF M	index catch	n.at.z	male	-44.926	-9.776
surveys data	SBS BSFRF F	index catch	abundance	female	0.000	0.000
surveys data	SBS BSFRF F	index catch	abundance	male	0.000	0.000
surveys data	SBS BSFRF F	index catch	biomass	female	1.928	2.210
surveys data	SBS BSFRF F	index catch	biomass	male	0.000	0.000

Table 32. Differences in objective function data component values between TCSAM02 models 24.01, 24.02 and 22.03b. Negative values indicate better fits. Table 2 of 3. Abbreviations: n.at.z: size composition data; M: males only; F: females only; NMFS: NMFS EBS shelf survey; SBS BSFRF: BSFRF side-by-side catchability study survey; TCF: directed Tanner crab fishery; SCF: snow crab fishery; RKF: BBRKC fishery; GF All: combined groundfish fisheries.

category	fleet	catch type	data type	sex	24.01	24.02
surveys data	SBS BSFRF F	index catch	n.at.z	female	-84.449	-60.227
fisheries data	TCF	retained catch	abundance	female	0.000	0.000
fisheries data	TCF	retained catch	abundance	male	0.000	0.000
fisheries data	TCF	retained catch	biomass	female	0.000	0.000
fisheries data	TCF	retained catch	biomass	male	0.107	0.322
fisheries data	TCF	retained catch	n.at.z	male	-1.080	-0.276
fisheries data	TCF	total catch	abundance	all sexes	0.000	0.000
fisheries data	TCF	total catch	biomass	all sexes	-0.214	-0.212
fisheries data	TCF	total catch	n.at.z	female	0.573	0.415
fisheries data	TCF	total catch	n.at.z	male	-3.115	-2.341
fisheries data	SCF	total catch	abundance	all sexes	0.000	0.000
fisheries data	SCF	total catch	biomass	all sexes	-0.011	0.019
fisheries data	SCF	total catch	n.at.z	female	0.002	-0.024
fisheries data	SCF	total catch	n.at.z	male	0.011	0.088
fisheries data	GF All	total catch	abundance	all sexes	0.026	0.000
fisheries data	GF All	total catch	biomass	all sexes	0.046	-0.034
fisheries data	GF All	total catch	n.at.z	female	1.047	1.758
fisheries data	GF All	total catch	n.at.z	male	3.676	3.750
fisheries data	RKF	total catch	abundance	all sexes	0.000	0.000

Table 33. Differences in objective function data component values between TCSAM02 models 24.01, 24.02 and 22.03b. Negative values indicate better fits. Table 3 of 3. Abbreviations: n.at.z: size composition data; M: males only; F: females only; NMFS: NMFS EBS shelf survey; SBS BSFRF: BSFRF side-by-side catchability study survey; TCF: directed Tanner crab fishery; SCF: snow crab fishery; RKF: BBRKC fishery; GF All: combined groundfish fisheries.

category	fleet	catch type	data type	sex	24.01	24.02
fisheries data	RKF	total catch	biomass	all sexes	0.028	0.075
			n.at.z	female	0.011	-0.006
				male	0.139	0.163
growth data			EBS molt increment data	female	-3.454	-2.996
				male	-2.806	-1.624
maturity ogive data	NMFS M		EBS mature male ratios	male	0.284	0.390

Table 34. Differences in objective function non-data component values between TCSAM02 models 24.01, 24.02 and 22.03b. Negative values indicate better fits. Table 1 of 1. Abbreviations: devsSumSq: sum of squared annual deviations (“devs”); pDevsLnC: fishery capture probablity devs; pDevsLnR: recruitment devs; pDevsM: natural mortality devs; pDevsS1: selectivity deviations; pDM1: natural mortality multiplier; pQ: survey catchability.

category	type	element	24.01	24.02
penalties	devsSumSq	pDevsLnC	0.000	0.000
		pDevsLnR	0.000	0.000
		pDevsS1	0.000	0.000
	maturity	smoothness	0.154	0.127
priors	natural mortality	pDM1	4.351	9.238
	recruitment	pDevsLnR	-0.146	-0.009
	surveys	pQ	0.185	-6.201

Table 35. Any GMACS model parameters estimated at a bound are listed here. Those estimated at a lower bound ("lb") are indicated by "type" = -1; those estimated at an upper bound ("ub") are indicated by "type" = 1. se: estimated standard error.

case	estimate	lb	ub	type	gradient	se	description
G24.02	5.011	1.609	5.011	1	0	0.000	Sel RKF male base Logistic mean
G24.02	3.912	0.000	3.912	1	0	0.000	Sel NMFSAM male base Logistic cv
G24.02a	-1.000	-1.000	1.000	-1	0	0.000	M base male immature
G24.02a	5.011	1.609	5.011	1	0	0.000	Sel TCF male base Logistic mean
G24.02a	5.011	1.609	5.011	1	0	0.000	Sel RKF male base Logistic mean
G24.02a	3.912	0.000	3.912	1	0	0.000	Sel NMFSAM male base Logistic cv
G24.03	5.011	1.609	5.011	1	0	0.000	Sel RKF male base Logistic mean
G24.04	5.011	1.609	5.011	1	0	0.000	Sel RKF male base Logistic mean
G24.05	5.011	1.609	5.011	1	0	0.000	Sel RKF male base Logistic mean
G24.06	5.011	1.609	5.011	1	0	0.000	Sel RKF male base Logistic mean
G24.07	5.011	1.609	5.011	1	0	0.000	Sel RKF male base Logistic mean
G24.07	0.015	0.000	3.912	-1	0	1.027	Sel RKF female base Logistic cv

Table 36. All GMACS model parameter values (and standard errors, if estimated) are listed here, by model case. id: overall parameter index (includes fixed parameters); par: index of estimated parameters; phase: first estimation phase (negative values indicate fixed parameters); lb: parameter lower bound; ub: parameter upper bound; est: estimate; se: standard error.

		G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lbub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
Log(R0)	– –	8.000	–	8.000	–	8.000	–	8.000	–	8.000	–	8.000	–	8.000	–
Log(Rinitial)	-10 20	7.749	0.099	7.117	0.046	7.442	0.044	7.421	0.044	7.500	0.043	7.480	0.043	7.497	0.039
Log(Rbar)	-10 20	5.658	0.161	4.619	0.073	5.208	0.073	5.212	0.073	5.312	0.072	5.313	0.072	5.324	0.068
Recruitment ra-males	– –	32.500	–	32.500	–	32.500	–	32.500	–	32.500	–	32.500	–	32.500	–
Recruitment rb-males	– –	1.000	–	1.000	–	1.000	–	1.000	–	1.000	–	1.000	–	1.000	–
Recruitment ra-females	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Recruitment rb-females	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
log(SigmaR)	– –	-0.900	–	-0.900	–	-0.900	–	-0.900	–	-0.900	–	-0.900	–	-0.900	–
Steepness	– –	0.750	–	0.750	–	0.750	–	0.750	–	0.750	–	0.750	–	0.750	–
Rho	– –	0.010	–	0.010	–	0.010	–	0.010	–	0.010	–	0.010	–	0.010	–
logN: male mat. class 2	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: male mat. class 3	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: male mat. class 4	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: male mat. class 5	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: male mat. class 6	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: male mat. class 7	-10 20	-4.018	0.519	-4.050	0.517	-4.073	0.516	-4.064	0.517	-4.079	0.516	-4.073	0.516	-4.022	0.518
logN: male mat. class 8	-10 20	-1.110	0.519	-1.227	0.499	-1.309	0.490	-1.278	0.496	-1.335	0.485	-1.315	0.489	-1.122	0.514
logN: male mat. class 9	-10 20	-0.452	0.445	-0.615	0.432	-0.775	0.426	-0.740	0.430	-0.812	0.417	-0.792	0.421	-0.548	0.427
logN: male mat. class 10	-10 20	-0.271	0.414	-0.403	0.409	-0.650	0.406	-0.635	0.409	-0.670	0.399	-0.671	0.402	-0.435	0.398
logN: male mat. class 11	-10 20	-0.119	0.393	-0.197	0.392	-0.531	0.395	-0.546	0.398	-0.532	0.386	-0.563	0.390	-0.360	0.377
logN: male mat. class 12	-10 20	0.068	0.342	0.025	0.347	-0.344	0.362	-0.370	0.367	-0.336	0.351	-0.372	0.357	-0.274	0.340
logN: male mat. class 13	-10 20	0.263	0.296	0.256	0.303	-0.100	0.324	-0.134	0.330	-0.097	0.314	-0.135	0.321	-0.096	0.303
logN: male mat. class 14	-10 20	0.470	0.275	0.513	0.276	0.183	0.300	0.151	0.306	0.158	0.294	0.123	0.301	0.205	0.269
logN: male mat. class 15	-10 20	0.541	0.261	0.625	0.259	0.361	0.272	0.327	0.278	0.331	0.268	0.298	0.273	0.338	0.244
logN: male mat. class 16	-10 20	0.686	0.226	0.782	0.226	0.572	0.232	0.527	0.237	0.556	0.226	0.516	0.231	0.429	0.219
logN: male mat. class 17	-10 20	0.653	0.213	0.760	0.216	0.546	0.222	0.512	0.227	0.529	0.216	0.498	0.221	0.352	0.216
logN: male mat. class 18	-10 20	0.414	0.240	0.546	0.242	0.254	0.262	0.233	0.266	0.211	0.262	0.188	0.267	0.097	0.243
logN: male mat. class 19	-10 20	0.045	0.300	0.228	0.296	-0.208	0.336	-0.220	0.338	-0.313	0.346	-0.338	0.349	-0.264	0.292
logN: male mat. class 20	-10 20	-0.202	0.331	0.020	0.324	-0.464	0.364	-0.471	0.364	-0.549	0.371	-0.571	0.374	-0.546	0.324
logN: male mat. class 21	-10 20	-0.536	0.348	-0.276	0.343	-0.746	0.369	-0.745	0.370	-0.830	0.372	-0.843	0.375	-0.859	0.343
logN: male mat. class 22	-10 20	-0.843	0.332	-0.538	0.330	-0.931	0.350	-0.934	0.351	-1.043	0.352	-1.056	0.354	-1.055	0.332
logN: male mat. class 23	-10 20	-0.762	0.288	-0.432	0.281	-0.741	0.307	-0.740	0.309	-0.830	0.313	-0.839	0.317	-0.855	0.294
logN: male mat. class 24	-10 20	0.009	0.213	0.264	0.212	0.151	0.216	0.108	0.218	0.223	0.210	0.186	0.213	-0.098	0.211
logN: male mat. class 25	-10 20	-0.281	0.215	-0.074	0.215	-0.097	0.214	-0.140	0.215	-0.025	0.211	-0.059	0.212	-0.254	0.205

Table 37. Parameters table continued.

		G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lbub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
logN: male mat. class 25	-10 20	-0.281	0.215	-0.074	0.215	-0.097	0.214	-0.140	0.215	-0.025	0.211	-0.059	0.212	-0.254	0.205
logN: male mat. class 26	-10 20	-0.564	0.224	-0.406	0.226	-0.354	0.223	-0.400	0.224	-0.267	0.220	-0.300	0.221	-0.425	0.215
logN: male mat. class 27	-10 20	-0.983	0.252	-0.871	0.255	-0.764	0.253	-0.816	0.254	-0.655	0.249	-0.691	0.250	-0.786	0.245
logN: male mat. class 28	-10 20	-1.486	0.280	-1.409	0.283	-1.258	0.282	-1.310	0.282	-1.131	0.278	-1.165	0.279	-1.263	0.275
logN: male mat. class 29	-10 20	-1.993	0.309	-1.926	0.313	-1.763	0.313	-1.810	0.314	-1.641	0.311	-1.669	0.312	-1.759	0.309
logN: male mat. class 30	-10 20	-2.381	0.323	-2.298	0.327	-2.148	0.328	-2.186	0.328	-2.050	0.326	-2.069	0.327	-2.142	0.326
logN: male mat. class 31	-10 20	-2.626	0.327	-2.505	0.332	-2.387	0.331	-2.413	0.332	-2.327	0.328	-2.336	0.329	-2.367	0.331
logN: male mat. class 32	-10 20	-2.768	0.341	-2.619	0.347	-2.523	0.347	-2.543	0.347	-2.487	0.344	-2.491	0.344	-2.494	0.347
logN: male imm. class 1	-10 20	0.883	0.494	0.607	0.469	0.939	0.495	0.860	0.492	1.139	0.502	1.037	0.503	3.426	0.195
logN: male imm. class 2	-10 20	1.969	0.257	1.563	0.238	1.817	0.243	1.857	0.247	1.872	0.241	1.913	0.245	2.335	0.255
logN: male imm. class 3	-10 20	2.199	0.218	1.753	0.208	1.929	0.211	2.009	0.209	1.916	0.215	1.992	0.214	2.300	0.208
logN: male imm. class 4	-10 20	1.436	0.285	1.094	0.270	1.208	0.274	1.284	0.275	1.198	0.277	1.271	0.277	1.446	0.275
logN: male imm. class 5	-10 20	1.210	0.283	0.893	0.273	0.968	0.275	1.049	0.273	0.948	0.279	1.024	0.278	1.057	0.277
logN: male imm. class 6	-10 20	0.624	0.323	0.390	0.312	0.432	0.311	0.458	0.312	0.411	0.315	0.435	0.315	0.399	0.313
logN: male imm. class 7	-10 20	0.599	0.311	0.394	0.302	0.431	0.300	0.506	0.299	0.416	0.304	0.488	0.303	0.382	0.303
logN: male imm. class 8	-10 20	0.329	0.355	0.166	0.344	0.171	0.339	0.231	0.337	0.157	0.344	0.214	0.342	0.017	0.350
logN: male imm. class 9	-10 20	-0.105	0.391	-0.189	0.378	-0.183	0.369	-0.163	0.370	-0.190	0.372	-0.171	0.372	-0.394	0.381
logN: male imm. class 10	-10 20	-0.103	0.401	-0.165	0.390	-0.134	0.376	-0.144	0.376	-0.119	0.379	-0.126	0.378	-0.430	0.390
logN: male imm. class 11	-10 20	0.101	0.408	0.037	0.398	0.059	0.371	0.058	0.370	0.091	0.374	0.093	0.371	-0.312	0.393
logN: male imm. class 12	-10 20	-0.187	0.407	-0.199	0.402	-0.188	0.378	-0.176	0.376	-0.171	0.379	-0.157	0.377	-0.508	0.387
logN: male imm. class 13	-10 20	-0.341	0.398	-0.317	0.398	-0.270	0.378	-0.247	0.376	-0.243	0.376	-0.216	0.374	-0.579	0.384
logN: male imm. class 14	-10 20	0.057	0.400	0.057	0.403	0.170	0.364	0.182	0.360	0.265	0.353	0.286	0.349	-0.309	0.390
logN: male imm. class 15	-10 20	0.229	0.375	0.201	0.385	0.264	0.345	0.268	0.342	0.378	0.331	0.390	0.327	-0.278	0.377
logN: male imm. class 16	-10 20	-0.027	0.373	0.001	0.383	-0.011	0.354	0.015	0.350	0.042	0.346	0.072	0.342	-0.434	0.366
logN: male imm. class 17	-10 20	-0.449	0.369	-0.343	0.378	-0.350	0.359	-0.318	0.357	-0.340	0.353	-0.302	0.351	-0.642	0.359
logN: male imm. class 18	-10 20	-0.518	0.371	-0.411	0.380	-0.322	0.359	-0.302	0.358	-0.238	0.350	-0.202	0.347	-0.663	0.363
logN: male imm. class 19	-10 20	-0.174	0.367	-0.145	0.380	0.096	0.335	0.094	0.334	0.318	0.311	0.347	0.306	-0.414	0.361
logN: male imm. class 20	-10 20	-0.276	0.342	-0.267	0.354	-0.002	0.317	-0.013	0.317	0.176	0.300	0.194	0.297	-0.365	0.341
logN: male imm. class 21	-10 20	-0.392	0.321	-0.374	0.332	-0.109	0.299	-0.109	0.299	0.045	0.286	0.074	0.284	-0.360	0.318
logN: male imm. class 22	-10 20	-0.931	0.328	-0.891	0.337	-0.650	0.317	-0.660	0.317	-0.503	0.305	-0.490	0.305	-0.850	0.326
logN: male imm. class 23	-10 20	-1.412	0.342	-1.359	0.351	-1.098	0.335	-1.103	0.337	-0.964	0.324	-0.943	0.324	-1.251	0.341
logN: male imm. class 24	-10 20	-2.238	0.374	-2.137	0.382	-1.999	0.385	-1.992	0.386	-1.967	0.383	-1.950	0.384	-2.021	0.388
logN: male imm. class 25	-10 20	-4.433	0.478	-4.383	0.484	-4.340	0.486	-4.335	0.487	-4.333	0.486	-4.325	0.487	-4.344	0.487
logN: male imm. class 26	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–

Table 38. Parameters table continued.

		G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lbub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
logN: male imm. class 26	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: male imm. class 27	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: male imm. class 28	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: male imm. class 29	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: male imm. class 30	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: male imm. class 31	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: male imm. class 32	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 1	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 2	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 3	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 4	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 5	-10 20	-4.091	0.511	-4.121	0.509	-4.118	0.510	-4.128	0.509	-4.108	0.510	-4.119	0.509	-4.014	0.513
logN: female mat. class 6	-10 20	-1.317	0.487	-1.415	0.475	-1.409	0.474	-1.441	0.469	-1.389	0.472	-1.421	0.467	-1.033	0.503
logN: female mat. class 7	-10 20	-0.567	0.454	-0.706	0.441	-0.678	0.442	-0.678	0.444	-0.622	0.440	-0.626	0.442	0.014	0.444
logN: female mat. class 8	-10 20	0.126	0.389	-0.018	0.386	0.006	0.379	0.025	0.380	0.002	0.381	0.014	0.381	0.714	0.319
logN: female mat. class 9	-10 20	0.794	0.281	0.717	0.285	0.680	0.277	0.798	0.276	0.596	0.285	0.706	0.285	1.340	0.238
logN: female mat. class 10	-10 20	1.579	0.200	1.570	0.202	1.535	0.197	1.626	0.196	1.468	0.204	1.549	0.203	2.187	0.167
logN: female mat. class 11	-10 20	1.687	0.188	1.726	0.189	1.685	0.185	1.754	0.184	1.679	0.186	1.737	0.186	2.388	0.151
logN: female mat. class 12	-10 20	1.291	0.219	1.362	0.221	1.335	0.212	1.360	0.213	1.447	0.195	1.464	0.195	2.113	0.159
logN: female mat. class 13	-10 20	1.127	0.232	1.228	0.235	1.225	0.223	1.241	0.223	1.377	0.193	1.390	0.193	2.074	0.158
logN: female mat. class 14	-10 20	0.742	0.267	0.860	0.273	0.872	0.256	0.822	0.259	1.038	0.214	0.993	0.214	1.579	0.178
logN: female mat. class 15	-10 20	0.288	0.313	0.410	0.323	0.469	0.302	0.370	0.306	0.509	0.272	0.419	0.274	0.928	0.222
logN: female mat. class 16	-10 20	-0.090	0.346	0.039	0.358	0.129	0.339	0.026	0.340	0.052	0.321	-0.038	0.322	0.476	0.265
logN: female mat. class 17	-10 20	-0.465	0.356	-0.310	0.368	-0.286	0.355	-0.362	0.354	-0.493	0.353	-0.562	0.351	-0.195	0.319
logN: female mat. class 18	-10 20	-0.818	0.364	-0.636	0.376	-0.686	0.365	-0.731	0.364	-0.830	0.365	-0.876	0.363	-0.614	0.345
logN: female mat. class 19	-10 20	-1.126	0.374	-0.932	0.387	-1.015	0.376	-1.023	0.376	-1.101	0.376	-1.113	0.376	-0.859	0.370
logN: female mat. class 20	-10 20	-1.706	0.409	-1.544	0.423	-1.606	0.412	-1.624	0.410	-1.636	0.407	-1.657	0.405	-1.533	0.403
logN: female mat. class 21	-10 20	-4.108	0.502	-4.049	0.509	-4.045	0.506	-4.053	0.505	-4.024	0.501	-4.032	0.500	-3.984	0.501
logN: female mat. class 22	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 23	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 24	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 25	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 26	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 27	– –	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–

Table 39. Parameters table continued.

			G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lb	ub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
logN: female mat. class 27	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 28	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 29	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 30	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 31	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female mat. class 32	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 1	-10	20	0.887	0.438	0.642	0.412	0.858	0.433	0.898	0.439	0.758	0.424	0.791	0.429	0.470	0.418
logN: female imm. class 2	-10	20	1.846	0.239	1.470	0.223	1.684	0.229	1.712	0.232	1.678	0.228	1.701	0.231	1.357	0.244
logN: female imm. class 3	-10	20	1.711	0.232	1.349	0.221	1.529	0.226	1.609	0.226	1.489	0.228	1.553	0.229	1.438	0.226
logN: female imm. class 4	-10	20	1.339	0.255	1.045	0.245	1.166	0.251	1.265	0.251	1.095	0.257	1.174	0.257	1.166	0.251
logN: female imm. class 5	-10	20	0.955	0.291	0.726	0.281	0.802	0.288	0.901	0.289	0.766	0.292	0.847	0.294	0.880	0.293
logN: female imm. class 6	-10	20	0.757	0.319	0.590	0.308	0.613	0.318	0.628	0.320	0.534	0.325	0.524	0.326	0.447	0.342
logN: female imm. class 7	-10	20	0.531	0.361	0.427	0.349	0.414	0.359	0.474	0.362	0.242	0.364	0.316	0.367	0.126	0.405
logN: female imm. class 8	-10	20	0.428	0.405	0.392	0.390	0.345	0.403	0.399	0.406	0.270	0.410	0.337	0.412	-0.091	0.428
logN: female imm. class 9	-10	20	0.092	0.443	0.097	0.436	0.044	0.440	0.068	0.446	0.045	0.447	0.070	0.454	-0.263	0.436
logN: female imm. class 10	-10	20	-0.142	0.452	-0.118	0.451	-0.153	0.454	-0.158	0.453	-0.188	0.450	-0.222	0.448	-0.394	0.428
logN: female imm. class 11	-10	20	-0.236	0.436	-0.190	0.438	-0.216	0.440	-0.216	0.441	-0.329	0.429	-0.368	0.428	-0.508	0.411
logN: female imm. class 12	-10	20	-0.265	0.400	-0.194	0.402	-0.197	0.407	-0.227	0.404	-0.338	0.404	-0.385	0.401	-0.609	0.385
logN: female imm. class 13	-10	20	-0.436	0.388	-0.343	0.391	-0.307	0.400	-0.371	0.395	-0.482	0.398	-0.544	0.394	-0.818	0.379
logN: female imm. class 14	-10	20	-0.715	0.380	-0.594	0.384	-0.567	0.390	-0.638	0.385	-0.754	0.385	-0.823	0.380	-1.111	0.369
logN: female imm. class 15	-10	20	-1.099	0.387	-0.956	0.394	-0.957	0.395	-0.994	0.393	-1.099	0.394	-1.140	0.392	-1.414	0.379
logN: female imm. class 16	-10	20	-1.677	0.418	-1.542	0.430	-1.541	0.428	-1.564	0.427	-1.683	0.430	-1.707	0.428	-1.914	0.412
logN: female imm. class 17	-10	20	-4.208	0.500	-4.160	0.504	-4.160	0.504	-4.168	0.504	-4.168	0.509	-4.177	0.508	-4.248	0.503
logN: female imm. class 18	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 19	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 20	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 21	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 22	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 23	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 24	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 25	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 26	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 27	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 28	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–

Table 40. Parameters table continued.

			G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lb	ub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
logN: female imm. class 28	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 29	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 30	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 31	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
logN: female imm. class 32	–	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–	-15.000	–
Alpha male (ln-scale)	–	–	0.340	–	0.340	–	0.340	–	0.340	–	0.340	–	0.340	–	0.340	–
Beta male	–	–	0.974	–	0.974	–	0.974	–	0.974	–	0.974	–	0.974	–	0.974	–
Gscale male (ln-scale)	–	–	-0.709	–	-0.709	–	-0.709	–	-0.709	–	-0.709	–	-0.709	–	-0.709	–
Alpha female (ln-scale)	–	–	0.575	–	0.575	–	0.575	–	0.575	–	0.575	–	0.575	–	0.575	–
Beta female	–	–	0.904	–	0.904	–	0.904	–	0.904	–	0.904	–	0.904	–	0.904	–
Gscale female (ln-scale)	–	–	-1.315	–	-1.315	–	-1.315	–	-1.315	–	-1.315	–	-1.315	–	-1.315	–
M male mature	0.100	1.500	0.273	0.004	0.267	0.004	0.276	0.004	0.279	0.004	0.252	0.004	0.253	0.004	0.286	0.004
M male immature	-1.000	1.000	-0.198	0.084	-1.000	0.000	-0.344	0.040	-0.330	0.039	-0.068	0.036	-0.053	0.036	-0.210	0.032
M female mature	-1.000	1.000	0.407	0.042	0.416	0.040	0.216	0.037	0.216	0.036	0.212	0.036	0.212	0.035	-0.209	0.029
Sel TCF male Logistic mean	1.609	5.011	4.974	0.008	5.011	0.000	4.965	0.008	4.970	0.008	4.941	0.007	4.943	0.007	4.935	0.006
Sel TCF male Logistic cv	0.000	3.912	2.306	0.022	2.310	0.012	2.276	0.023	2.284	0.023	2.248	0.023	2.252	0.023	2.224	0.023
Sel SCF male Logistic mean	1.609	5.011	4.666	0.007	4.671	0.008	4.668	0.007	4.668	0.007	4.663	0.007	4.663	0.007	4.663	0.007
Sel SCF male Logistic cv	0.000	3.912	1.840	0.047	1.897	0.049	1.852	0.047	1.853	0.047	1.823	0.047	1.824	0.047	1.814	0.047
Sel RKF male Logistic mean	1.609	5.011	5.011	0.000	5.011	0.000	5.011	0.000	5.011	0.000	5.011	0.000	5.011	0.000	5.011	0.000
Sel RKF male Logistic cv	0.000	3.912	2.145	0.034	2.093	0.032	2.151	0.035	2.146	0.035	2.179	0.036	2.172	0.035	2.201	0.036
Sel GFT male Logistic mean	1.609	5.011	4.212	0.033	4.124	0.033	4.183	0.031	4.180	0.031	4.184	0.029	4.181	0.029	4.209	0.030
Sel GFT male Logistic cv	0.000	3.912	2.394	0.079	2.393	0.094	2.365	0.081	2.358	0.081	2.330	0.078	2.323	0.077	2.366	0.076
Sel GFF male Logistic mean	1.609	5.011	4.791	0.012	4.817	0.015	4.795	0.013	4.796	0.013	4.788	0.012	4.788	0.013	4.783	0.012
Sel GFF male Logistic cv	0.000	3.912	2.287	0.042	2.375	0.044	2.301	0.042	2.305	0.042	2.283	0.043	2.285	0.043	2.264	0.043
Sel GFA male Logistic mean	1.609	5.011	4.103	0.058	3.961	0.050	4.059	0.046	4.102	0.047	3.992	0.037	4.023	0.038	4.311	0.051
Sel GFA male Logistic cv	0.000	3.912	2.465	0.133	2.317	0.156	2.375	0.119	2.438	0.115	2.228	0.110	2.274	0.107	2.682	0.092
Sel NMFSAM male Logistic mean	1.609	5.011	4.965	0.080	4.133	0.085	–	–	–	–	–	–	–	–	–	–
Sel NMFSAM male Logistic cv	0.000	3.912	3.912	0.000	3.912	0.000	–	–	–	–	–	–	–	–	–	–
Sel TCF female Logistic mean	1.609	5.011	4.758	0.009	4.583	0.027	4.589	0.026	4.590	0.026	4.556	0.023	4.556	0.023	4.554	0.024
Sel TCF female Logistic cv	0.000	3.912	1.870	0.040	1.709	0.088	1.695	0.083	1.694	0.083	1.649	0.092	1.650	0.093	1.673	0.096
Sel SCF female Logistic mean	1.609	5.011	4.741	0.022	4.372	0.032	4.382	0.032	4.382	0.032	4.360	0.030	4.359	0.030	4.350	0.030
Sel SCF female Logistic cv	0.000	3.912	2.300	0.078	1.631	0.186	1.641	0.181	1.640	0.180	1.595	0.187	1.593	0.187	1.590	0.193
Sel RKF female Logistic mean	1.609	5.011	4.805	0.029	4.795	0.230	4.754	0.163	4.763	0.173	4.785	0.282	4.812	0.406	4.138	0.030
Sel RKF female Logistic cv	0.000	3.912	1.774	0.132	1.828	0.208	1.779	0.218	1.783	0.214	1.884	0.262	1.900	0.277	0.015	1.027

Table 41. Parameters table continued.

			G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lb	ub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
Sel RKF female Logistic cv	0.000	3.912	1.774	0.132	1.828	0.208	1.779	0.218	1.783	0.214	1.884	0.262	1.900	0.277	0.015	1.027
Sel GFT female Logistic mean	1.609	5.011	4.373	0.026	4.347	0.030	4.426	0.028	4.423	0.028	4.448	0.029	4.446	0.029	4.508	0.028
Sel GFT female Logistic cv	0.000	3.912	2.550	0.066	2.685	0.076	2.717	0.068	2.712	0.068	2.745	0.068	2.744	0.068	2.840	0.063
Sel GFF female Logistic mean	1.609	5.011	4.695	0.014	4.721	0.016	4.723	0.015	4.723	0.015	4.737	0.016	4.738	0.016	4.742	0.015
Sel GFF female Logistic cv	0.000	3.912	2.083	0.055	2.164	0.057	2.135	0.055	2.136	0.055	2.169	0.056	2.173	0.056	2.168	0.056
Sel GFA female Logistic mean	1.609	5.011	4.277	0.059	4.203	0.068	4.343	0.064	4.372	0.061	4.318	0.076	4.337	0.070	4.975	0.142
Sel GFA female Logistic cv	0.000	3.912	2.882	0.114	3.031	0.144	3.084	0.122	3.069	0.112	3.146	0.151	3.118	0.137	3.725	0.127
Sel NMFSIF female Logistic mean	1.609	5.011	4.283	0.081	2.273	0.846	–	–	–	–	–	–	–	–	–	–
Sel NMFSIF female Logistic cv	0.000	3.912	3.498	0.080	3.538	0.189	–	–	–	–	–	–	–	–	–	–
Ret TCF male Logistic mean	1.609	5.011	4.888	0.002	4.889	0.002	4.883	0.002	4.884	0.002	4.882	0.002	4.883	0.002	4.883	0.002
Ret TCF male Logistic cv	0.000	3.912	1.202	0.045	1.159	0.042	1.197	0.046	1.200	0.046	1.177	0.048	1.181	0.048	1.187	0.048
Log fbar TCF	-1,000.000	1,000.000	-2.084	0.061	-1.328	0.034	-1.856	0.053	-1.791	0.054	-2.056	0.045	-2.022	0.046	-1.905	0.041
Log fbar SCF	-1,000.000	1,000.000	-4.296	0.067	-3.940	0.051	-4.007	0.048	-3.994	0.048	-3.982	0.046	-3.974	0.046	-3.930	0.044
Log fbar RKF	-1,000.000	1,000.000	-4.213	0.072	-3.457	0.059	-3.904	0.061	-3.890	0.061	-3.932	0.059	-3.926	0.059	-3.922	0.058
Log fbar GFT	-1,000.000	1,000.000	-6.020	0.071	-5.647	0.046	-5.698	0.044	-5.683	0.044	-5.653	0.044	-5.641	0.044	-5.545	0.043
Log fbar GFF	-1,000.000	1,000.000	-6.393	0.123	-5.906	0.094	-6.037	0.078	-6.021	0.077	-6.036	0.085	-6.026	0.082	-6.008	0.069
Log fbar GFA	-1,000.000	1,000.000	-5.766	0.087	-5.454	0.082	-5.628	0.604	-5.557	0.163	-5.763	0.071	-5.736	0.071	-5.302	0.083
Log fbar NMFSAM	–	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–
Log fbar NMFSIF	–	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–
Log fbar NMFSMF	–	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–	-4.000	–
fdev TCF 1982	-1,000.000	1,000.000	-0.745	0.106	-0.936	0.113	-0.985	0.109	-0.936	0.109	-1.032	0.105	-0.988	0.105	-0.628	0.092
fdev TCF 1983	-1,000.000	1,000.000	-2.657	0.062	-2.871	0.065	-2.939	0.056	-2.909	0.058	-3.002	0.044	-2.983	0.046	-2.429	0.060
fdev TCF 1984	-1,000.000	1,000.000	-1.539	0.057	-1.761	0.060	-1.803	0.052	-1.773	0.054	-1.880	0.040	-1.861	0.042	-1.246	0.059
fdev TCF 1987	-1,000.000	1,000.000	-1.264	0.046	-1.487	0.048	-1.458	0.042	-1.426	0.045	-1.563	0.033	-1.543	0.035	-0.886	0.053
fdev TCF 1988	-1,000.000	1,000.000	0.033	0.037	-0.174	0.040	-0.114	0.035	-0.085	0.037	-0.205	0.028	-0.187	0.030	0.368	0.043
fdev TCF 1989	-1,000.000	1,000.000	1.432	0.025	1.310	0.028	1.355	0.025	1.373	0.026	1.295	0.021	1.306	0.022	1.580	0.026
fdev TCF 1990	-1,000.000	1,000.000	2.236	0.019	2.244	0.020	2.255	0.019	2.244	0.019	2.278	0.017	2.268	0.018	2.232	0.020
fdev TCF 1991	-1,000.000	1,000.000	2.408	0.035	2.414	0.037	2.438	0.036	2.394	0.036	2.692	0.032	2.658	0.033	2.428	0.033
fdev TCF 1992	-1,000.000	1,000.000	2.702	0.046	2.705	0.045	2.709	0.046	2.636	0.046	3.036	0.049	2.968	0.049	2.641	0.049
fdev TCF 1993	-1,000.000	1,000.000	1.872	0.046	1.853	0.045	1.865	0.045	1.774	0.045	1.642	0.047	1.558	0.047	1.181	0.044
fdev TCF 1994	-1,000.000	1,000.000	1.019	0.049	1.000	0.054	1.023	0.050	0.919	0.050	0.842	0.047	0.742	0.046	0.405	0.039
fdev TCF 1995	-1,000.000	1,000.000	0.224	0.038	0.109	0.042	0.232	0.038	0.138	0.039	0.028	0.037	-0.064	0.037	-0.270	0.030
fdev TCF 1996	-1,000.000	1,000.000	-0.671	0.036	-0.895	0.039	-0.659	0.037	-0.741	0.037	-0.611	0.037	-0.699	0.038	-0.845	0.030
fdev TCF 2005	-1,000.000	1,000.000	-1.280	0.033	-1.720	0.040	-1.223	0.035	-1.232	0.035	-1.190	0.033	-1.201	0.033	-1.299	0.026

Table 42. Parameters table continued.

description	lb	ub	G24.02 est	G24.02 se	G24.02a est	G24.02a se	G24.03 est	G24.03 se	G24.04 est	G24.04 se	G24.05 est	G24.05 se	G24.06 est	G24.06 se	G24.07 est	G24.07 se
fdev TCF 2005	-1,000	1,000	-1.280	0.033	-1.720	0.040	-1.223	0.035	-1.232	0.035	-1.190	0.033	-1.201	0.033	-1.299	0.026
fdev TCF 2006	-1,000	1,000	-0.626	0.034	0.115	0.050	-0.573	0.036	-0.563	0.036	-0.593	0.034	-0.585	0.034	-0.633	0.027
fdev TCF 2007	-1,000	1,000	-0.926	0.034	0.066	0.056	-0.878	0.035	-0.858	0.035	-0.740	0.033	-0.723	0.033	-0.730	0.027
fdev TCF 2008	-1,000	1,000	-1.323	0.031	-0.930	0.038	-1.294	0.032	-1.292	0.032	-1.034	0.030	-1.026	0.030	-1.072	0.025
fdev TCF 2009	-1,000	1,000	-1.824	0.031	-1.699	0.036	-1.810	0.032	-1.824	0.032	-1.662	0.031	-1.670	0.032	-1.765	0.026
fdev TCF 2013	-1,000	1,000	-0.728	0.029	-0.814	0.032	-0.707	0.029	-0.722	0.029	-0.505	0.029	-0.512	0.029	-0.597	0.025
fdev TCF 2014	-1,000	1,000	0.929	0.030	0.873	0.034	0.988	0.031	0.987	0.031	1.054	0.030	1.058	0.030	0.863	0.027
fdev TCF 2015	-1,000	1,000	1.294	0.034	1.266	0.041	1.413	0.037	1.444	0.037	1.429	0.036	1.461	0.036	1.195	0.029
fdev TCF 2017	-1,000	1,000	-0.760	0.034	-0.927	0.040	-0.649	0.036	-0.592	0.036	-0.638	0.035	-0.581	0.035	-0.814	0.027
fdev TCF 2018	-1,000	1,000	-0.620	0.035	-0.811	0.041	-0.502	0.037	-0.434	0.038	-0.413	0.036	-0.349	0.036	-0.548	0.027
fdev TCF 2020	-1,000	1,000	0.712	0.061	0.924	0.066	0.910	0.064	0.938	0.062	0.294	0.048	0.331	0.048	0.340	0.047
fdev TCF 2021	-1,000	1,000	-0.083	0.046	-0.004	0.050	0.081	0.048	0.138	0.047	0.058	0.042	0.118	0.042	0.125	0.039
fdev TCF 2022	-1,000	1,000	0.185	0.047	0.148	0.052	0.325	0.049	0.400	0.049	0.419	0.042	0.504	0.042	0.404	0.035
fdev SCF 1982	-1,000	1,000	0.054	0.194	0.042	0.194	0.043	0.194	0.042	0.194	0.044	0.194	0.044	0.194	0.069	0.196
fdev SCF 1983	-1,000	1,000	-0.455	0.194	-0.468	0.194	-0.468	0.193	-0.469	0.193	-0.467	0.193	-0.468	0.193	-0.453	0.194
fdev SCF 1984	-1,000	1,000	0.295	0.193	0.282	0.193	0.274	0.192	0.275	0.192	0.269	0.191	0.270	0.191	0.291	0.192
fdev SCF 1985	-1,000	1,000	0.655	0.191	0.640	0.191	0.624	0.189	0.626	0.189	0.611	0.188	0.612	0.188	0.634	0.189
fdev SCF 1986	-1,000	1,000	0.769	0.190	0.753	0.190	0.734	0.187	0.737	0.188	0.716	0.186	0.718	0.186	0.697	0.183
fdev SCF 1987	-1,000	1,000	0.944	0.188	0.928	0.188	0.902	0.185	0.905	0.186	0.878	0.183	0.879	0.183	0.823	0.178
fdev SCF 1988	-1,000	1,000	0.833	0.189	0.820	0.189	0.795	0.186	0.798	0.186	0.773	0.184	0.773	0.184	0.666	0.175
fdev SCF 1989	-1,000	1,000	1.155	0.189	1.139	0.189	1.102	0.185	1.106	0.185	1.076	0.183	1.078	0.183	0.891	0.169
fdev SCF 1990	-1,000	1,000	1.577	0.198	1.379	0.188	1.375	0.187	1.344	0.187	1.431	0.185	1.407	0.185	1.217	0.182
fdev SCF 1991	-1,000	1,000	1.877	0.208	1.644	0.195	1.618	0.192	1.580	0.193	1.859	0.195	1.833	0.196	2.031	0.239
fdev SCF 1992	-1,000	1,000	0.615	0.200	0.515	0.198	0.483	0.197	0.432	0.197	0.738	0.199	0.693	0.199	0.598	0.208
fdev SCF 1993	-1,000	1,000	0.875	0.207	0.860	0.209	0.785	0.206	0.718	0.205	0.823	0.202	0.760	0.202	0.672	0.210
fdev SCF 1994	-1,000	1,000	0.061	0.200	0.035	0.201	0.003	0.200	-0.062	0.200	0.022	0.197	-0.040	0.198	-0.100	0.201
fdev SCF 1995	-1,000	1,000	-0.195	0.198	-0.265	0.197	-0.245	0.197	-0.301	0.197	-0.159	0.197	-0.215	0.197	-0.220	0.200
fdev SCF 1996	-1,000	1,000	0.663	0.201	0.585	0.203	0.637	0.202	0.585	0.202	0.764	0.202	0.712	0.202	0.780	0.208
fdev SCF 1997	-1,000	1,000	0.868	0.203	0.791	0.204	0.864	0.204	0.819	0.205	0.995	0.204	0.946	0.204	1.024	0.209
fdev SCF 1998	-1,000	1,000	-0.134	0.198	-0.223	0.198	-0.130	0.198	-0.176	0.198	-0.014	0.198	-0.065	0.198	-0.027	0.198
fdev SCF 1999	-1,000	1,000	-1.668	0.197	-1.761	0.197	-1.646	0.197	-1.688	0.197	-1.593	0.197	-1.642	0.197	-1.617	0.197
fdev SCF 2000	-1,000	1,000	-0.770	0.197	-0.869	0.198	-0.730	0.198	-0.765	0.198	-0.675	0.198	-0.717	0.198	-0.691	0.197
fdev SCF 2001	-1,000	1,000	-0.215	0.198	-0.324	0.198	-0.161	0.198	-0.185	0.198	-0.142	0.198	-0.171	0.198	-0.153	0.198
fdev SCF 2002	-1,000	1,000	-1.448	0.198	-1.570	0.198	-1.389	0.198	-1.404	0.198	-1.419	0.198	-1.438	0.198	-1.441	0.197

Table 43. Parameters table continued.

description	lb	ub	G24.02 est	G24.02 se	G24.02a est	G24.02a se	G24.03 est	G24.03 se	G24.04 est	G24.04 se	G24.05 est	G24.05 se	G24.06 est	G24.06 se	G24.07 est	G24.07 se
fdev SCF 2002	-1,000	1,000	-1.448	0.198	-1.570	0.198	-1.389	0.198	-1.404	0.198	-1.419	0.198	-1.438	0.198	-1.441	0.197
fdev SCF 2003	-1,000	1,000	-2.477	0.198	-2.626	0.198	-2.422	0.198	-2.430	0.198	-2.521	0.198	-2.532	0.198	-2.548	0.197
fdev SCF 2004	-1,000	1,000	-1.899	0.198	-2.093	0.198	-1.850	0.198	-1.845	0.198	-1.931	0.198	-1.930	0.198	-1.927	0.197
fdev SCF 2005	-1,000	1,000	0.108	0.201	-0.093	0.198	0.157	0.202	0.179	0.202	0.095	0.201	0.108	0.201	0.162	0.202
fdev SCF 2006	-1,000	1,000	0.107	0.201	0.423	0.201	0.155	0.202	0.184	0.202	0.064	0.200	0.086	0.200	0.180	0.201
fdev SCF 2007	-1,000	1,000	-0.008	0.197	0.357	0.196	0.014	0.197	0.030	0.197	0.044	0.196	0.059	0.195	0.131	0.197
fdev SCF 2008	-1,000	1,000	-0.664	0.197	-0.425	0.197	-0.659	0.197	-0.655	0.197	-0.602	0.196	-0.595	0.196	-0.562	0.197
fdev SCF 2009	-1,000	1,000	-0.313	0.197	-0.134	0.198	-0.315	0.197	-0.315	0.198	-0.280	0.197	-0.279	0.197	-0.256	0.197
fdev SCF 2010	-1,000	1,000	-0.302	0.197	-0.158	0.198	-0.305	0.198	-0.304	0.198	-0.242	0.197	-0.239	0.197	-0.212	0.197
fdev SCF 2011	-1,000	1,000	0.211	0.197	0.337	0.198	0.213	0.197	0.215	0.197	0.246	0.196	0.250	0.196	0.286	0.196
fdev SCF 2012	-1,000	1,000	-0.001	0.197	0.105	0.198	0.005	0.197	0.011	0.197	0.047	0.196	0.052	0.196	0.077	0.196
fdev SCF 2013	-1,000	1,000	0.148	0.196	0.231	0.198	0.165	0.197	0.177	0.197	0.202	0.196	0.214	0.196	0.187	0.198
fdev SCF 2014	-1,000	1,000	1.136	0.197	1.215	0.201	1.177	0.198	1.211	0.199	1.146	0.198	1.179	0.199	1.152	0.207
fdev SCF 2015	-1,000	1,000	0.834	0.198	0.869	0.199	0.888	0.198	0.938	0.199	0.870	0.199	0.917	0.199	0.847	0.204
fdev SCF 2016	-1,000	1,000	0.507	0.199	0.514	0.199	0.568	0.199	0.625	0.199	0.530	0.200	0.583	0.200	0.513	0.202
fdev SCF 2017	-1,000	1,000	-0.224	0.198	-0.242	0.199	-0.161	0.199	-0.093	0.199	-0.216	0.199	-0.153	0.199	-0.204	0.200
fdev SCF 2018	-1,000	1,000	-0.276	0.198	-0.306	0.199	-0.206	0.199	-0.129	0.199	-0.256	0.199	-0.186	0.199	-0.195	0.200
fdev SCF 2019	-1,000	1,000	0.339	0.198	0.428	0.199	0.450	0.199	0.505	0.198	0.149	0.198	0.216	0.198	0.273	0.199
fdev SCF 2020	-1,000	1,000	-1.498	0.199	-1.355	0.199	-1.373	0.199	-1.319	0.198	-1.709	0.197	-1.637	0.197	-1.557	0.197
fdev SCF 2021	-1,000	1,000	-2.084	0.199	-1.978	0.199	-1.970	0.199	-1.902	0.199	-2.165	0.198	-2.083	0.198	-2.037	0.197
fdev RKF 1982	-1,000	1,000	0.371	0.193	0.377	0.194	0.373	0.193	0.372	0.193	0.373	0.193	0.373	0.193	0.380	0.194
fdev RKF 1984	-1,000	1,000	0.094	0.193	0.095	0.193	0.091	0.192	0.091	0.192	0.088	0.192	0.088	0.192	0.093	0.192
fdev RKF 1985	-1,000	1,000	-0.150	0.192	-0.153	0.192	-0.154	0.192	-0.154	0.192	-0.157	0.191	-0.157	0.191	-0.154	0.191
fdev RKF 1986	-1,000	1,000	0.569	0.191	0.560	0.190	0.558	0.190	0.560	0.190	0.550	0.189	0.552	0.189	0.544	0.188
fdev RKF 1987	-1,000	1,000	0.788	0.190	0.775	0.189	0.773	0.188	0.775	0.189	0.762	0.187	0.764	0.188	0.752	0.186
fdev RKF 1988	-1,000	1,000	0.384	0.191	0.374	0.190	0.374	0.190	0.376	0.190	0.368	0.189	0.369	0.189	0.357	0.188
fdev RKF 1989	-1,000	1,000	0.718	0.190	0.709	0.189	0.706	0.189	0.709	0.189	0.698	0.188	0.700	0.188	0.670	0.186
fdev RKF 1990	-1,000	1,000	2.689	0.185	2.398	0.181	2.577	0.178	2.592	0.179	2.528	0.177	2.541	0.177	2.508	0.171
fdev RKF 1991	-1,000	1,000	2.491	0.195	2.125	0.187	2.379	0.187	2.356	0.188	2.596	0.188	2.584	0.188	2.550	0.195
fdev RKF 1992	-1,000	1,000	2.253	0.198	1.961	0.197	2.181	0.195	2.137	0.196	2.502	0.202	2.467	0.202	2.343	0.211
fdev RKF 1993	-1,000	1,000	2.933	0.187	2.621	0.184	2.807	0.181	2.759	0.182	2.746	0.194	2.700	0.196	2.624	0.211
fdev RKF 1996	-1,000	1,000	0.373	0.194	-0.071	0.193	0.342	0.193	0.287	0.193	0.333	0.194	0.273	0.194	0.265	0.194
fdev RKF 1997	-1,000	1,000	0.070	0.199	-0.388	0.200	0.064	0.200	0.013	0.200	0.147	0.200	0.084	0.200	0.104	0.199
fdev RKF 1998	-1,000	1,000	-0.103	0.199	-0.570	0.199	-0.097	0.199	-0.144	0.199	0.029	0.200	-0.032	0.200	0.005	0.198

Table 44. Parameters table continued.

			G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lb	ub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
fdev RKF 1998	-1,000	1,000	-0.103	0.199	-0.570	0.199	-0.097	0.199	-0.144	0.199	0.029	0.200	-0.032	0.200	0.005	0.198
fdev RKF 1999	-1,000	1,000	-0.448	0.199	-0.925	0.199	-0.428	0.199	-0.471	0.199	-0.353	0.199	-0.408	0.199	-0.377	0.198
fdev RKF 2000	-1,000	1,000	-0.540	0.199	-1.031	0.199	-0.504	0.199	-0.542	0.199	-0.414	0.199	-0.464	0.199	-0.426	0.198
fdev RKF 2001	-1,000	1,000	-1.001	0.232	-1.508	0.232	-0.954	0.232	-0.983	0.232	-0.867	0.232	-0.904	0.232	-0.873	0.231
fdev RKF 2002	-1,000	1,000	-0.666	0.199	-1.190	0.199	-0.611	0.199	-0.627	0.199	-0.678	0.199	-0.696	0.199	-0.684	0.198
fdev RKF 2003	-1,000	1,000	-0.857	0.199	-1.405	0.199	-0.805	0.199	-0.813	0.199	-0.987	0.199	-0.993	0.199	-0.992	0.199
fdev RKF 2004	-1,000	1,000	-1.056	0.200	-1.635	0.200	-1.013	0.200	-1.012	0.200	-1.124	0.200	-1.124	0.200	-1.117	0.199
fdev RKF 2005	-1,000	1,000	-1.414	0.237	-2.048	0.236	-1.379	0.237	-1.362	0.237	-1.418	0.237	-1.405	0.237	-1.373	0.236
fdev RKF 2006	-1,000	1,000	-1.925	0.324	6.628	0.086	-1.896	0.325	-1.861	0.325	-1.961	0.324	-1.931	0.324	-1.852	0.324
fdev RKF 2007	-1,000	1,000	-1.496	0.199	-0.877	0.202	-1.469	0.199	-1.430	0.199	-1.388	0.199	-1.352	0.199	-1.242	0.198
fdev RKF 2008	-1,000	1,000	-0.261	0.197	-0.129	0.198	-0.257	0.197	-0.234	0.197	-0.077	0.196	-0.049	0.196	0.028	0.196
fdev RKF 2009	-1,000	1,000	-0.773	0.198	-0.861	0.198	-0.784	0.198	-0.774	0.198	-0.709	0.198	-0.695	0.198	-0.661	0.197
fdev RKF 2010	-1,000	1,000	-2.529	0.300	-2.710	0.300	-2.549	0.300	-2.544	0.300	-2.385	0.300	-2.373	0.300	-2.331	0.299
fdev RKF 2011	-1,000	1,000	-3.060	0.516	-3.302	0.517	-3.094	0.516	-3.085	0.516	-2.934	0.515	-2.920	0.515	-2.876	0.515
fdev RKF 2012	-1,000	1,000	-2.025	0.232	-2.288	0.232	-2.040	0.232	-2.032	0.232	-1.910	0.232	-1.897	0.232	-1.833	0.231
fdev RKF 2013	-1,000	1,000	-0.792	0.198	-1.064	0.199	-0.795	0.198	-0.784	0.198	-0.657	0.198	-0.640	0.198	-0.603	0.198
fdev RKF 2014	-1,000	1,000	0.126	0.199	-0.123	0.201	0.162	0.199	0.187	0.200	0.176	0.199	0.205	0.199	0.141	0.199
fdev RKF 2015	-1,000	1,000	-0.269	0.200	-0.512	0.201	-0.177	0.200	-0.123	0.200	-0.209	0.200	-0.155	0.200	-0.285	0.199
fdev RKF 2016	-1,000	1,000	-0.450	0.200	-0.758	0.201	-0.355	0.200	-0.282	0.200	-0.402	0.200	-0.331	0.200	-0.463	0.199
fdev RKF 2017	-1,000	1,000	-0.347	0.200	-0.708	0.201	-0.264	0.200	-0.183	0.200	-0.311	0.200	-0.233	0.200	-0.328	0.199
fdev RKF 2018	-1,000	1,000	-1.100	0.199	-1.487	0.200	-1.011	0.200	-0.920	0.200	-0.982	0.200	-0.896	0.200	-0.960	0.198
fdev RKF 2019	-1,000	1,000	7.405	0.114	7.121	0.122	7.251	0.119	7.147	0.116	6.028	0.088	5.956	0.090	6.065	0.083
fdev GFT 1991	-1,000	1,000	1.712	0.203	1.546	0.197	1.496	0.195	1.448	0.196	1.696	0.198	1.654	0.198	1.713	0.227
fdev GFT 1992	-1,000	1,000	1.911	0.207	1.798	0.203	1.738	0.201	1.680	0.201	1.909	0.200	1.855	0.201	1.972	0.238
fdev GFT 1993	-1,000	1,000	1.540	0.205	1.486	0.206	1.432	0.204	1.366	0.204	1.516	0.201	1.455	0.201	1.458	0.217
fdev GFT 1994	-1,000	1,000	1.824	0.207	1.778	0.209	1.751	0.208	1.689	0.208	1.825	0.204	1.769	0.205	1.896	0.233
fdev GFT 1995	-1,000	1,000	1.531	0.205	1.470	0.207	1.486	0.207	1.430	0.207	1.581	0.205	1.527	0.205	1.609	0.221
fdev GFT 1996	-1,000	1,000	1.787	0.208	1.743	0.214	1.789	0.214	1.737	0.215	1.895	0.212	1.843	0.213	2.006	0.239
fdev GFT 1997	-1,000	1,000	1.617	0.203	1.553	0.206	1.618	0.206	1.573	0.207	1.721	0.205	1.673	0.206	1.759	0.216
fdev GFT 1998	-1,000	1,000	1.403	0.199	1.323	0.199	1.405	0.200	1.361	0.200	1.493	0.199	1.445	0.199	1.469	0.202
fdev GFT 1999	-1,000	1,000	1.002	0.198	0.917	0.198	1.021	0.199	0.982	0.199	1.076	0.198	1.031	0.198	1.031	0.199
fdev GFT 2000	-1,000	1,000	1.243	0.198	1.149	0.199	1.280	0.200	1.252	0.200	1.326	0.200	1.293	0.200	1.299	0.202
fdev GFT 2001	-1,000	1,000	1.655	0.200	1.539	0.200	1.708	0.203	1.692	0.204	1.712	0.202	1.690	0.202	1.709	0.207
fdev GFT 2002	-1,000	1,000	1.025	0.199	0.888	0.198	1.070	0.200	1.060	0.201	1.027	0.199	1.012	0.200	1.005	0.202

Table 45. Parameters table continued.

description	lb	ub	G24.02 est	G24.02 se	G24.02a est	G24.02a se	G24.03 est	G24.03 se	G24.04 est	G24.04 se	G24.05 est	G24.05 se	G24.06 est	G24.06 se	G24.07 est	G24.07 se
fdev GFT 2002	-1,000	1,000	1.025	0.199	0.888	0.198	1.070	0.200	1.060	0.201	1.027	0.199	1.012	0.200	1.005	0.202
fdev GFT 2003	-1,000	1,000	0.438	0.198	0.300	0.197	0.472	0.199	0.471	0.199	0.395	0.198	0.388	0.198	0.383	0.199
fdev GFT 2004	-1,000	1,000	0.654	0.198	0.551	0.197	0.678	0.199	0.685	0.199	0.608	0.198	0.608	0.198	0.627	0.198
fdev GFT 2005	-1,000	1,000	0.190	0.197	0.168	0.197	0.200	0.197	0.209	0.197	0.145	0.196	0.149	0.196	0.178	0.196
fdev GFT 2006	-1,000	1,000	-0.295	0.196	-0.076	0.196	-0.292	0.197	-0.287	0.197	-0.338	0.196	-0.334	0.196	-0.314	0.196
fdev GFT 2007	-1,000	1,000	-0.947	0.196	-0.695	0.197	-0.952	0.197	-0.953	0.197	-0.941	0.196	-0.941	0.196	-0.940	0.197
fdev GFT 2008	-1,000	1,000	-0.869	0.197	-0.680	0.197	-0.880	0.197	-0.885	0.197	-0.853	0.197	-0.856	0.197	-0.869	0.197
fdev GFT 2009	-1,000	1,000	-1.315	0.197	-1.167	0.197	-1.329	0.197	-1.335	0.197	-1.314	0.197	-1.319	0.197	-1.338	0.196
fdev GFT 2010	-1,000	1,000	-1.494	0.196	-1.375	0.197	-1.507	0.197	-1.512	0.197	-1.479	0.196	-1.483	0.196	-1.500	0.196
fdev GFT 2011	-1,000	1,000	-1.301	0.196	-1.205	0.196	-1.310	0.196	-1.312	0.196	-1.292	0.196	-1.294	0.196	-1.325	0.196
fdev GFT 2012	-1,000	1,000	-1.467	0.196	-1.395	0.196	-1.472	0.196	-1.468	0.196	-1.446	0.196	-1.442	0.196	-1.506	0.196
fdev GFT 2013	-1,000	1,000	-1.070	0.196	-1.024	0.196	-1.069	0.196	-1.054	0.196	-1.050	0.196	-1.036	0.196	-1.141	0.196
fdev GFT 2014	-1,000	1,000	-1.037	0.196	-1.011	0.197	-1.024	0.197	-0.994	0.197	-1.039	0.197	-1.011	0.197	-1.144	0.197
fdev GFT 2015	-1,000	1,000	-1.675	0.197	-1.663	0.197	-1.645	0.197	-1.602	0.197	-1.669	0.197	-1.629	0.197	-1.761	0.197
fdev GFT 2016	-1,000	1,000	-1.018	0.197	-1.021	0.197	-0.978	0.197	-0.924	0.197	-1.021	0.197	-0.971	0.197	-1.078	0.197
fdev GFT 2017	-1,000	1,000	-1.956	0.198	-1.972	0.198	-1.914	0.198	-1.851	0.198	-1.975	0.198	-1.917	0.198	-1.987	0.198
fdev GFT 2018	-1,000	1,000	-1.704	0.197	-1.717	0.197	-1.654	0.197	-1.583	0.197	-1.725	0.197	-1.658	0.197	-1.689	0.197
fdev GFT 2019	-1,000	1,000	-0.798	0.197	-0.730	0.197	-0.725	0.197	-0.668	0.197	-0.962	0.197	-0.895	0.197	-0.884	0.196
fdev GFT 2020	-1,000	1,000	-0.750	0.197	-0.675	0.198	-0.674	0.198	-0.617	0.197	-0.899	0.197	-0.829	0.197	-0.818	0.197
fdev GFT 2021	-1,000	1,000	-0.790	0.198	-0.753	0.198	-0.725	0.198	-0.662	0.198	-0.856	0.198	-0.782	0.197	-0.797	0.197
fdev GFT 2022	-1,000	1,000	-1.045	0.198	-1.049	0.198	-0.992	0.198	-0.927	0.198	-1.066	0.198	-0.992	0.198	-1.023	0.197
fdev GFF 1991	-1,000	1,000	0.307	0.201	0.194	0.199	0.190	0.199	0.146	0.199	0.395	0.209	0.362	0.207	0.231	0.201
fdev GFF 1992	-1,000	1,000	-0.024	0.202	-0.102	0.200	-0.133	0.199	-0.189	0.199	0.119	0.208	0.070	0.206	-0.093	0.201
fdev GFF 1993	-1,000	1,000	-1.461	0.400	-1.498	0.400	-1.552	0.399	-1.618	0.399	-1.515	0.401	-1.579	0.400	-1.750	0.400
fdev GFF 1994	-1,000	1,000	-1.445	0.394	-1.473	0.394	-1.515	0.393	-1.584	0.393	-1.514	0.393	-1.583	0.393	-1.689	0.393
fdev GFF 1995	-1,000	1,000	0.226	0.198	0.150	0.198	0.164	0.198	0.102	0.198	0.196	0.198	0.134	0.198	0.108	0.198
fdev GFF 1996	-1,000	1,000	0.284	0.199	0.171	0.198	0.231	0.198	0.175	0.198	0.343	0.198	0.284	0.198	0.303	0.198
fdev GFF 1997	-1,000	1,000	-0.131	0.199	-0.251	0.199	-0.168	0.199	-0.221	0.199	-0.035	0.199	-0.094	0.199	-0.050	0.198
fdev GFF 1998	-1,000	1,000	0.330	0.199	0.209	0.199	0.311	0.199	0.262	0.199	0.436	0.199	0.379	0.199	0.429	0.198
fdev GFF 1999	-1,000	1,000	0.373	0.199	0.247	0.199	0.371	0.199	0.326	0.199	0.428	0.199	0.375	0.199	0.416	0.198
fdev GFF 2000	-1,000	1,000	-0.062	0.199	-0.196	0.199	-0.048	0.199	-0.086	0.198	0.016	0.199	-0.031	0.198	0.012	0.198
fdev GFF 2001	-1,000	1,000	0.787	0.199	0.642	0.199	0.815	0.199	0.787	0.199	0.841	0.199	0.807	0.199	0.838	0.198
fdev GFF 2002	-1,000	1,000	0.477	0.199	0.317	0.199	0.511	0.199	0.493	0.199	0.483	0.199	0.461	0.199	0.478	0.198
fdev GFF 2003	-1,000	1,000	-1.146	0.453	-1.333	0.453	-1.116	0.453	-1.126	0.453	-1.222	0.453	-1.235	0.453	-1.230	0.453

Table 46. Parameters table continued.

			G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lb	ub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
fdev GFF 2003	-1,000	1,000	-1.146	0.453	-1.333	0.453	-1.116	0.453	-1.126	0.453	-1.222	0.453	-1.235	0.453	-1.230	0.453
fdev GFF 2004	-1,000	1,000	-0.130	0.199	-0.352	0.199	-0.107	0.199	-0.105	0.199	-0.185	0.199	-0.188	0.199	-0.170	0.198
fdev GFF 2005	-1,000	1,000	0.407	0.199	0.176	0.199	0.423	0.199	0.441	0.199	0.381	0.199	0.391	0.199	0.445	0.198
fdev GFF 2006	-1,000	1,000	1.135	0.200	1.490	0.201	1.151	0.200	1.179	0.200	1.072	0.200	1.093	0.200	1.190	0.199
fdev GFF 2007	-1,000	1,000	1.149	0.199	1.617	0.201	1.150	0.199	1.171	0.199	1.203	0.199	1.222	0.198	1.311	0.198
fdev GFF 2008	-1,000	1,000	0.472	0.198	0.740	0.199	0.452	0.198	0.459	0.198	0.544	0.198	0.553	0.198	0.602	0.197
fdev GFF 2009	-1,000	1,000	0.206	0.199	0.377	0.199	0.176	0.199	0.175	0.199	0.227	0.199	0.228	0.199	0.260	0.198
fdev GFF 2010	-1,000	1,000	-0.379	0.199	-0.259	0.199	-0.412	0.199	-0.413	0.199	-0.321	0.199	-0.320	0.199	-0.277	0.198
fdev GFF 2011	-1,000	1,000	-0.693	0.200	-0.606	0.199	-0.725	0.199	-0.724	0.199	-0.652	0.199	-0.650	0.199	-0.597	0.198
fdev GFF 2012	-1,000	1,000	-1.083	0.215	-1.017	0.214	-1.109	0.214	-1.107	0.214	-1.037	0.214	-1.034	0.214	-0.986	0.213
fdev GFF 2013	-1,000	1,000	0.311	0.198	0.357	0.199	0.295	0.198	0.303	0.198	0.355	0.198	0.363	0.198	0.355	0.198
fdev GFF 2014	-1,000	1,000	0.619	0.198	0.649	0.199	0.625	0.198	0.648	0.198	0.596	0.198	0.618	0.198	0.535	0.198
fdev GFF 2015	-1,000	1,000	0.664	0.199	0.680	0.199	0.699	0.199	0.743	0.199	0.672	0.199	0.713	0.199	0.607	0.199
fdev GFF 2016	-1,000	1,000	0.185	0.199	0.168	0.199	0.226	0.199	0.284	0.199	0.179	0.199	0.233	0.199	0.138	0.198
fdev GFF 2017	-1,000	1,000	-0.033	0.200	-0.081	0.200	0.006	0.199	0.073	0.199	-0.050	0.199	0.011	0.199	-0.050	0.198
fdev GFF 2018	-1,000	1,000	0.194	0.200	0.132	0.200	0.240	0.199	0.317	0.199	0.201	0.200	0.271	0.200	0.250	0.198
fdev GFF 2019	-1,000	1,000	-0.208	0.221	-0.109	0.222	-0.110	0.221	-0.060	0.221	-0.471	0.220	-0.406	0.220	-0.349	0.219
fdev GFF 2020	-1,000	1,000	-0.605	0.403	-0.448	0.403	-0.489	0.402	-0.441	0.401	-0.868	0.400	-0.802	0.400	-0.701	0.400
fdev GFF 2021	-1,000	1,000	0.047	0.202	0.159	0.201	0.147	0.201	0.212	0.200	-0.038	0.199	0.041	0.199	0.115	0.198
fdev GFF 2022	-1,000	1,000	-0.773	0.328	-0.749	0.328	-0.697	0.327	-0.621	0.327	-0.779	0.327	-0.691	0.327	-0.680	0.326
fdev GFA 1982	-1,000	1,000	-0.330	0.191	-0.269	0.191	-0.339	0.204	-0.298	0.191	-0.416	0.189	-0.383	0.189	-0.168	0.190
fdev GFA 1983	-1,000	1,000	0.050	0.189	0.099	0.188	0.020	0.190	0.048	0.188	-0.054	0.187	-0.029	0.187	0.246	0.188
fdev GFA 1984	-1,000	1,000	0.121	0.188	0.160	0.187	0.107	0.194	0.133	0.188	0.034	0.187	0.057	0.187	0.344	0.187
fdev GFA 1985	-1,000	1,000	-0.282	0.187	-0.250	0.187	-0.270	0.192	-0.249	0.187	-0.334	0.186	-0.315	0.186	-0.078	0.185
fdev GFA 1986	-1,000	1,000	0.191	0.186	0.209	0.186	0.219	0.186	0.228	0.185	0.184	0.185	0.192	0.185	0.255	0.180
fdev GFA 1987	-1,000	1,000	0.109	0.186	0.105	0.186	0.140	0.185	0.131	0.185	0.151	0.185	0.142	0.184	0.013	0.180
fdev GFA 1988	-1,000	1,000	-0.294	0.187	-0.329	0.187	-0.272	0.186	-0.300	0.186	-0.212	0.186	-0.236	0.186	-0.507	0.182
fdev GFA 1989	-1,000	1,000	0.034	0.188	-0.036	0.187	0.028	0.187	-0.012	0.187	0.125	0.186	0.090	0.186	-0.264	0.183
fdev GFA 1990	-1,000	1,000	0.401	0.189	0.310	0.187	0.368	0.192	0.319	0.187	0.523	0.187	0.482	0.187	0.160	0.187
Log foff TCF	-1,000	1,000	-0.500	0.000	-3.070	0.266	-2.727	0.271	-2.740	0.273	-2.891	0.236	-2.901	0.237	-3.103	0.233
Log foff SCF	-1,000	1,000	-0.500	0.000	-2.399	0.196	-2.565	0.200	-2.560	0.200	-2.733	0.187	-2.733	0.186	-2.932	0.180
Log foff RKF	-1,000	1,000	-0.500	0.001	-1.336	3.635	-1.693	2.378	-1.553	2.595	-1.595	4.060	-1.184	6.208	-4.856	0.346
Log foff GFT	-1,000	1,000	-6.994	13.591	-6.479	14.118	-6.752	13.923	-6.774	13.886	-6.600	14.098	-6.651	14.048	-7.764	13.445
Log foff GFF	-1,000	1,000	-2.158	16.941	-2.807	16.761	-3.188	16.138	-3.283	16.061	-2.800	16.565	-2.894	16.473	-3.694	15.690

Table 47. Parameters table continued.

description	lb	ub	G24.02 est	G24.02 se	G24.02a est	G24.02a se	G24.03 est	G24.03 se	G24.04 est	G24.04 se	G24.05 est	G24.05 se	G24.06 est	G24.06 se	G24.07 est	G24.07 se
Log foff GFF	-1,000	1,000	-2.158	16.941	-2.807	16.761	-3.188	16.138	-3.283	16.061	-2.800	16.565	-2.894	16.473	-3.694	15.690
Log foff GFA	-1,000	1,000	-5.215	13.632	-4.463	14.341	-1.714	15.615	-3.124	15.343	-0.500	0.003	-0.500	0.003	-0.500	0.004
Log foff NMFSAM	–	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–
Log foff NMFSIF	–	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–
Log foff NMFSMF	–	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–	-5.250	–
fdov TCF 1990	-1,000	1,000	0.039	0.033	0.046	0.189	0.038	0.189	0.039	0.189	0.051	0.190	0.053	0.190	-0.078	0.189
fdov TCF 1991	-1,000	1,000	0.724	0.044	0.593	0.228	0.588	0.229	0.574	0.228	0.021	0.231	-0.001	0.231	-0.065	0.230
fdov TCF 1992	-1,000	1,000	0.342	0.047	0.241	0.230	0.224	0.230	0.231	0.229	-0.300	0.232	-0.289	0.232	-0.287	0.234
fdov TCF 1993	-1,000	1,000	0.717	0.043	0.687	0.229	0.627	0.229	0.648	0.229	0.622	0.231	0.643	0.231	0.667	0.232
fdov TCF 1994	-1,000	1,000	1.489	0.045	1.453	0.231	1.392	0.230	1.427	0.230	1.507	0.231	1.546	0.231	1.468	0.231
fdov TCF 1995	-1,000	1,000	2.660	0.039	2.731	0.231	2.580	0.230	2.607	0.229	2.868	0.231	2.899	0.231	2.610	0.231
fdov TCF 1996	-1,000	1,000	0.890	0.038	1.077	0.228	0.791	0.228	0.813	0.228	0.854	0.230	0.885	0.230	0.824	0.229
fdov TCF 2005	-1,000	1,000	0.570	0.053	0.946	0.404	0.626	0.404	0.639	0.404	0.692	0.403	0.704	0.403	0.635	0.403
fdov TCF 2006	-1,000	1,000	1.257	0.043	0.615	0.231	1.302	0.229	1.297	0.229	1.565	0.231	1.560	0.230	1.471	0.229
fdov TCF 2007	-1,000	1,000	0.263	0.045	-0.587	0.252	0.318	0.250	0.288	0.250	0.413	0.252	0.388	0.252	0.264	0.251
fdov TCF 2008	-1,000	1,000	-1.158	0.098	-1.403	0.916	-1.070	0.916	-1.098	0.915	-1.269	0.916	-1.300	0.916	-1.449	0.915
fdov TCF 2009	-1,000	1,000	-1.950	0.167	-1.917	1.644	-1.851	1.644	-1.872	1.644	-1.882	1.648	-1.900	1.648	-1.948	1.640
fdov TCF 2013	-1,000	1,000	-0.212	0.053	-0.050	0.408	-0.187	0.408	-0.184	0.408	-0.586	0.408	-0.583	0.408	-0.635	0.408
fdov TCF 2014	-1,000	1,000	-1.509	0.041	-1.415	0.271	-1.502	0.271	-1.496	0.271	-1.793	0.271	-1.785	0.271	-1.525	0.271
fdov TCF 2015	-1,000	1,000	-1.545	0.038	-1.466	0.229	-1.565	0.228	-1.578	0.228	-1.703	0.229	-1.712	0.228	-1.138	0.232
fdov TCF 2017	-1,000	1,000	0.432	0.040	0.668	0.275	0.413	0.275	0.391	0.275	0.380	0.275	0.358	0.275	0.750	0.276
fdov TCF 2018	-1,000	1,000	0.399	0.043	0.651	0.298	0.347	0.298	0.326	0.298	0.305	0.298	0.281	0.298	0.559	0.299
fdov TCF 2020	-1,000	1,000	-0.747	0.070	-0.857	0.313	-0.881	0.313	-0.851	0.312	-0.025	0.310	-0.008	0.310	-0.098	0.310
fdov TCF 2021	-1,000	1,000	-0.711	0.067	-0.711	0.554	-0.795	0.554	-0.791	0.554	-0.520	0.554	-0.517	0.554	-0.688	0.554
fdov TCF 2022	-1,000	1,000	-1.340	0.074	-1.298	0.650	-1.393	0.650	-1.409	0.650	-1.201	0.650	-1.221	0.650	-1.328	0.650
fdov SCF 1982	-1,000	1,000	-0.031	0.275	-0.014	0.275	-0.015	0.275	-0.015	0.275	-0.017	0.275	-0.016	0.275	-0.041	0.276
fdov SCF 1983	-1,000	1,000	-0.026	0.275	-0.007	0.275	-0.008	0.274	-0.007	0.274	-0.009	0.274	-0.008	0.274	-0.022	0.275
fdov SCF 1984	-1,000	1,000	-0.019	0.274	-0.001	0.274	0.007	0.273	0.006	0.274	0.012	0.273	0.011	0.273	-0.008	0.274
fdov SCF 1985	-1,000	1,000	0.003	0.273	0.023	0.273	0.039	0.271	0.037	0.271	0.052	0.270	0.051	0.270	0.031	0.271
fdov SCF 1986	-1,000	1,000	0.016	0.272	0.037	0.272	0.056	0.270	0.053	0.270	0.074	0.269	0.072	0.269	0.091	0.267
fdov SCF 1987	-1,000	1,000	0.033	0.270	0.054	0.270	0.080	0.269	0.077	0.269	0.105	0.267	0.104	0.267	0.154	0.263
fdov SCF 1988	-1,000	1,000	0.028	0.271	0.045	0.271	0.071	0.269	0.068	0.269	0.095	0.268	0.094	0.268	0.196	0.262
fdov SCF 1989	-1,000	1,000	0.022	0.271	0.043	0.271	0.080	0.269	0.076	0.269	0.107	0.267	0.106	0.267	0.285	0.257
fdov SCF 1990	-1,000	1,000	-0.378	0.289	-0.650	0.303	-0.606	0.303	-0.624	0.303	-0.790	0.303	-0.809	0.303	-0.835	0.300

Table 48. Parameters table continued.

			G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lb	ub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
fdov SCF 1990	-1,000	1,000	-0.378	0.289	-0.650	0.303	-0.606	0.303	-0.624	0.303	-0.790	0.303	-0.809	0.303	-0.835	0.300
fdov SCF 1991	-1,000	1,000	-0.396	0.297	-0.638	0.308	-0.600	0.306	-0.613	0.306	-0.900	0.308	-0.918	0.309	-1.352	0.338
fdov SCF 1992	-1,000	1,000	1.008	0.291	0.698	0.309	0.702	0.308	0.699	0.308	0.412	0.309	0.408	0.310	0.249	0.316
fdov SCF 1993	-1,000	1,000	1.728	0.296	1.348	0.316	1.386	0.314	1.398	0.313	1.332	0.312	1.344	0.311	1.172	0.318
fdov SCF 1994	-1,000	1,000	1.924	0.292	1.552	0.311	1.560	0.310	1.574	0.310	1.652	0.308	1.667	0.309	1.413	0.312
fdov SCF 1995	-1,000	1,000	1.901	0.291	1.618	0.309	1.558	0.308	1.568	0.308	1.648	0.308	1.658	0.308	1.277	0.311
fdov SCF 1996	-1,000	1,000	1.314	0.294	1.047	0.312	0.929	0.312	0.938	0.312	0.964	0.312	0.974	0.312	0.819	0.316
fdov SCF 1997	-1,000	1,000	1.091	0.294	0.805	0.313	0.660	0.313	0.665	0.313	0.655	0.313	0.663	0.313	0.865	0.319
fdov SCF 1998	-1,000	1,000	2.097	0.291	1.810	0.309	1.667	0.309	1.675	0.309	1.583	0.309	1.593	0.309	1.765	0.311
fdov SCF 1999	-1,000	1,000	1.411	0.780	1.428	0.780	1.305	0.780	1.315	0.780	1.268	0.780	1.282	0.780	1.366	0.781
fdov SCF 2000	-1,000	1,000	-0.518	1.129	-0.093	1.136	-0.191	1.136	-0.178	1.136	-0.259	1.136	-0.242	1.137	-0.243	1.140
fdov SCF 2001	-1,000	1,000	0.728	0.502	0.520	0.508	0.448	0.508	0.456	0.508	0.334	0.508	0.347	0.508	0.310	0.509
fdov SCF 2002	-1,000	1,000	1.344	0.672	1.247	0.673	1.210	0.673	1.216	0.673	1.118	0.673	1.128	0.673	1.073	0.674
fdov SCF 2003	-1,000	1,000	1.152	1.045	1.404	1.049	1.412	1.048	1.422	1.048	1.342	1.047	1.354	1.048	1.309	1.050
fdov SCF 2004	-1,000	1,000	2.701	0.323	2.435	0.340	2.393	0.340	2.403	0.340	2.386	0.340	2.397	0.340	2.357	0.340
fdov SCF 2005	-1,000	1,000	-0.600	0.598	-0.578	0.599	-0.786	0.601	-0.787	0.601	-0.690	0.601	-0.687	0.601	-0.765	0.601
fdov SCF 2006	-1,000	1,000	0.939	0.291	0.351	0.311	0.571	0.312	0.552	0.312	0.761	0.312	0.748	0.312	0.633	0.313
fdov SCF 2007	-1,000	1,000	0.369	0.289	-0.237	0.307	0.061	0.308	0.041	0.308	0.135	0.308	0.118	0.308	0.001	0.309
fdov SCF 2008	-1,000	1,000	0.205	0.437	-0.175	0.445	0.003	0.445	-0.012	0.445	-0.047	0.445	-0.062	0.445	-0.165	0.445
fdov SCF 2009	-1,000	1,000	-0.624	0.613	-0.809	0.615	-0.705	0.615	-0.715	0.615	-0.742	0.615	-0.751	0.615	-0.658	0.616
fdov SCF 2010	-1,000	1,000	-1.262	0.890	-1.141	0.890	-1.091	0.890	-1.099	0.890	-1.170	0.890	-1.178	0.890	-0.909	0.890
fdov SCF 2011	-1,000	1,000	-1.056	0.692	-1.121	0.692	-1.100	0.692	-1.108	0.692	-1.145	0.692	-1.152	0.692	-1.012	0.692
fdov SCF 2012	-1,000	1,000	-1.176	0.825	-1.186	0.824	-1.151	0.824	-1.155	0.824	-1.226	0.824	-1.229	0.825	-1.235	0.825
fdov SCF 2013	-1,000	1,000	-0.826	0.614	-1.080	0.617	-1.016	0.616	-1.013	0.616	-1.164	0.616	-1.159	0.616	-1.214	0.617
fdov SCF 2014	-1,000	1,000	-0.575	0.289	-0.991	0.311	-0.922	0.309	-0.925	0.310	-1.018	0.309	-1.019	0.310	-0.853	0.315
fdov SCF 2015	-1,000	1,000	-1.501	0.583	-1.674	0.586	-1.663	0.585	-1.671	0.585	-1.726	0.585	-1.733	0.586	-1.289	0.589
fdov SCF 2016	-1,000	1,000	-1.021	0.586	-1.137	0.589	-1.174	0.589	-1.181	0.589	-1.201	0.589	-1.208	0.589	-0.845	0.592
fdov SCF 2017	-1,000	1,000	-1.447	1.060	-1.069	1.064	-1.148	1.064	-1.156	1.064	-1.138	1.063	-1.147	1.063	-0.894	1.067
fdov SCF 2018	-1,000	1,000	-0.768	0.911	-0.562	0.911	-0.682	0.911	-0.690	0.911	-0.634	0.910	-0.643	0.910	-0.507	0.911
fdov SCF 2019	-1,000	1,000	-0.476	0.631	-0.630	0.632	-0.697	0.632	-0.678	0.632	-0.348	0.632	-0.346	0.632	-0.353	0.632
fdov SCF 2020	-1,000	1,000	-4.490	2.076	-1.921	2.235	-1.931	2.235	-1.908	2.235	-1.475	2.235	-1.471	2.234	-1.650	2.232
fdov SCF 2021	-1,000	1,000	-2.461	1.828	-0.750	1.917	-0.714	1.917	-0.705	1.916	-0.337	1.916	-0.340	1.916	-0.521	1.916
fdov RKF 1982	-1,000	1,000	-0.007	0.274	-0.013	0.274	-0.009	0.274	-0.009	0.274	-0.009	0.274	-0.009	0.274	-0.016	0.274
fdov RKF 1984	-1,000	1,000	0.001	0.273	0.000	0.273	0.004	0.273	0.004	0.273	0.007	0.273	0.007	0.273	0.002	0.273

Table 49. Parameters table continued.

description	lb	ub	G24.02 est	G24.02 se	G24.02a est	G24.02a se	G24.03 est	G24.03 se	G24.04 est	G24.04 se	G24.05 est	G24.05 se	G24.06 est	G24.06 se	G24.07 est	G24.07 se
fdov RKF 1984	-1,000	1,000	0.001	0.273	0.000	0.273	0.004	0.273	0.004	0.273	0.007	0.273	0.007	0.273	0.002	0.273
fdov RKF 1985	-1,000	1,000	0.005	0.273	0.007	0.273	0.009	0.273	0.008	0.273	0.011	0.272	0.011	0.273	0.008	0.273
fdov RKF 1986	-1,000	1,000	0.018	0.272	0.027	0.272	0.029	0.271	0.027	0.272	0.037	0.271	0.036	0.271	0.043	0.270
fdov RKF 1987	-1,000	1,000	0.028	0.272	0.041	0.271	0.043	0.270	0.041	0.271	0.054	0.270	0.052	0.270	0.063	0.269
fdov RKF 1988	-1,000	1,000	0.019	0.272	0.028	0.271	0.029	0.271	0.027	0.272	0.036	0.271	0.034	0.271	0.045	0.270
fdov RKF 1989	-1,000	1,000	0.026	0.272	0.035	0.271	0.038	0.271	0.035	0.271	0.046	0.270	0.044	0.270	0.073	0.268
fdov RKF 1990	-1,000	1,000	-0.367	0.388	-0.157	0.500	-0.395	0.515	-0.425	0.513	-0.888	0.519	-0.939	0.518	-1.634	0.464
fdov RKF 1991	-1,000	1,000	-0.362	0.447	-0.147	0.536	-0.444	0.544	-0.445	0.542	-1.042	0.555	-1.065	0.554	-1.962	0.521
fdov RKF 1992	-1,000	1,000	-0.448	0.560	-0.308	0.629	-0.578	0.631	-0.566	0.631	-1.126	0.643	-1.126	0.643	-2.057	0.622
fdov RKF 1993	-1,000	1,000	1.019	0.333	1.214	0.449	0.951	0.450	0.960	0.449	0.749	0.469	0.754	0.469	-0.156	0.444
fdov RKF 1996	-1,000	1,000	-0.099	1.686	0.248	1.689	-0.228	1.689	-0.208	1.689	-0.080	1.695	-0.058	1.694	9.397	0.399
fdov RKF 1997	-1,000	1,000	0.097	1.875	0.463	1.877	-0.072	1.877	-0.051	1.876	-0.037	1.883	-0.009	1.882	-0.752	1.873
fdov RKF 1998	-1,000	1,000	0.459	1.875	0.847	1.876	0.291	1.877	0.310	1.877	0.168	1.882	0.196	1.882	-0.683	1.869
fdov RKF 1999	-1,000	1,000	1.220	1.723	1.633	1.725	1.080	1.725	1.097	1.726	0.944	1.730	0.966	1.730	-0.004	1.725
fdov RKF 2000	-1,000	1,000	0.832	1.970	1.281	1.970	0.744	1.970	0.761	1.971	0.607	1.974	0.631	1.974	-0.543	1.972
fdov RKF 2001	-1,000	1,000	0.918	2.125	1.393	2.127	0.881	2.127	0.898	2.127	0.690	2.129	0.714	2.130	-0.584	2.127
fdov RKF 2002	-1,000	1,000	1.016	1.899	1.496	1.899	1.011	1.898	1.023	1.899	0.978	1.898	0.986	1.898	-0.439	1.900
fdov RKF 2003	-1,000	1,000	1.261	1.823	1.740	1.823	1.290	1.822	1.299	1.822	1.392	1.822	1.397	1.822	-0.112	1.824
fdov RKF 2004	-1,000	1,000	1.169	1.878	1.644	1.878	1.232	1.877	1.244	1.877	1.338	1.875	1.342	1.875	-0.290	1.874
fdov RKF 2005	-1,000	1,000	0.786	2.114	1.356	2.114	0.883	2.114	0.893	2.113	1.155	2.113	1.154	2.113	-0.814	2.110
fdov RKF 2006	-1,000	1,000	1.429	1.948	-7.025	1.921	1.536	1.946	1.533	1.946	2.038	1.950	2.023	1.949	-0.119	1.943
fdov RKF 2007	-1,000	1,000	0.657	1.952	0.229	1.950	0.768	1.950	0.750	1.949	1.174	1.956	1.150	1.956	-0.848	1.947
fdov RKF 2008	-1,000	1,000	-0.117	1.664	-0.091	1.663	-0.005	1.663	-0.023	1.662	0.049	1.669	0.024	1.669	-1.548	1.660
fdov RKF 2009	-1,000	1,000	-0.394	2.050	-0.147	2.049	-0.275	2.049	-0.286	2.049	-0.102	2.053	-0.120	2.053	9.846	0.410
fdov RKF 2010	-1,000	1,000	0.750	2.355	1.094	2.360	0.866	2.361	0.861	2.361	0.893	2.366	0.879	2.365	-0.126	2.358
fdov RKF 2011	-1,000	1,000	-0.621	3.037	-0.189	3.085	-0.484	3.086	-0.488	3.086	-0.409	3.092	-0.422	3.092	-1.719	3.083
fdov RKF 2012	-1,000	1,000	1.467	1.985	1.860	1.980	1.522	1.983	1.518	1.982	1.571	1.990	1.562	1.989	-0.027	1.985
fdov RKF 2013	-1,000	1,000	0.174	2.002	0.556	1.997	0.231	1.999	0.231	1.998	0.001	2.004	-0.004	2.004	-1.485	2.001
fdov RKF 2014	-1,000	1,000	-1.142	2.109	-0.807	2.107	-1.091	2.108	-1.089	2.108	-1.219	2.113	-1.218	2.113	9.196	0.405
fdov RKF 2015	-1,000	1,000	0.935	1.213	1.219	1.225	0.920	1.225	0.906	1.225	0.934	1.229	0.919	1.229	0.304	1.222
fdov RKF 2016	-1,000	1,000	0.923	1.380	1.266	1.386	0.902	1.386	0.880	1.386	1.008	1.390	0.983	1.390	0.311	1.384
fdov RKF 2017	-1,000	1,000	-0.082	1.948	0.317	1.945	-0.100	1.946	-0.122	1.946	0.081	1.951	0.054	1.951	-0.812	1.946
fdov RKF 2018	-1,000	1,000	-1.565	2.831	-1.109	2.862	-1.574	2.862	-1.594	2.862	-1.374	2.868	-1.405	2.868	-2.556	2.860
fdov RKF 2019	-1,000	1,000	-10.000	0.002	-10.000	0.002	-10.000	0.002	-10.000	0.002	-9.676	3.326	-9.545	3.326	-10.000	0.002

Table 50. Parameters table continued.

			G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lb	ub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
fdov RKF 2019	-1,000	1,000	-10.000	0.002	-10.000	0.002	-10.000	0.002	-10.000	0.002	-9.676	3.326	-9.545	3.326	-10.000	0.002
Rec dev 1982	-8	8	0.871	0.022	0.865	0.022	0.865	0.022	0.955	0.022	0.752	0.022	0.851	0.022	0.783	0.022
Rec dev 1983	-8	8	0.440	0.022	0.731	0.022	0.659	0.022	0.771	0.022	0.511	0.022	0.619	0.022	1.217	0.022
Rec dev 1984	-8	8	0.214	0.022	0.548	0.022	0.568	0.022	0.596	0.022	0.407	0.022	0.428	0.022	0.090	0.022
Rec dev 1985	-8	8	0.867	0.097	1.030	0.100	1.042	0.100	1.113	0.097	0.652	0.103	0.715	0.099	0.829	0.108
Rec dev 1986	-8	8	0.439	0.131	0.254	0.119	0.556	0.122	0.615	0.119	0.420	0.124	0.486	0.122	0.686	0.093
Rec dev 1987	-8	8	-0.271	0.142	-0.292	0.132	-0.260	0.127	-0.105	0.130	0.464	0.123	0.592	0.126	0.508	0.163
Rec dev 1988	-8	8	0.634	0.101	0.761	0.095	0.676	0.096	0.706	0.096	0.035	0.103	0.014	0.103	-0.420	0.099
Rec dev 1989	-8	8	-1.831	0.129	-1.873	0.145	-1.858	0.128	-1.819	0.130	-1.762	0.126	-1.712	0.126	-1.765	0.116
Rec dev 1990	-8	8	-1.843	0.176	-1.742	0.184	-1.875	0.184	-1.809	0.179	-1.616	0.120	-1.550	0.117	-1.517	0.121
Rec dev 1991	-8	8	-1.137	0.097	-1.087	0.093	-1.200	0.096	-1.171	0.099	-1.198	0.142	-1.158	0.148	-0.978	0.162
Rec dev 1992	-8	8	-0.936	0.228	-0.907	0.230	-1.037	0.228	-0.973	0.229	-1.118	0.223	-1.046	0.223	-1.054	0.213
Rec dev 1993	-8	8	-0.882	0.183	-0.837	0.185	-0.986	0.184	-0.942	0.184	-0.981	0.176	-0.924	0.176	-0.928	0.169
Rec dev 1994	-8	8	-0.649	0.153	-0.580	0.156	-0.737	0.154	-0.720	0.155	-0.844	0.156	-0.824	0.157	-0.785	0.140
Rec dev 1995	-8	8	-0.654	0.154	-0.578	0.158	-0.732	0.156	-0.746	0.155	-0.823	0.158	-0.839	0.157	-0.835	0.159
Rec dev 1996	-8	8	-0.269	0.155	-0.154	0.158	-0.327	0.156	-0.297	0.156	-0.305	0.152	-0.271	0.152	-0.262	0.146
Rec dev 1997	-8	8	-0.577	0.140	-0.451	0.143	-0.611	0.140	-0.612	0.141	-0.398	0.141	-0.388	0.142	-0.337	0.134
Rec dev 1998	-8	8	0.413	0.142	0.751	0.146	0.372	0.142	0.352	0.144	0.474	0.141	0.464	0.143	0.341	0.139
Rec dev 1999	-8	8	-0.259	0.118	-0.669	0.120	-0.255	0.118	-0.330	0.117	-0.434	0.116	-0.493	0.116	-0.771	0.111
Rec dev 2000	-8	8	1.087	0.148	0.512	0.154	1.035	0.147	1.014	0.147	1.191	0.139	1.173	0.140	0.959	0.133
Rec dev 2001	-8	8	1.041	0.103	1.147	0.097	1.076	0.103	1.128	0.103	0.951	0.102	1.001	0.102	1.096	0.099
Rec dev 2002	-8	8	0.397	0.167	0.102	0.202	0.398	0.164	0.449	0.166	0.435	0.178	0.490	0.180	0.438	0.184
Rec dev 2003	-8	8	0.313	0.099	0.262	0.108	0.318	0.099	0.340	0.100	0.290	0.096	0.314	0.096	0.330	0.093
Rec dev 2004	-8	8	-0.487	0.124	-0.630	0.096	-0.525	0.119	-0.529	0.117	-0.486	0.127	-0.491	0.125	-0.552	0.106
Rec dev 2005	-8	8	-0.669	0.149	-0.768	0.163	-0.699	0.149	-0.662	0.148	-0.640	0.144	-0.595	0.142	-0.623	0.141
Rec dev 2006	-8	8	-0.224	0.129	-0.274	0.126	-0.259	0.129	-0.247	0.129	-0.334	0.130	-0.322	0.130	-0.043	0.124
Rec dev 2007	-8	8	0.578	0.184	0.586	0.189	0.550	0.186	0.544	0.188	0.371	0.183	0.366	0.185	0.565	0.185
Rec dev 2008	-8	8	0.825	0.193	0.844	0.194	0.797	0.193	0.737	0.192	0.818	0.190	0.770	0.189	0.900	0.188
Rec dev 2009	-8	8	0.101	0.168	0.048	0.169	0.063	0.168	-0.005	0.168	0.112	0.168	0.047	0.168	0.051	0.150
Rec dev 2010	-8	8	-0.681	0.121	-0.646	0.120	-0.729	0.120	-0.785	0.120	-0.570	0.122	-0.614	0.122	-0.656	0.116
Rec dev 2011	-8	8	-1.050	0.109	-0.929	0.109	-1.116	0.109	-1.221	0.110	-1.037	0.104	-1.139	0.105	-1.252	0.100
Rec dev 2012	-8	8	-0.720	0.145	-0.747	0.152	-0.792	0.145	-0.918	0.145	-0.759	0.142	-0.872	0.143	-1.112	0.144
Rec dev 2013	-8	8	-0.809	0.174	-1.006	0.176	-0.901	0.174	-0.971	0.172	-0.769	0.169	-0.857	0.167	-1.128	0.163
Rec dev 2014	-8	8	-0.396	0.192	-0.667	0.190	-0.523	0.192	-0.578	0.192	-0.115	0.194	-0.221	0.194	-0.224	0.188

Table 51. Parameters table continued.

		G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lbub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
Rec dev 2014	-8 8	-0.396	0.192	-0.667	0.190	-0.523	0.192	-0.578	0.192	-0.115	0.194	-0.221	0.194	-0.224	0.188
Rec dev 2015	-8 8	-0.500	0.155	-0.399	0.153	-0.548	0.154	-0.648	0.155	-0.529	0.158	-0.607	0.157	-0.439	0.155
Rec dev 2016	-8 8	0.500	0.161	0.599	0.160	0.451	0.159	0.387	0.158	0.337	0.170	0.266	0.168	0.330	0.166
Rec dev 2017	-8 8	-0.191	0.135	-0.245	0.144	-0.234	0.136	-0.239	0.133	-0.152	0.137	-0.163	0.138	-0.314	0.125
Rec dev 2018	-8 8	0.183	0.154	0.193	0.145	0.137	0.150	0.045	0.151	0.150	0.165	0.052	0.164	-0.113	0.147
Rec dev 2019	-8 8	-0.314	0.101	-0.338	0.100	-0.552	0.101	-0.535	0.101	-0.522	0.106	-0.506	0.106	-0.578	0.097
Rec dev 2020	-8 8	0.788	0.155	0.842	0.164	0.868	0.154	0.809	0.151	0.836	0.148	0.774	0.145	0.797	0.145
Rec dev 2021	-8 8	1.309	0.139	1.356	0.140	1.499	0.136	1.556	0.138	1.441	0.137	1.500	0.139	1.714	0.133
Rec dev 2022	-8 8	0.912	0.225	0.945	0.233	1.378	0.233	1.299	0.227	1.302	0.230	1.223	0.224	1.604	0.214
Logit rec prop 1982	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1983	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1984	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1985	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1986	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1987	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1988	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1989	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1990	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1991	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1992	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1993	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1994	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1995	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1996	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1997	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1998	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 1999	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 2000	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 2001	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 2002	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 2003	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 2004	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 2005	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–
Logit rec prop 2006	– –	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–	0.000	–

Table 52. Parameters table continued.

		G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
description	lbub	est	se	est	se	est	se	est	se	est	se	est	se	est	se
Logit rec prop 2006	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2007	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2008	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2009	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2010	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2011	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2012	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2013	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2014	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2015	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2016	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2017	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2018	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2019	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2020	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2021	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Logit rec prop 2022	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 1	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 2	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 3	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 4	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 5	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 6	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 7	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 8	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 9	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 10	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Survey q survey 1	– –	0.50	–	0.50	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Survey q survey 2	– –	0.30	–	0.30	–	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Log add cvt survey 1	– –	-9.21	–	-9.21	–	-9.21	–	-9.21	–	-9.21	–	-9.21	–	-9.21	–
Log add cvt survey 2	– –	-9.21	–	-9.21	–	-9.21	–	-9.21	–	-9.21	–	-9.21	–	-9.21	–
Dummy dev par	– –	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 11	– –	–	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–
Log vn size comp 12	– –	–	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–	0.00	–

Table 53. Parameters table continued.

description	lbub	G24.02		G24.02a		G24.03		G24.04		G24.05		G24.06		G24.07	
		est	se	est	se	est	se	est	se	est	se	est	se	est	se
Log vn size comp 12	– –	–	–	0	–	0	–	0	–	0	–	0	–	0	–
Log vn size comp 13	– –	–	–	0	–	0	–	0	–	0	–	0	–	0	–

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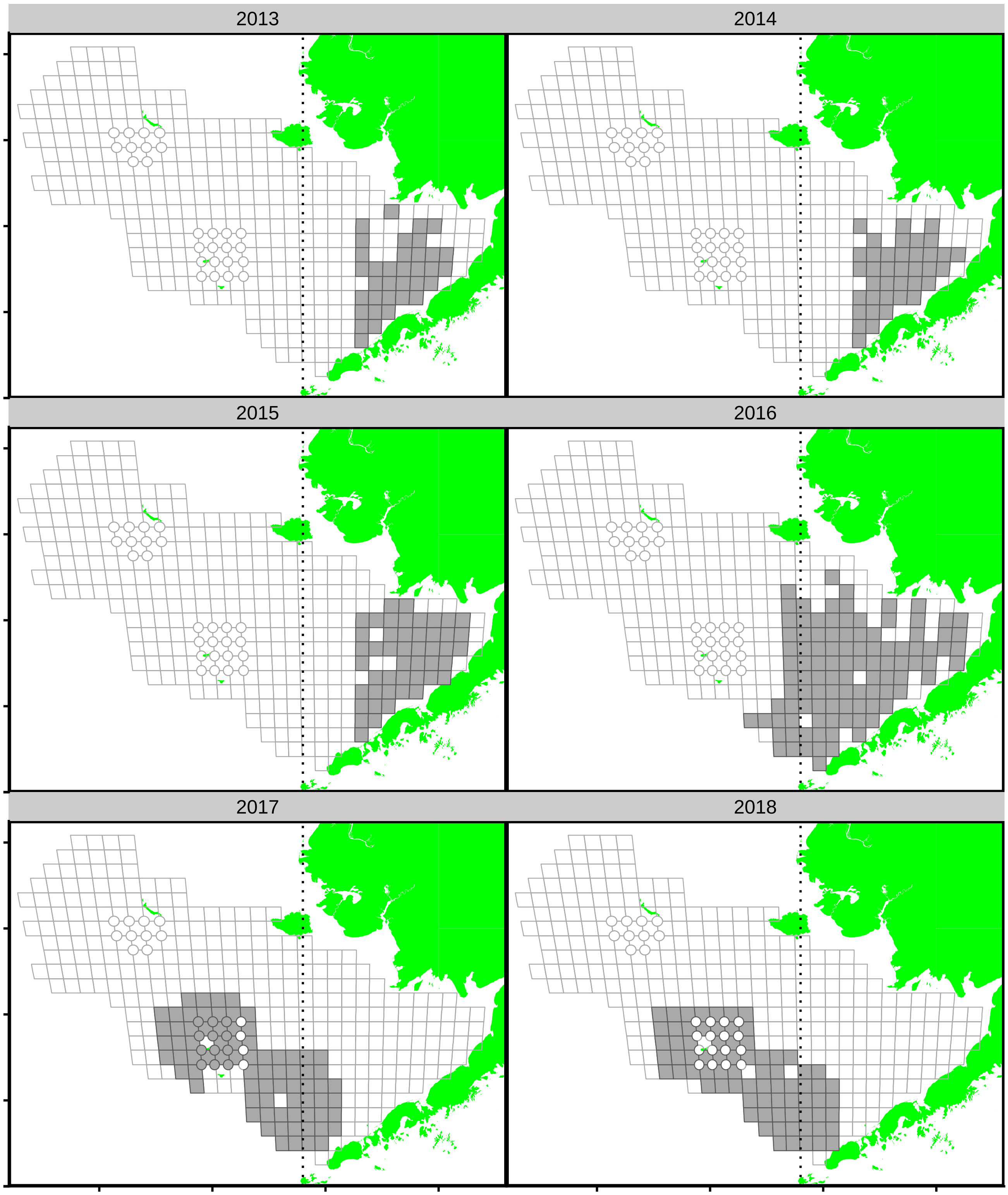
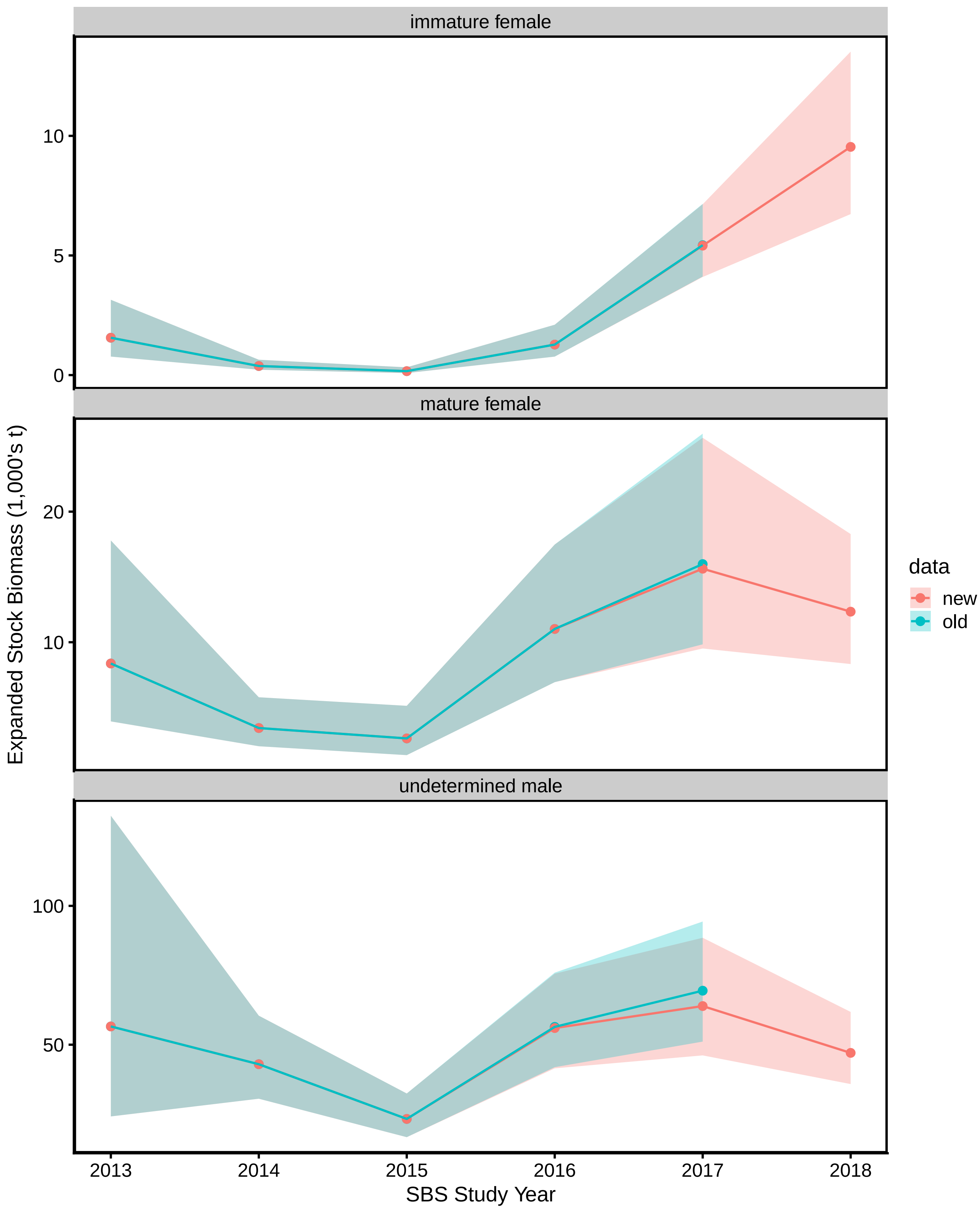


Figure 1. Cooperative BSFRF/NMFS side-by-side (SBS) selectivity study stations (dark grey) and full NMFS EBS survey grid (lines and circles).



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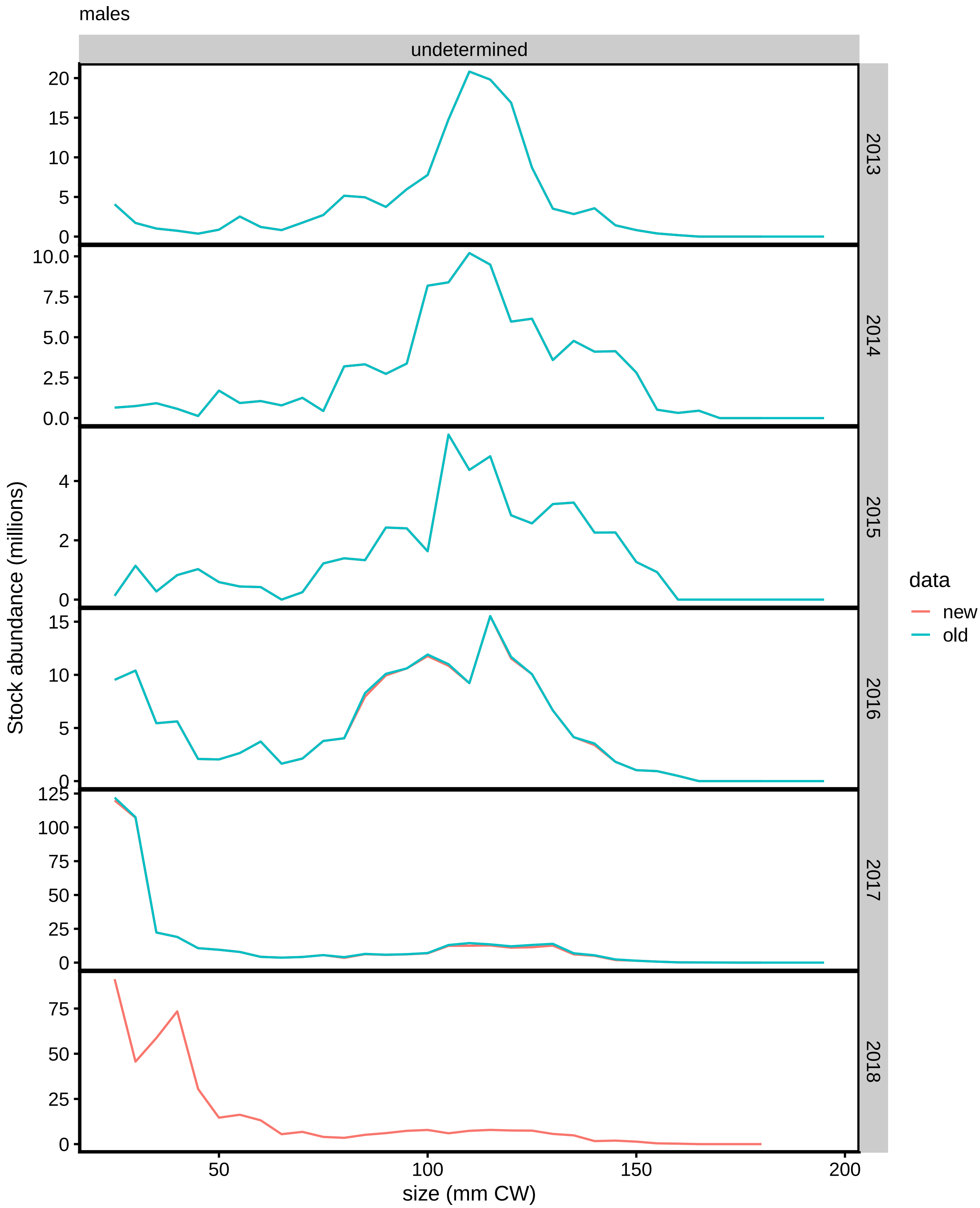

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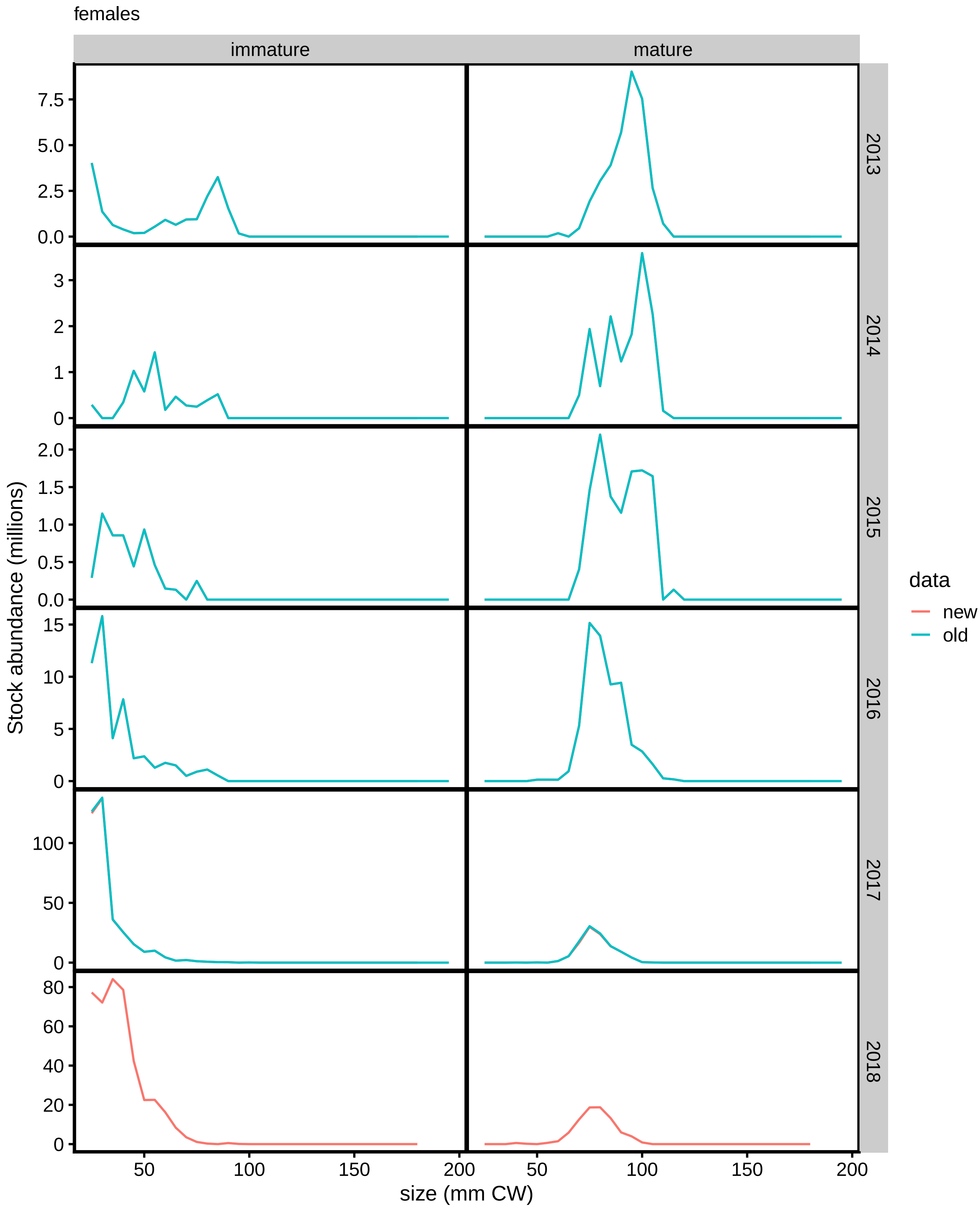

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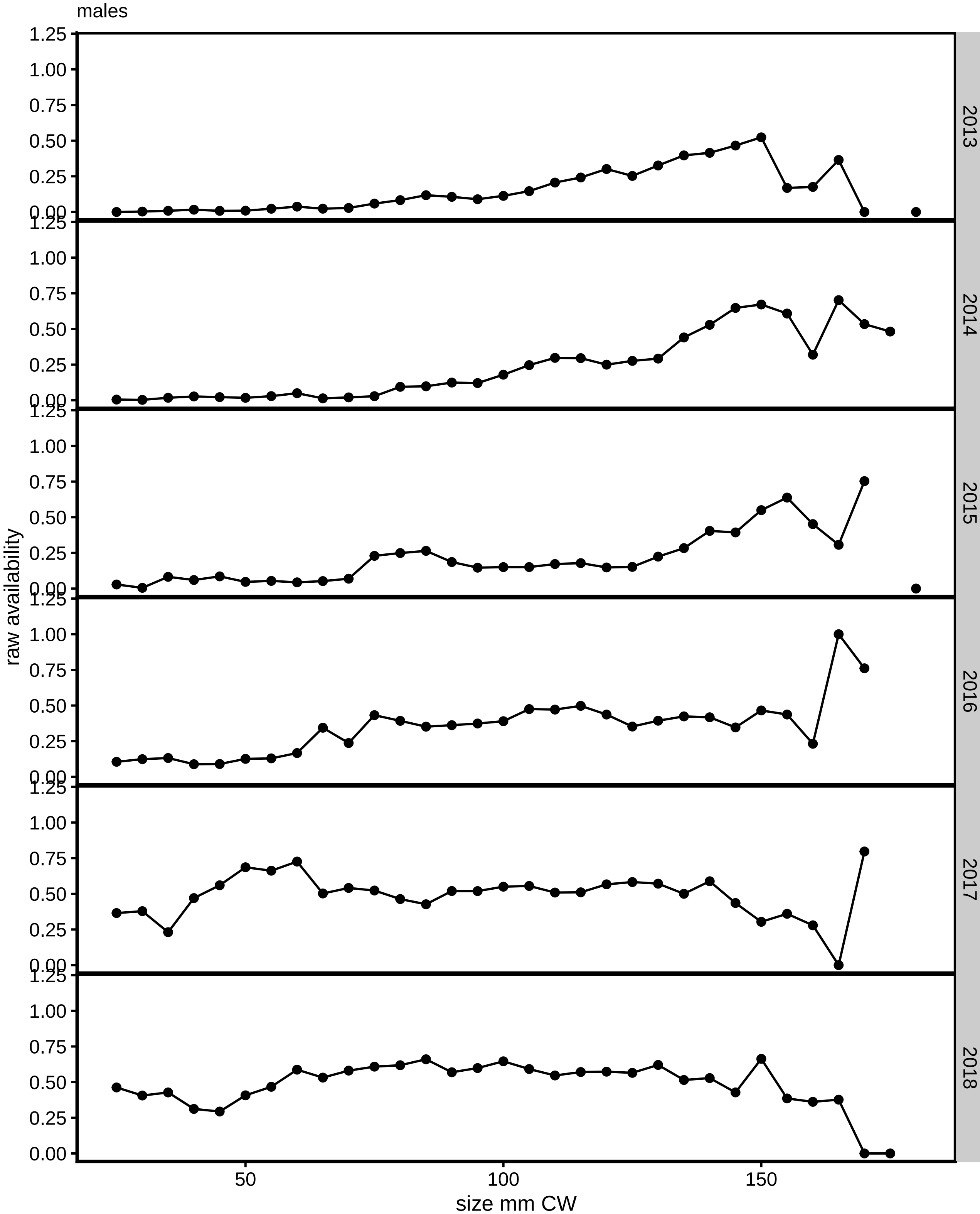

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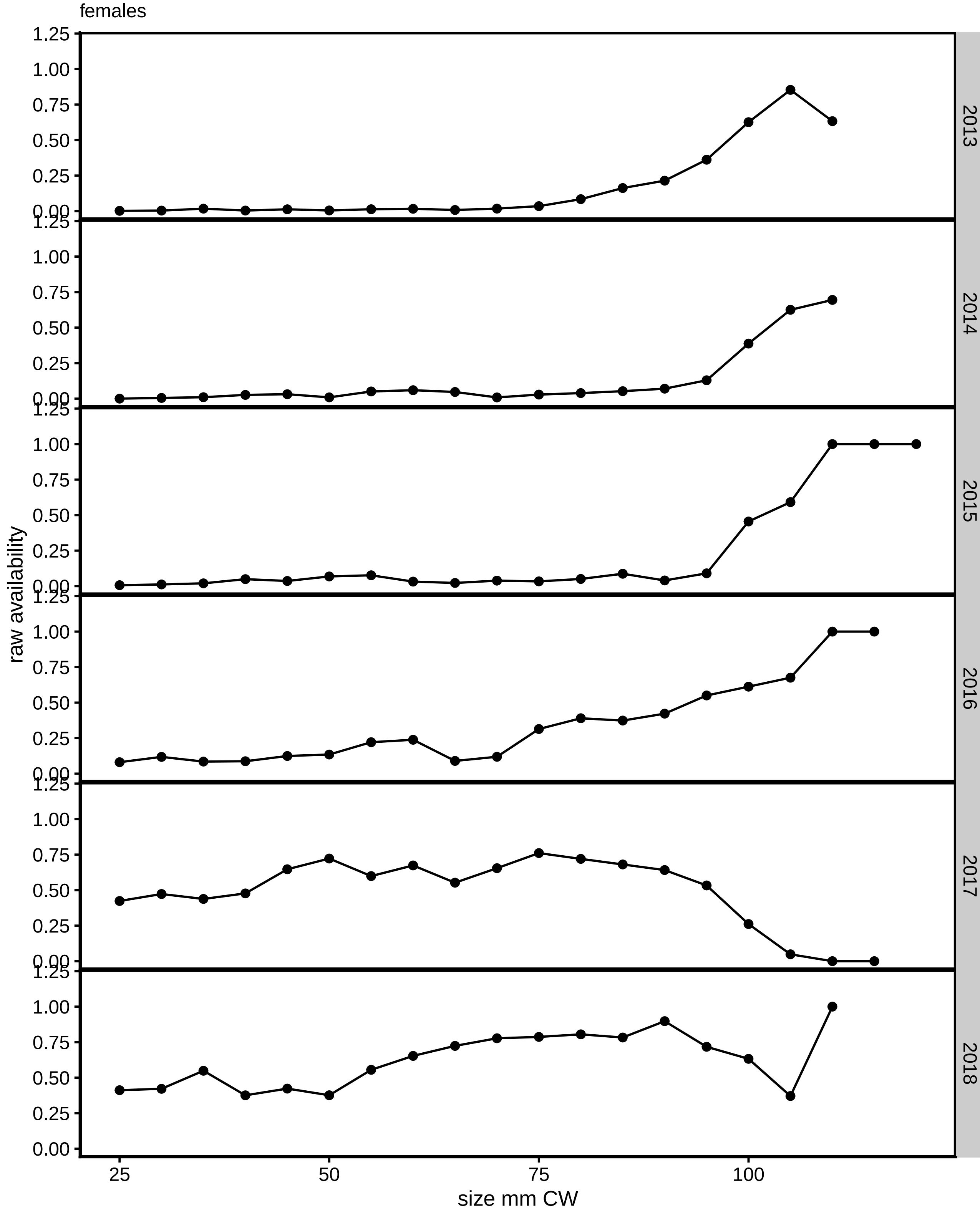

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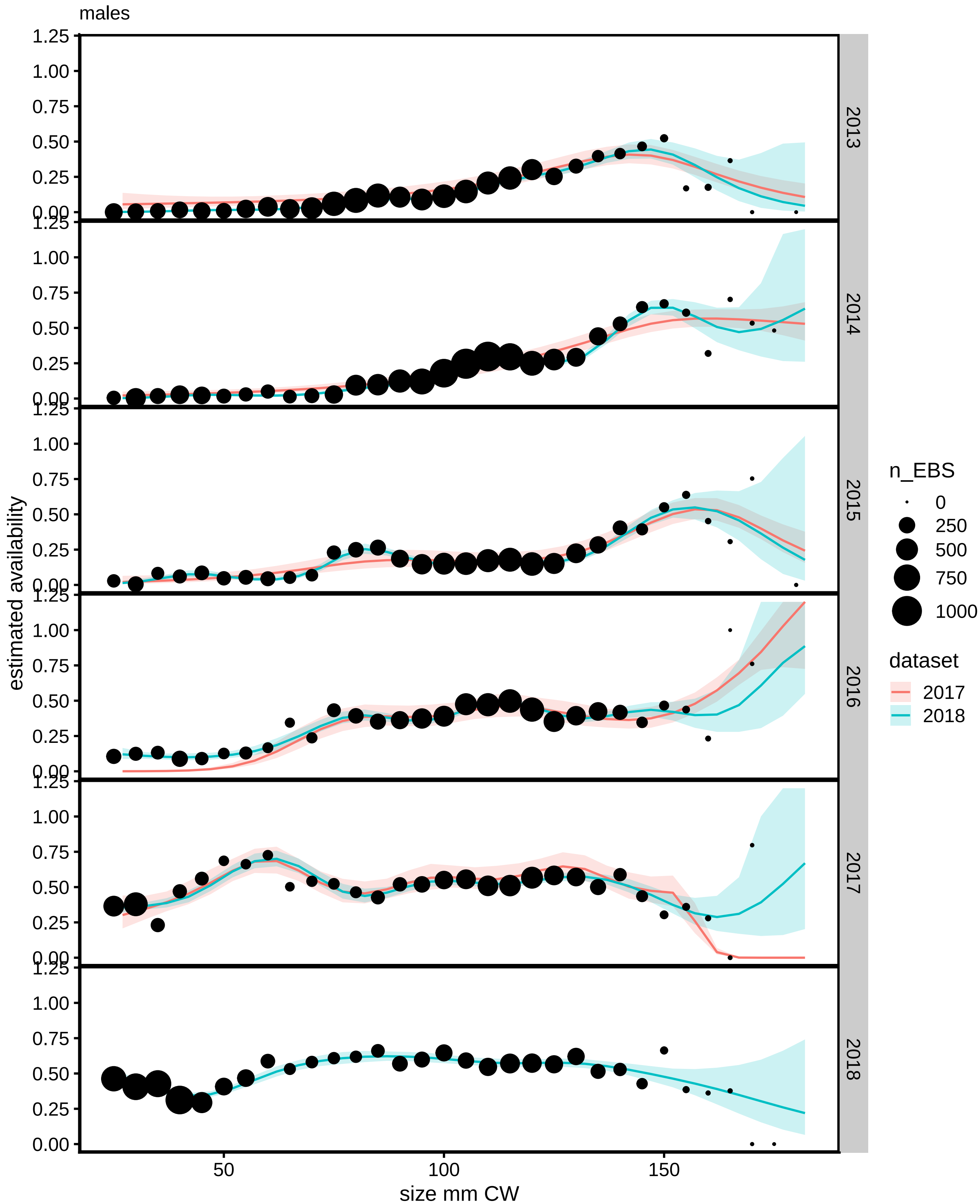

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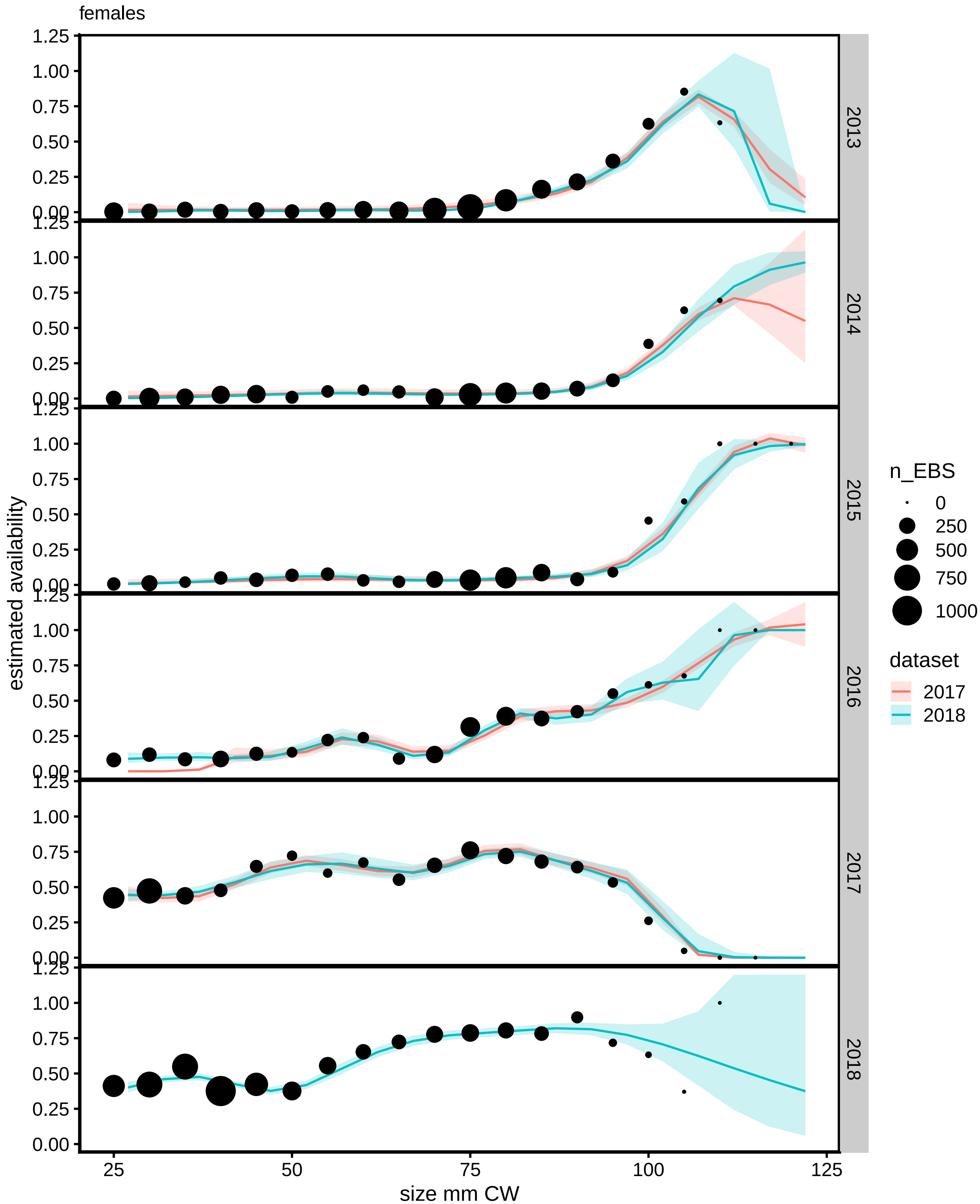

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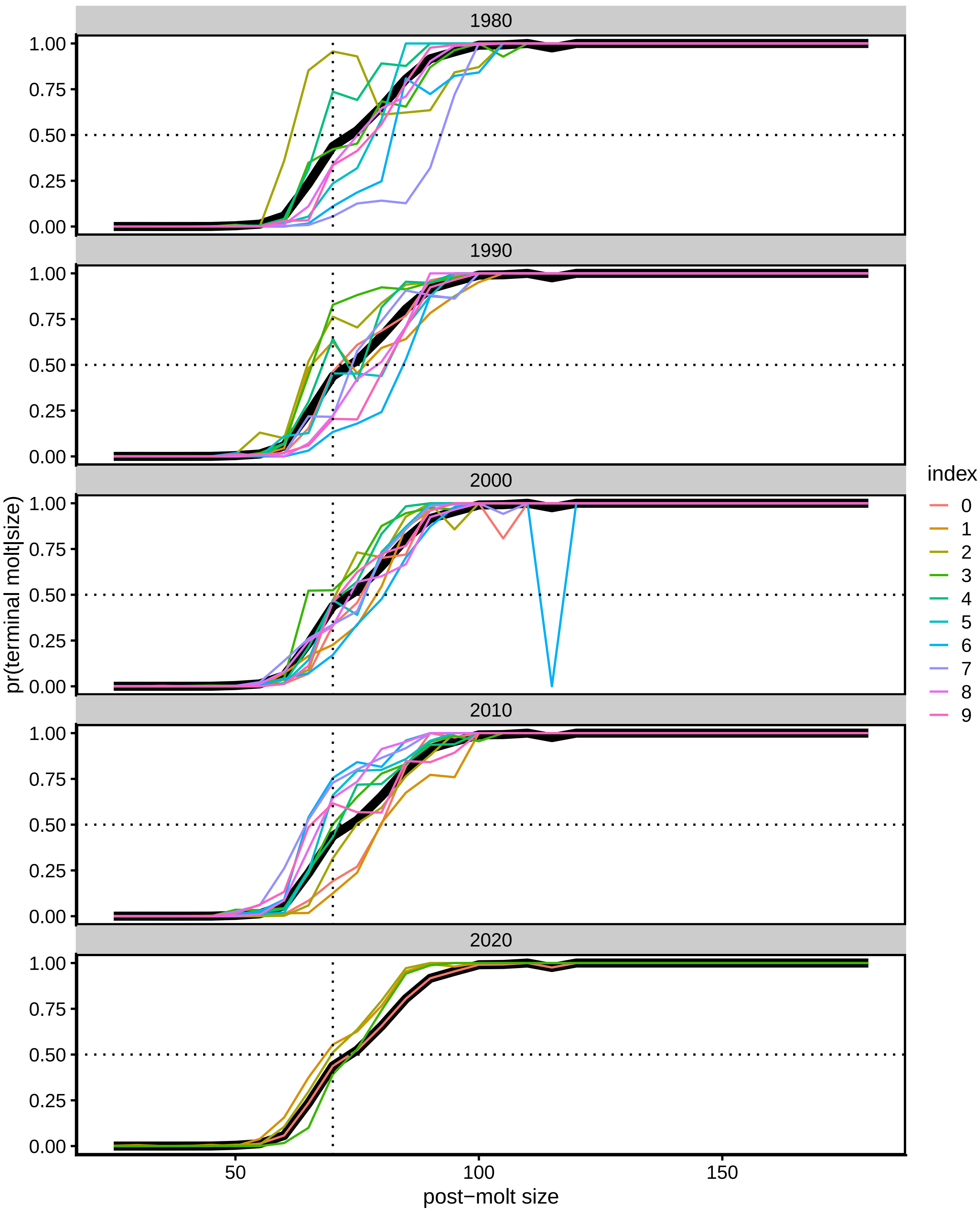

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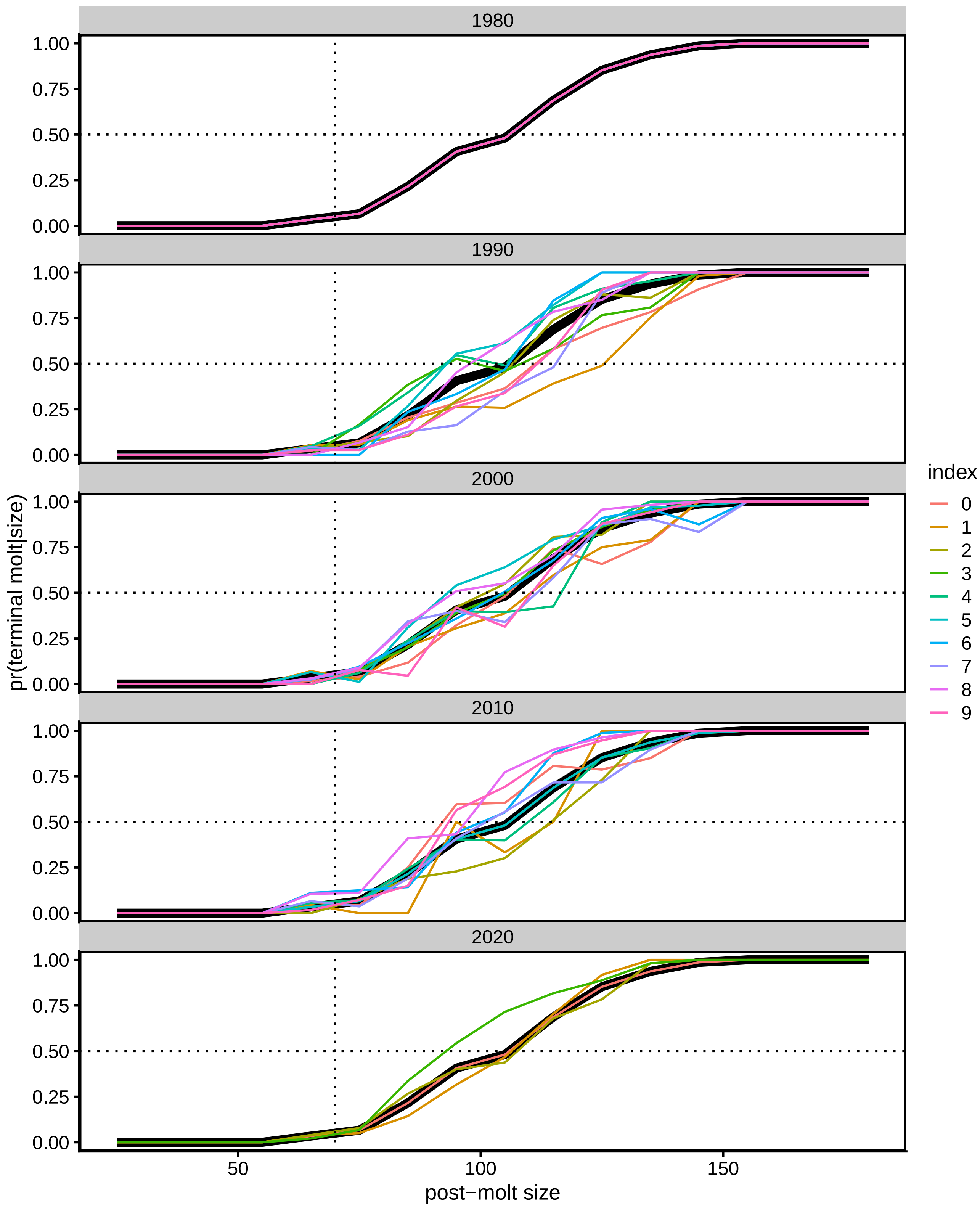

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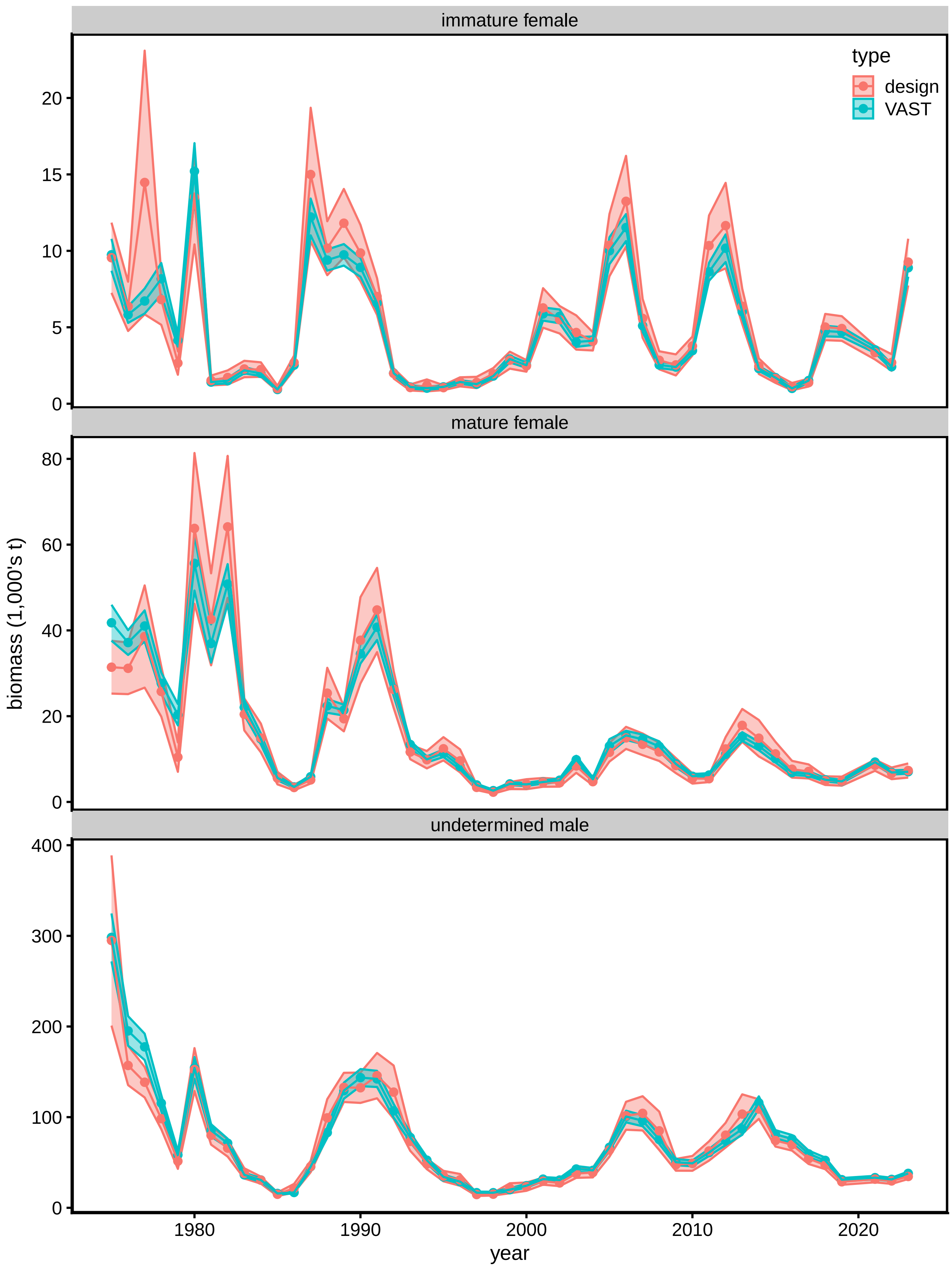

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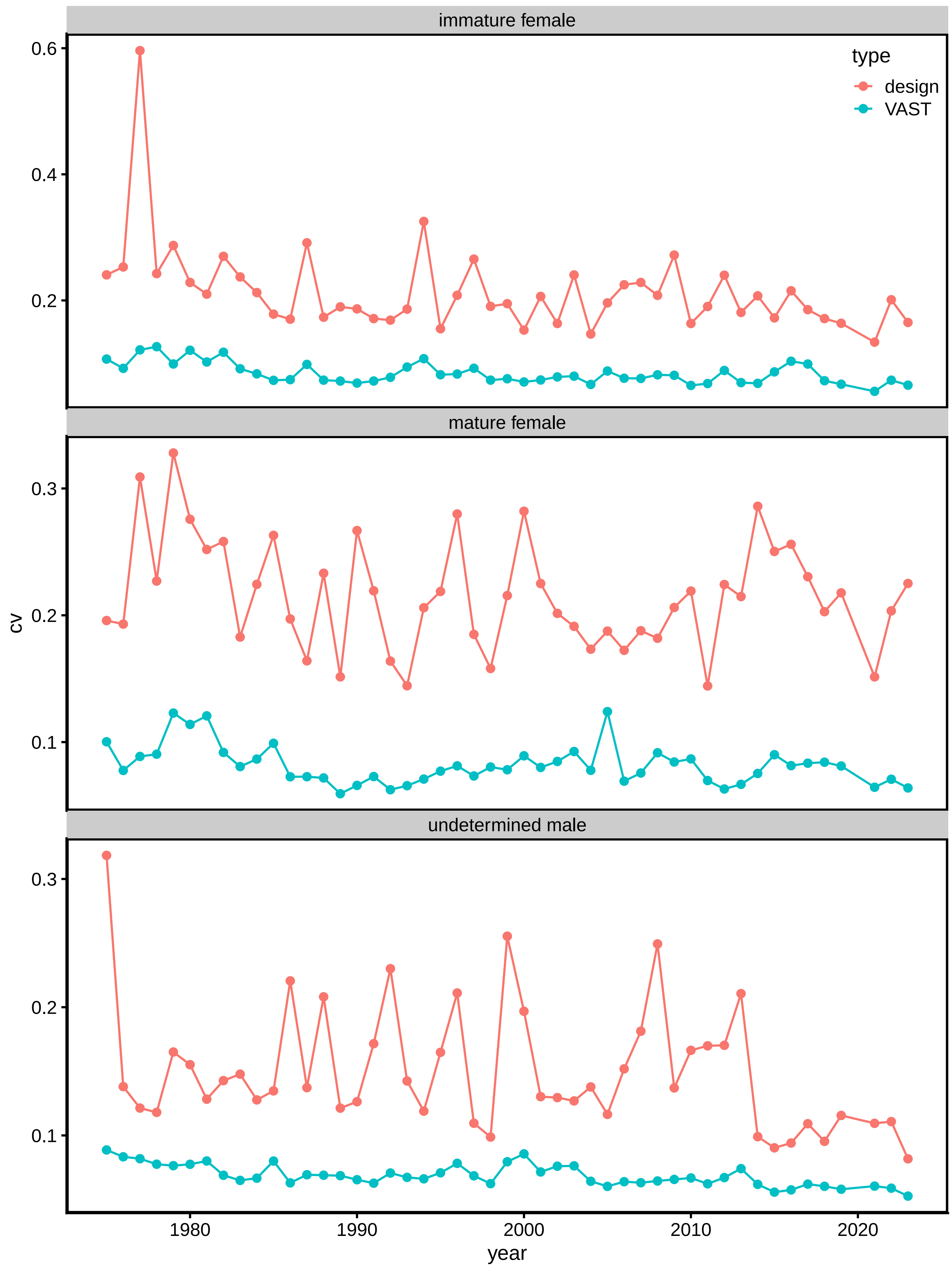

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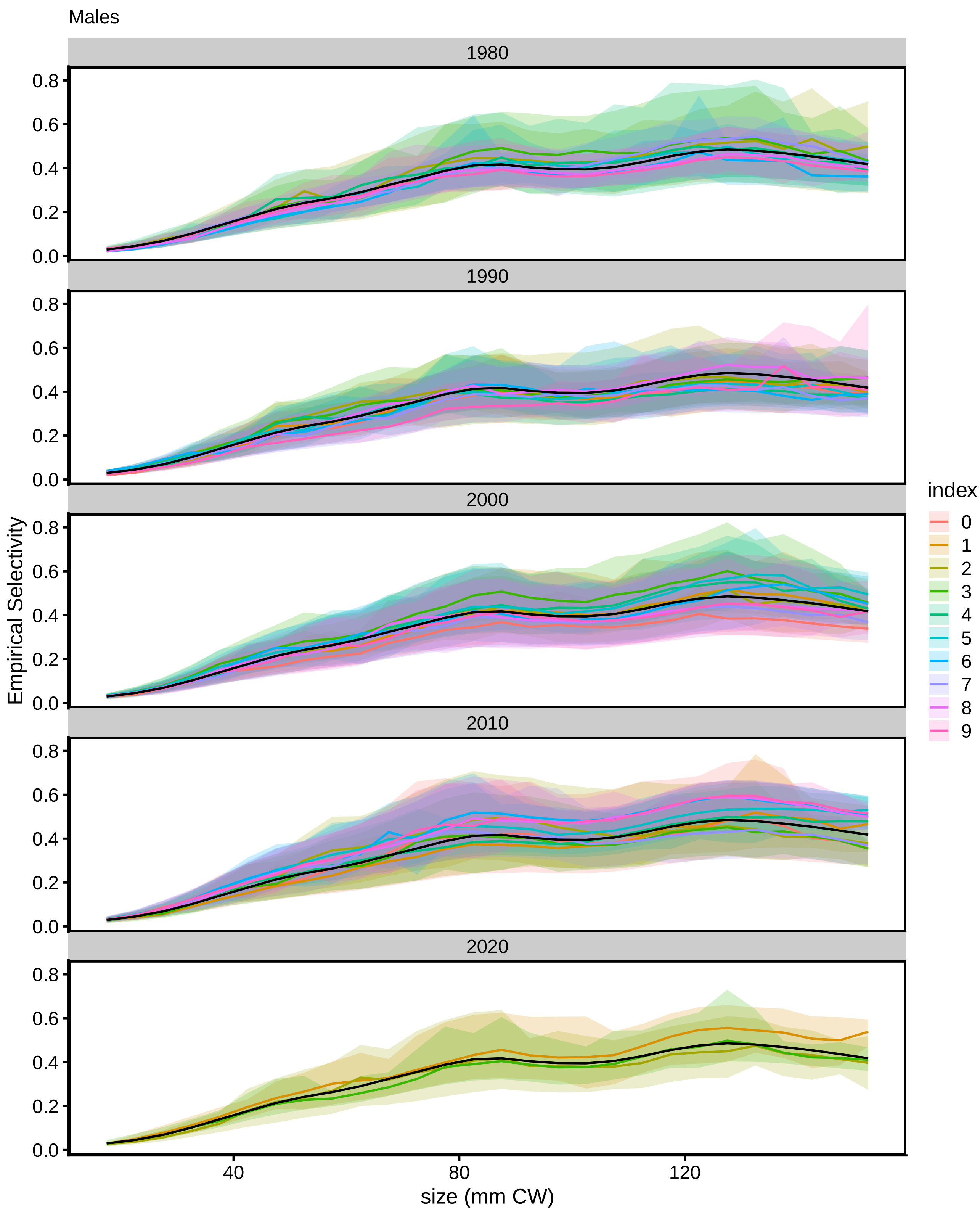

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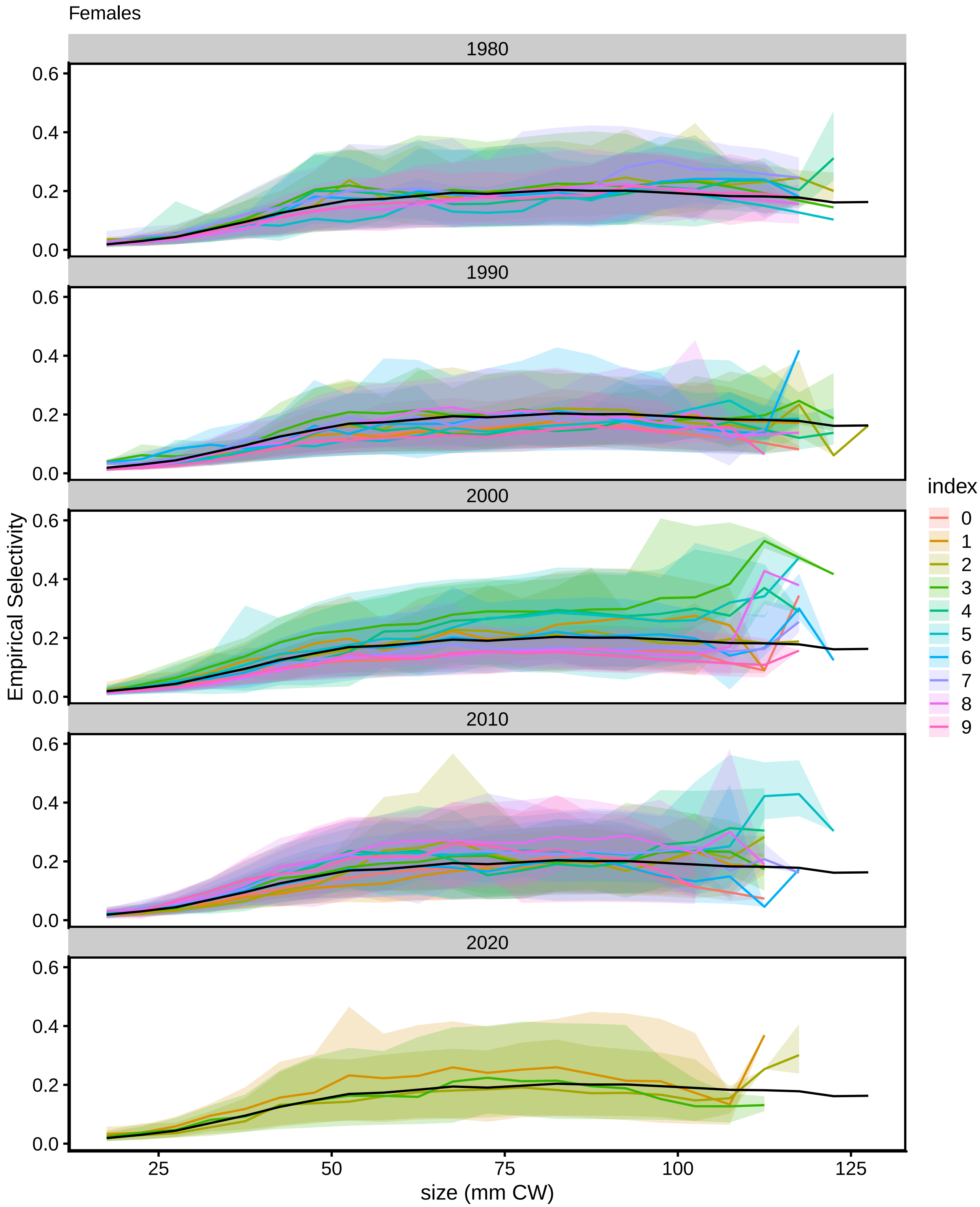

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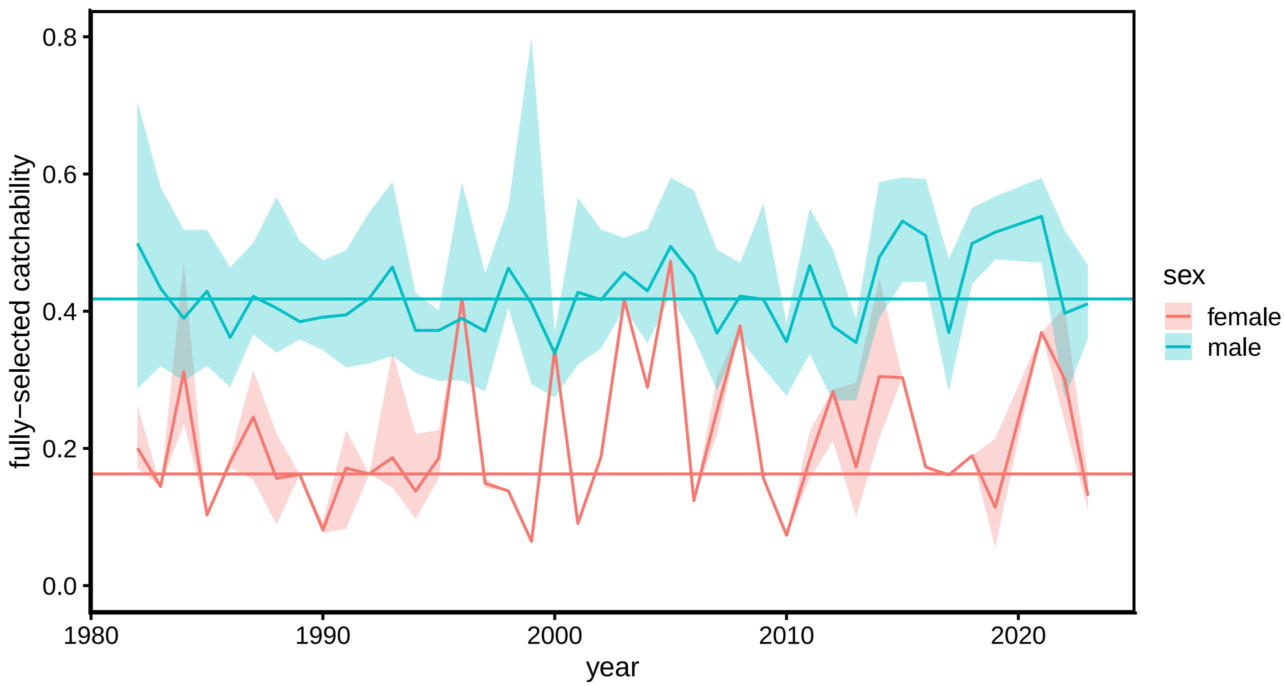

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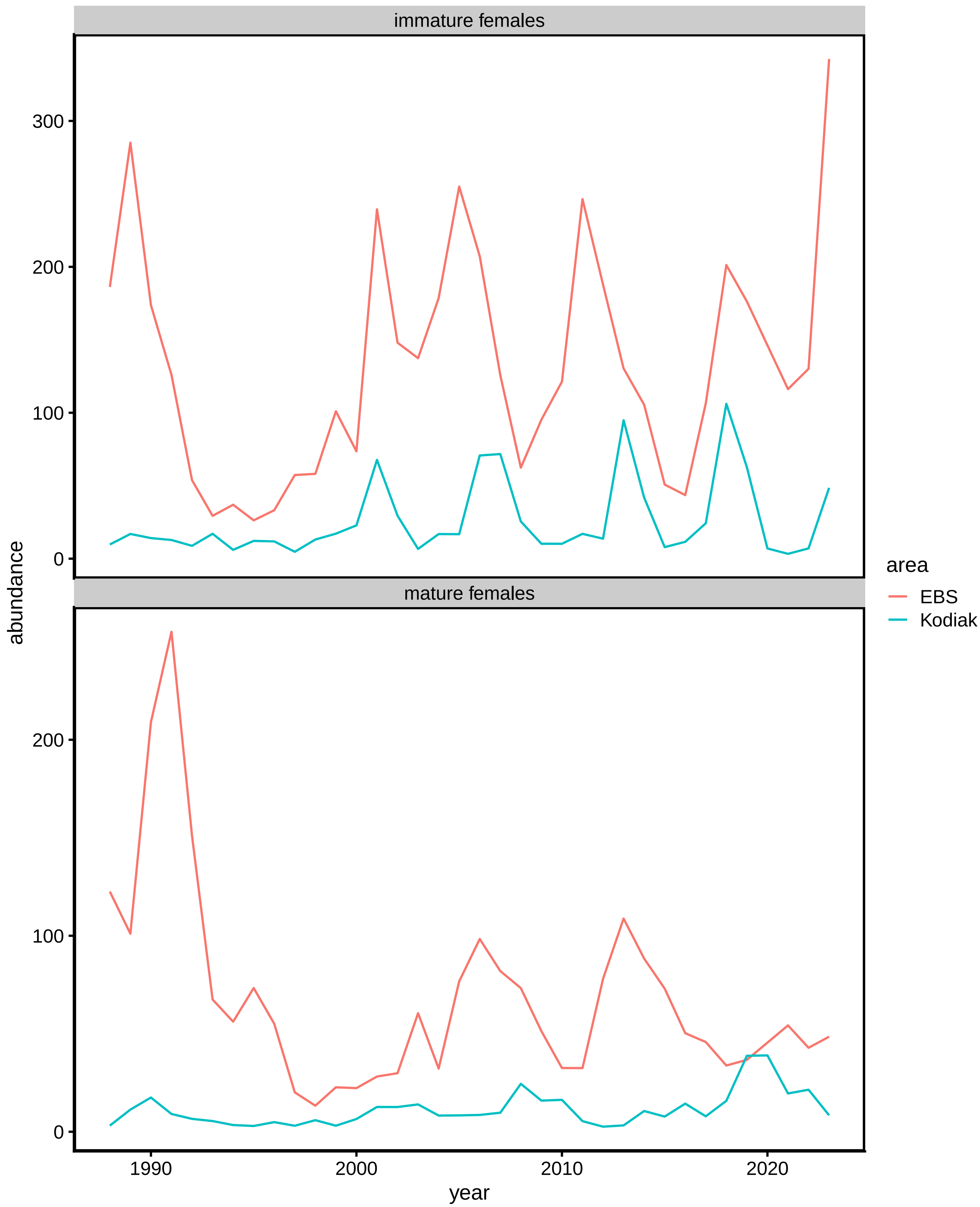

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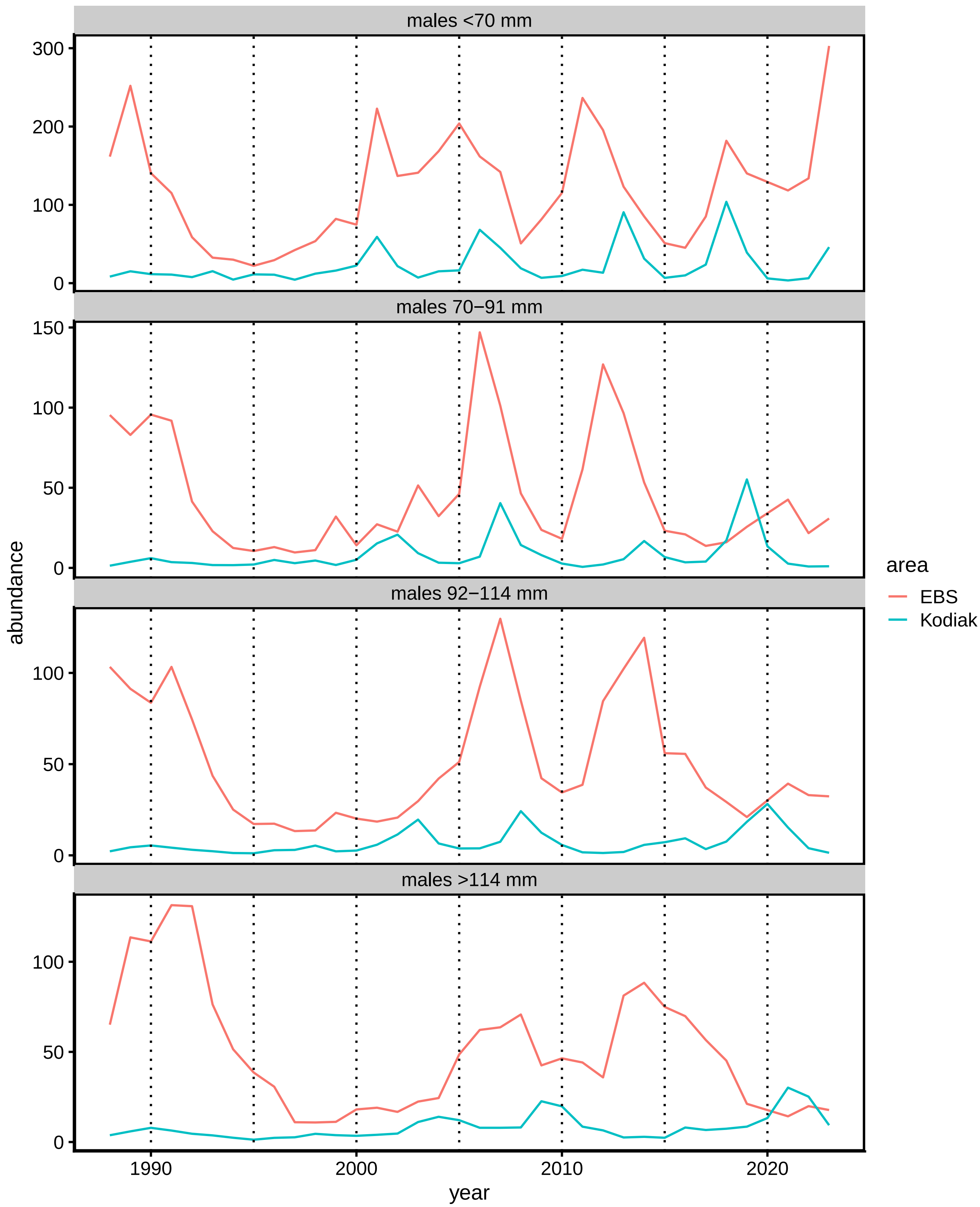

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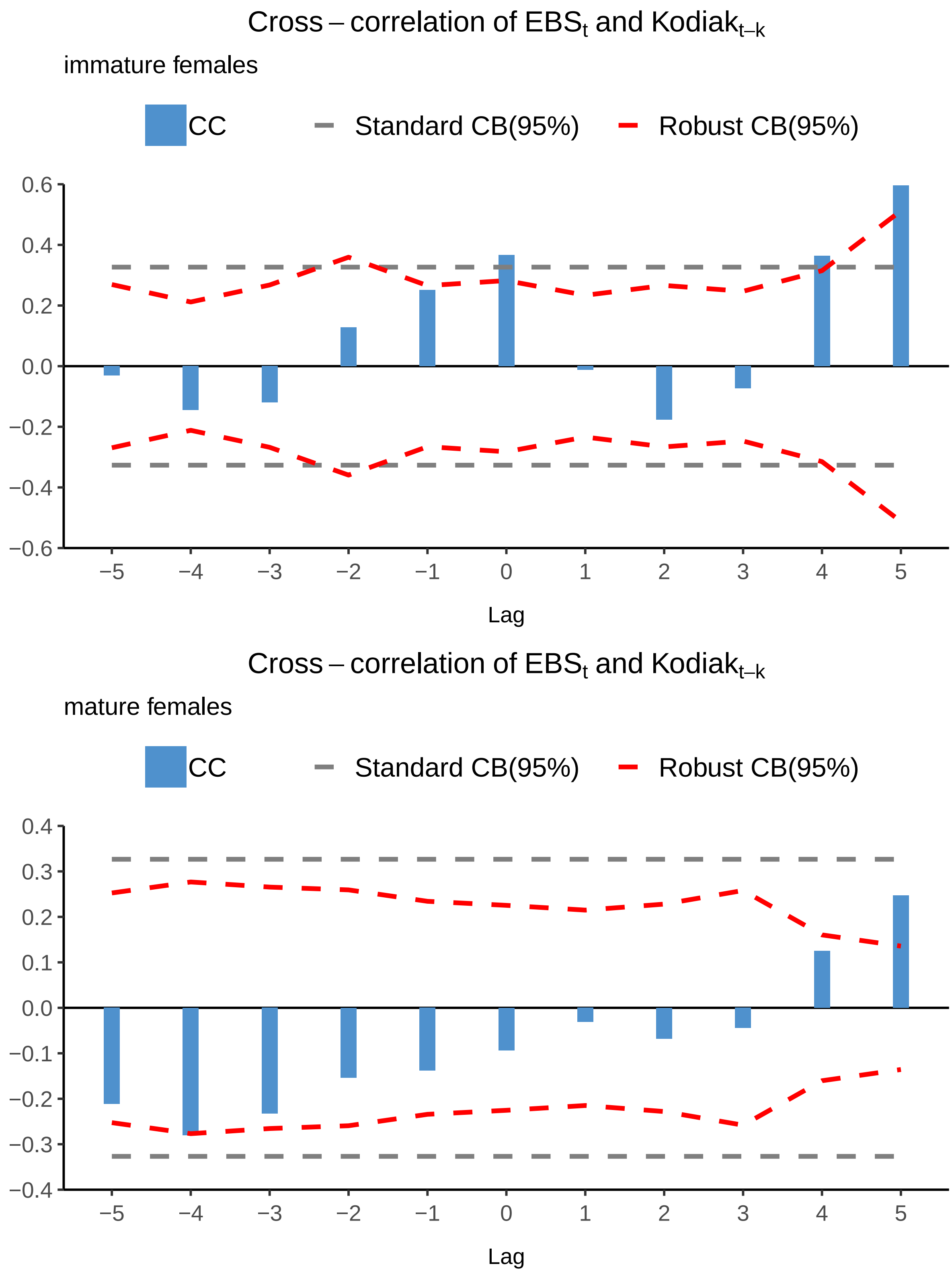

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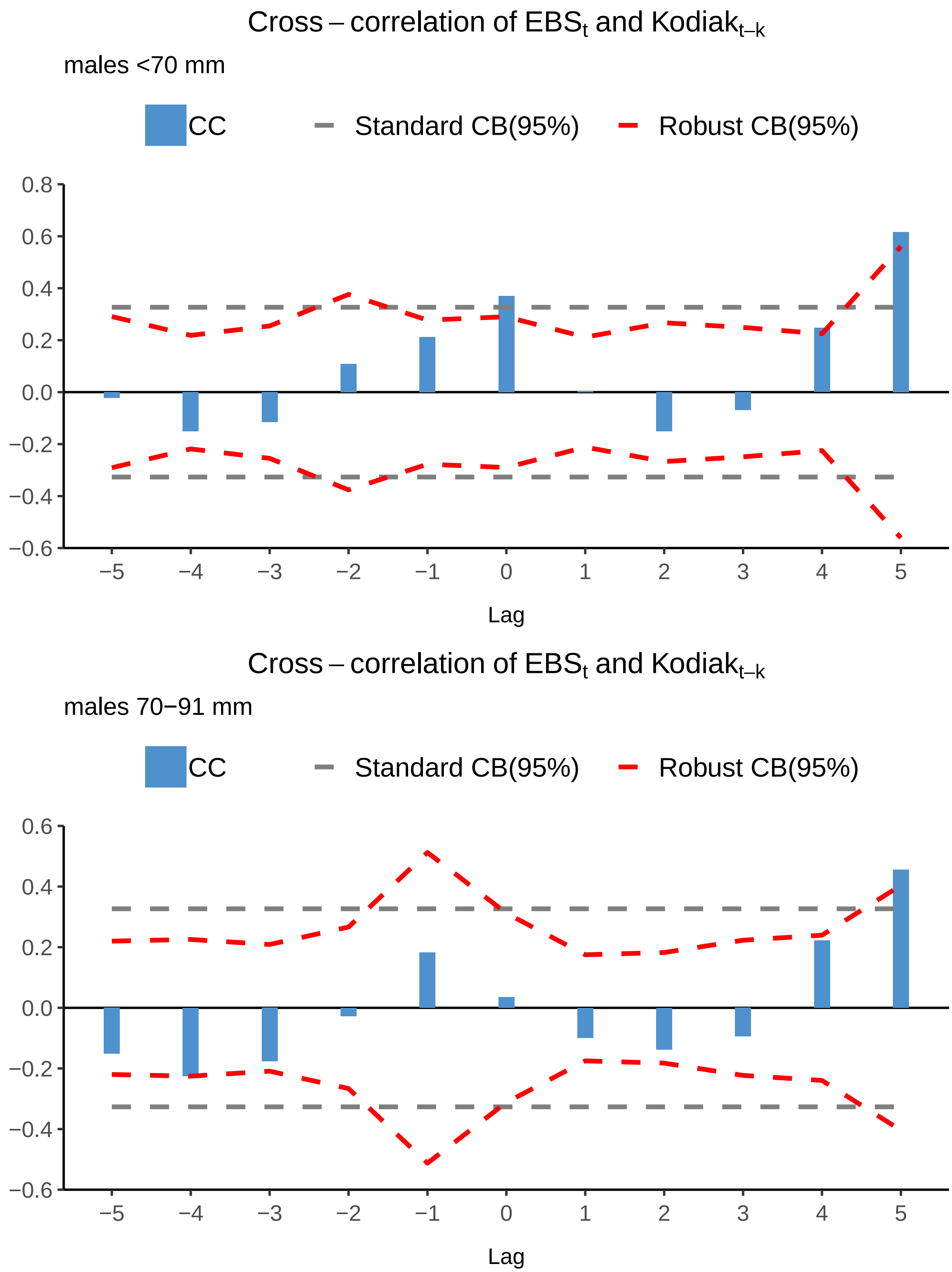

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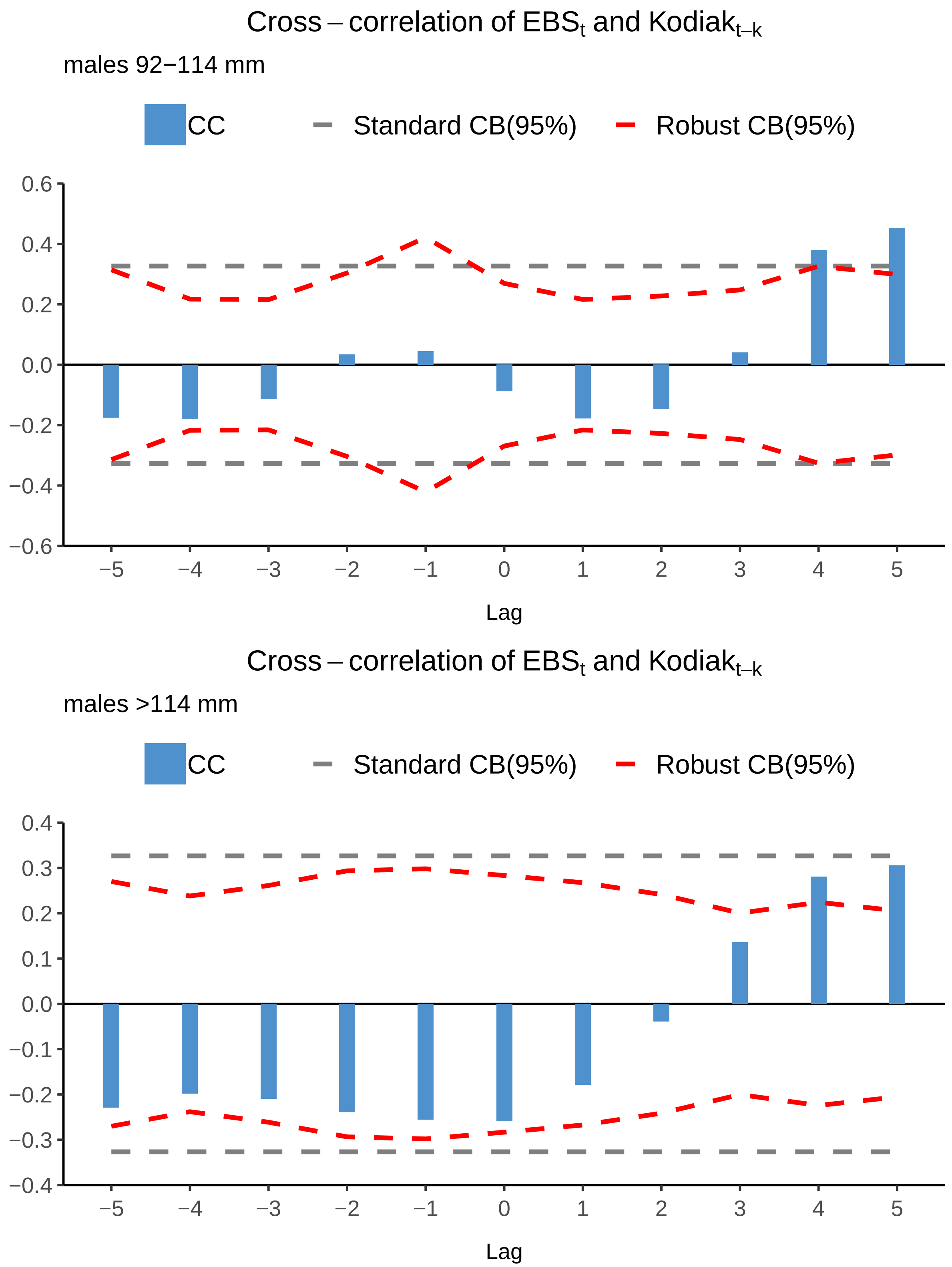

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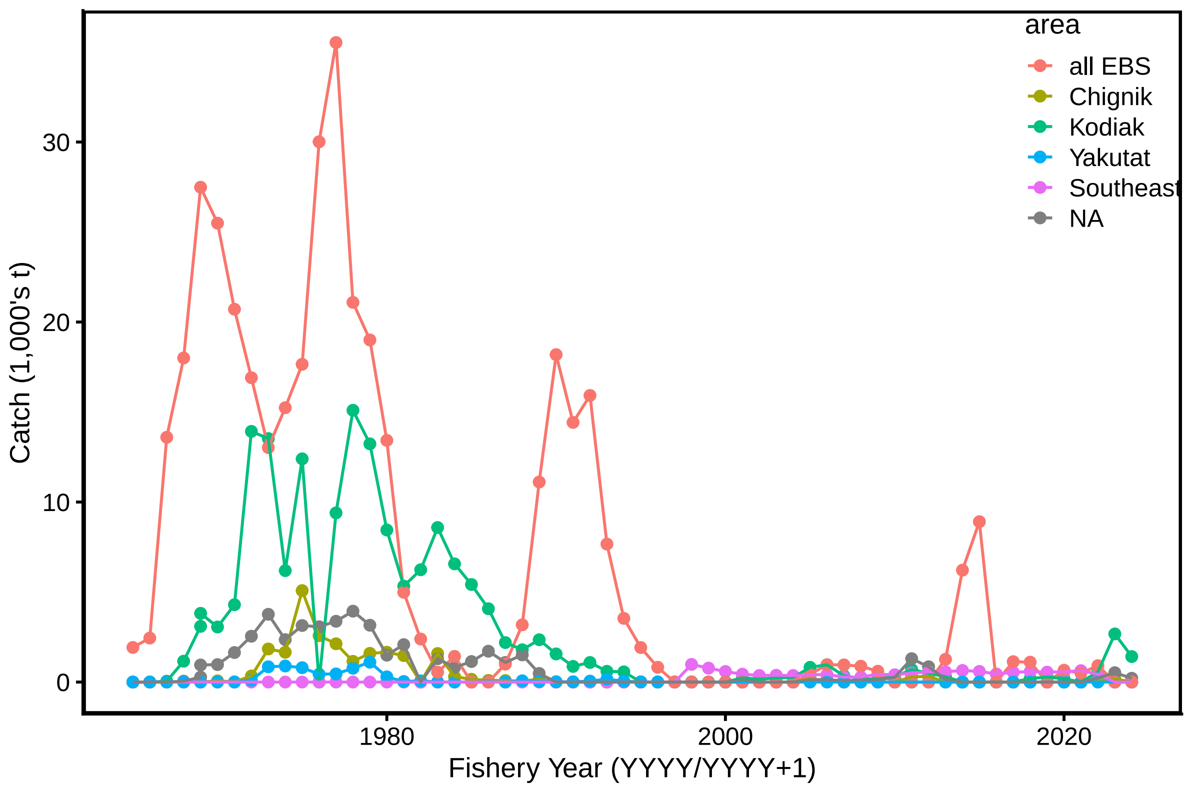

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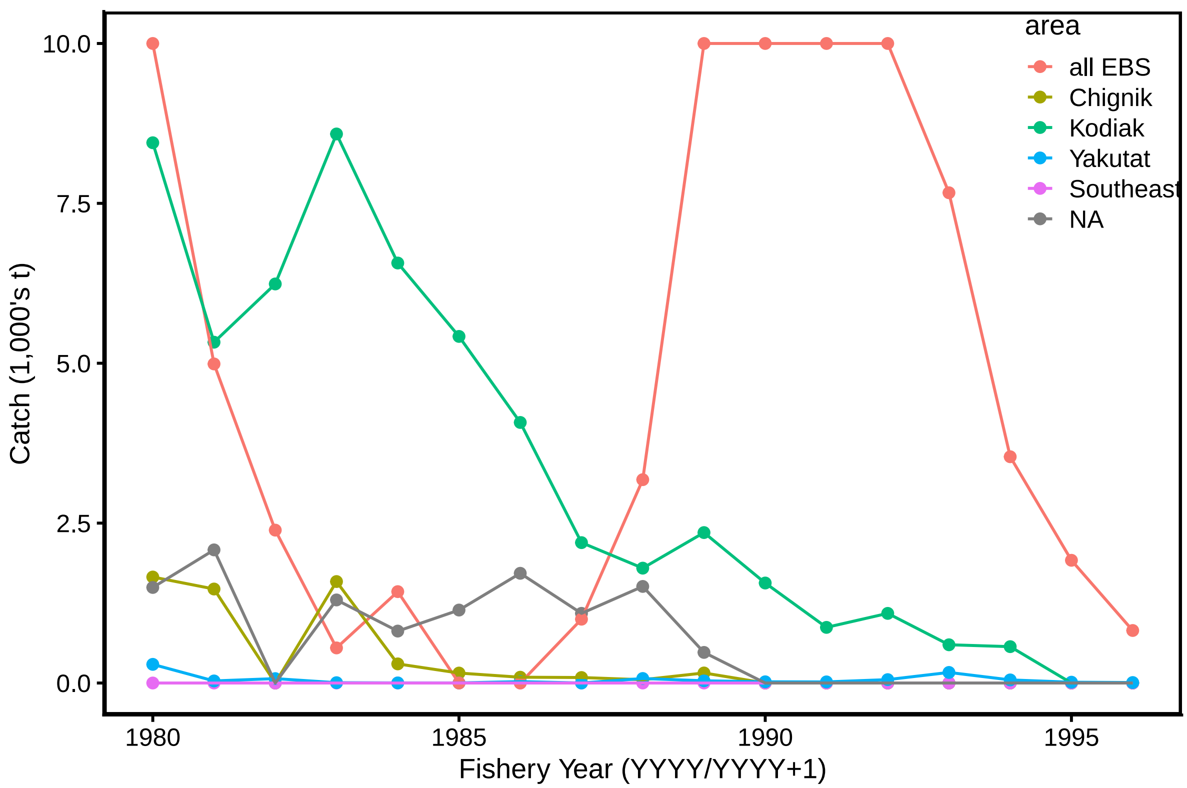

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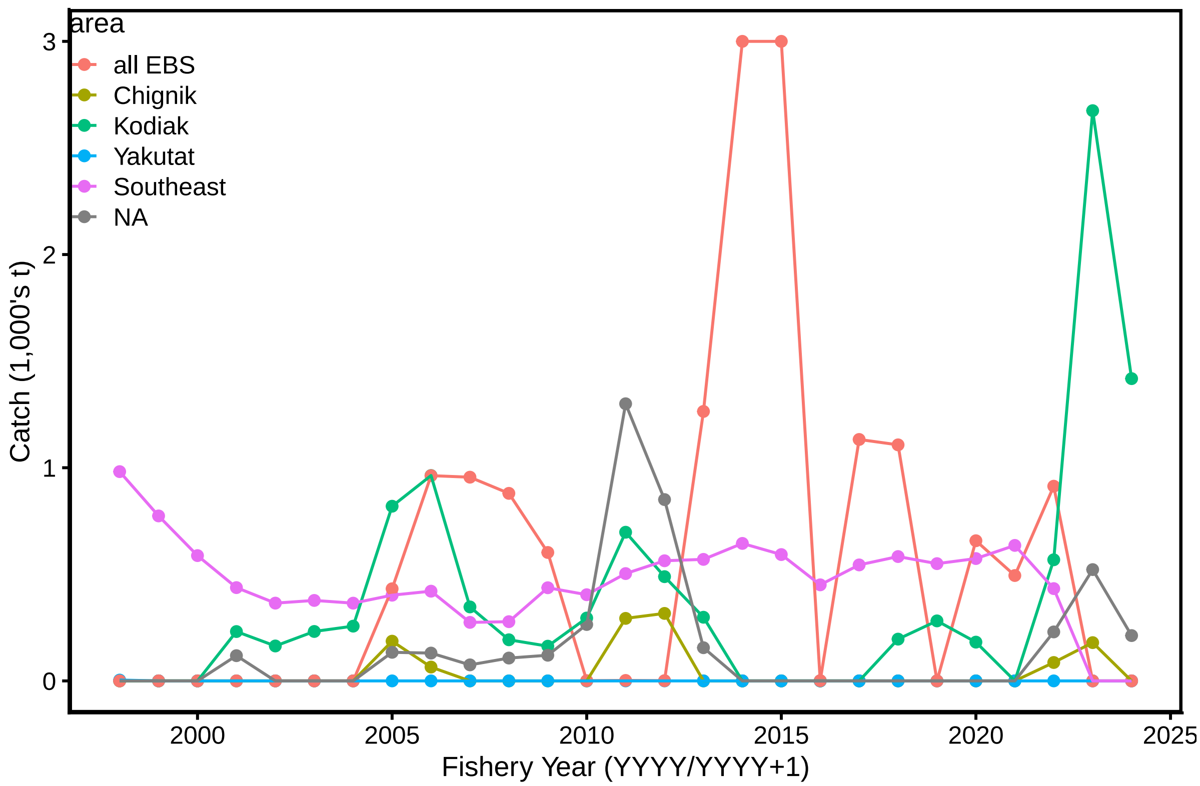

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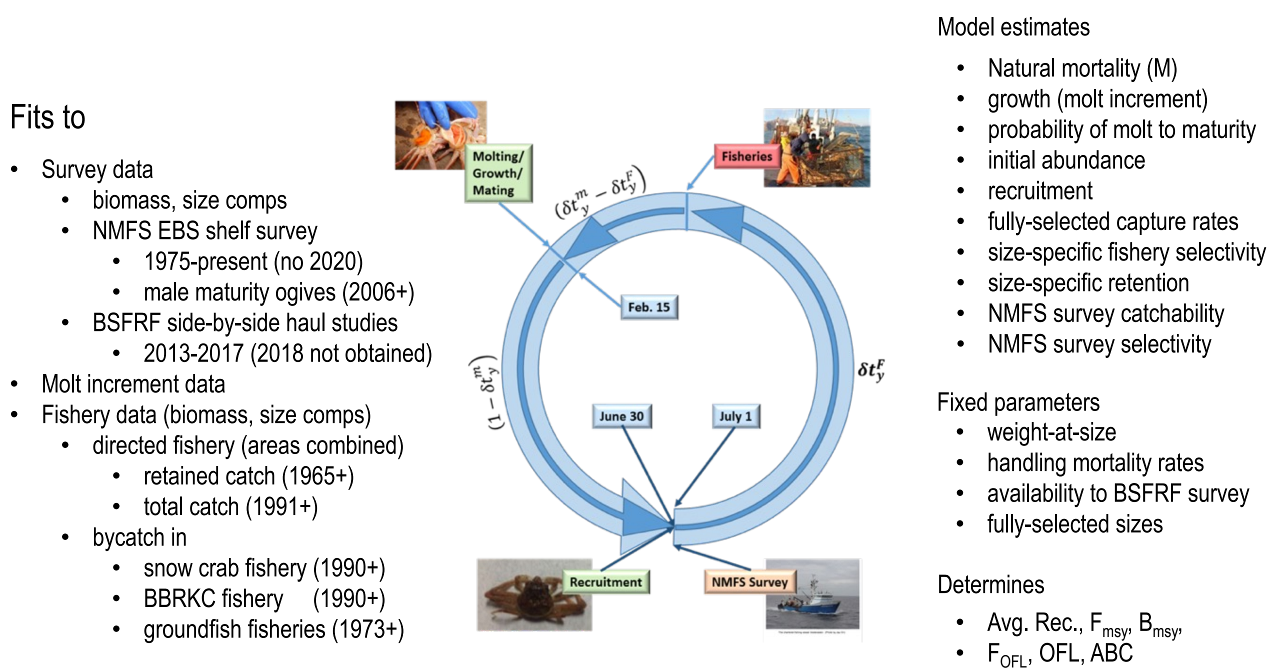

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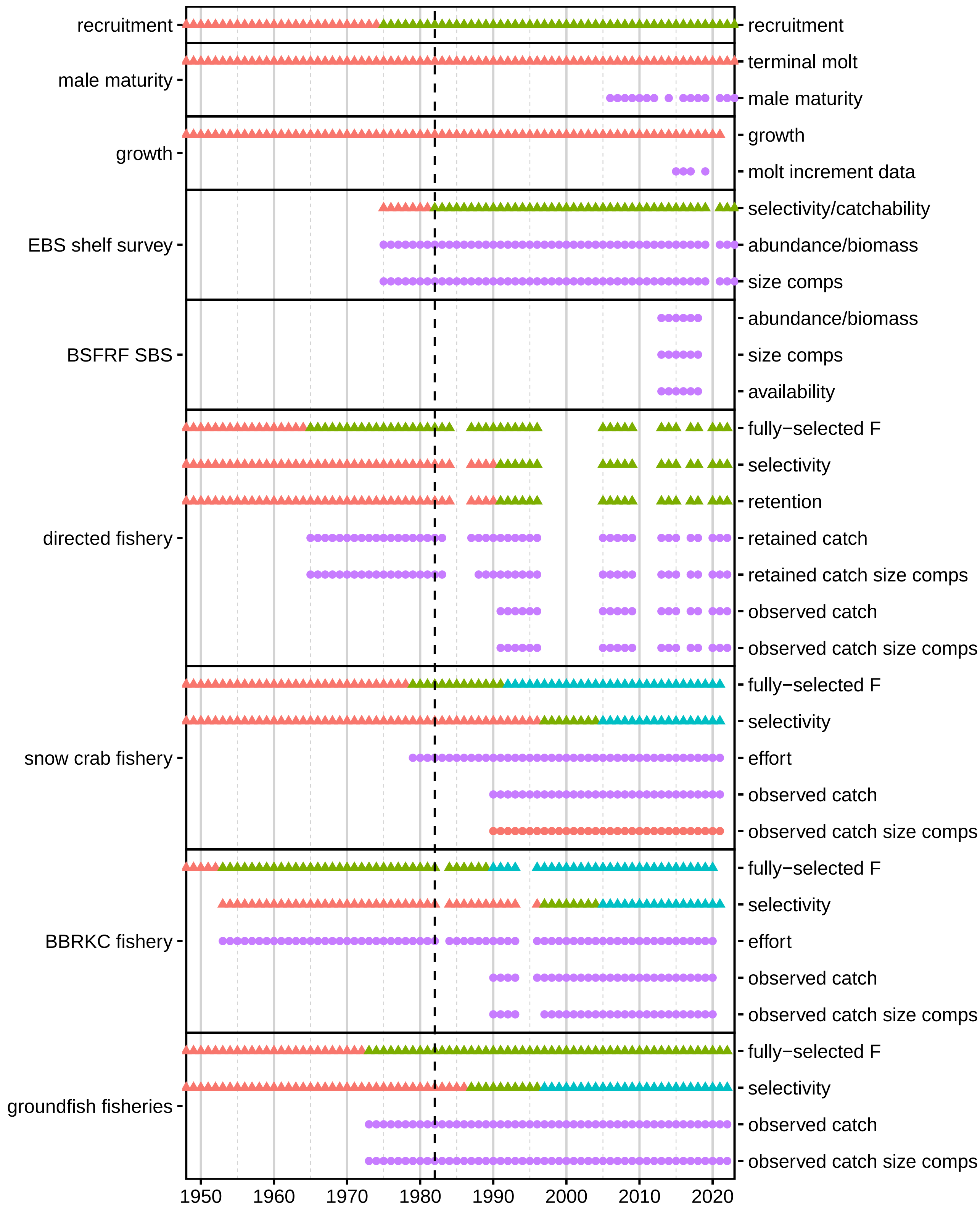

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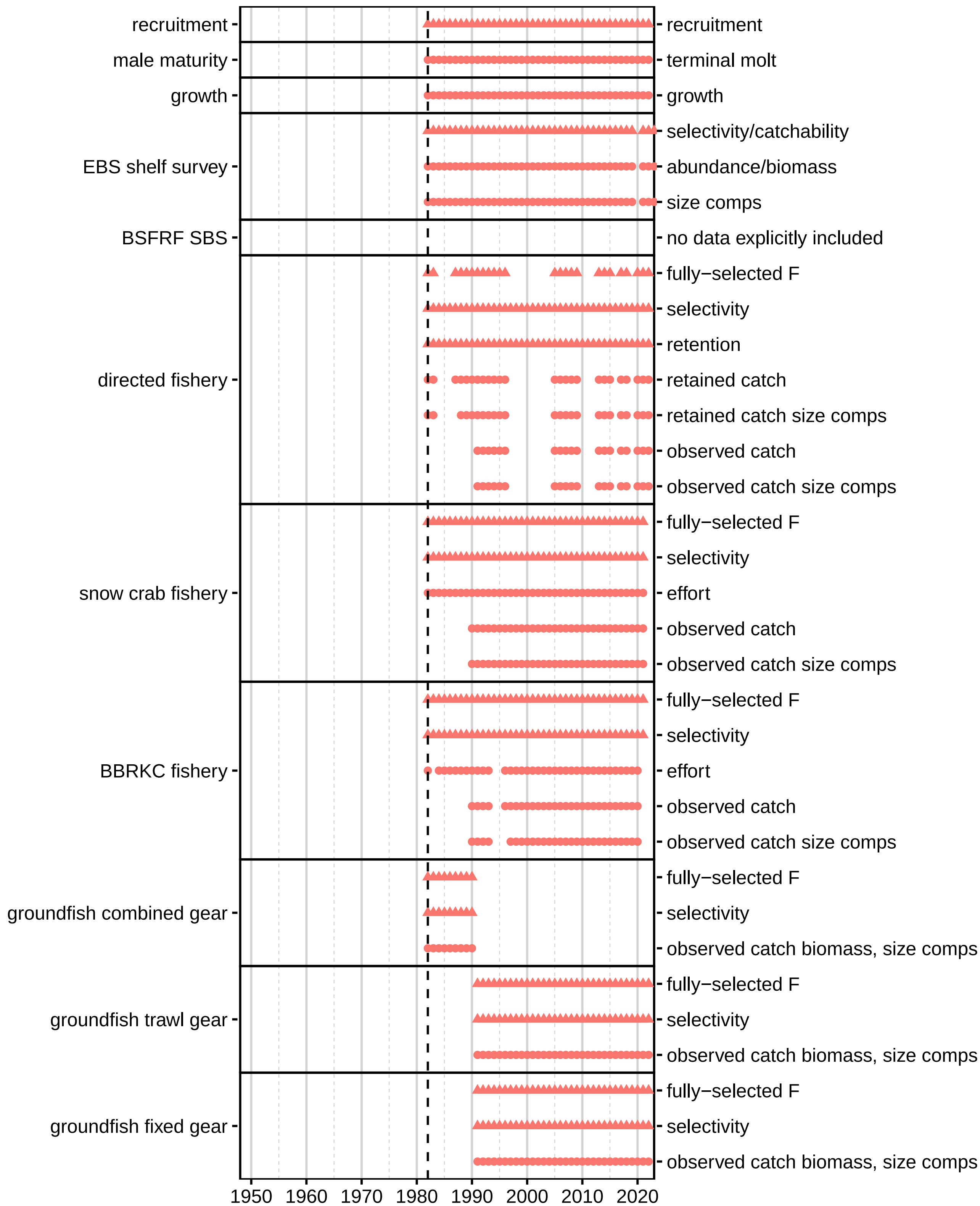

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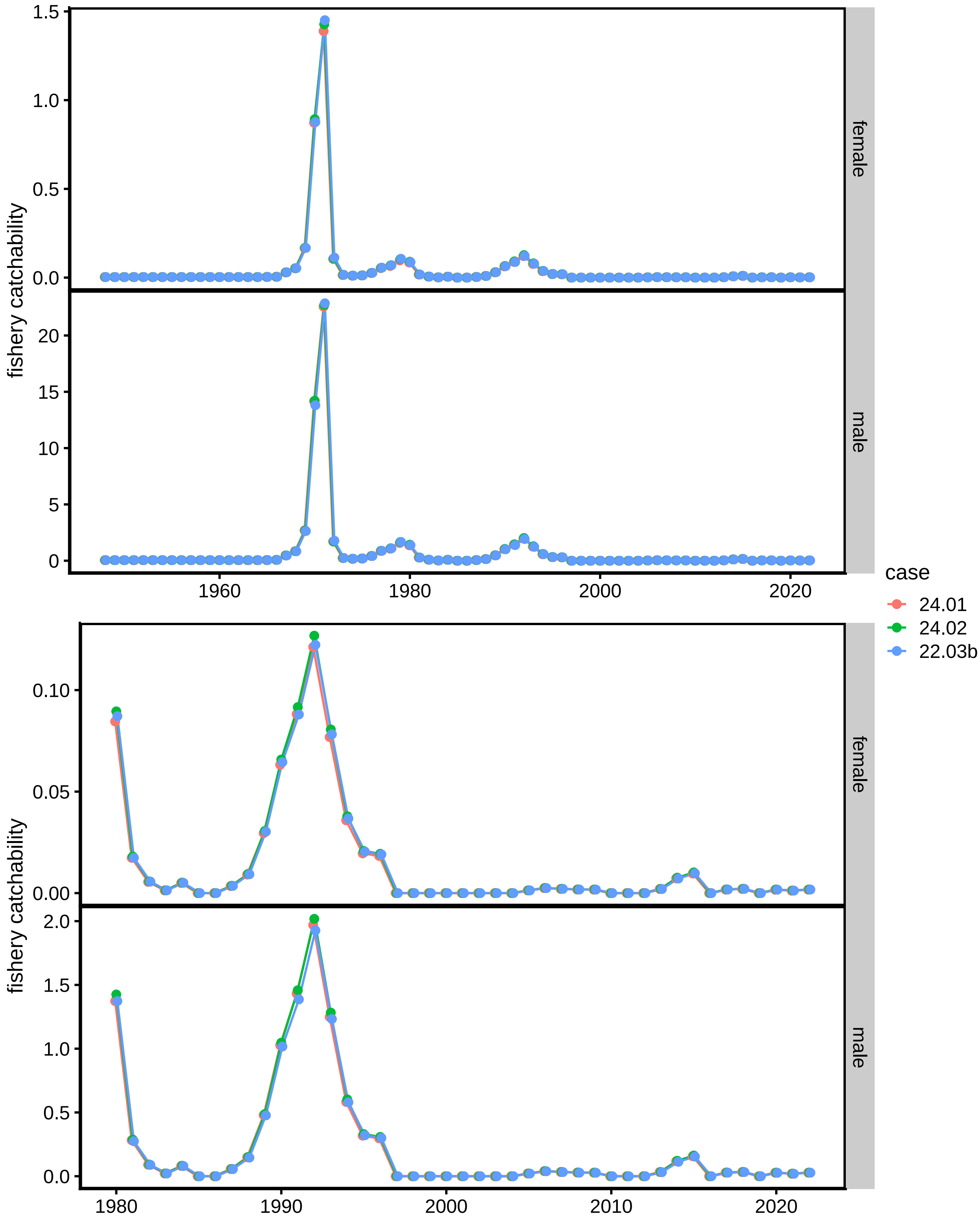

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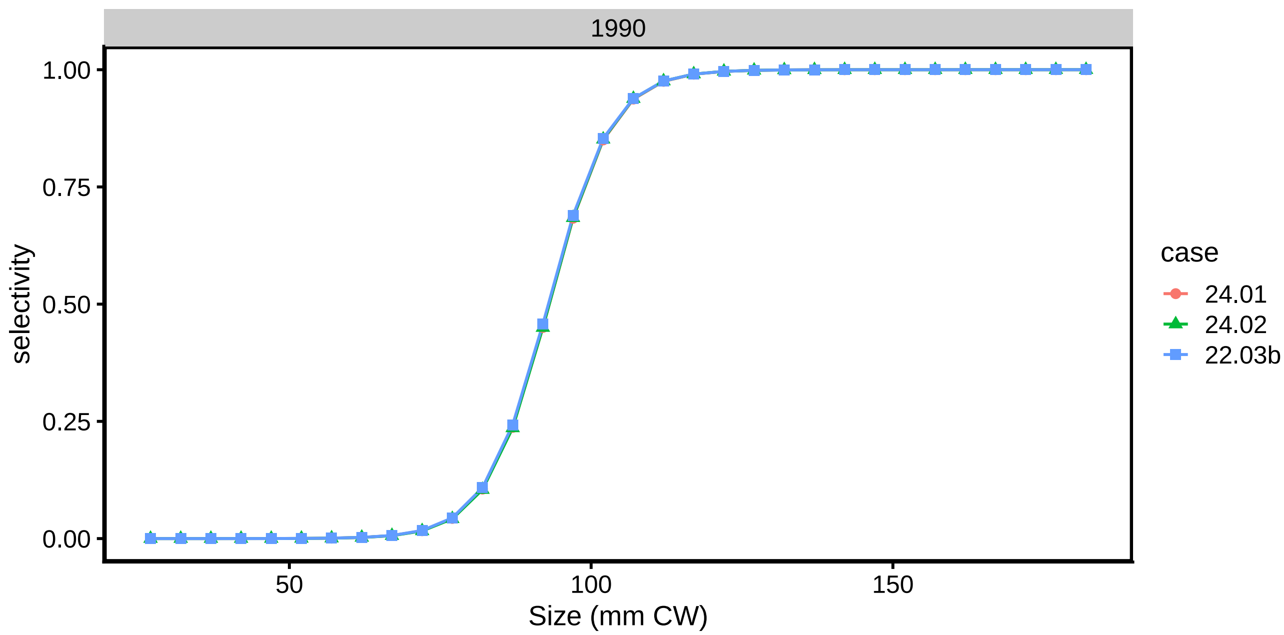

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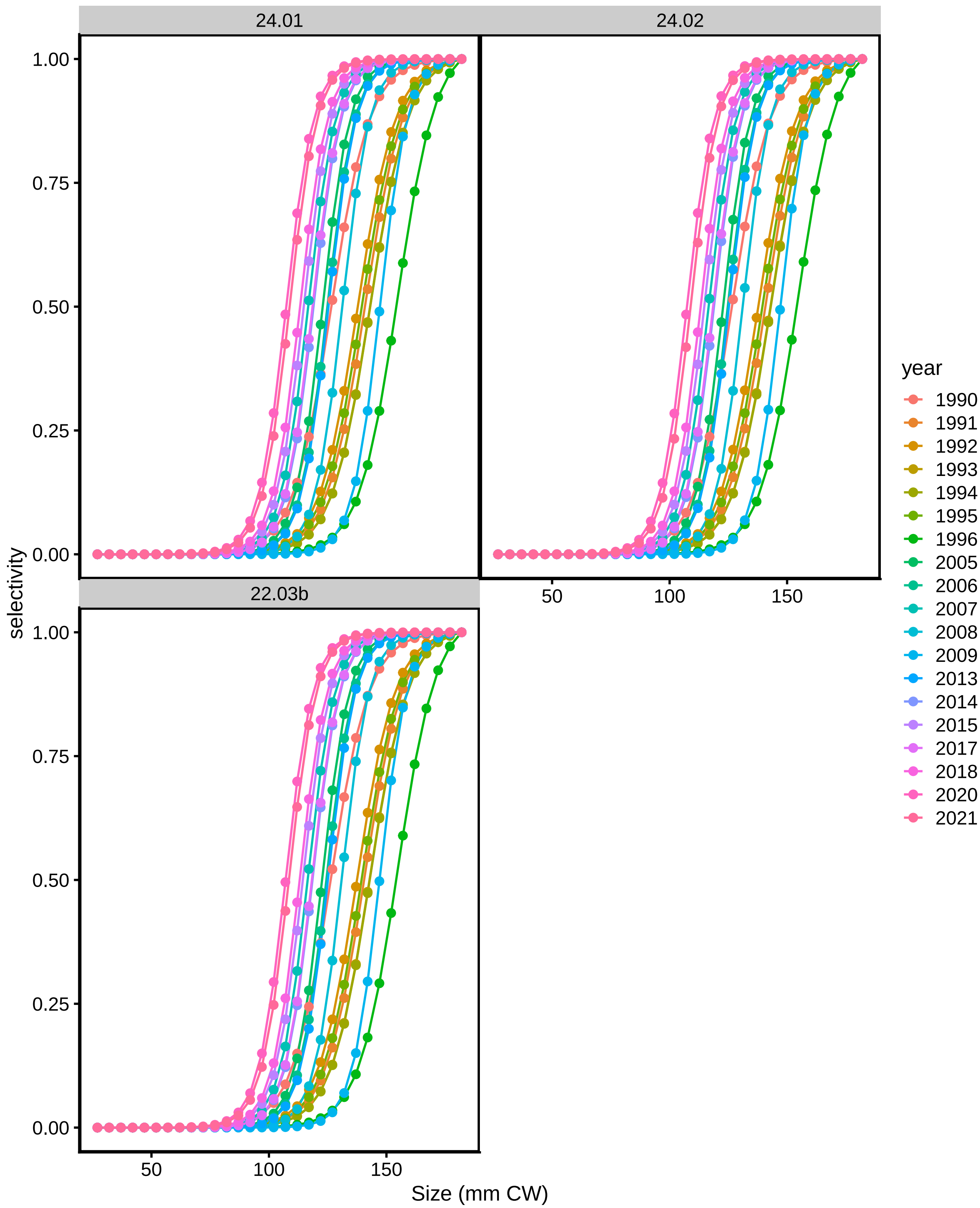

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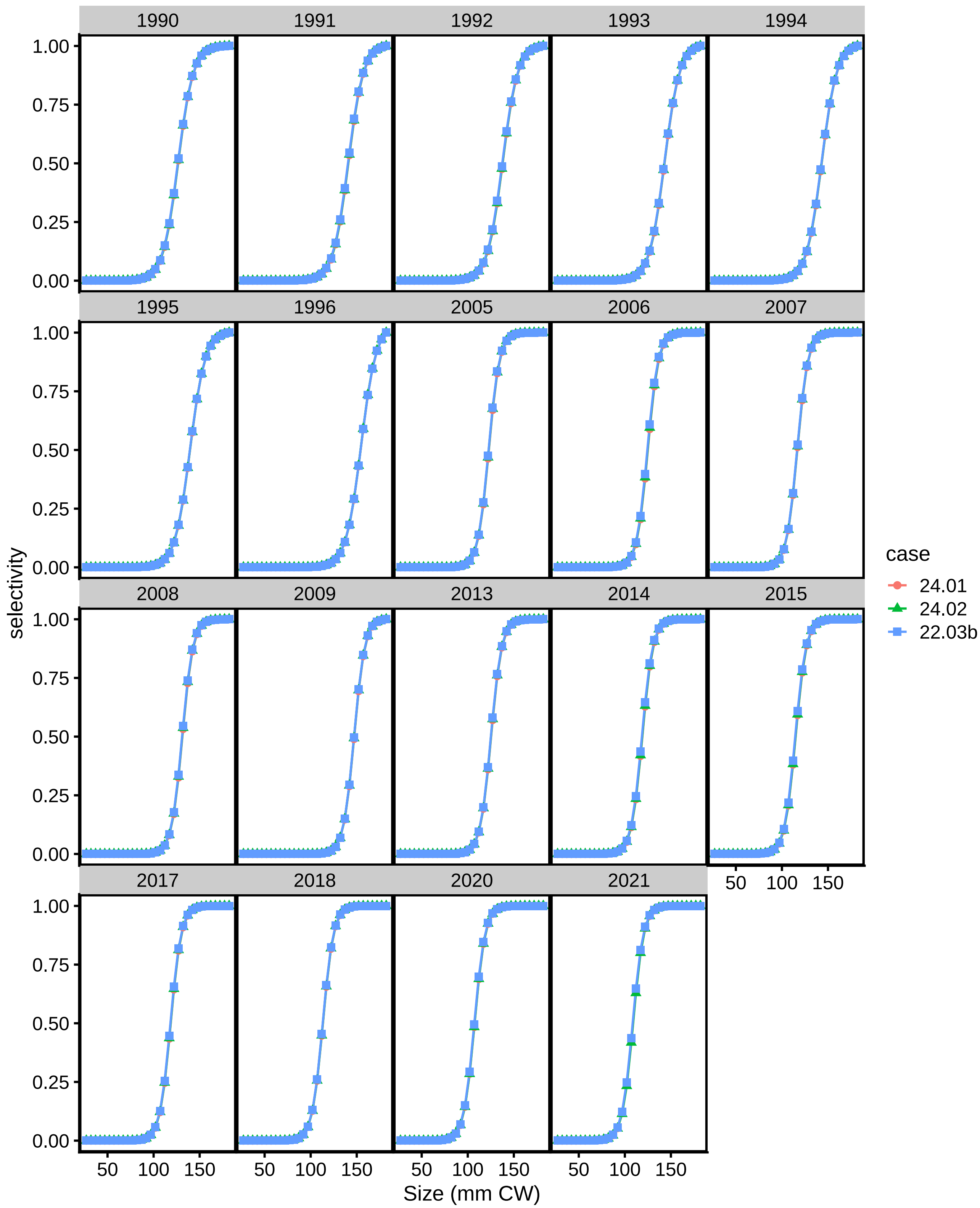

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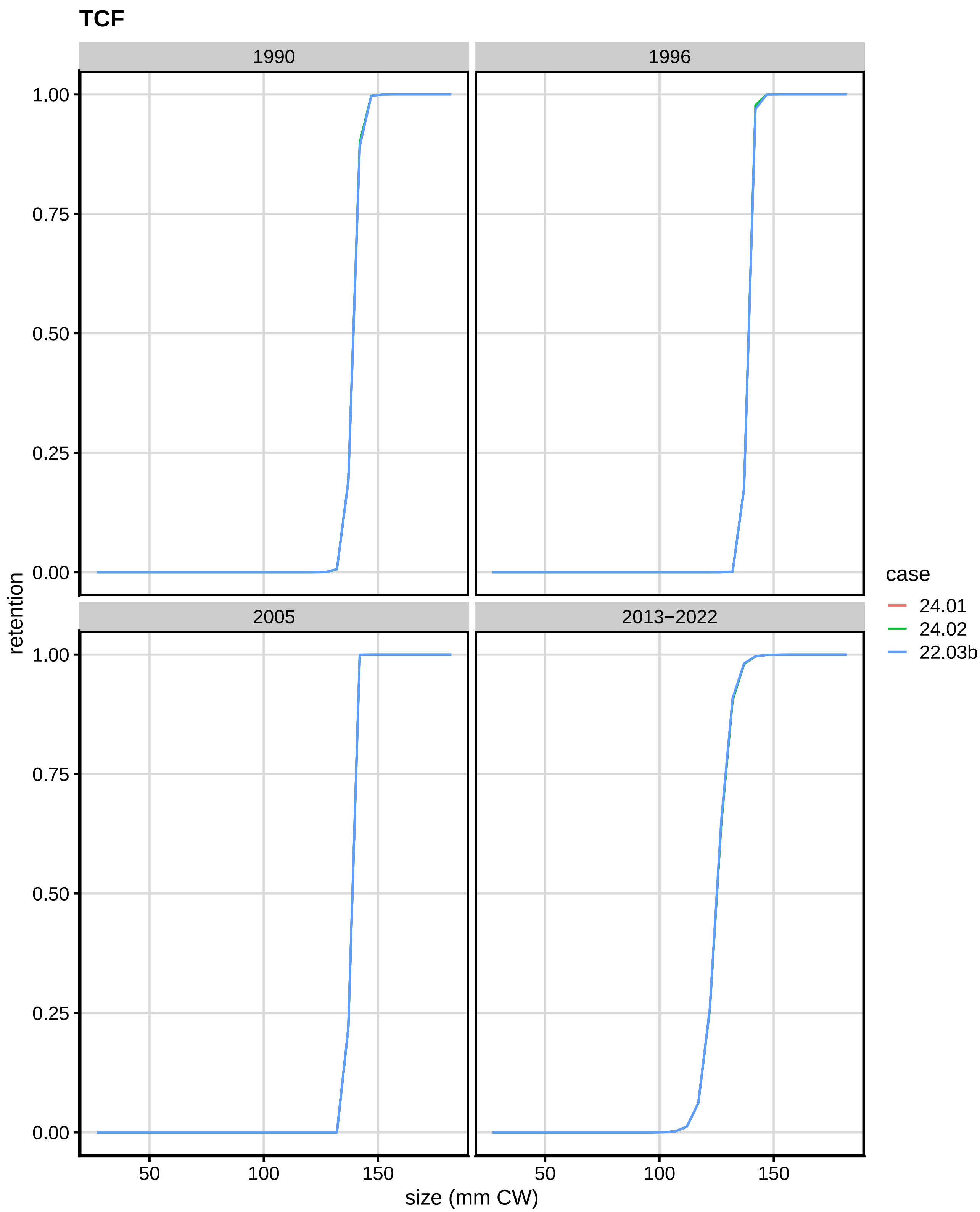

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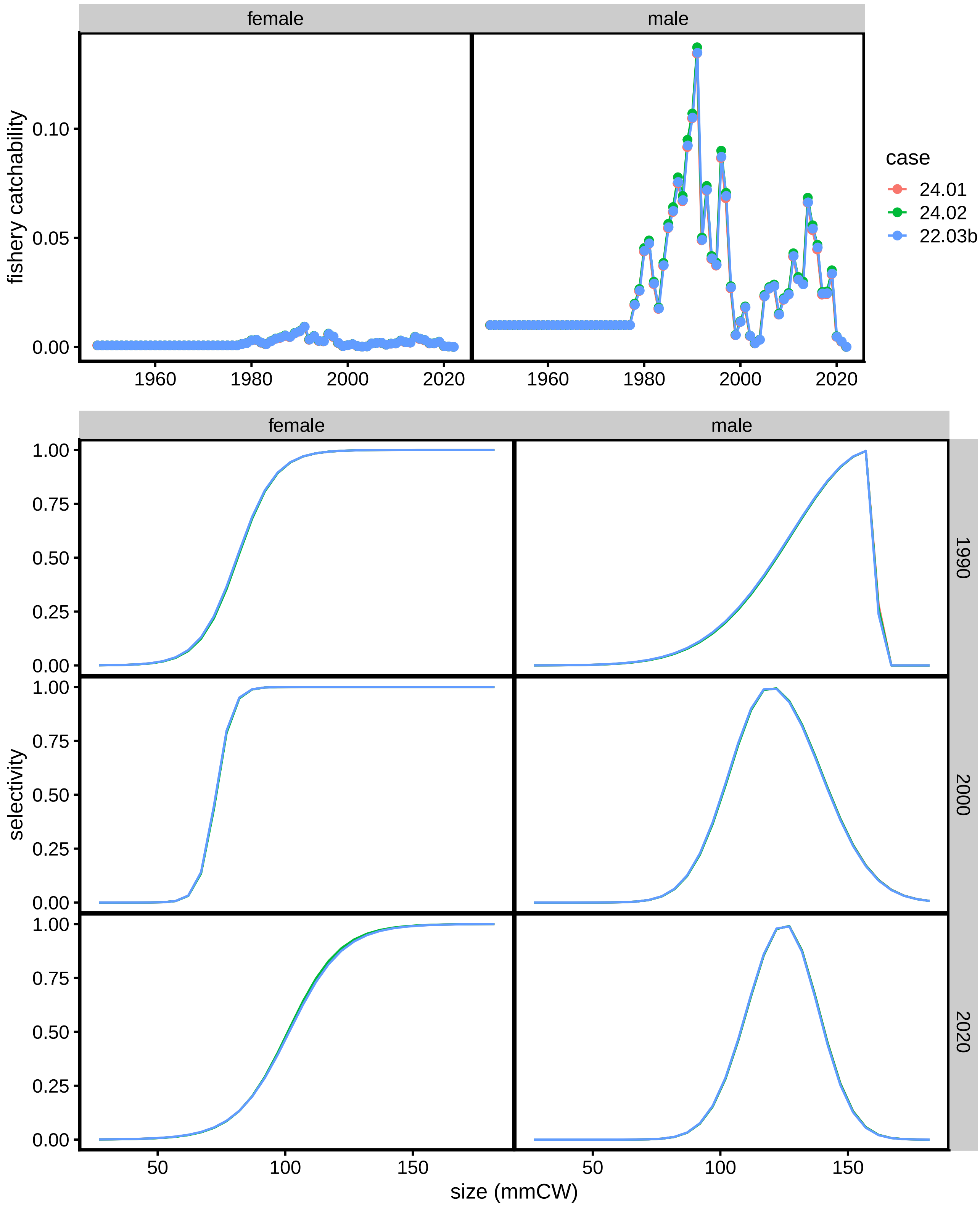

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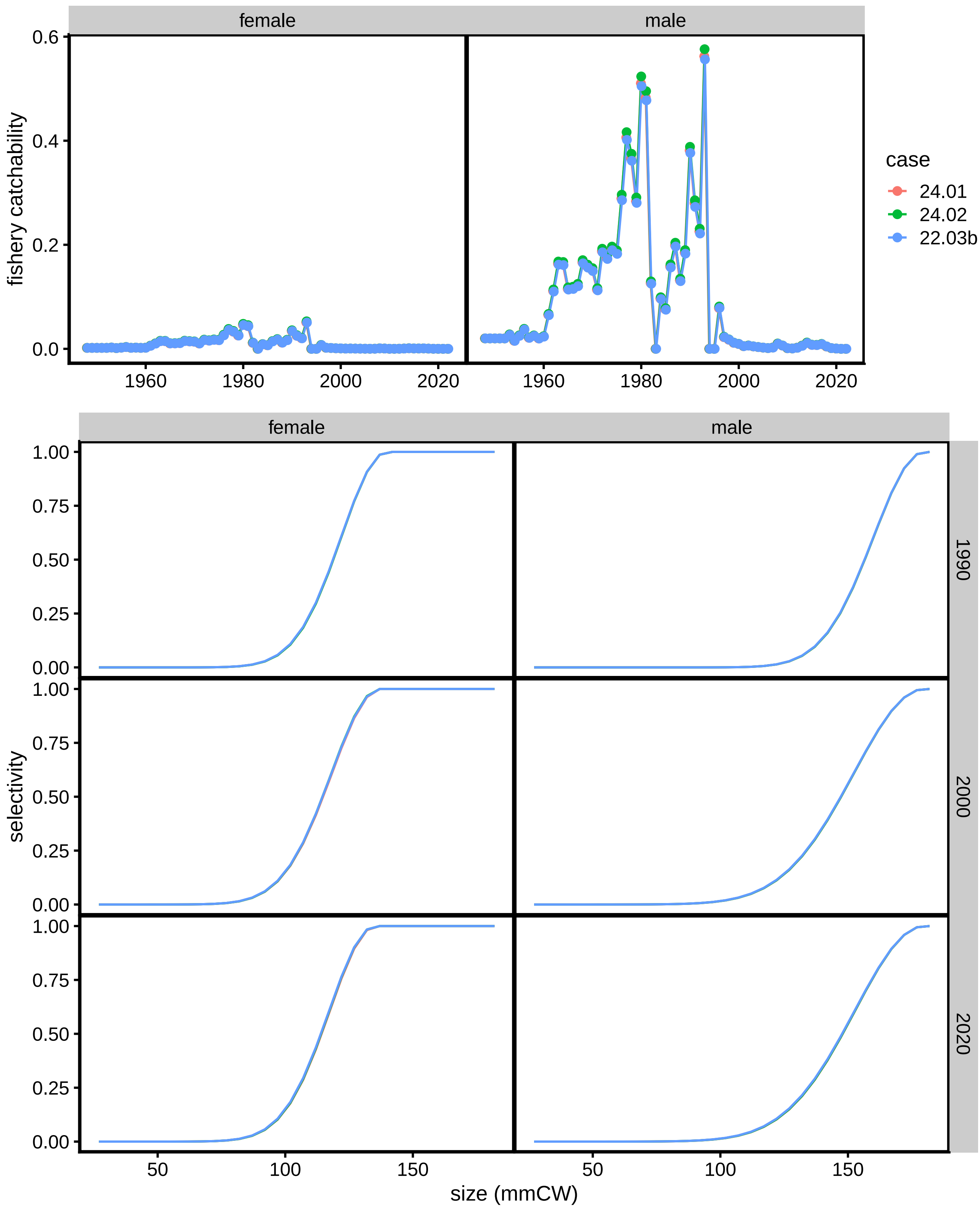

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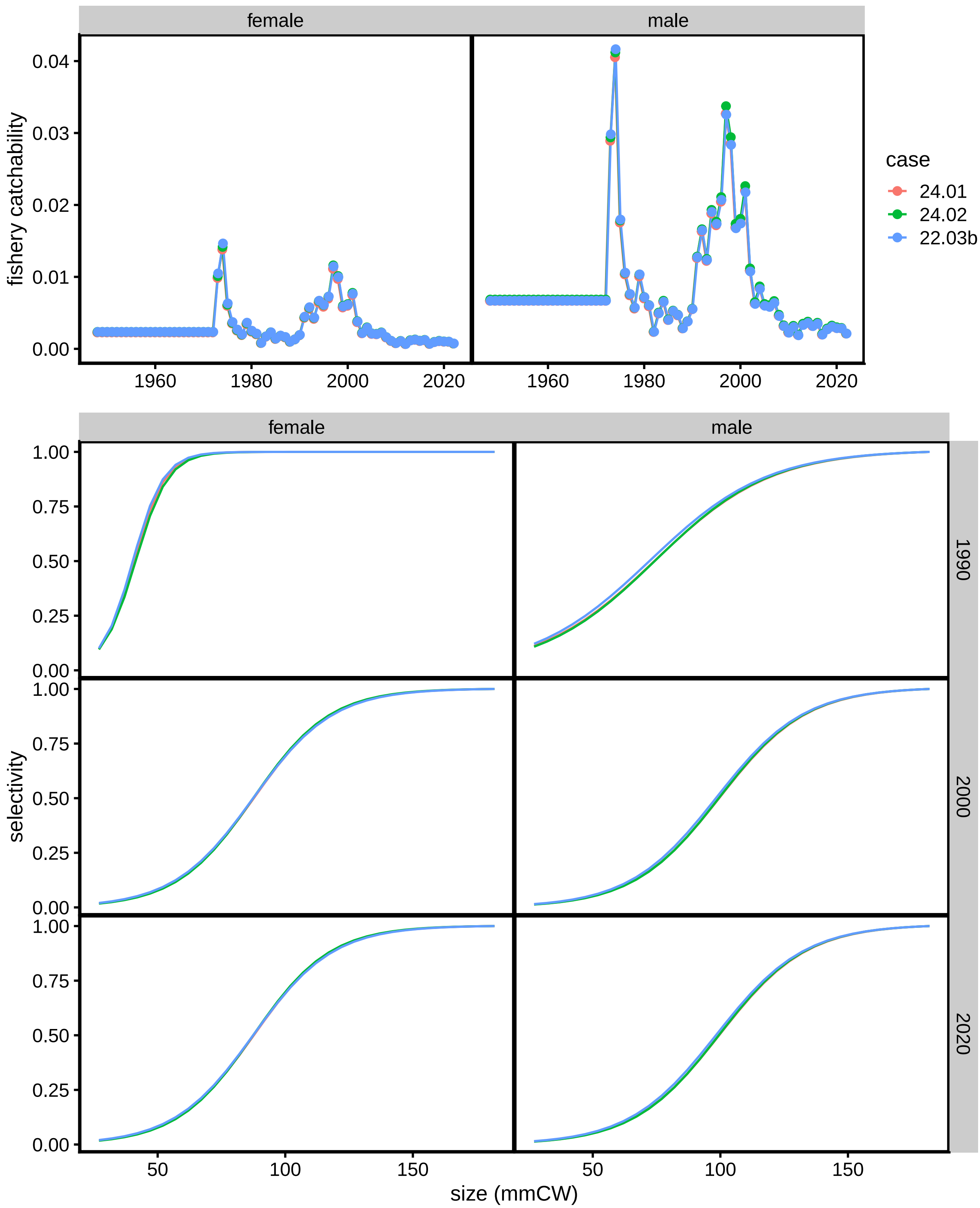

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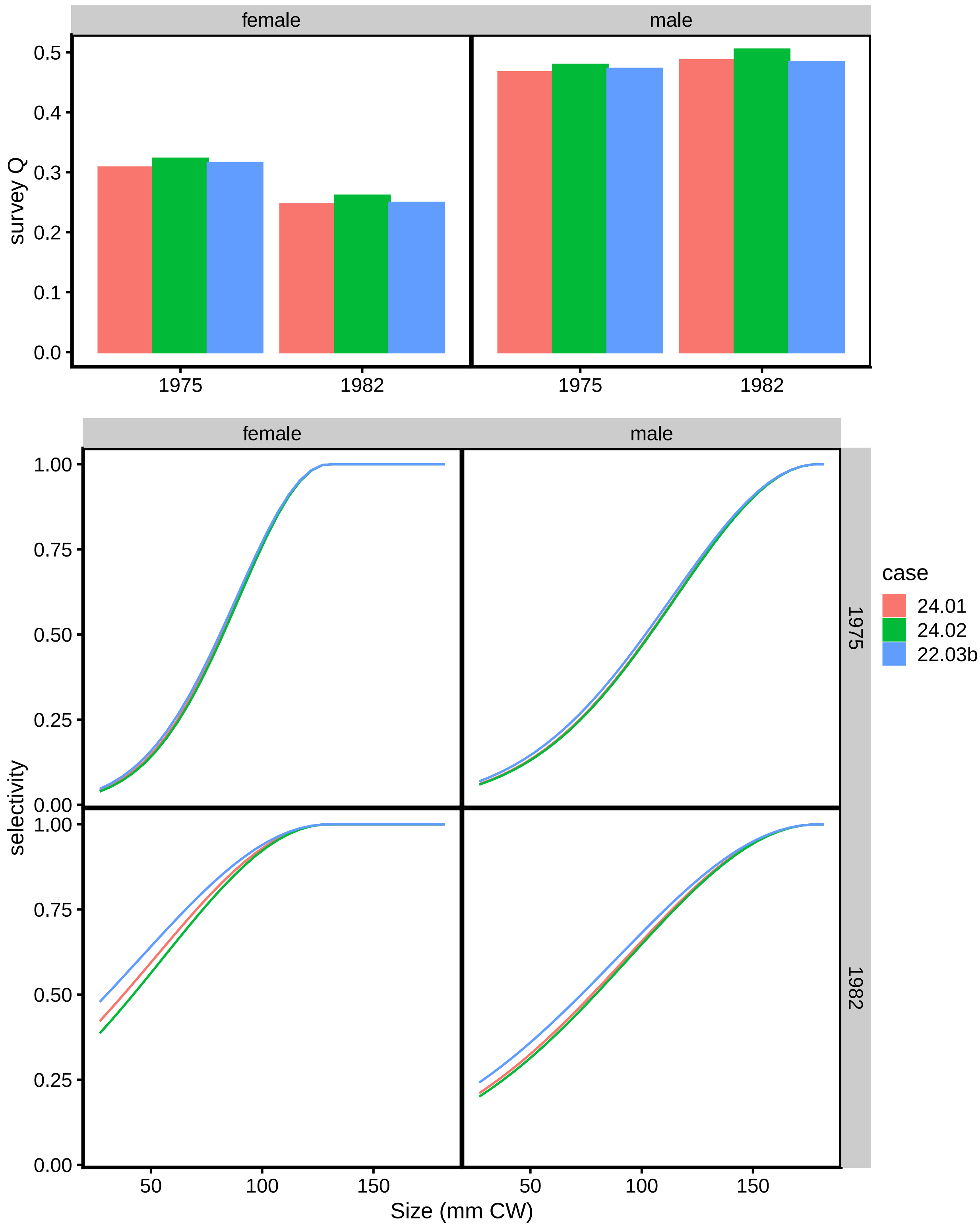

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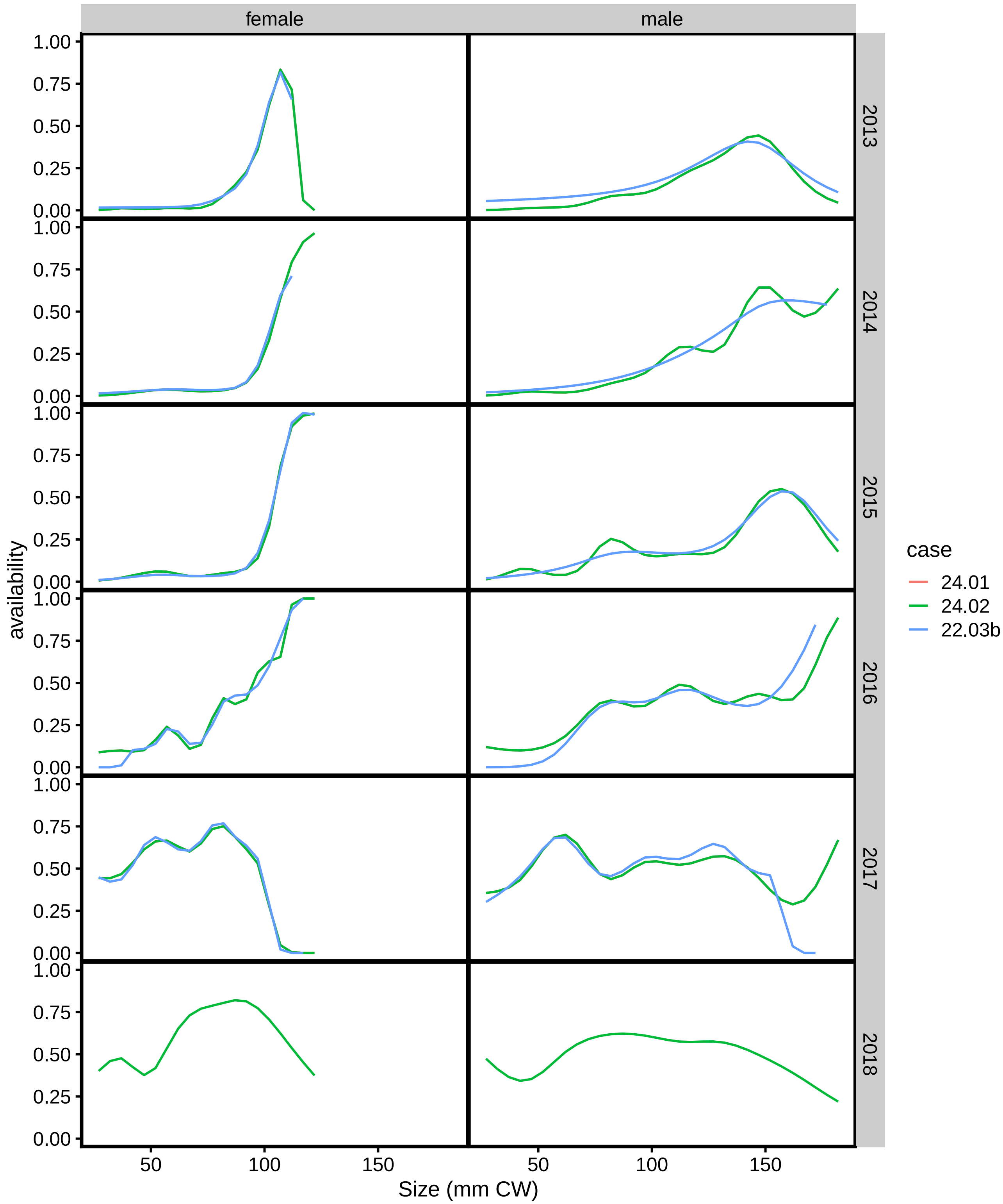

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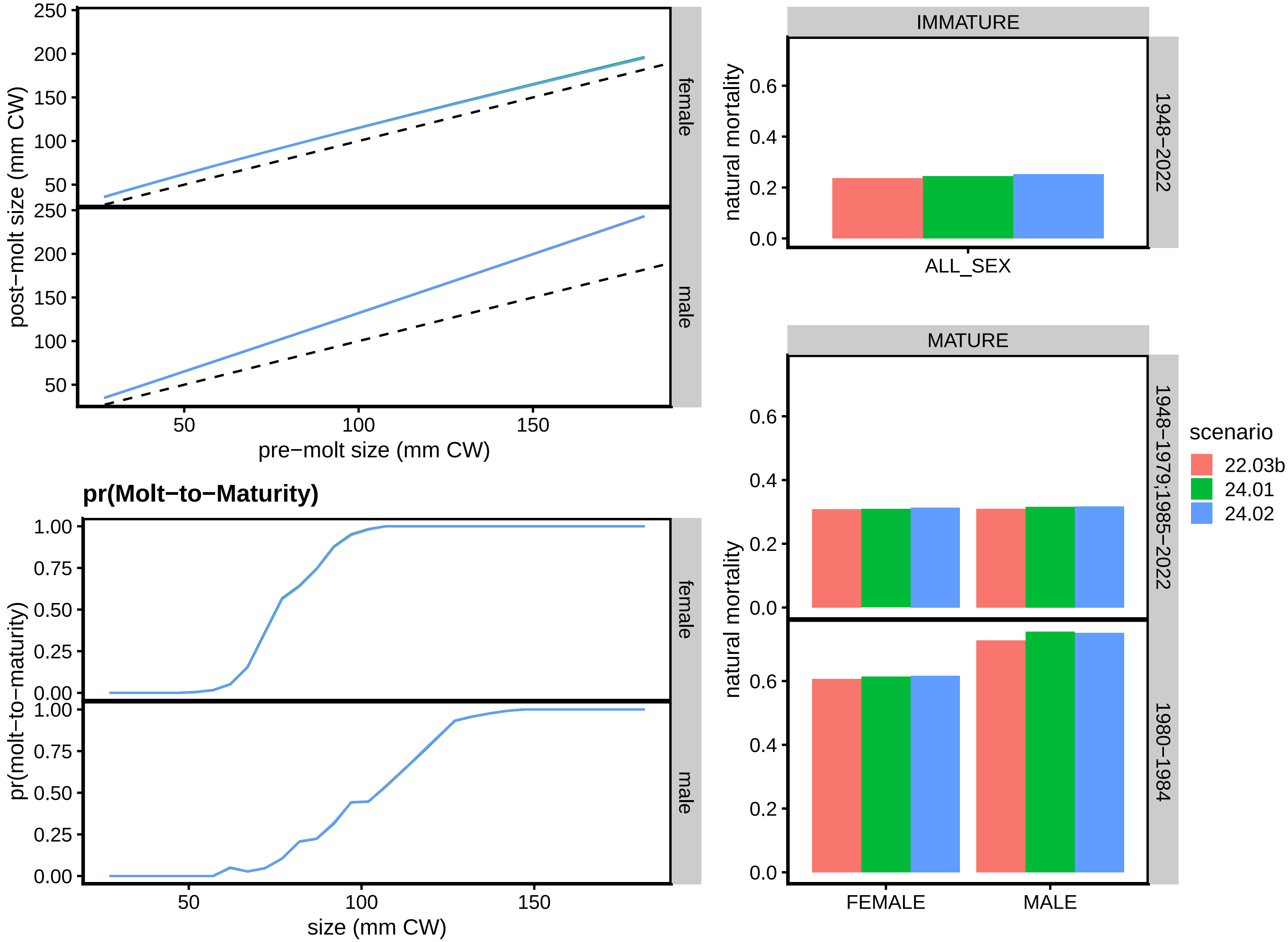

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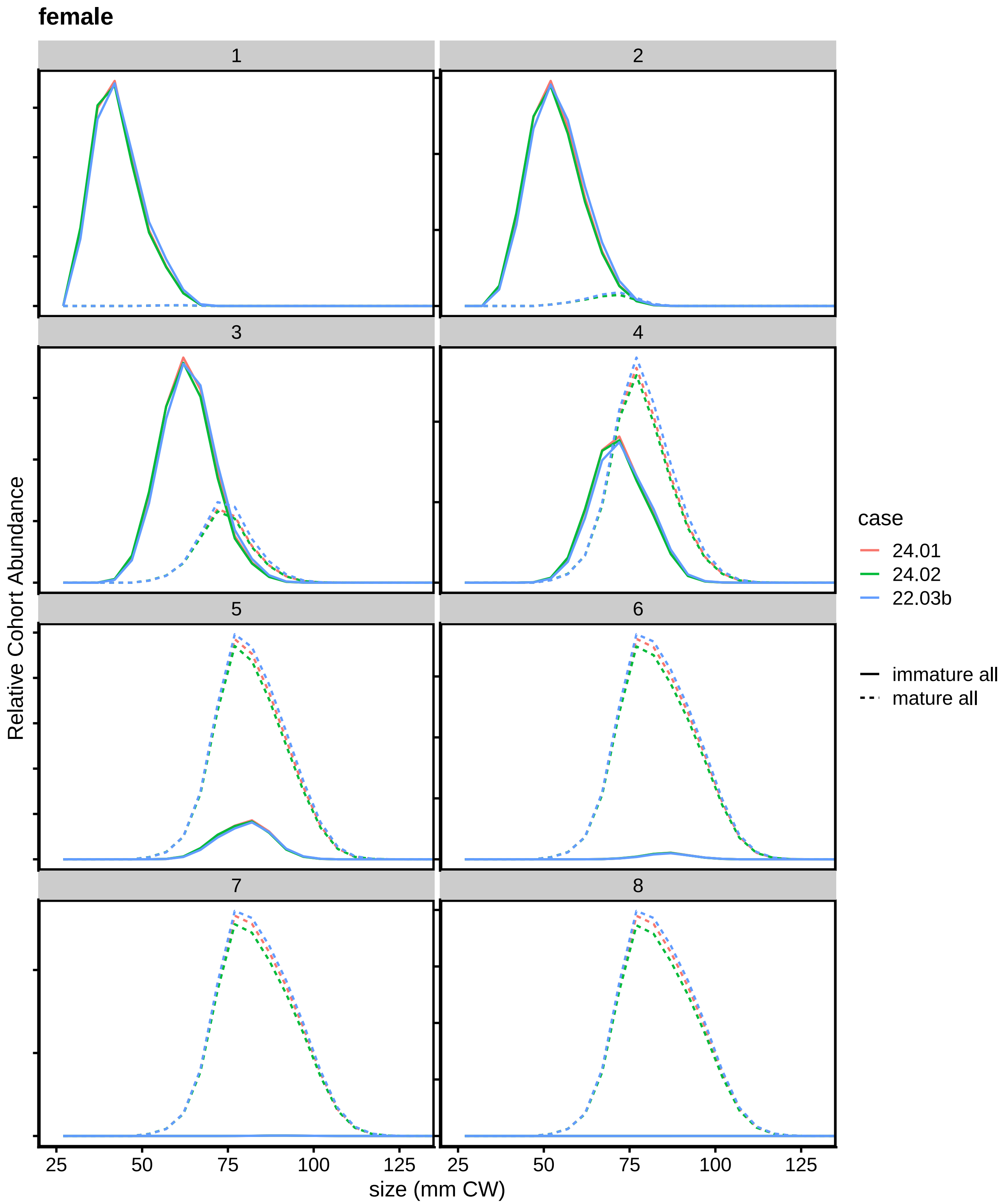

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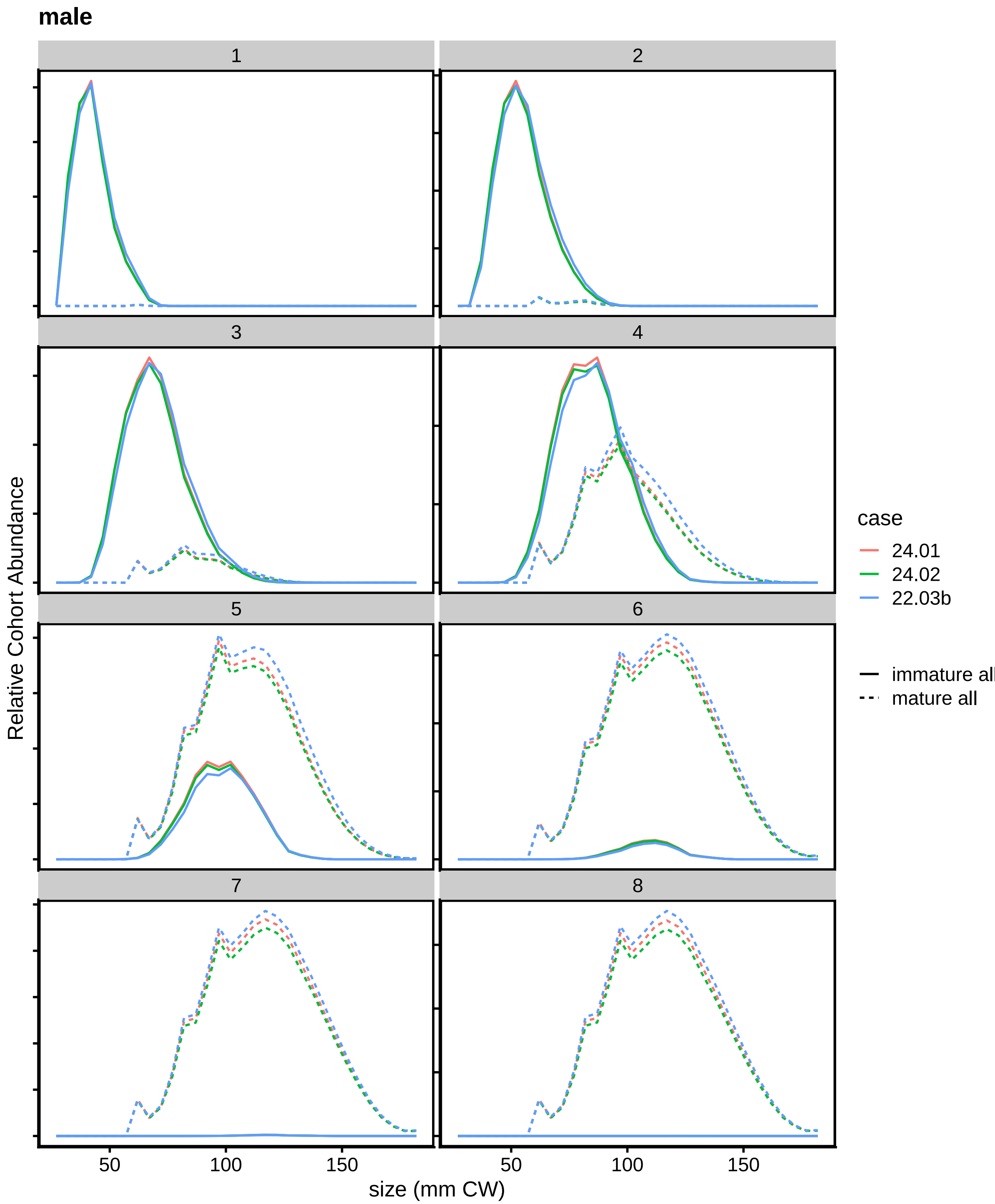

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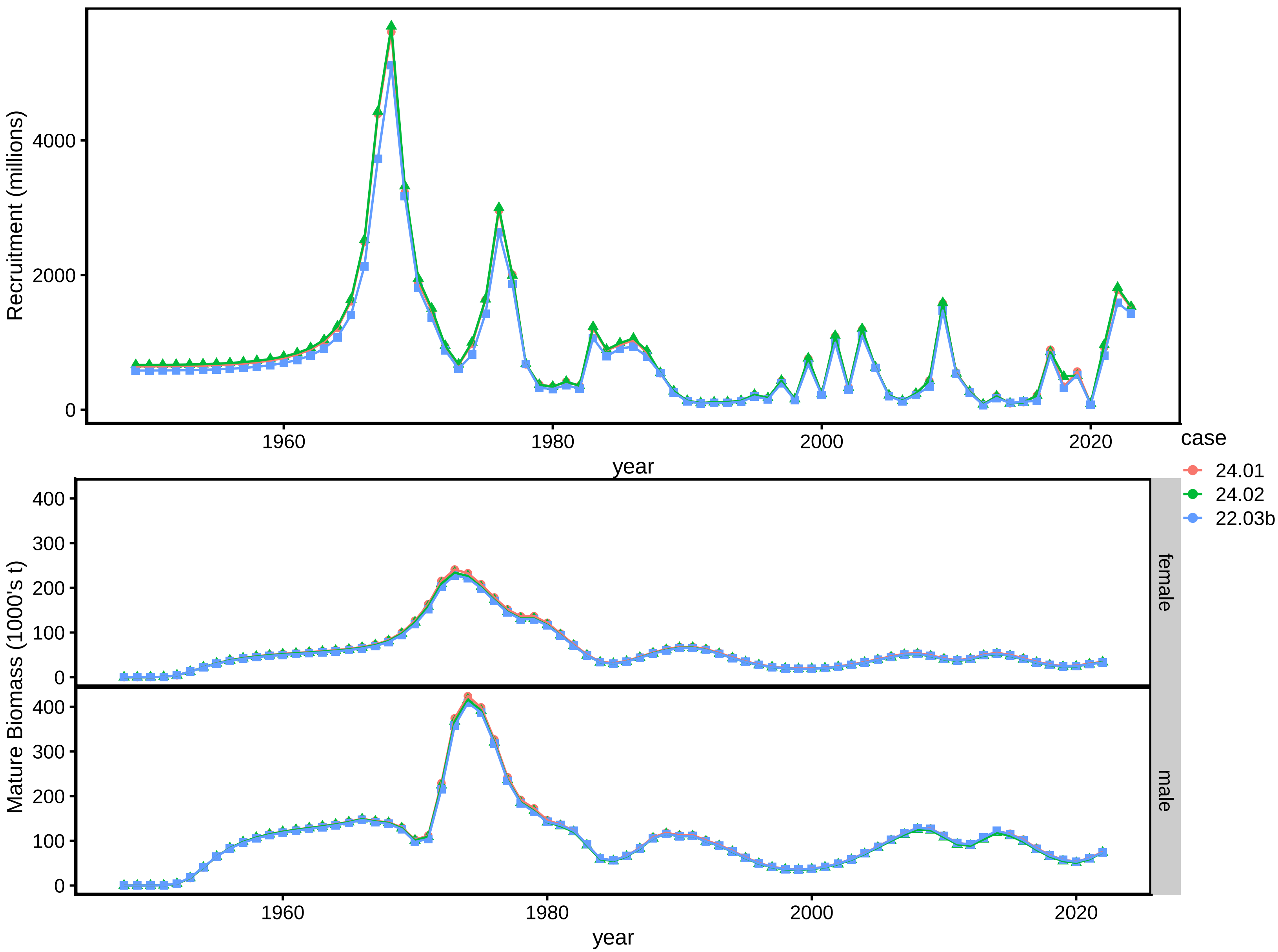

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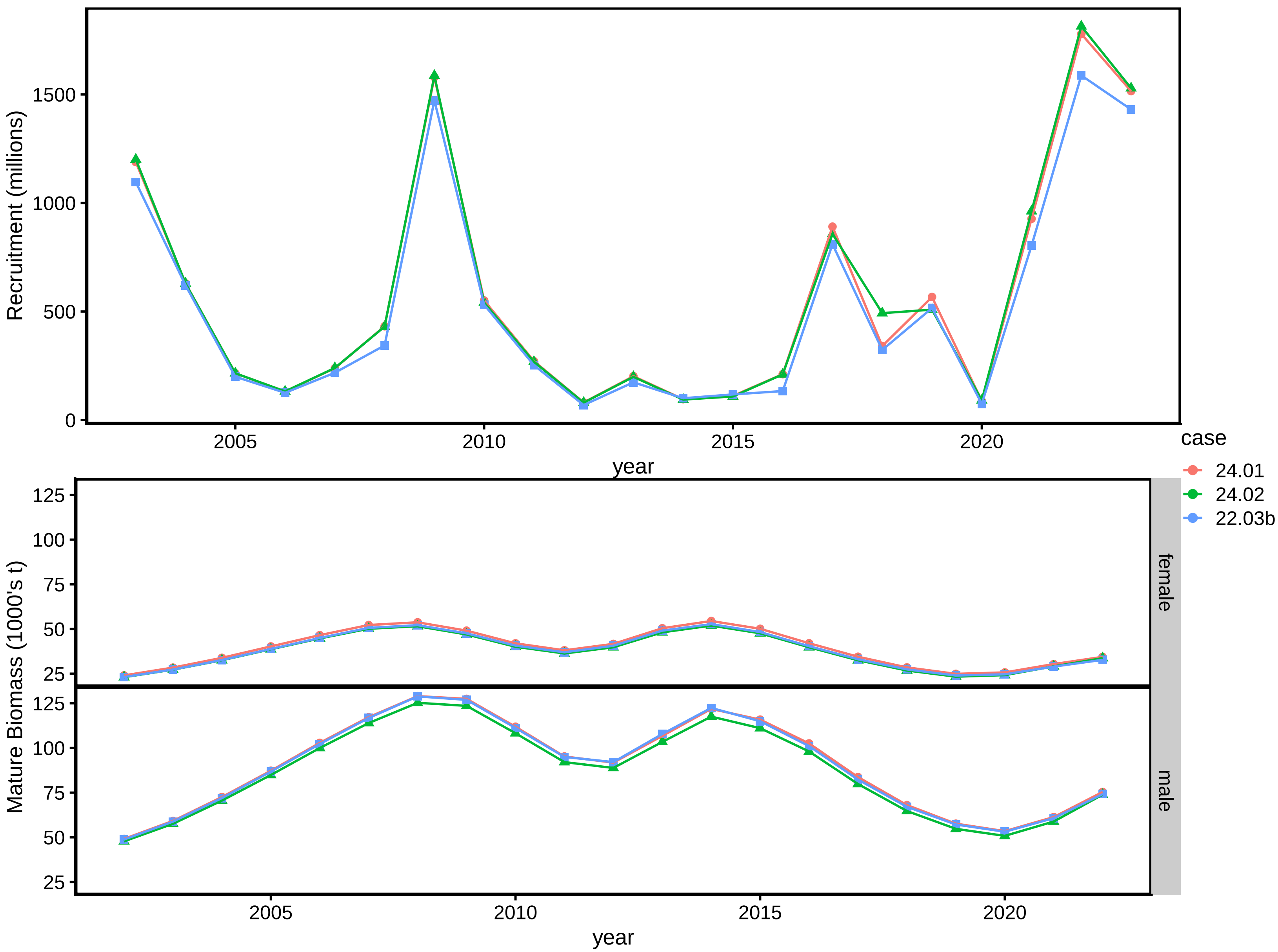

Figure 41. TCSAM02 models estimated recruitment and mature biomass time series (recent years). Upper plot: recruitment; lower plots: sex-specific mature biomass-at-mating.

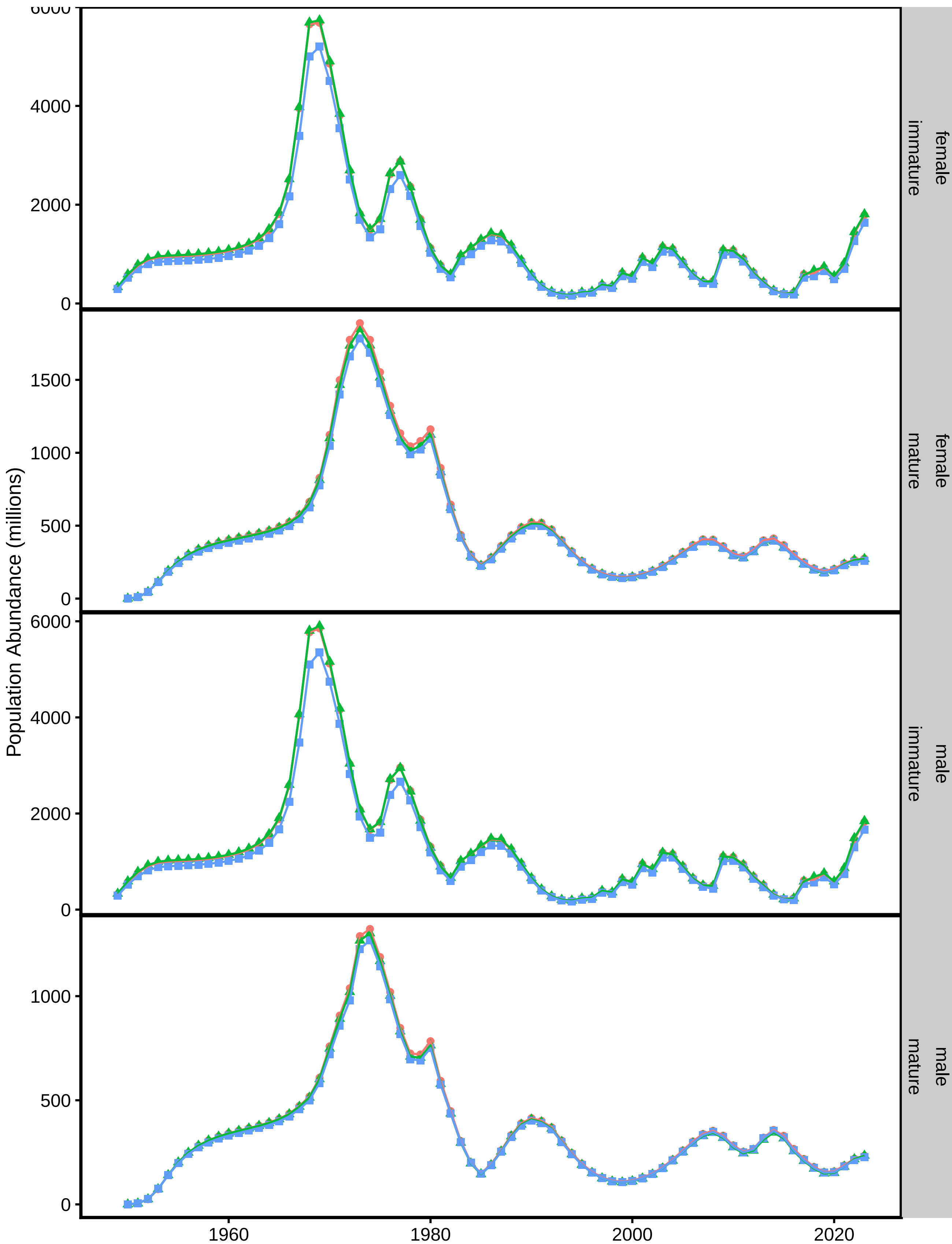

Figure 42. TCSAM02 models estimated population abundance trends, by sex and maturity state. Upper plots: all years; lower plots: recent years.

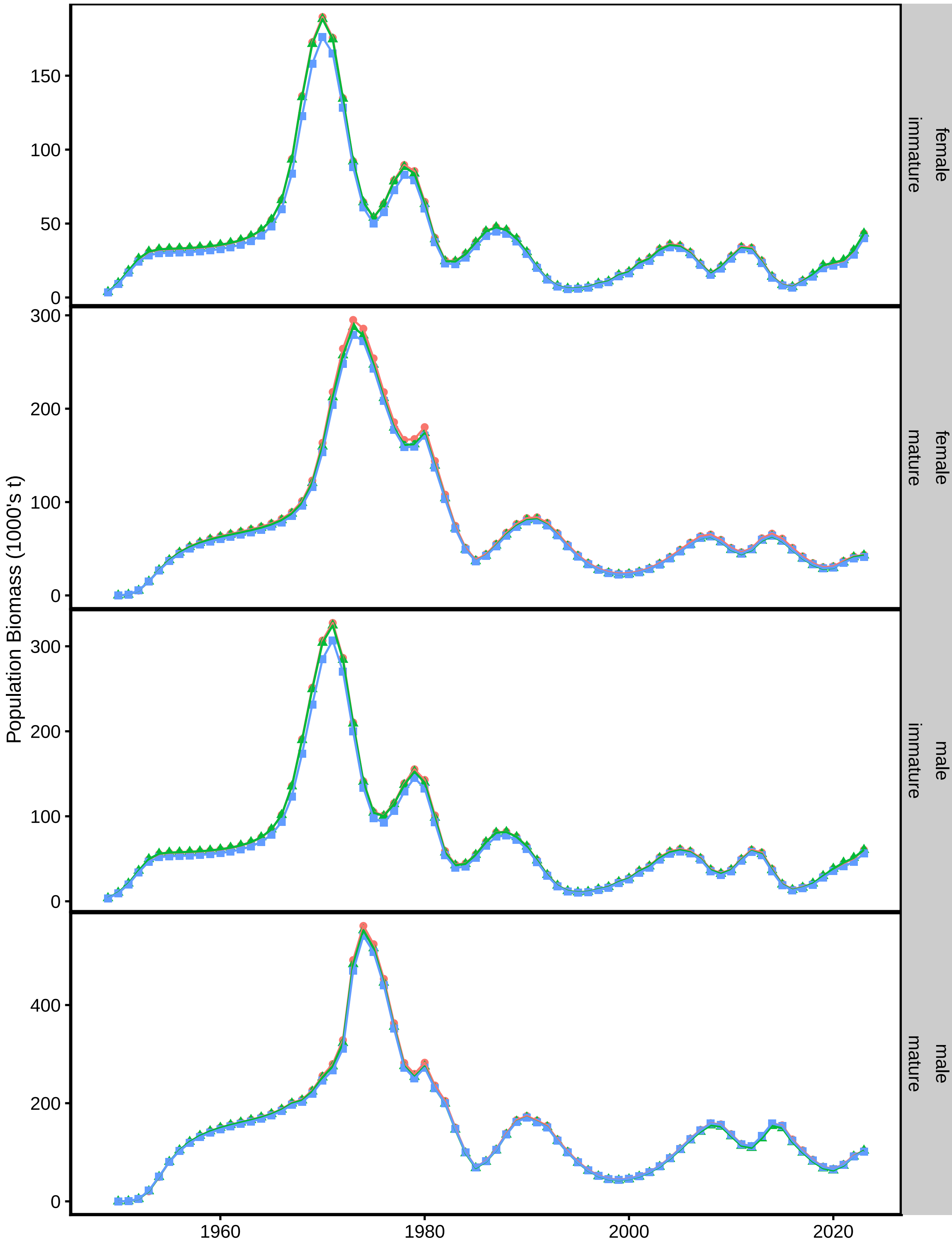

Figure 43. TCSAM02 models estimated population biomass trends, by sex and maturity state. Upper plots: all years; lower plots: recent years.

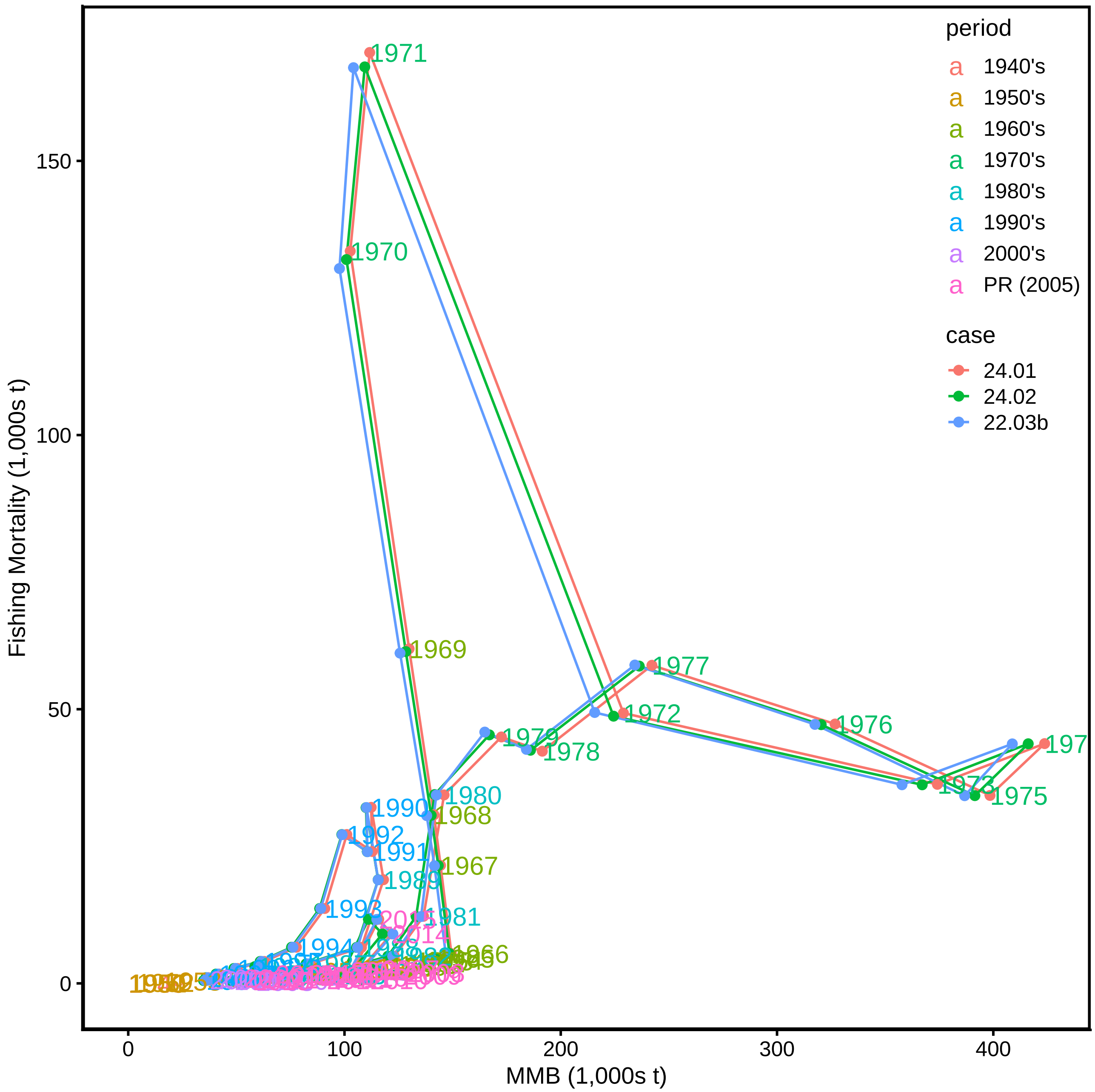

Figure 44. TCSAM02 models estimated total fishing mortality vs. MMB.

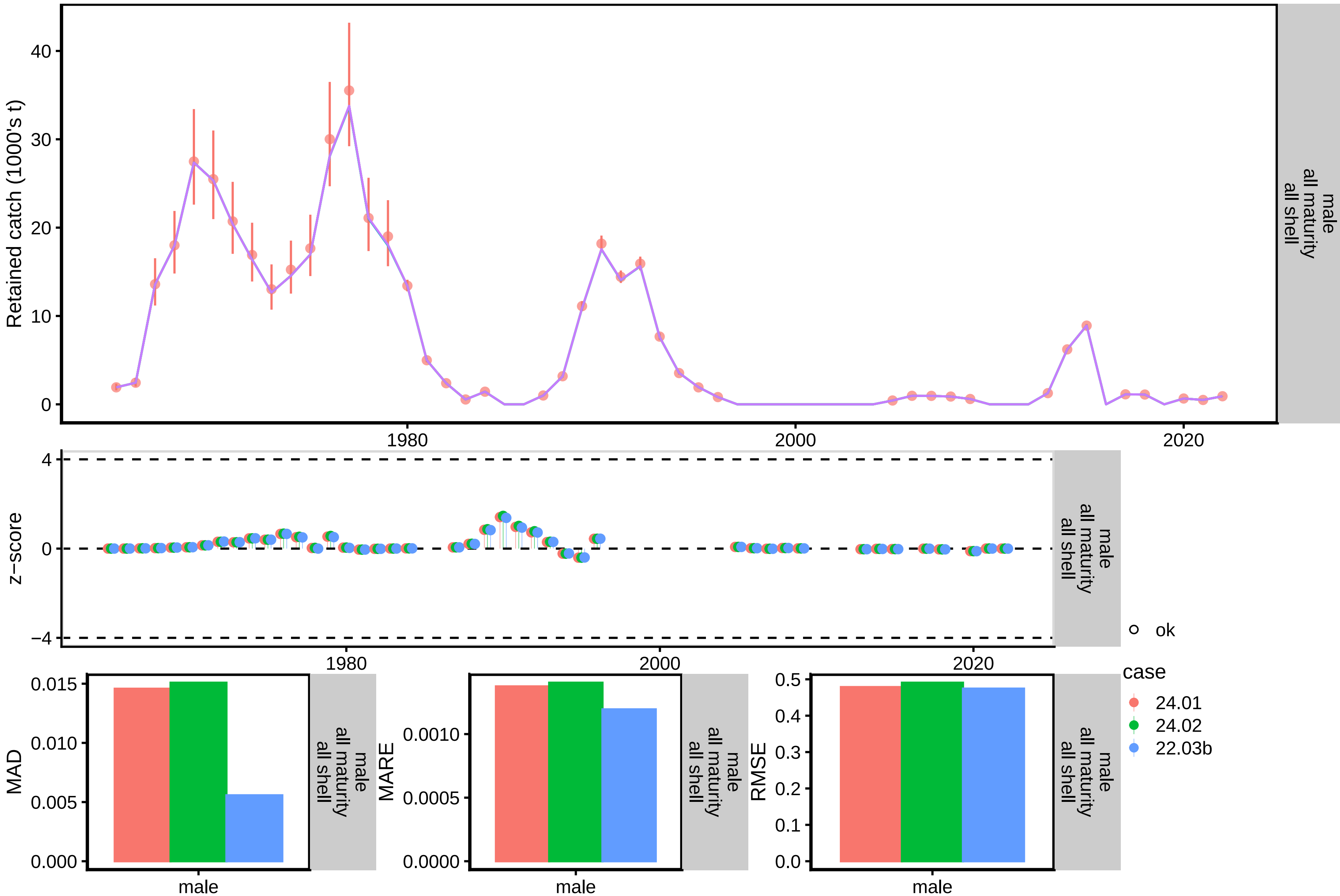

Figure 45. TCSAM02 models fits to retained catch biomass in the directed fishery (upper two rows) and residuals analysis plots (lower two rows). Confidence intervals are 95%.

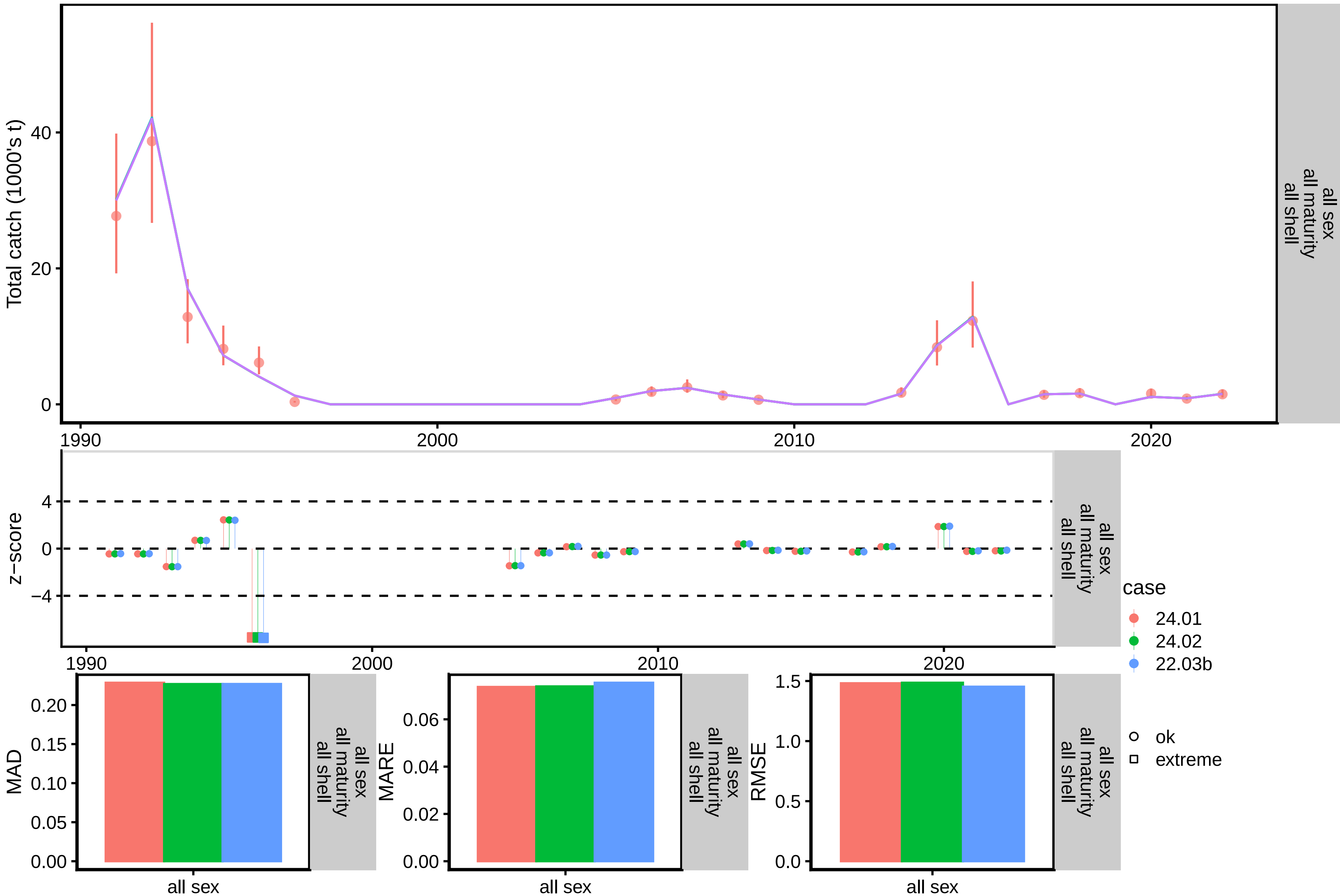

Figure 46. TCSAM02 models fits to total catch biomass of all crab in the TCF fishery (upper row) and residuals analysis plots (lower two rows). Confidence intervals are 95%.

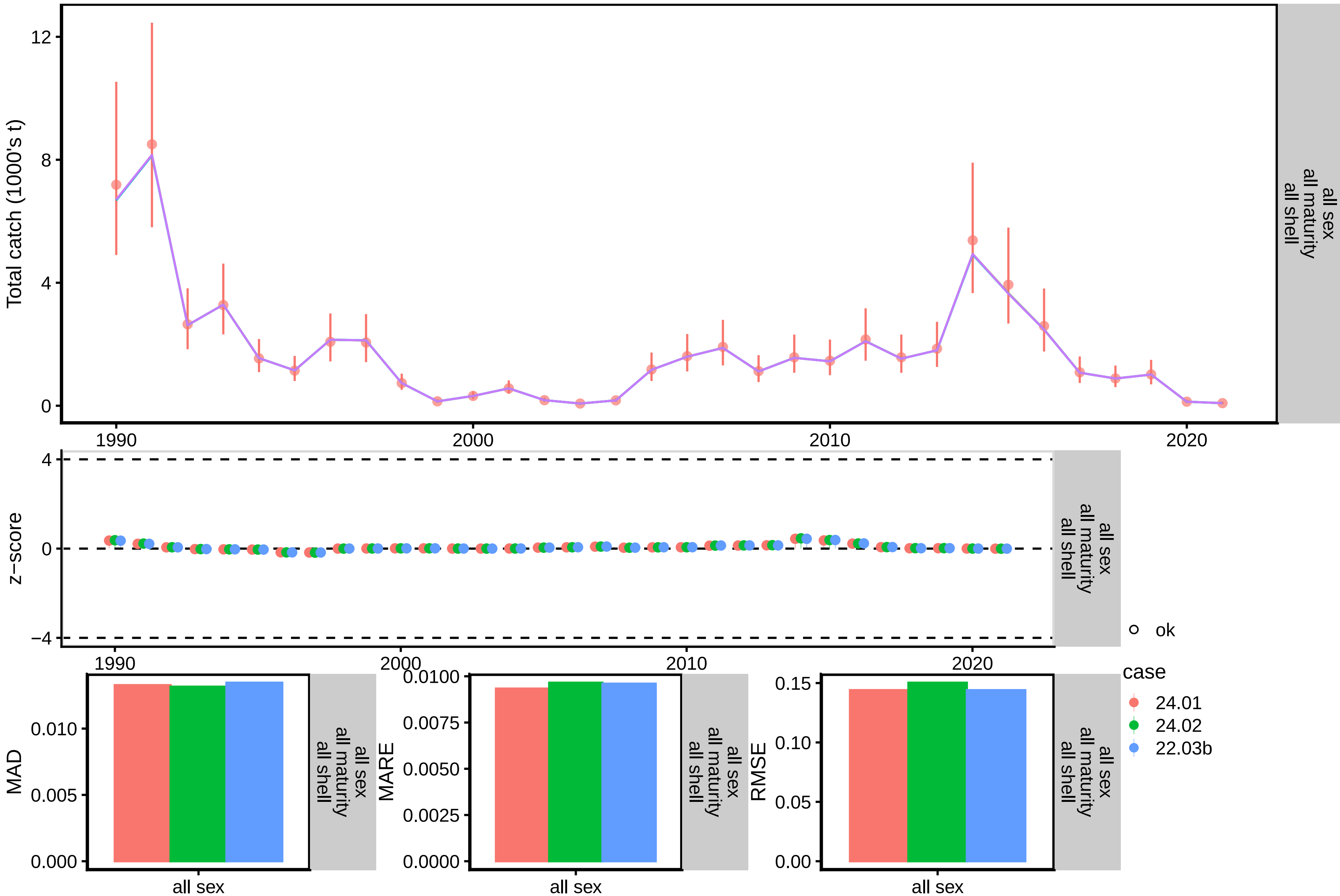

Figure 47. TCSAM02 models fits to total catch biomass of all crab in the SCF fishery (upper row) and residuals analysis plots (lower two rows). Confidence intervals are 95%.

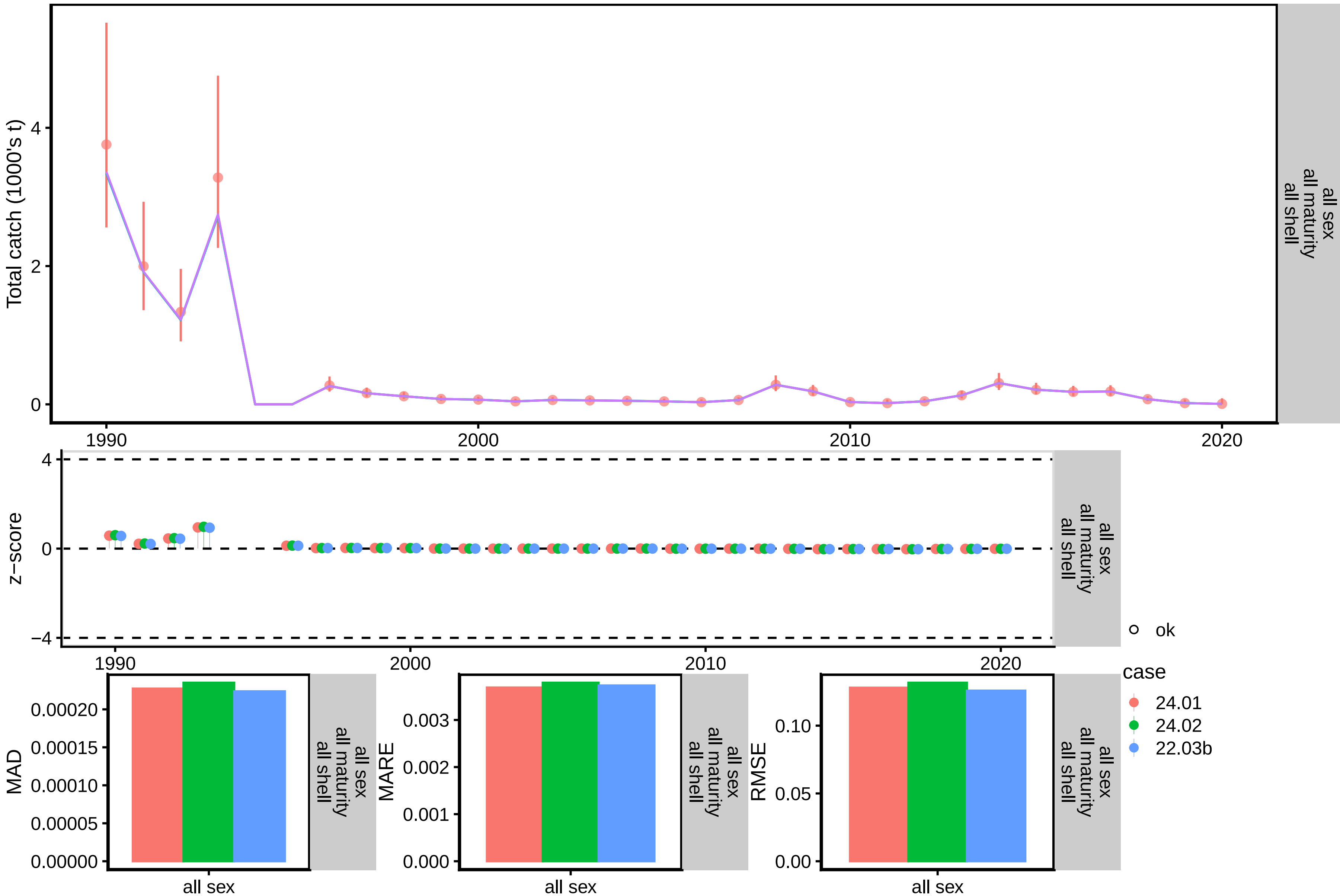

Figure 48. TCSAM02 models fits to total catch biomass of all crab in the RKF fishery (upper row) and residuals analysis plots (lower two rows). Confidence intervals are 95%.

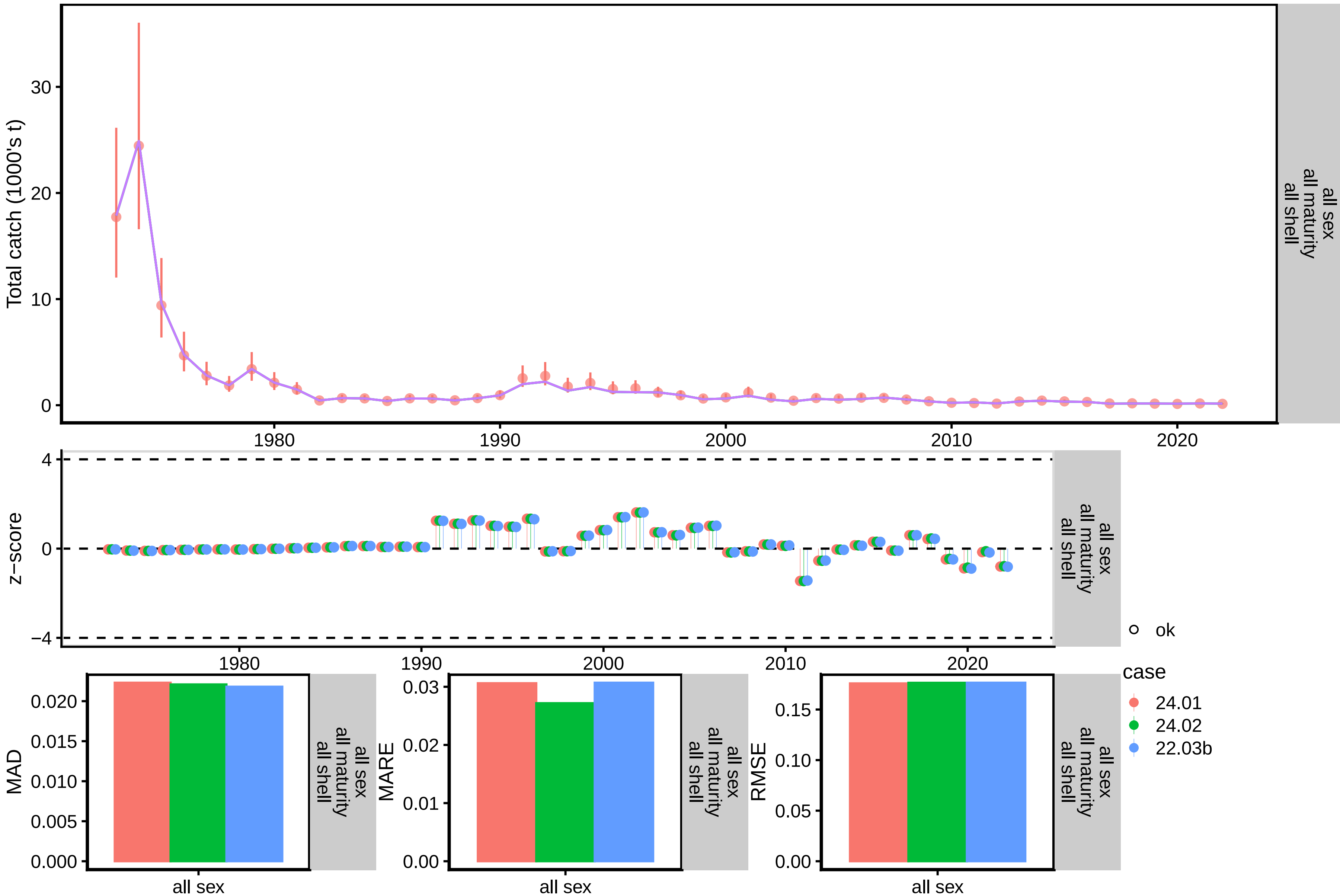

Figure 49. TCSAM02 models fits to total catch biomass of all crab in the GF All fishery (upper row) and residuals analysis plots (lower two rows). Confidence intervals are 95%.

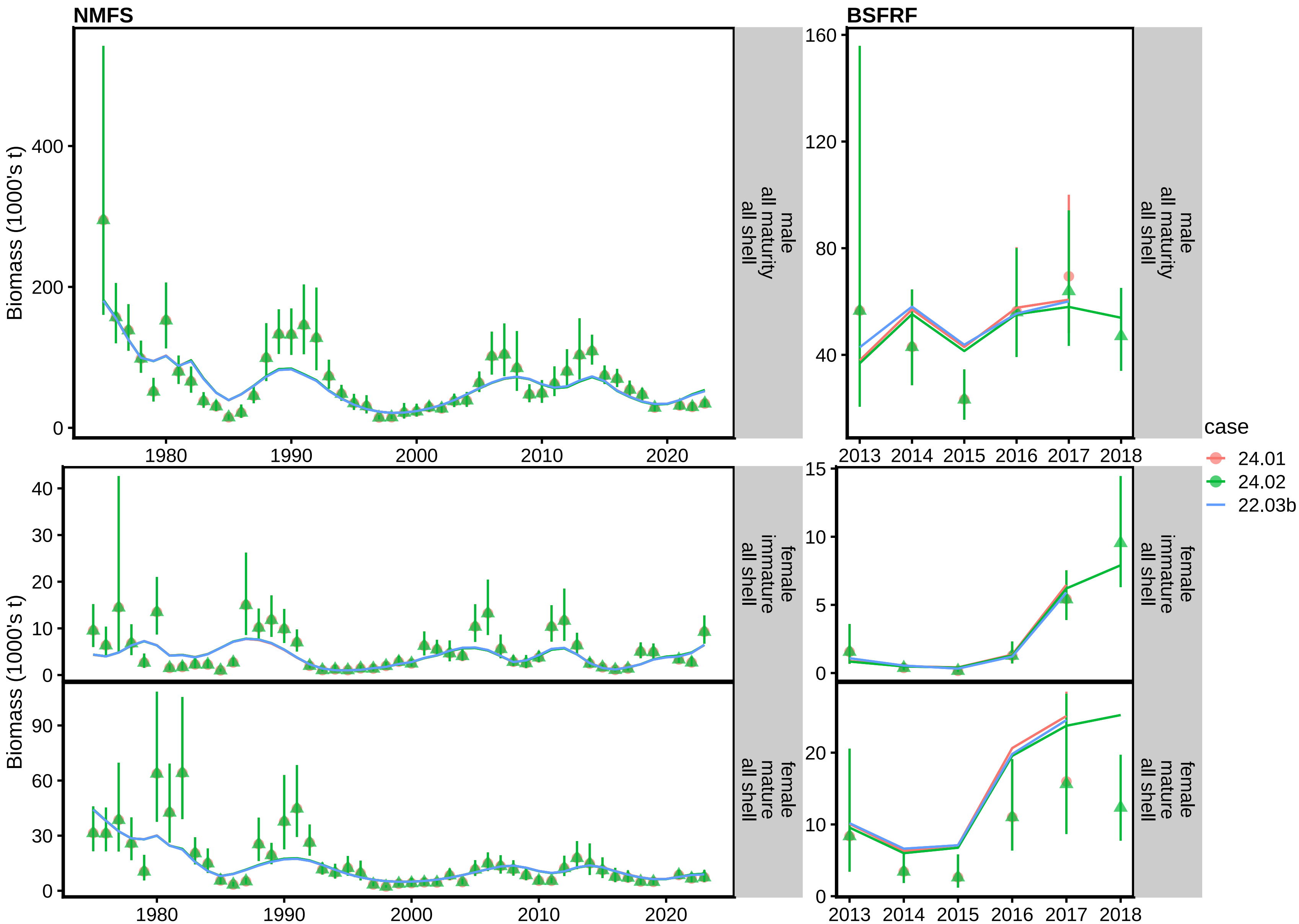

Figure 50. TCSAM02 models fits to time series of all male (upper graph), immature female (center graph), and mature female (lower plot) biomass from the NMFS EBS shelf bottom trawl survey (left column) and the BSFRF SBS trawl survey (right column). Confidence intervals are 95%.

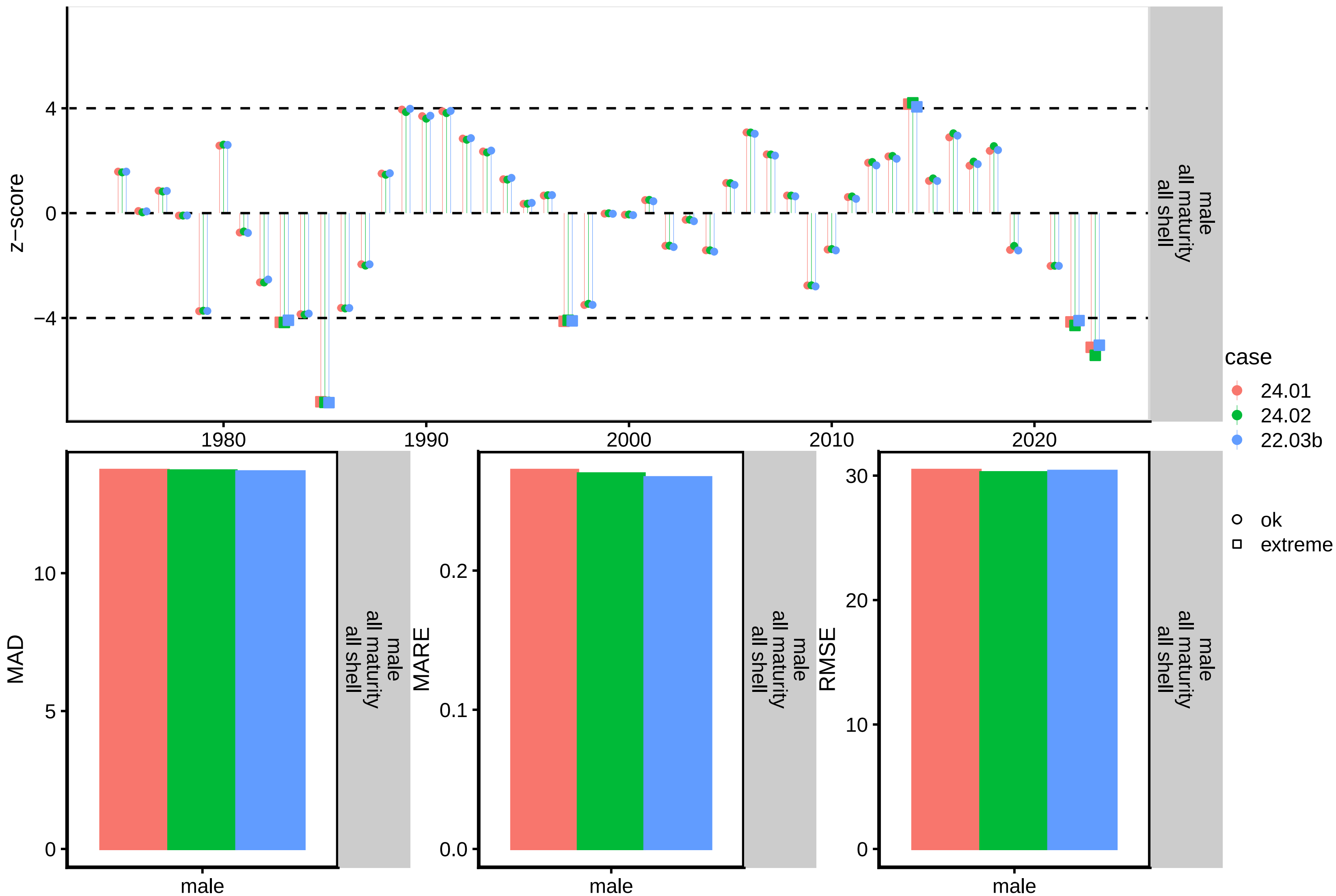

Figure 51. TCSAM02 models residuals analysis by model scenario for fits to male biomass in the NMFS EBS bottom trawl survey. Upper row: annual z-scores; bottom row: 1) MAD: median absolute deviations, 2) MARE: median absolute relative error; 3) RMSE: root mean square error.

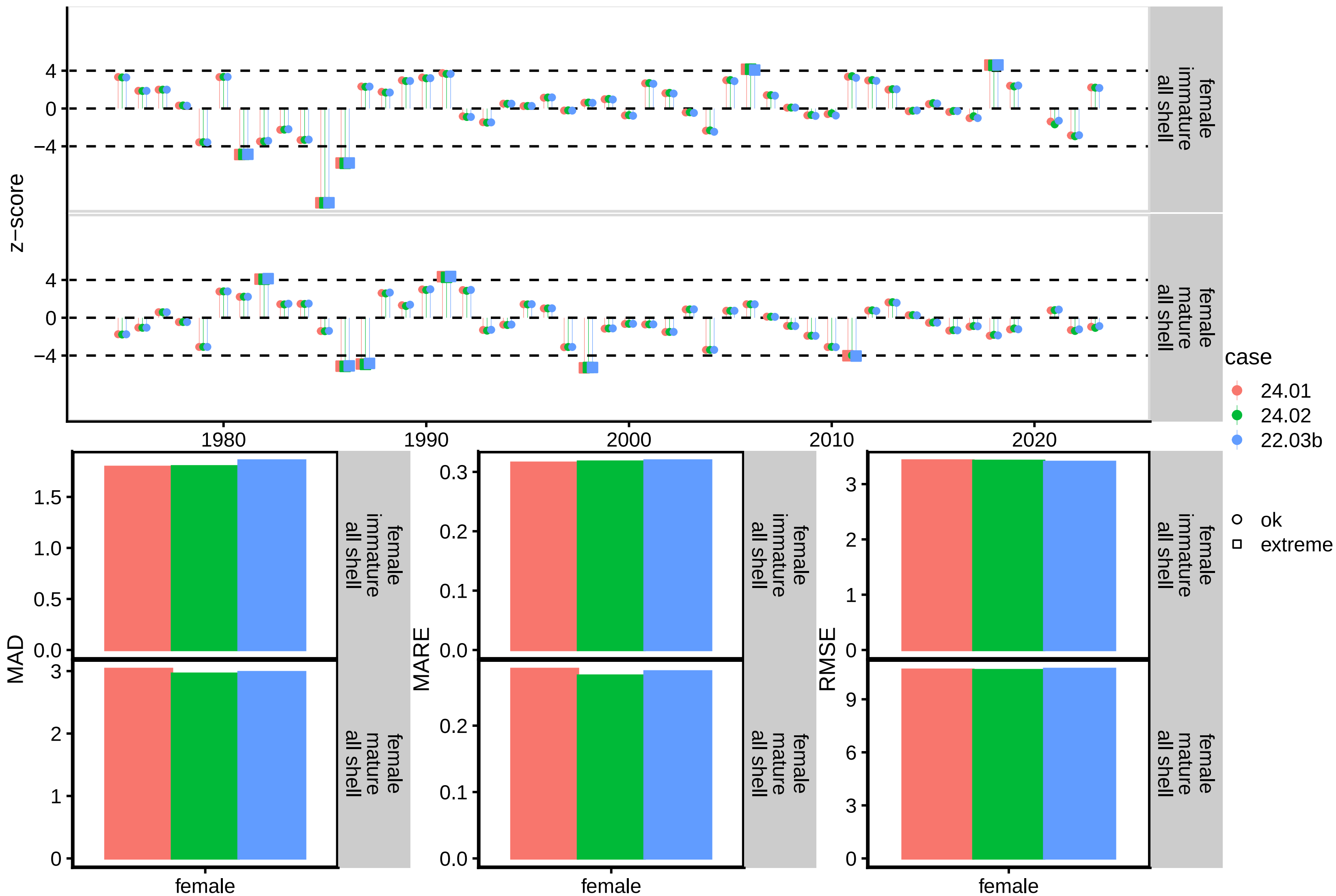

Figure 52. TCSAM02 models residuals analysis by model scenario for fits to female biomass in the NMFS EBS bottom trawl survey. Upper row: annual z-scores; bottom row: 1) MAD: median absolute deviations, 2) MARE: median absolute relative error; 3) RMSE: root mean square error.

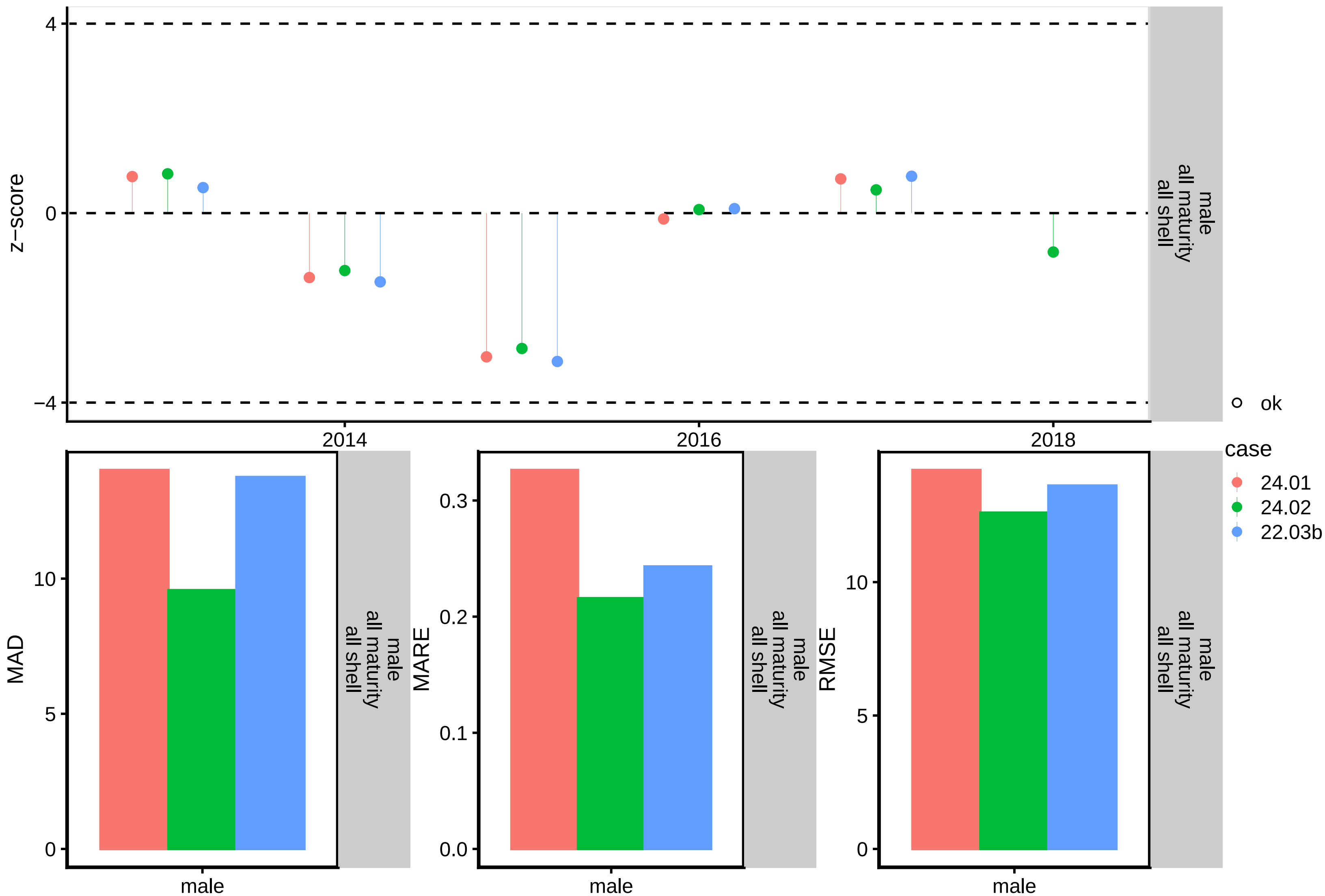

Figure 53. TCSAM02 models residuals analysis by model scenario for fits to male biomass in the BSFRF SBS bottom trawl survey. Upper row: annual z-scores; bottom row: 1) MAD: median absolute deviations, 2) MARE: median absolute relative error; 3) RMSE: root mean square error.

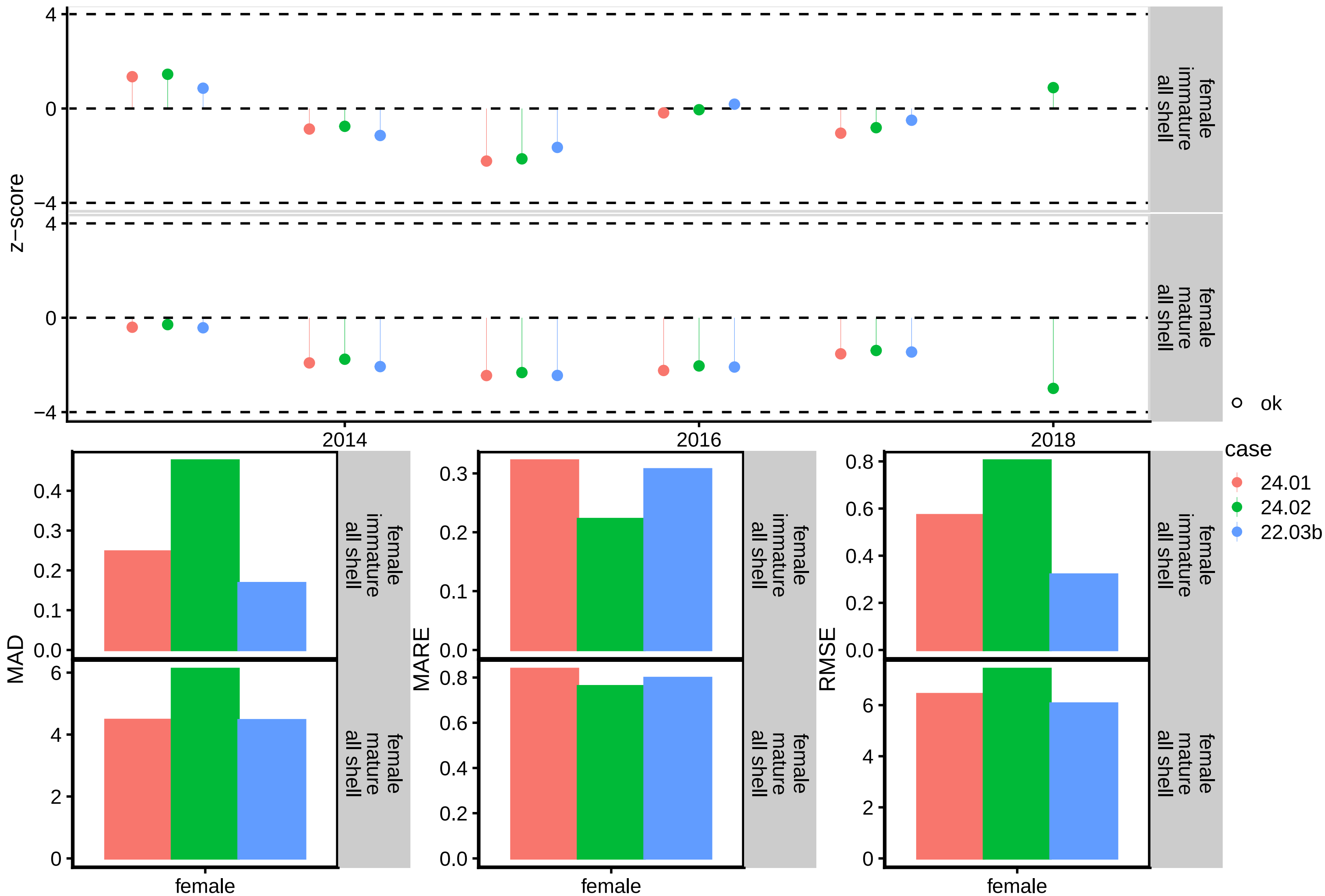

Figure 54. TCSAM02 models residuals analysis by model scenario for fits to female biomass in the BSFRF SBS bottom trawl survey. Upper row: annual z-scores; bottom row: 1) MAD: median absolute deviations, 2) MARE: median absolute relative error; 3) RMSE: root mean square error.

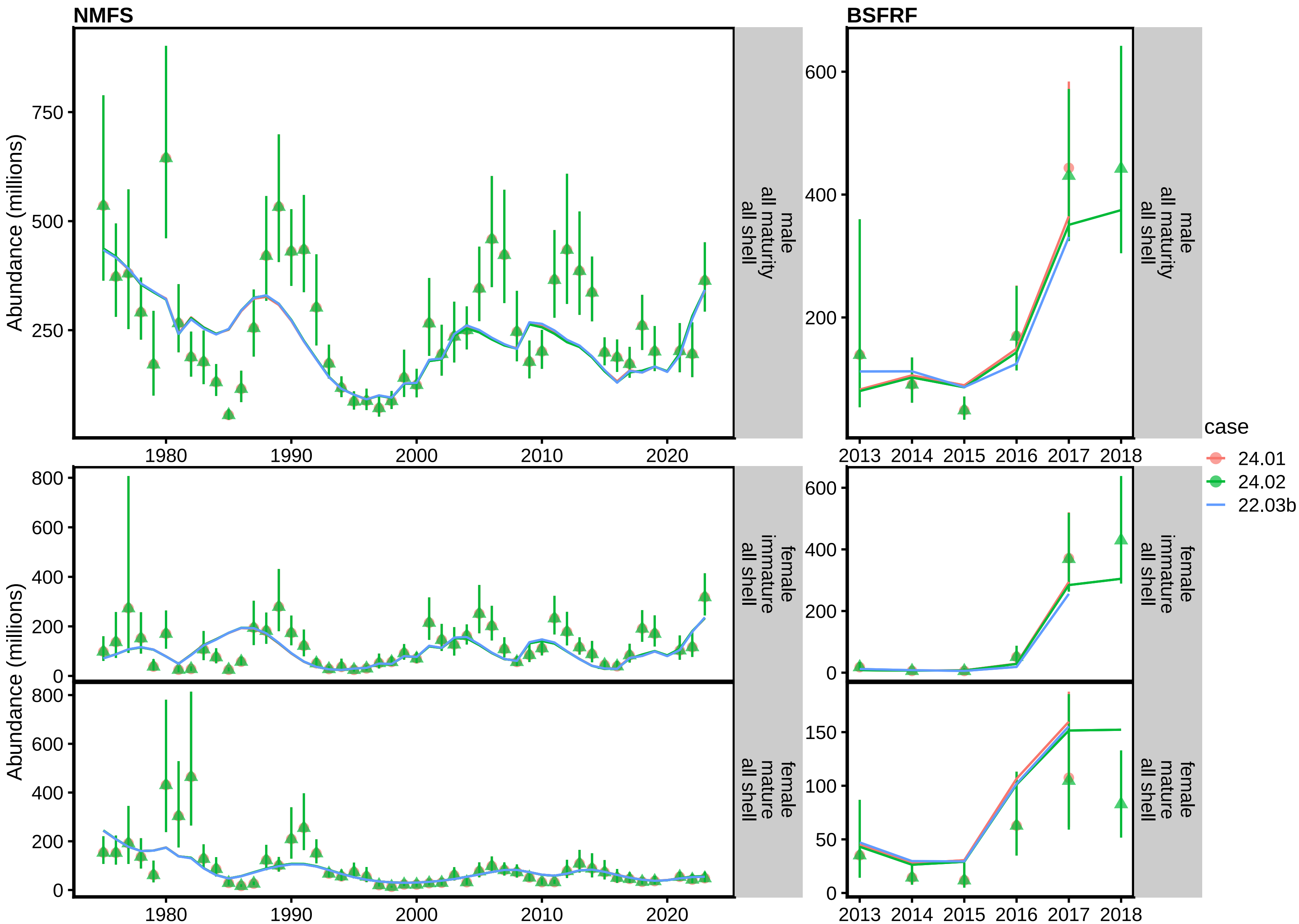

Figure 55. TCSAM02 models fits to time series of all male (upper graph), immature female (center graph), and mature female (lower plot) abundance from the NMFS EBS shelf bottom trawl survey (left column) and the BSFRF SBS trawl survey (right column). Note that these fits are not included in the model objective function and simply provide a diagnostic check. Confidence intervals are 95%.

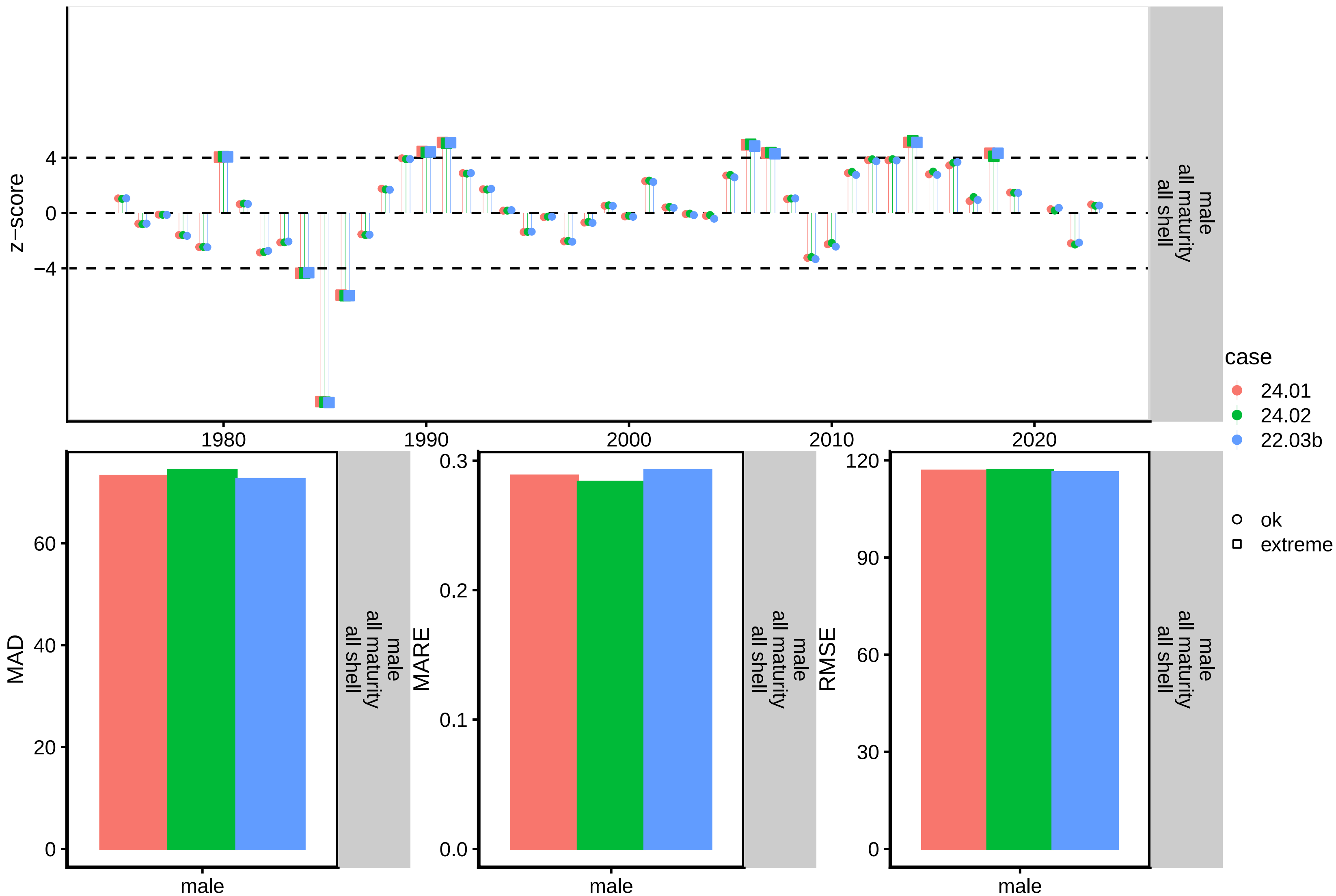

Figure 56. TCSAM02 models residuals analysis by model scenario for fits to male abundance in the NMFS EBS bottom trawl survey. Upper row: annual z-scores; bottom row: 1) MAD: median absolute deviations, 2) MARE: median absolute relative error; 3) RMSE: root mean square error.

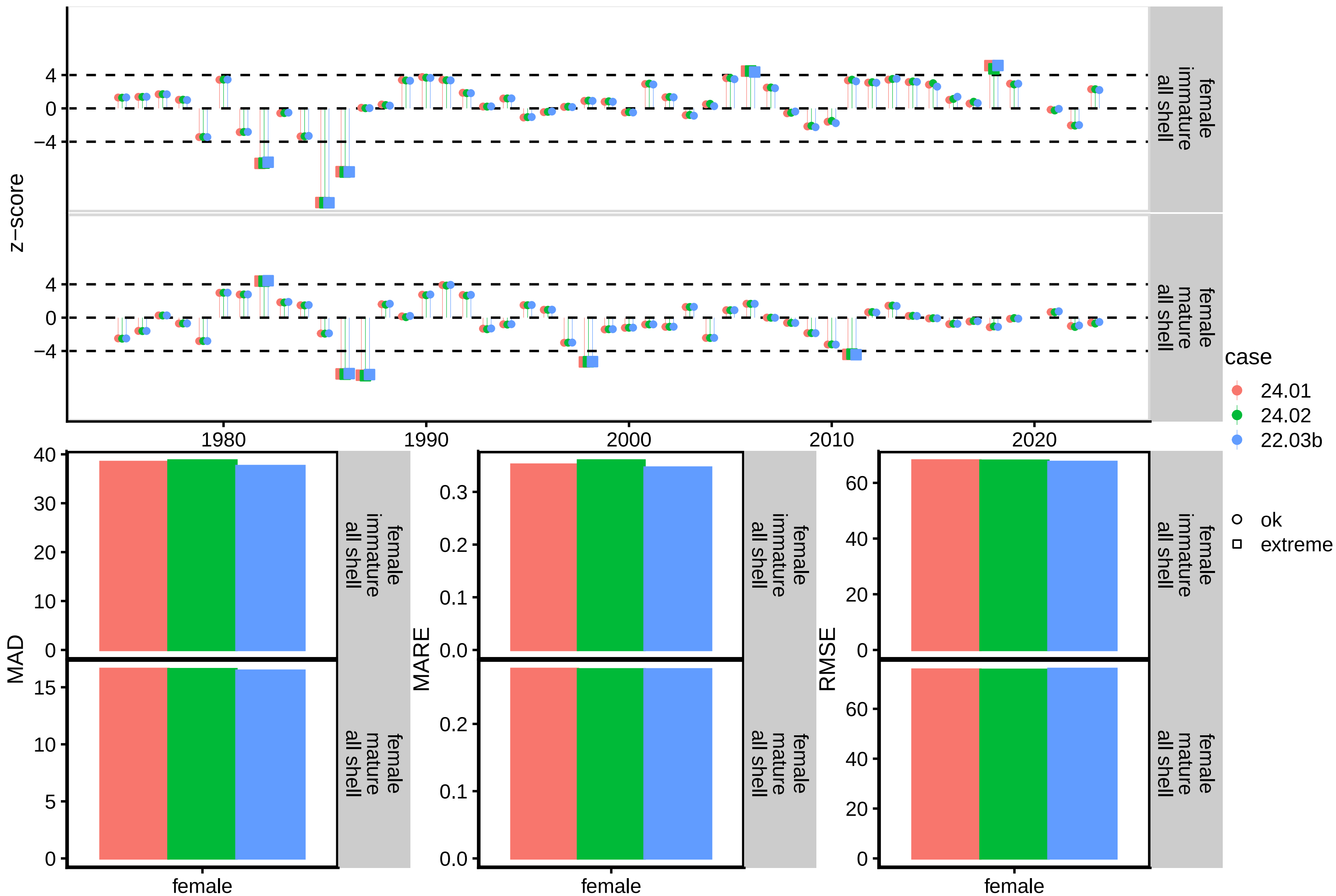

Figure 57. TCSAM02 models residuals analysis by model scenario for fits to female abundance in the NMFS EBS bottom trawl survey. Upper row: annual z-scores; bottom row: 1) MAD: median absolute deviations, 2) MARE: median absolute relative error; 3) RMSE: root mean square error.

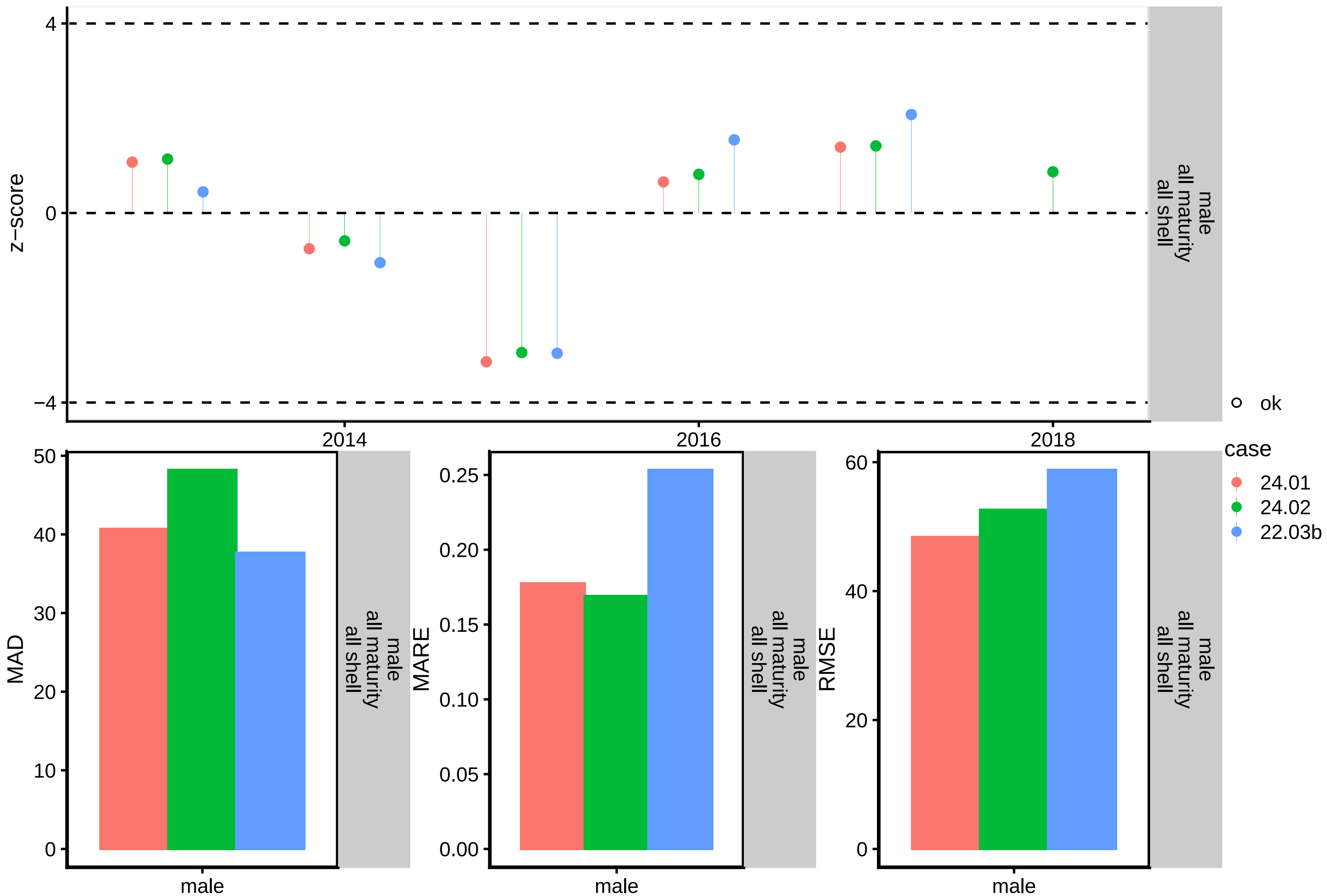

Figure 58. TCSAM02 models residuals analysis by model scenario for fits to male abundance in the BSFRF SBS bottom trawl survey. Upper row: annual z-scores; bottom row: 1) MAD: median absolute deviations, 2) MARE: median absolute relative error; 3) RMSE: root mean square error.

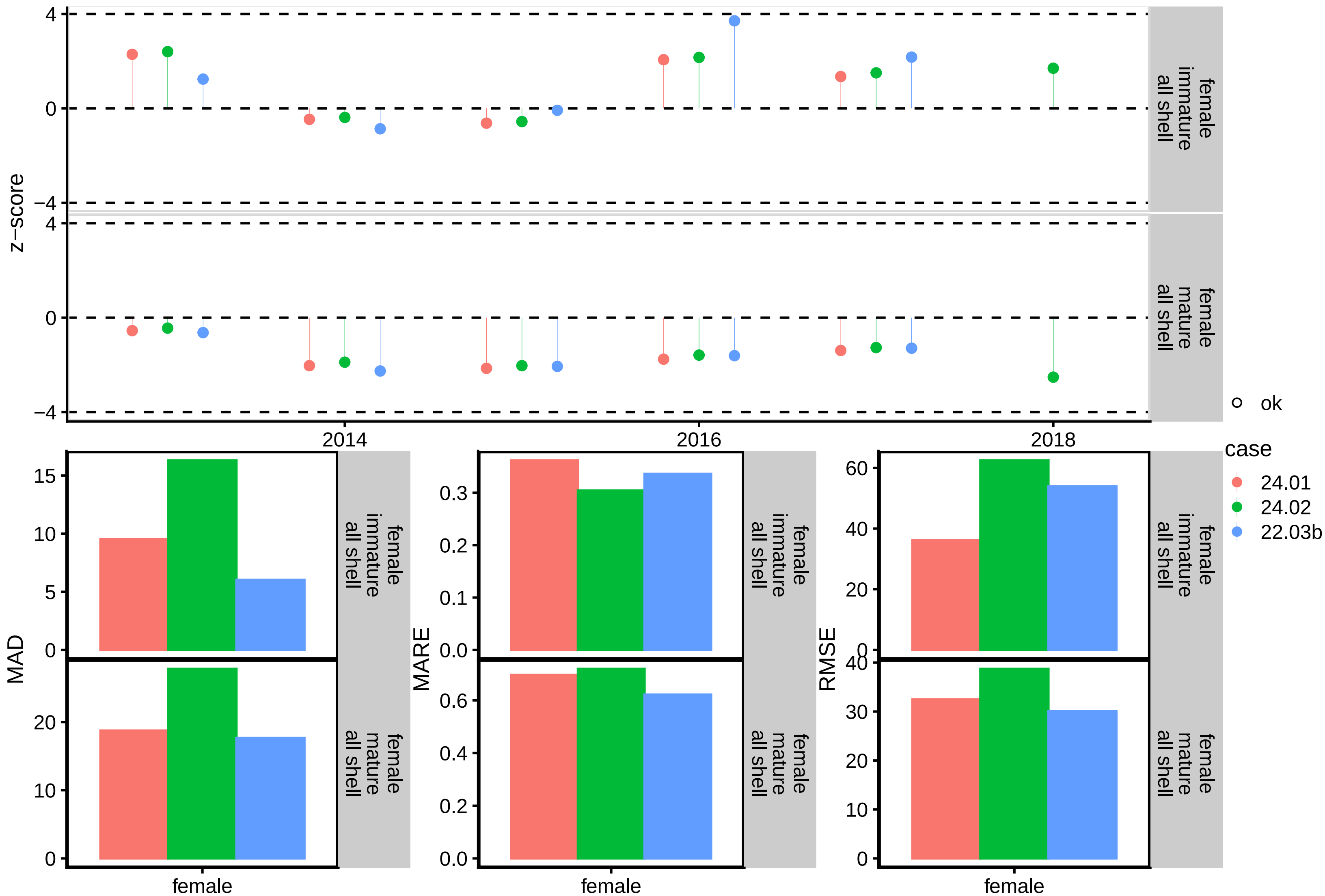

Figure 59. TCSAM02 models residuals analysis by model scenario for fits to female abundance in the BSFRF SBS bottom trawl survey. Upper row: annual z-scores; bottom row: 1) MAD: median absolute deviations, 2) MARE: median absolute relative error; 3) RMSE: root mean square error.

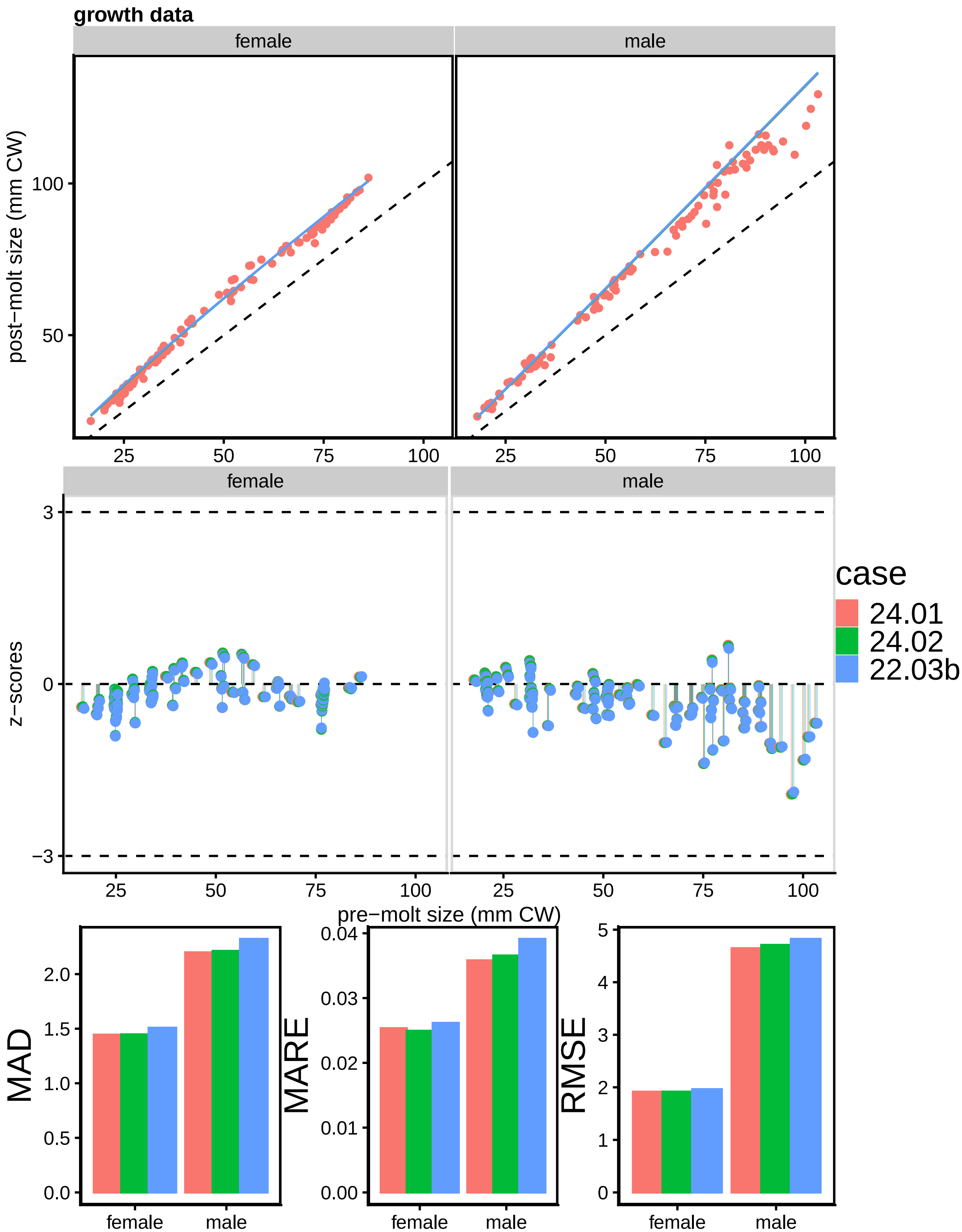

Figure 60. TCSAM02 models fits and residuals analysis by model scenario for fits to molt increment data. Upper row: fits to data; center row: annual z-scores; bottom row: 1) MAD: median absolute deviations, 2) MARE: median absolute relative error; 3) RMSE: root mean square error.

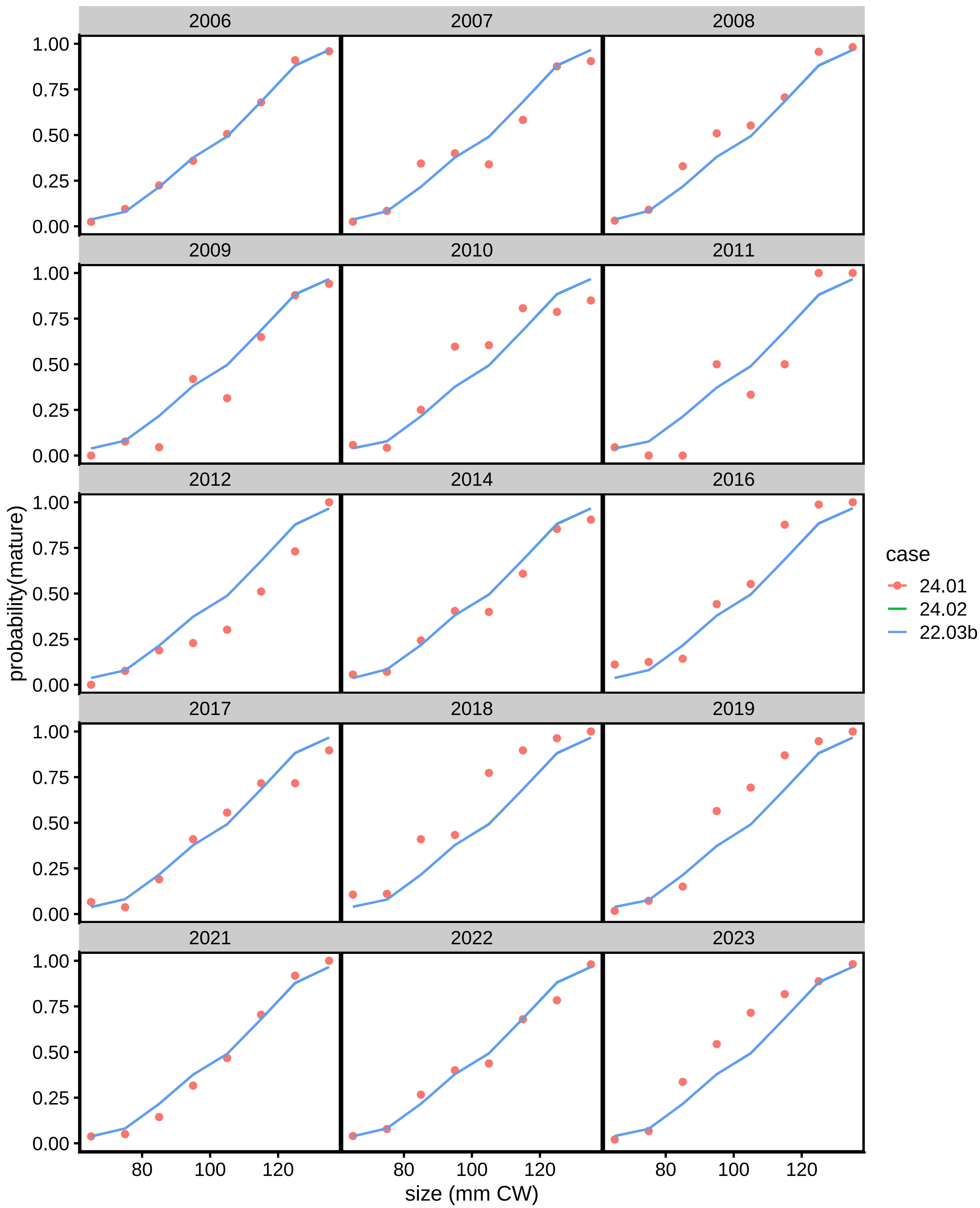

Figure 61. TCSAM02 models fits to maturity ogive data by model scenario and year.

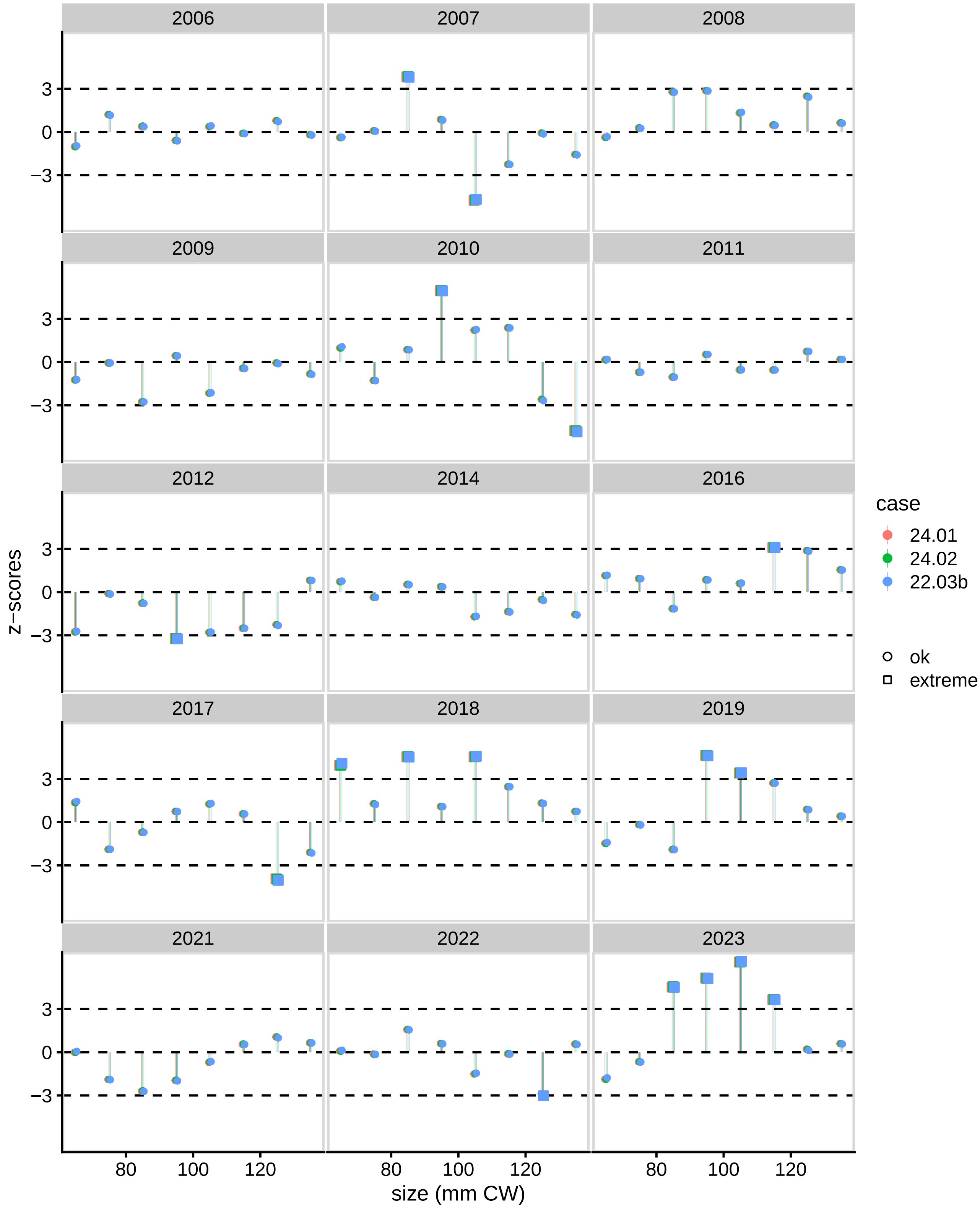

Figure 62. TCSAM02 models residuals analysis for maturity ogive data, by model scenario and year.

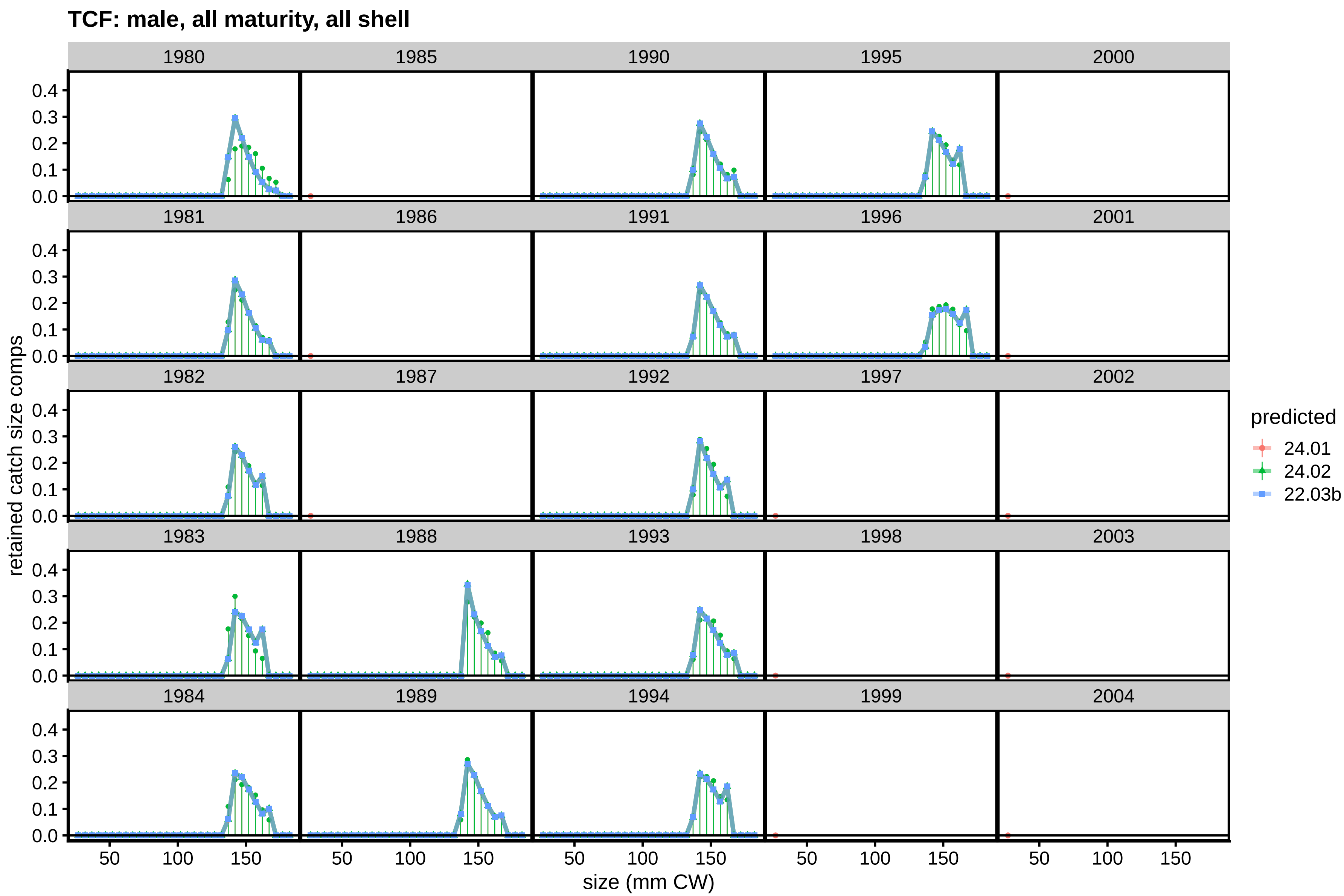

Figure 63. TCSAM02 models fits to retained catch size compositions in the directed fishery. Preferred model is 24.01.TCSAM02 models fits to retained catch size compositions in the directed fishery. Preferred model is 24.02.

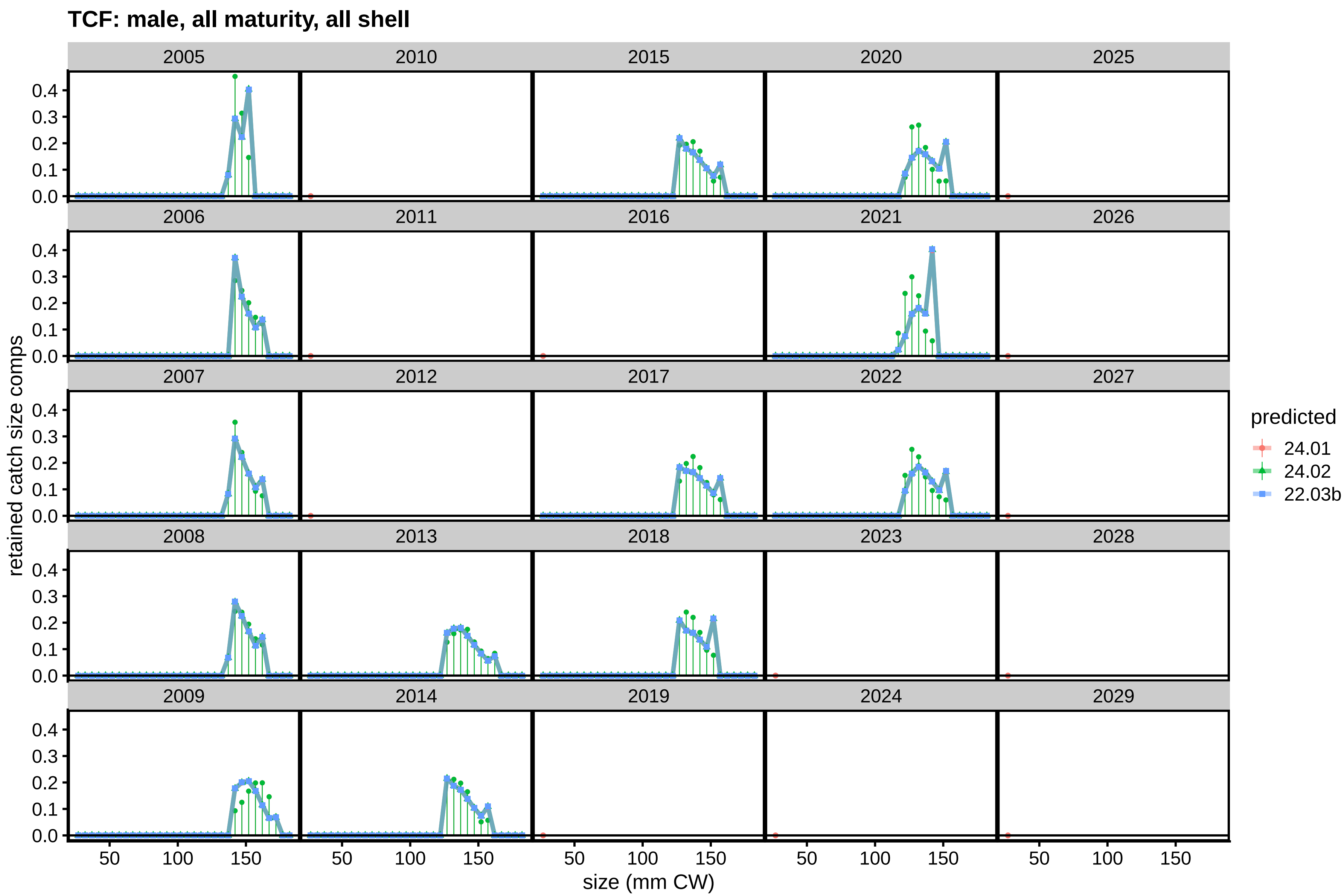

Figure 64. TCSAM02 models fits to retained catch size compositions in the directed fishery. Preferred model is 24.01.TCSAM02 models fits to retained catch size compositions in the directed fishery. Preferred model is 24.02.

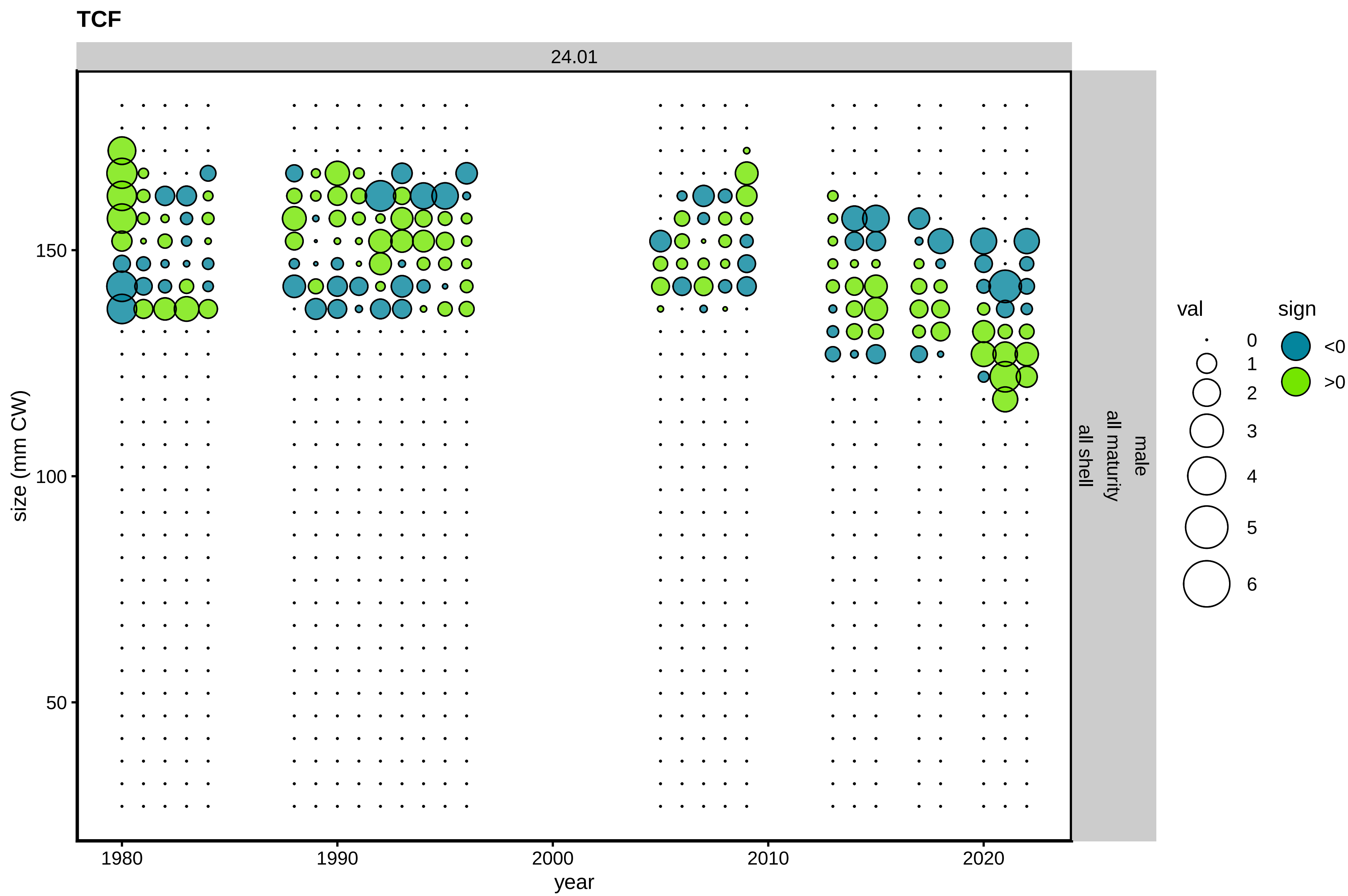

Figure 65. Pearson's residuals for fits to retained catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

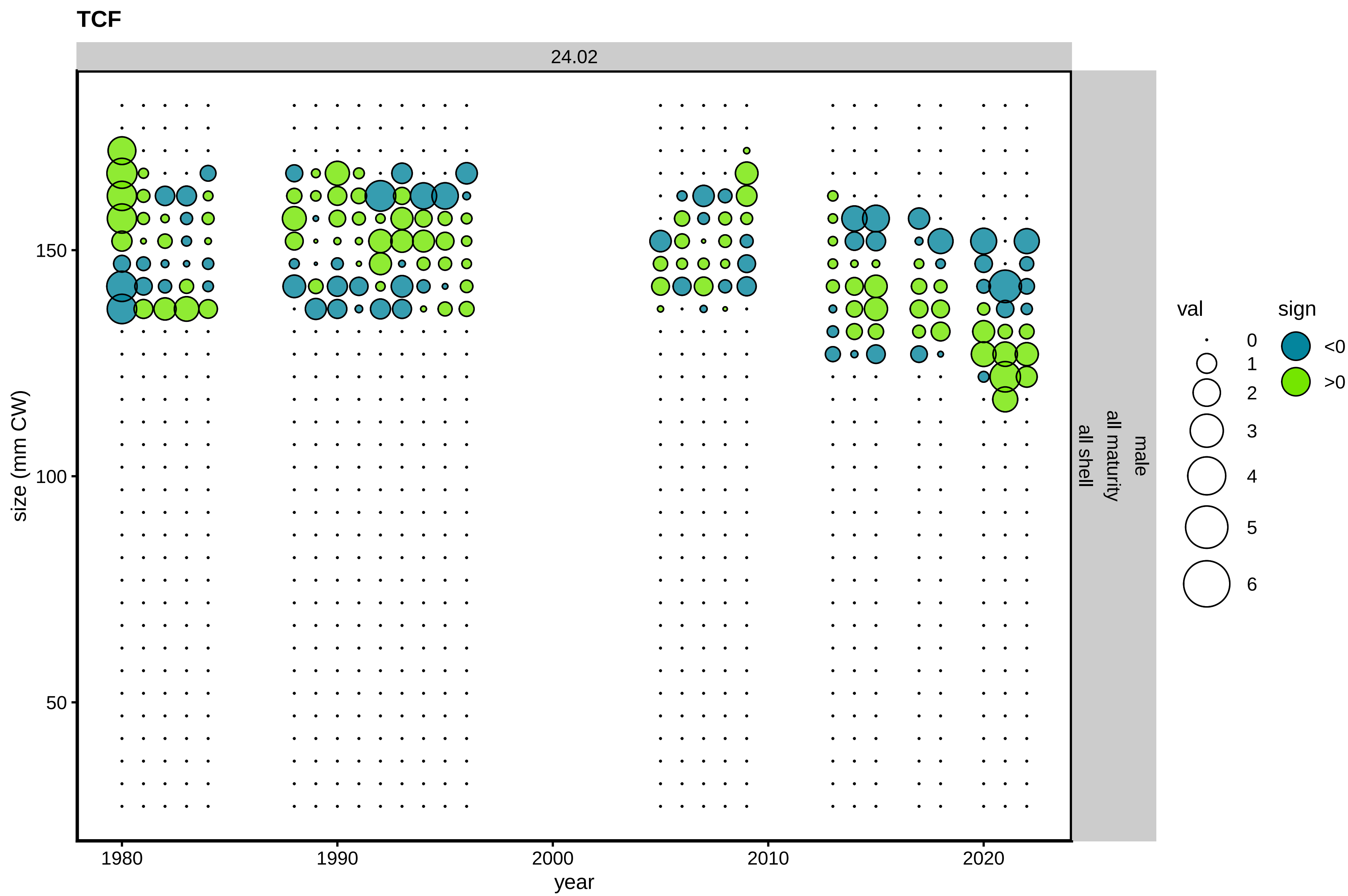

Figure 66. Pearson's residuals for fits to retained catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

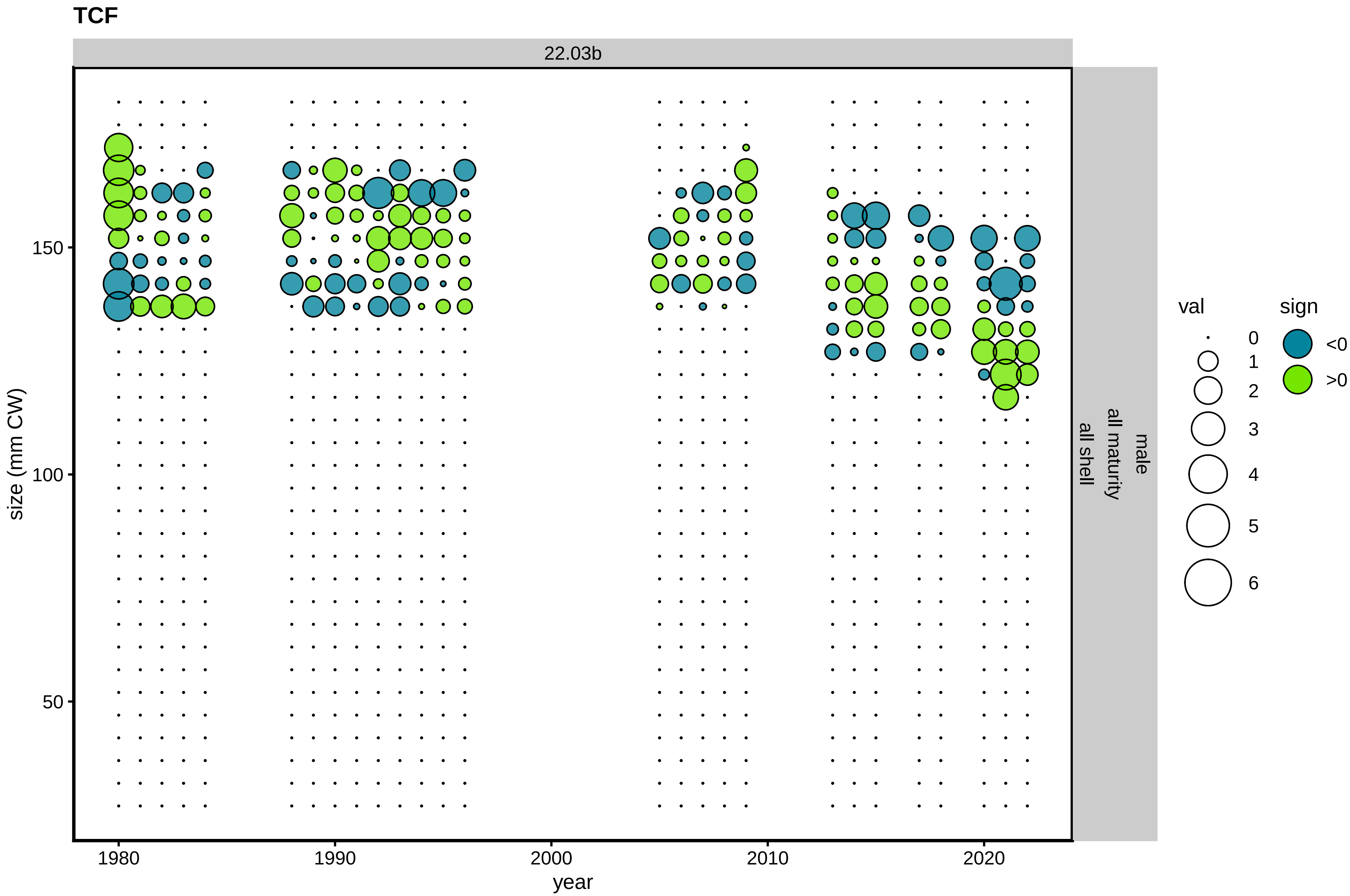

Figure 67. Pearson's residuals for fits to retained catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

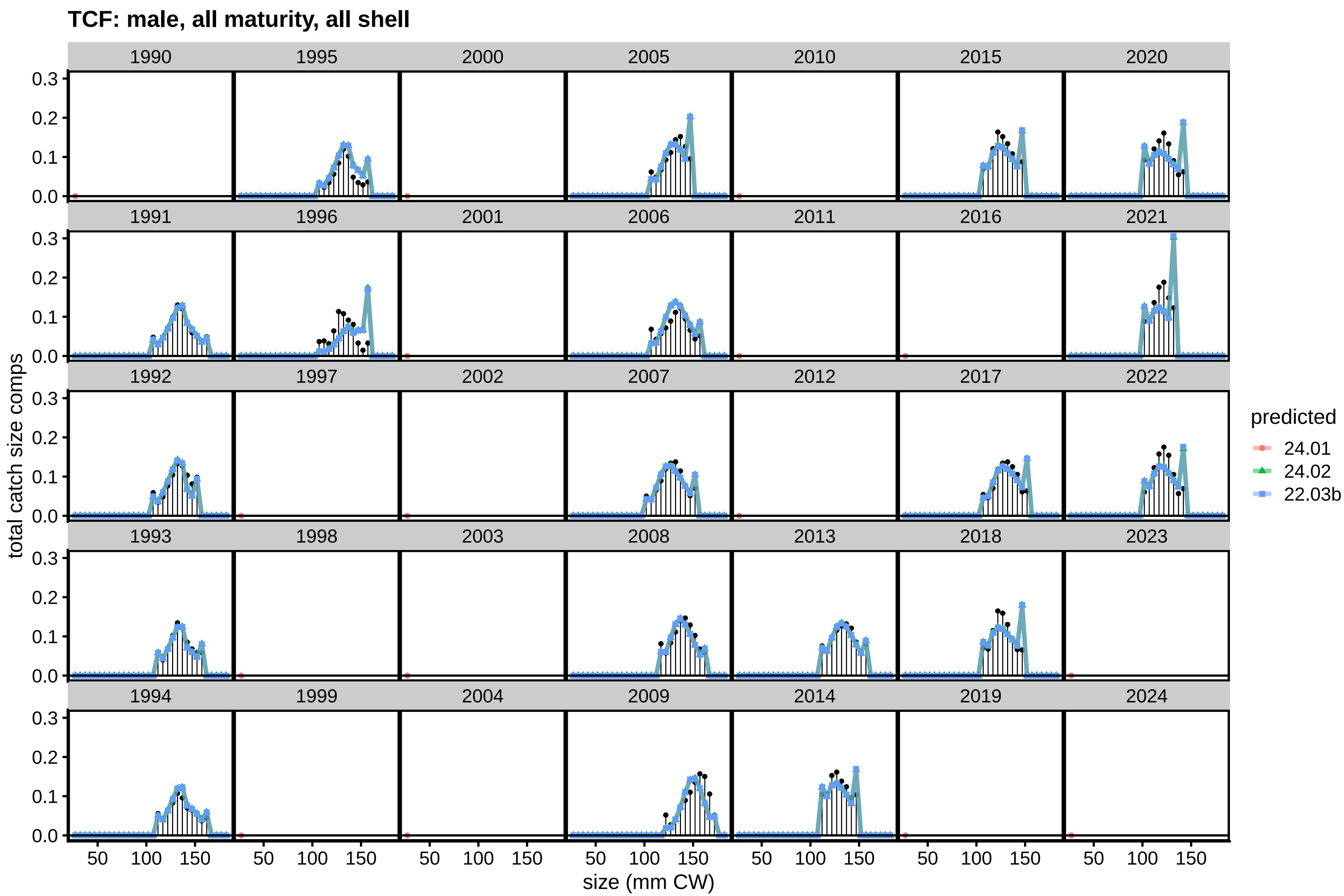

Figure 68. TCSAM02 models fits to total catch size compostiions in the TCF fishery. Preferred model is 24.01.TCSAM02 models fits to total catch size compostiions in the TCF fishery. Preferred model is 24.02.

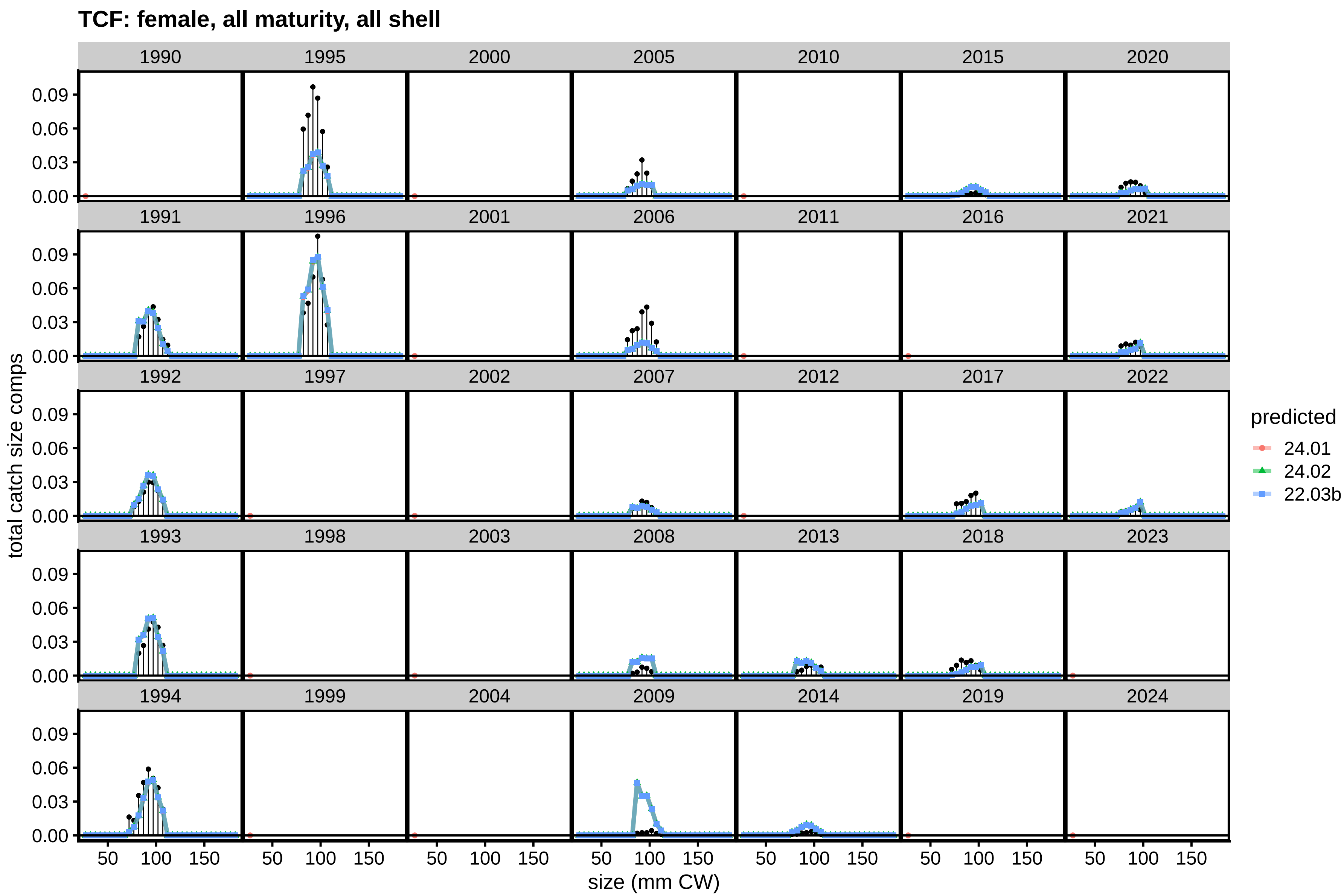

Figure 69. TCSAM02 models fits to total catch size compostiions in the TCF fishery. Preferred model is 24.01.TCSAM02 models fits to total catch size compostiions in the TCF fishery. Preferred model is 24.02.

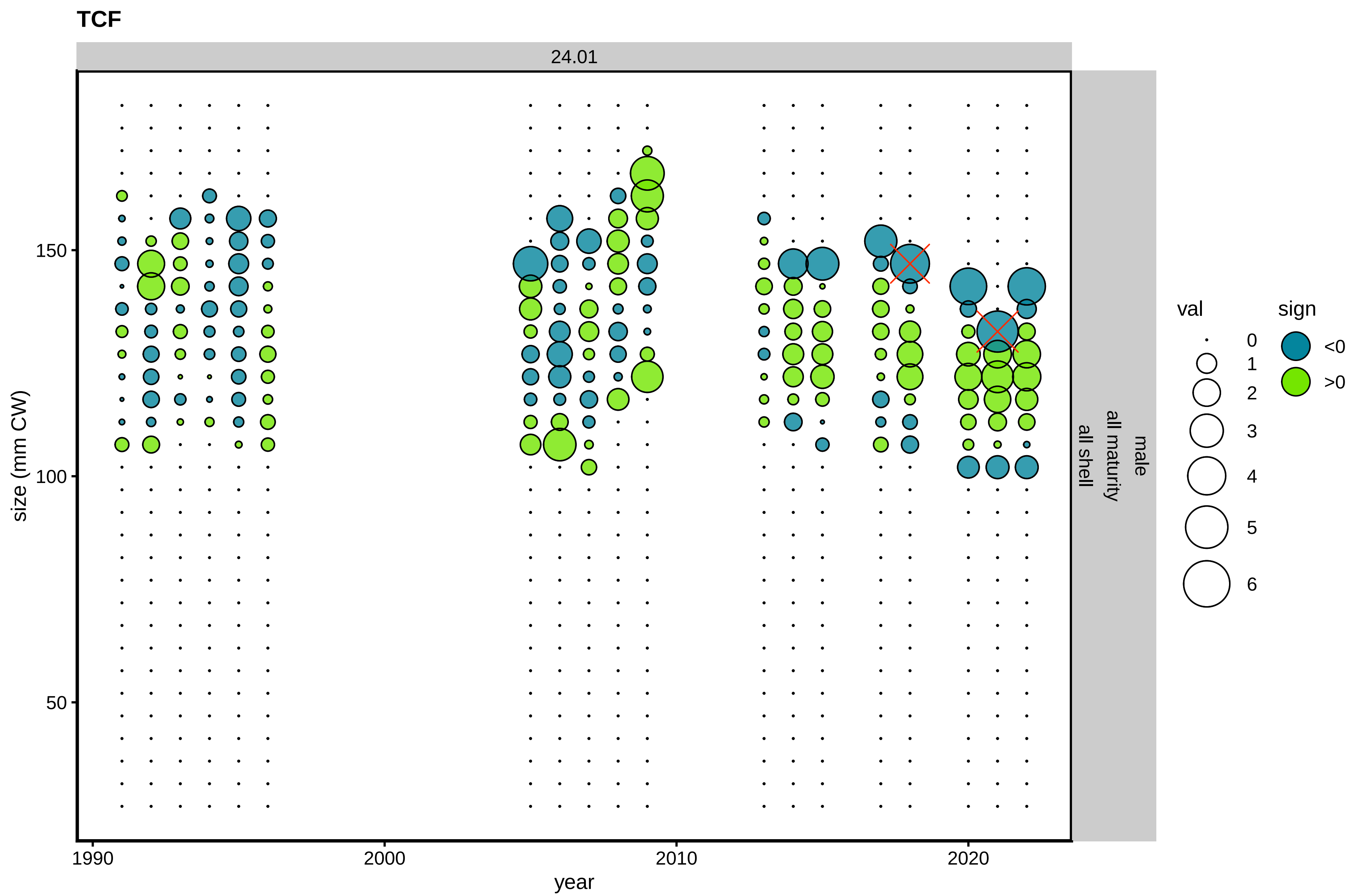

Figure 70. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

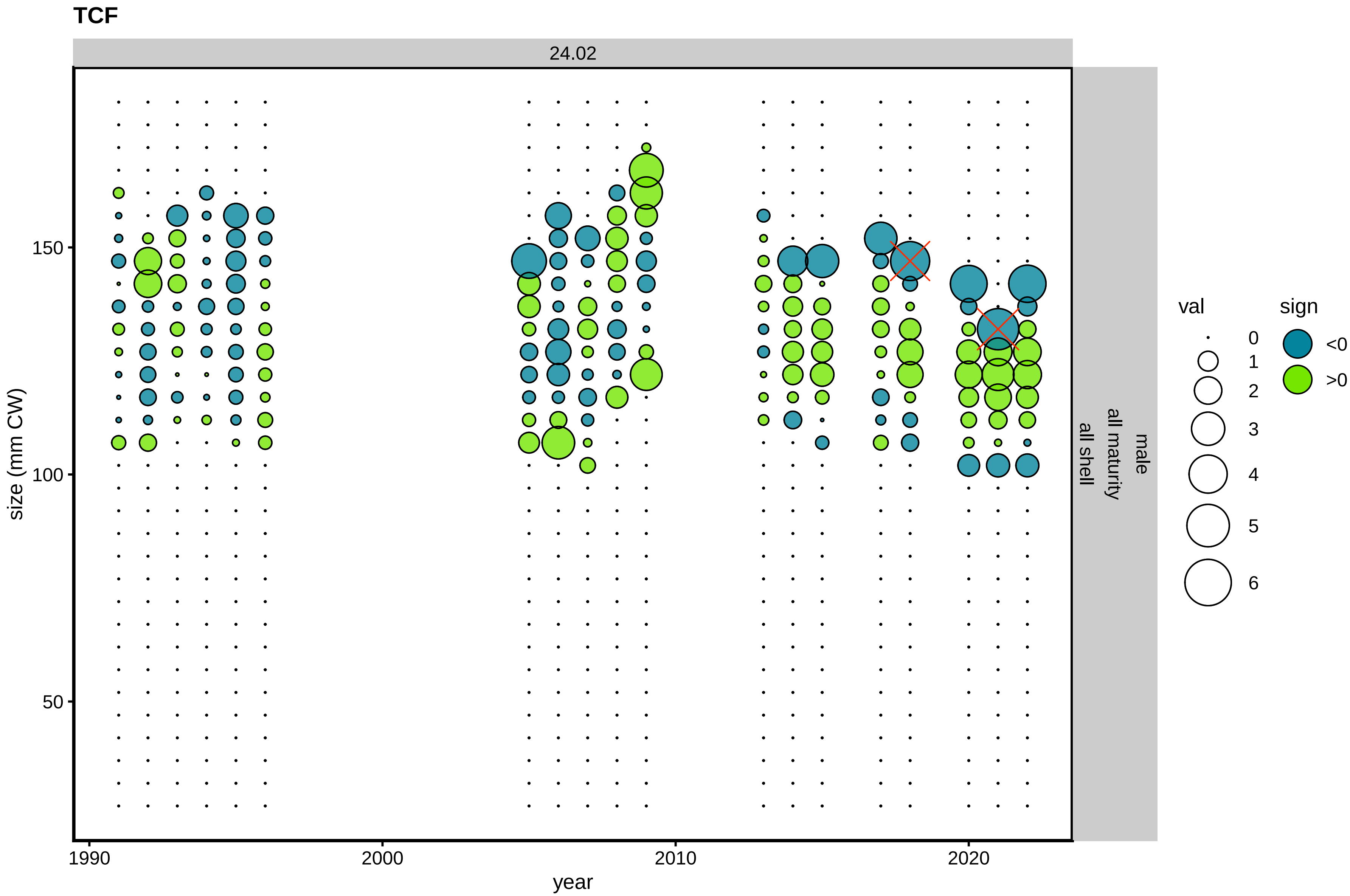

Figure 71. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

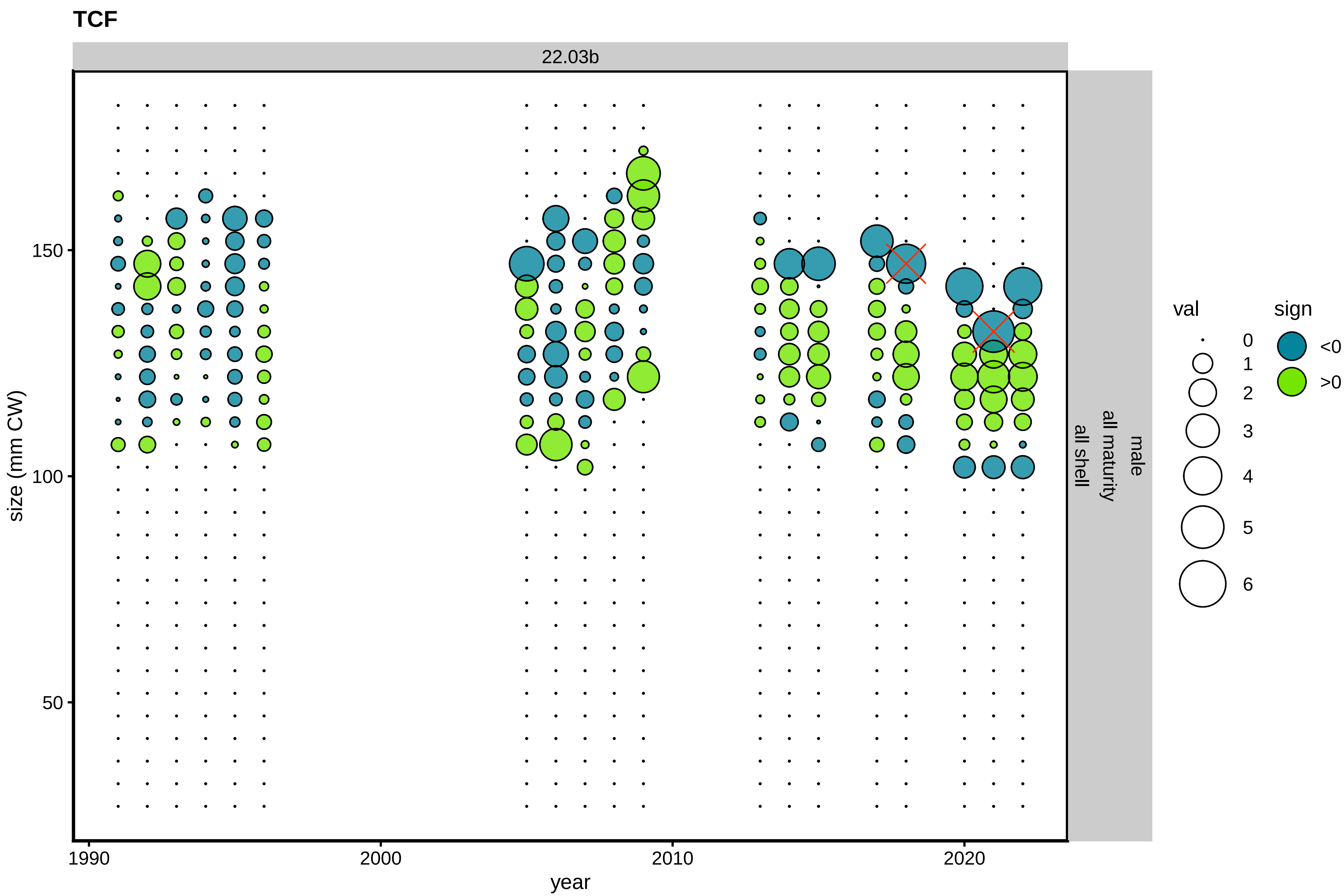

Figure 72. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

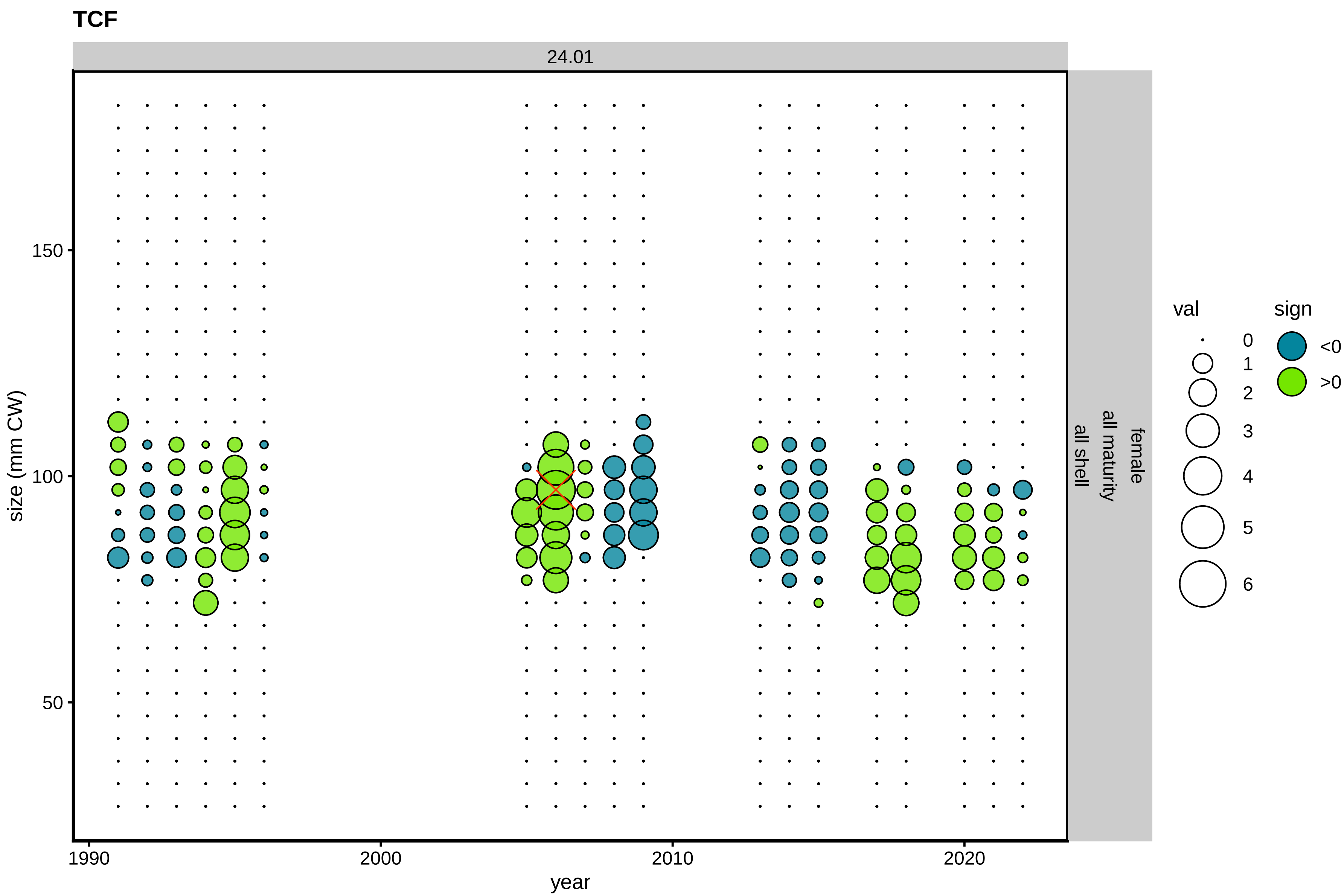

Figure 73. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

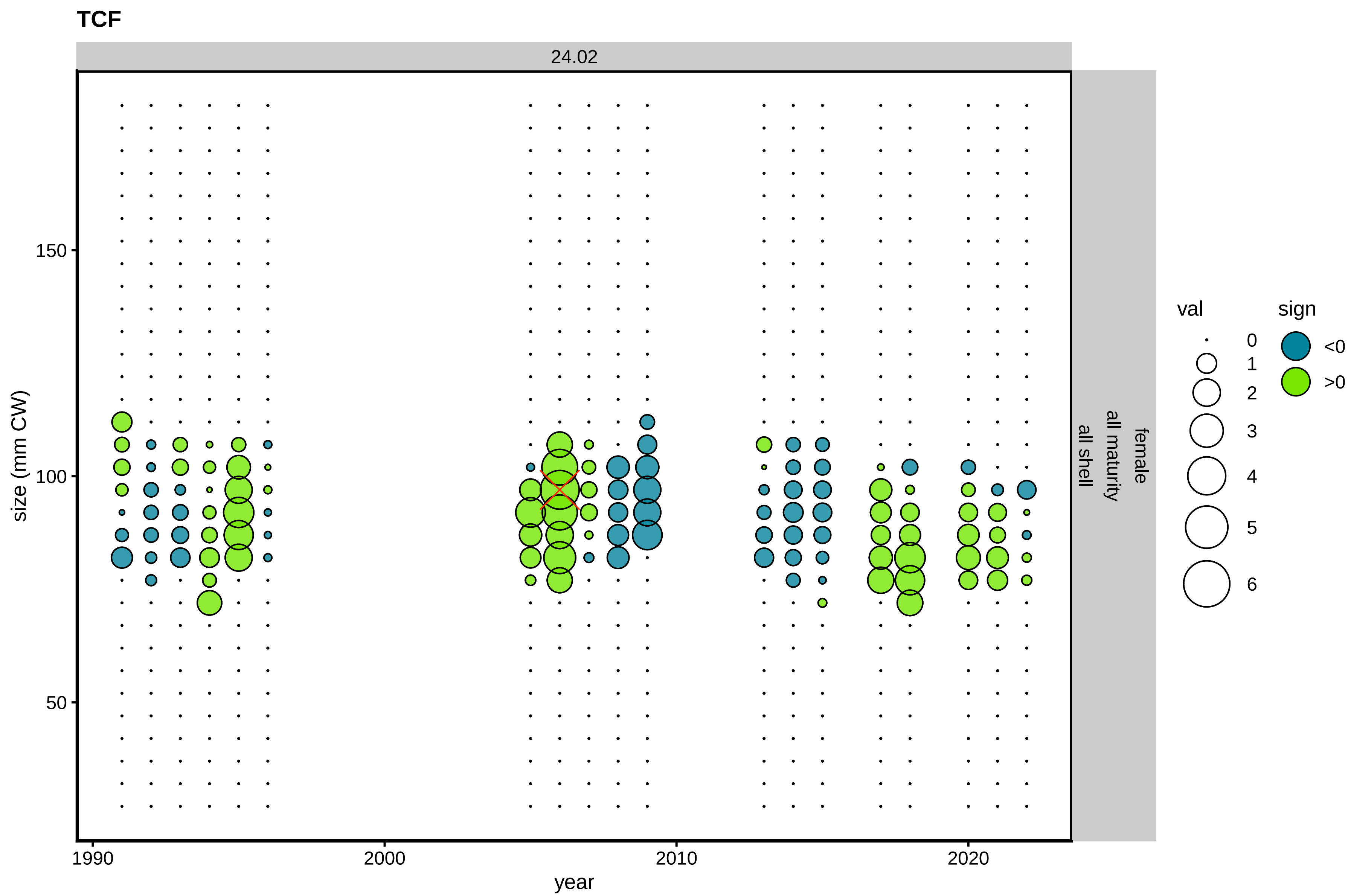

Figure 74. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

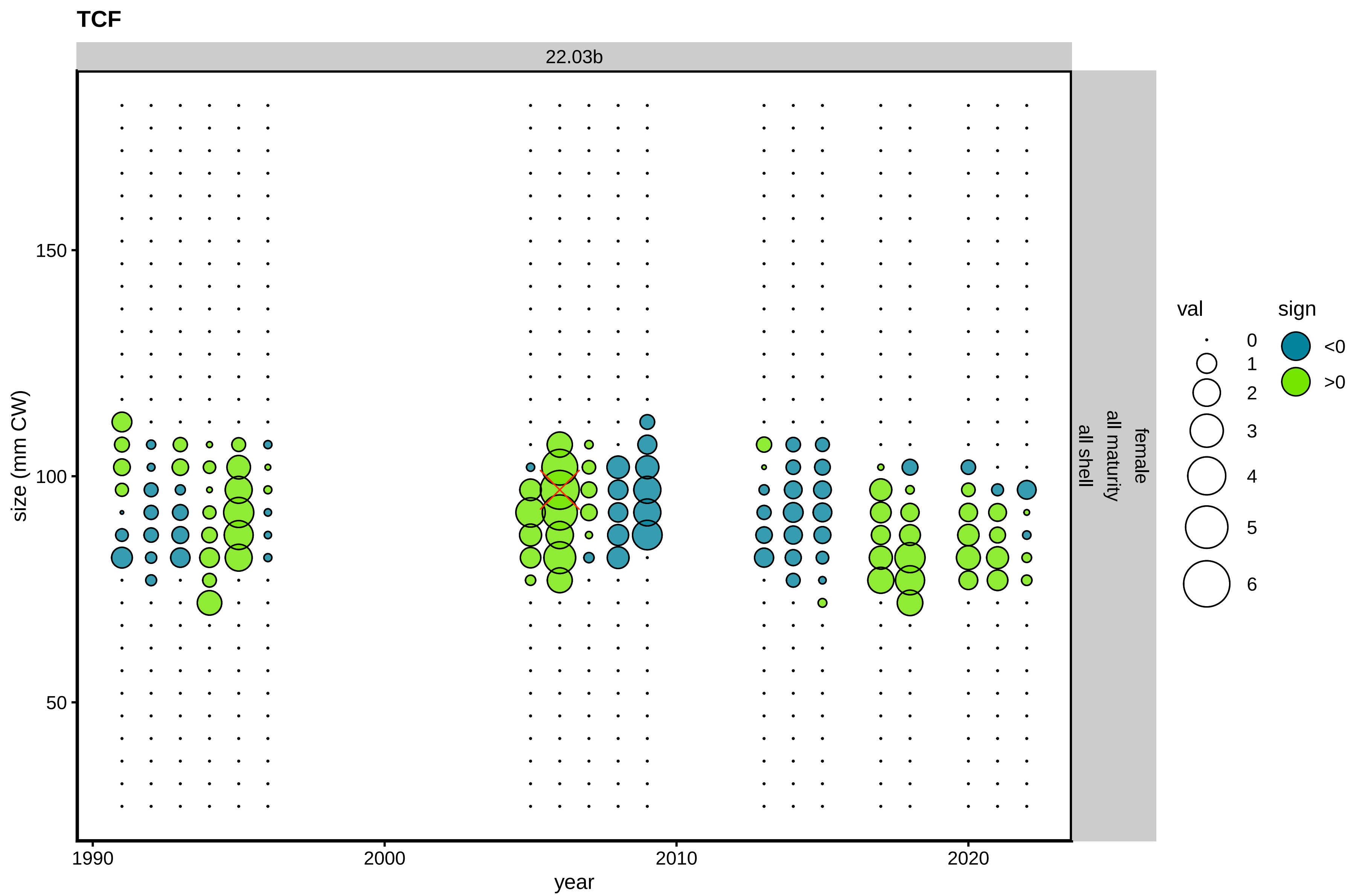

Figure 75. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

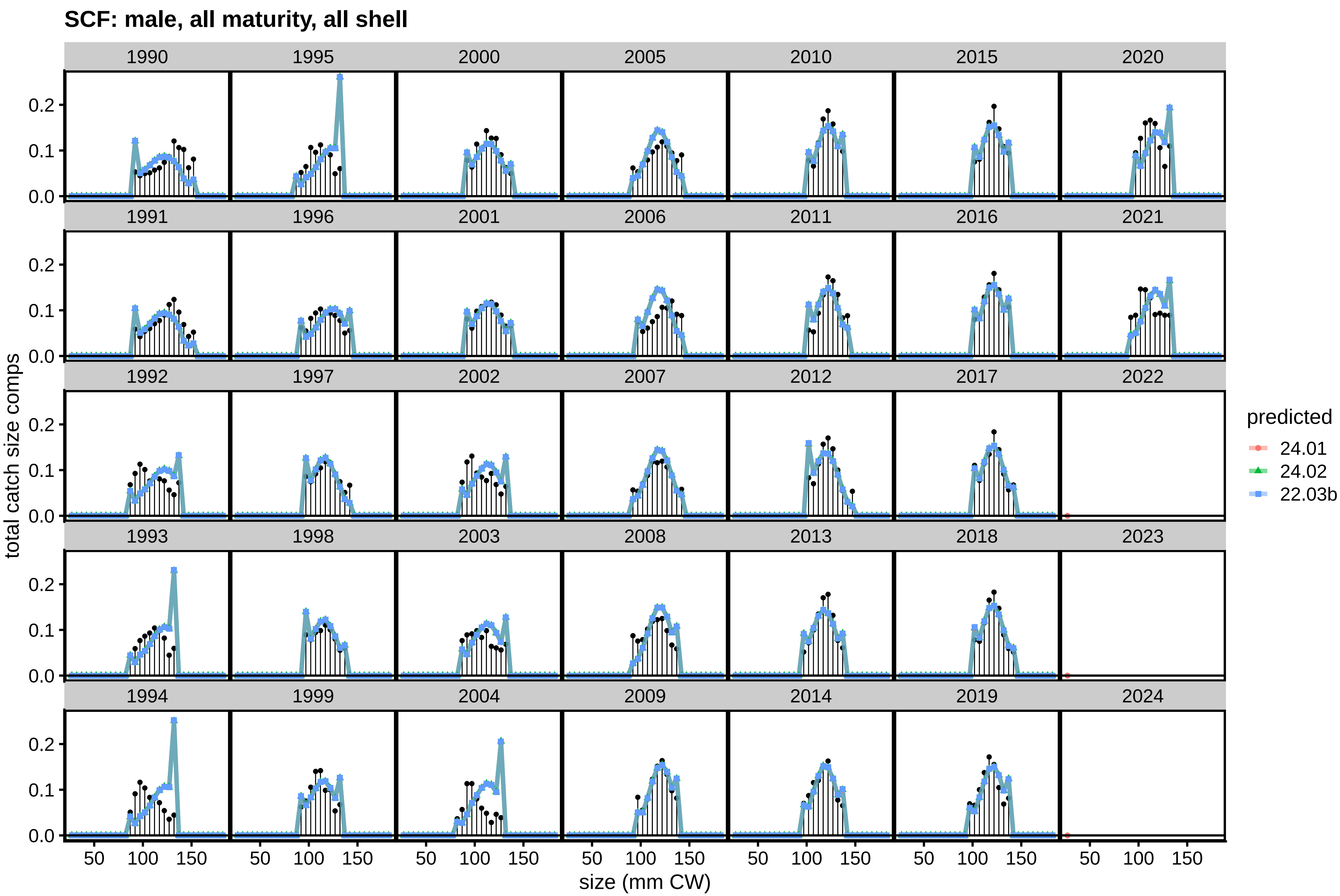

Figure 76. TCSAM02 models fits to total catch size compostiions in the SCF fishery. Preferred model is 24.01.TCSAM02 models fits to total catch size compostiions in the SCF fishery. Preferred model is 24.02.

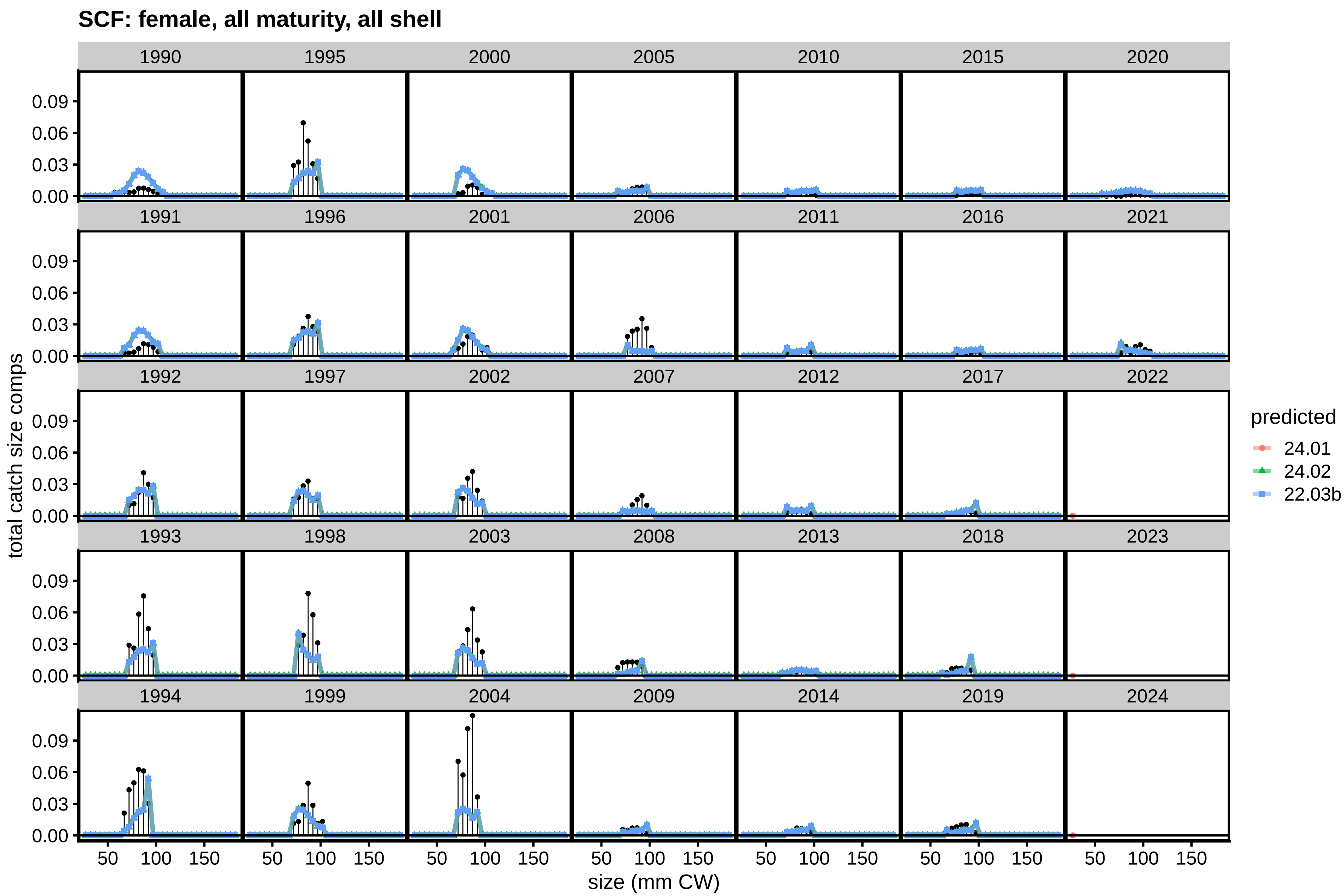

Figure 77. TCSAM02 models fits to total catch size compostiions in the SCF fishery. Preferred model is 24.01.TCSAM02 models fits to total catch size compostiions in the SCF fishery. Preferred model is 24.02.

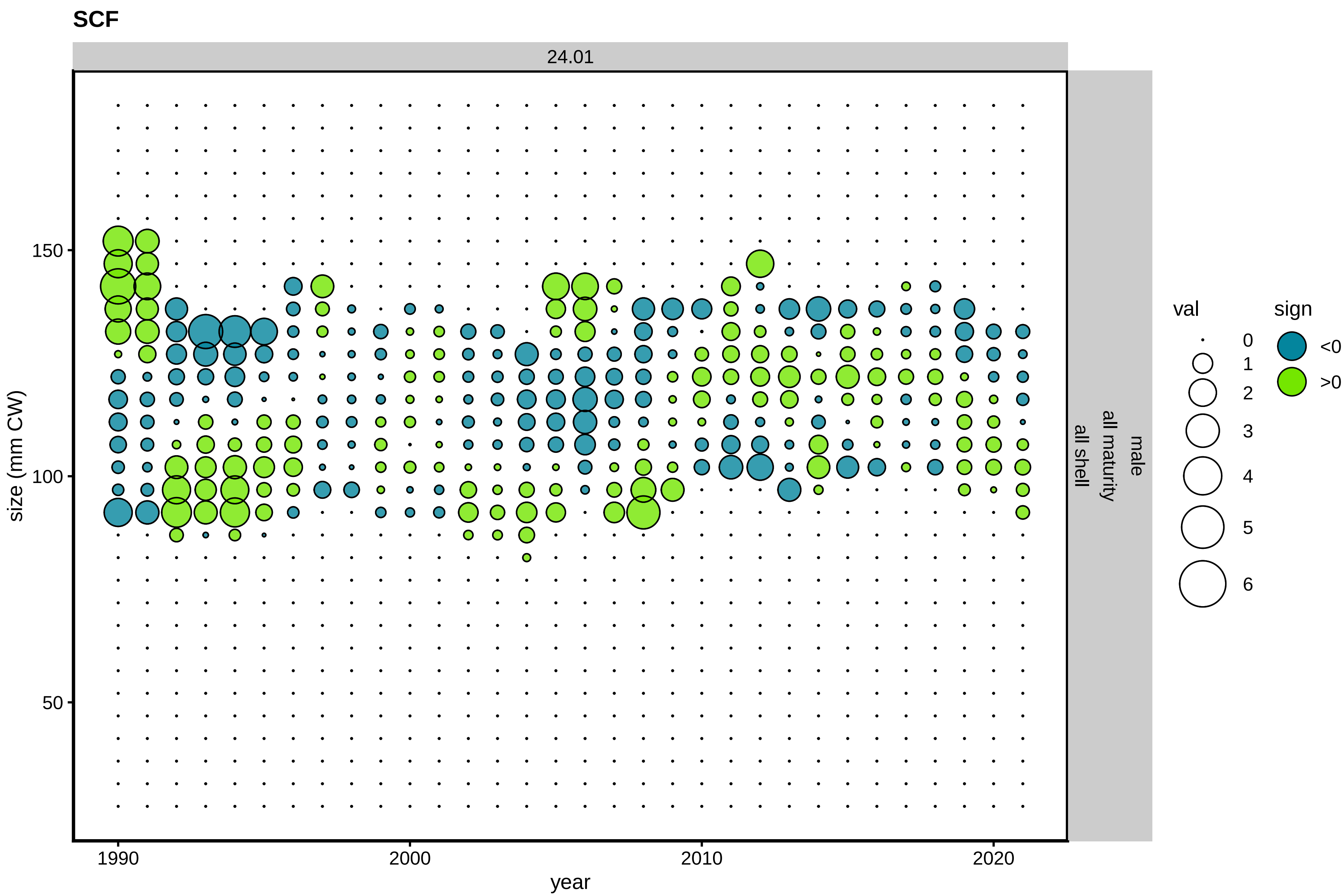

Figure 78. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

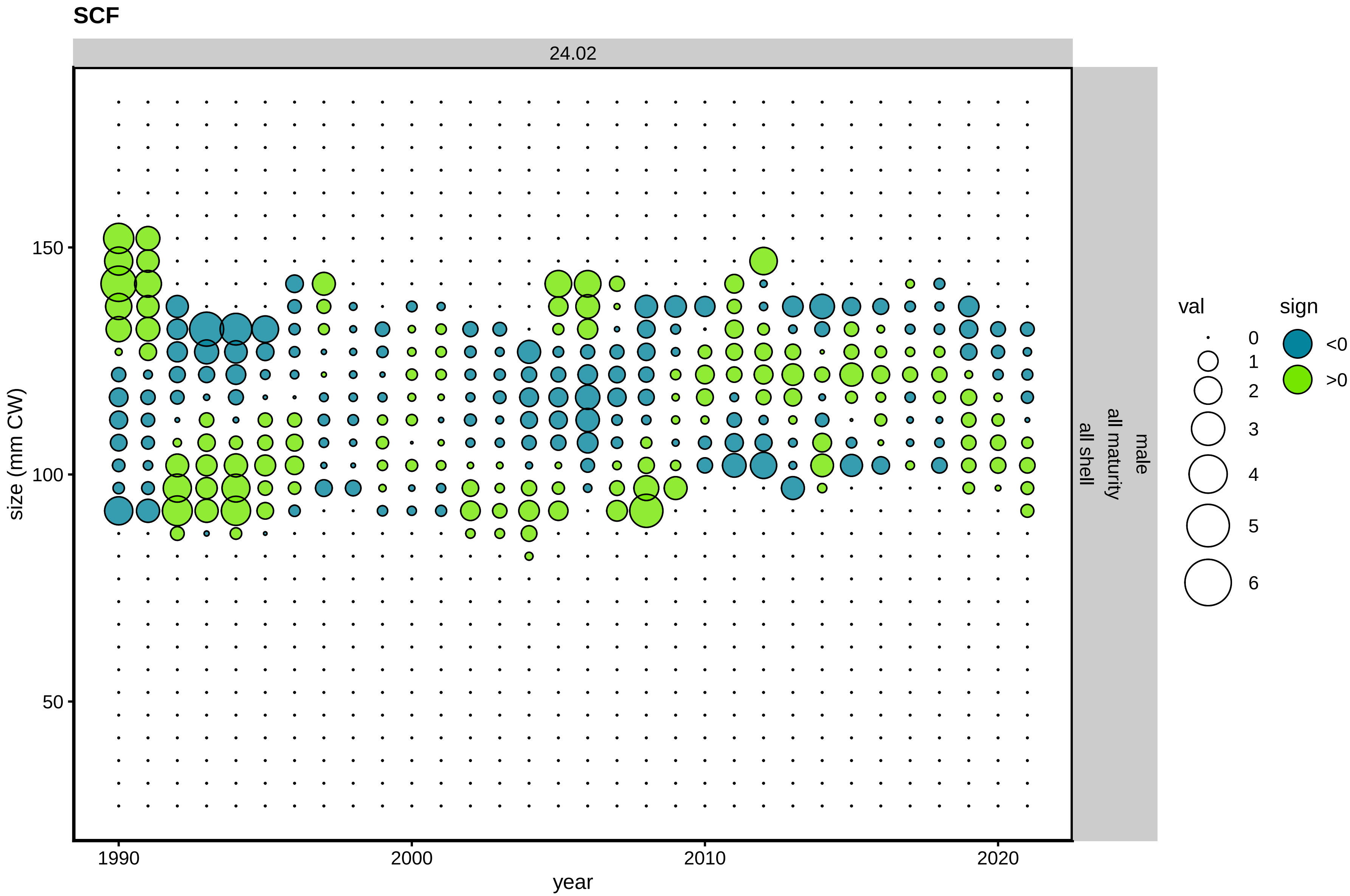

Figure 79. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

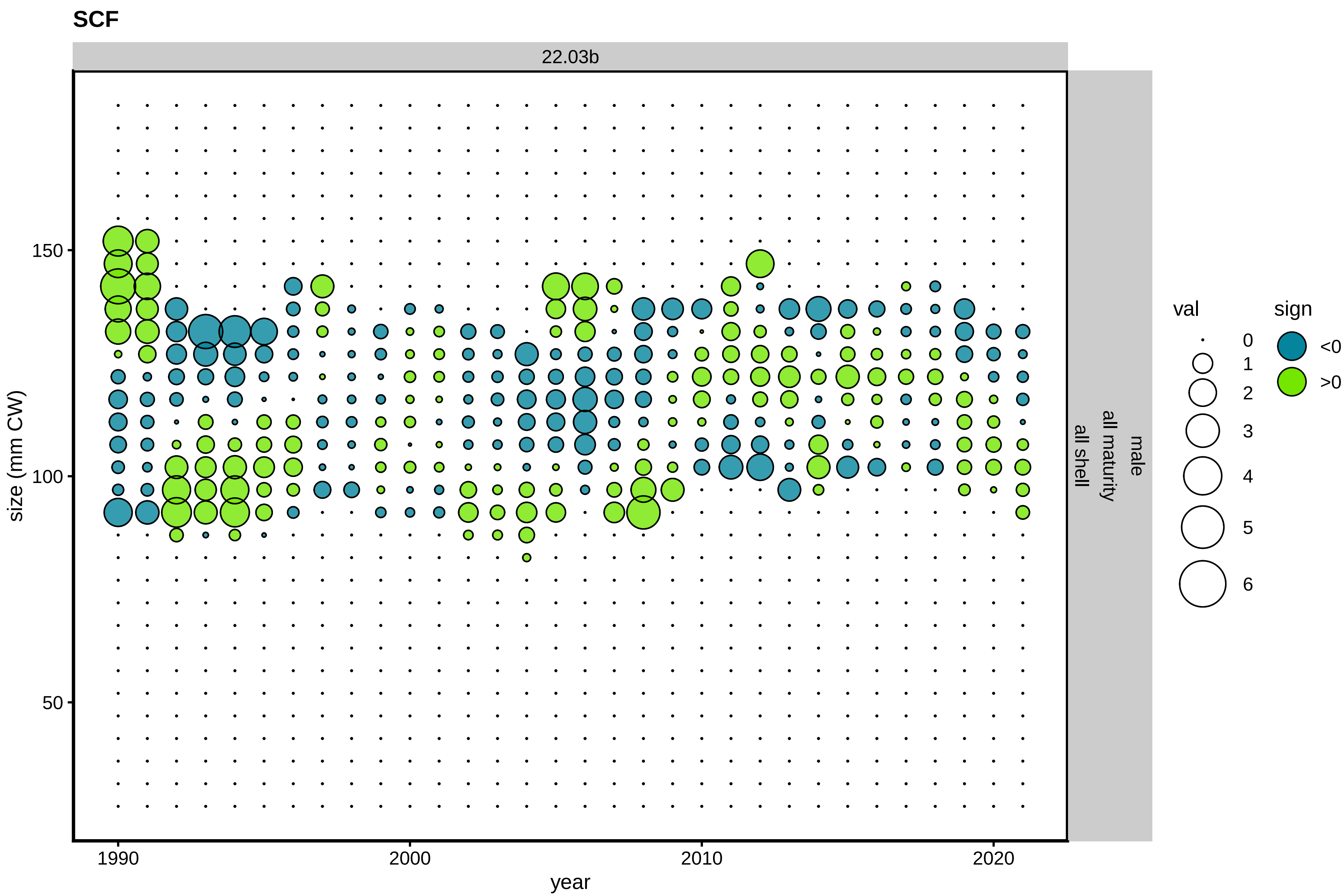

Figure 80. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

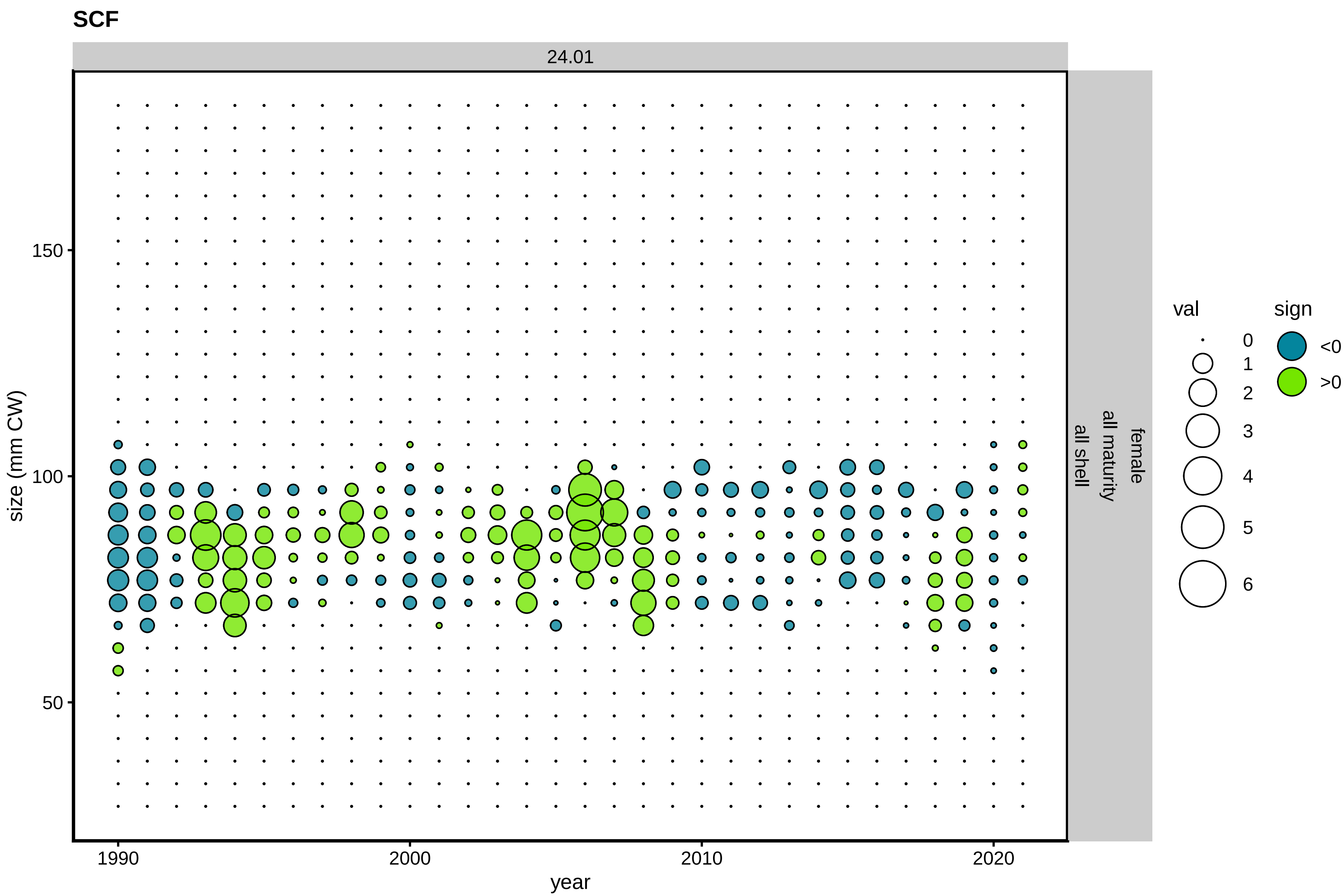

Figure 81. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

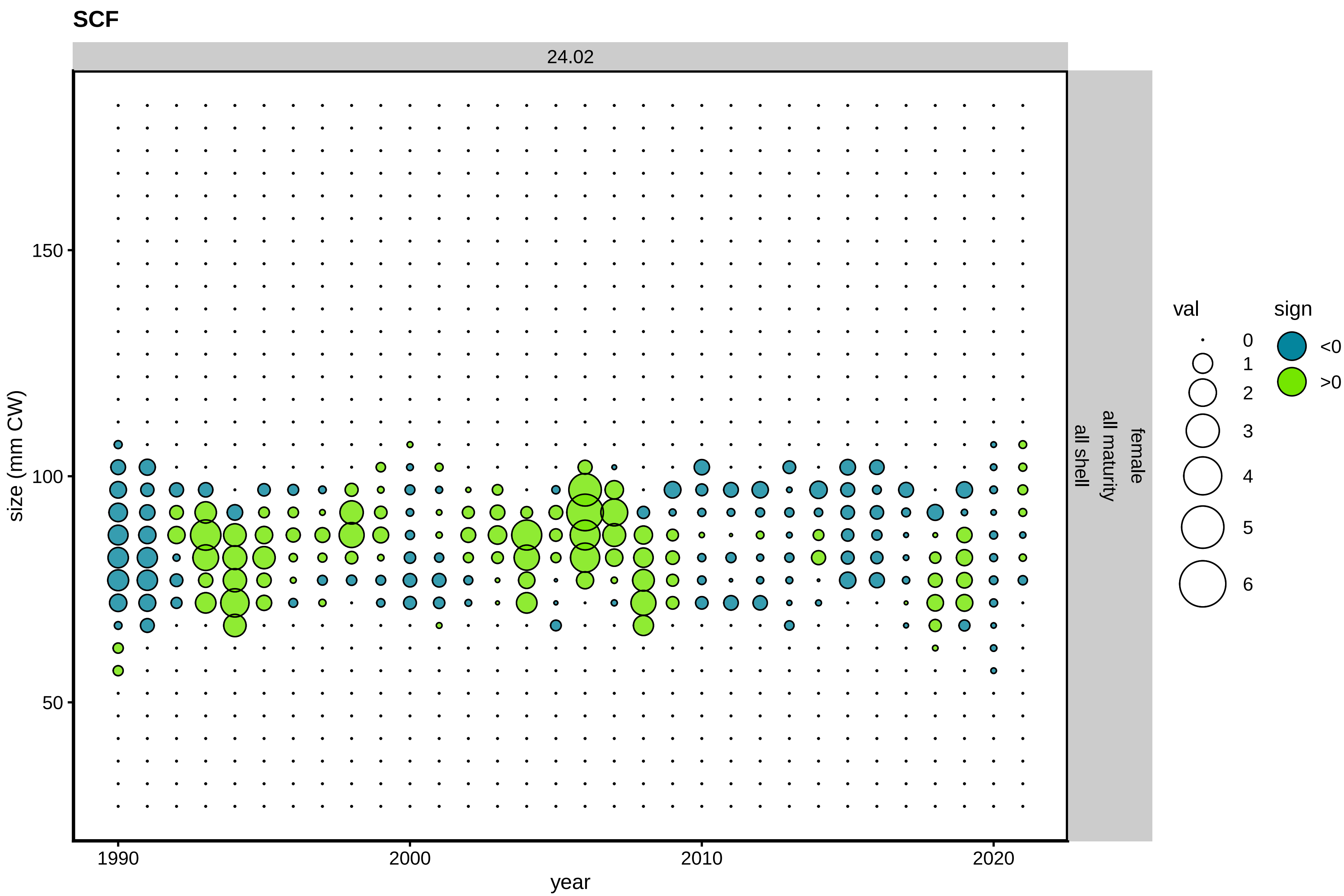

Figure 82. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

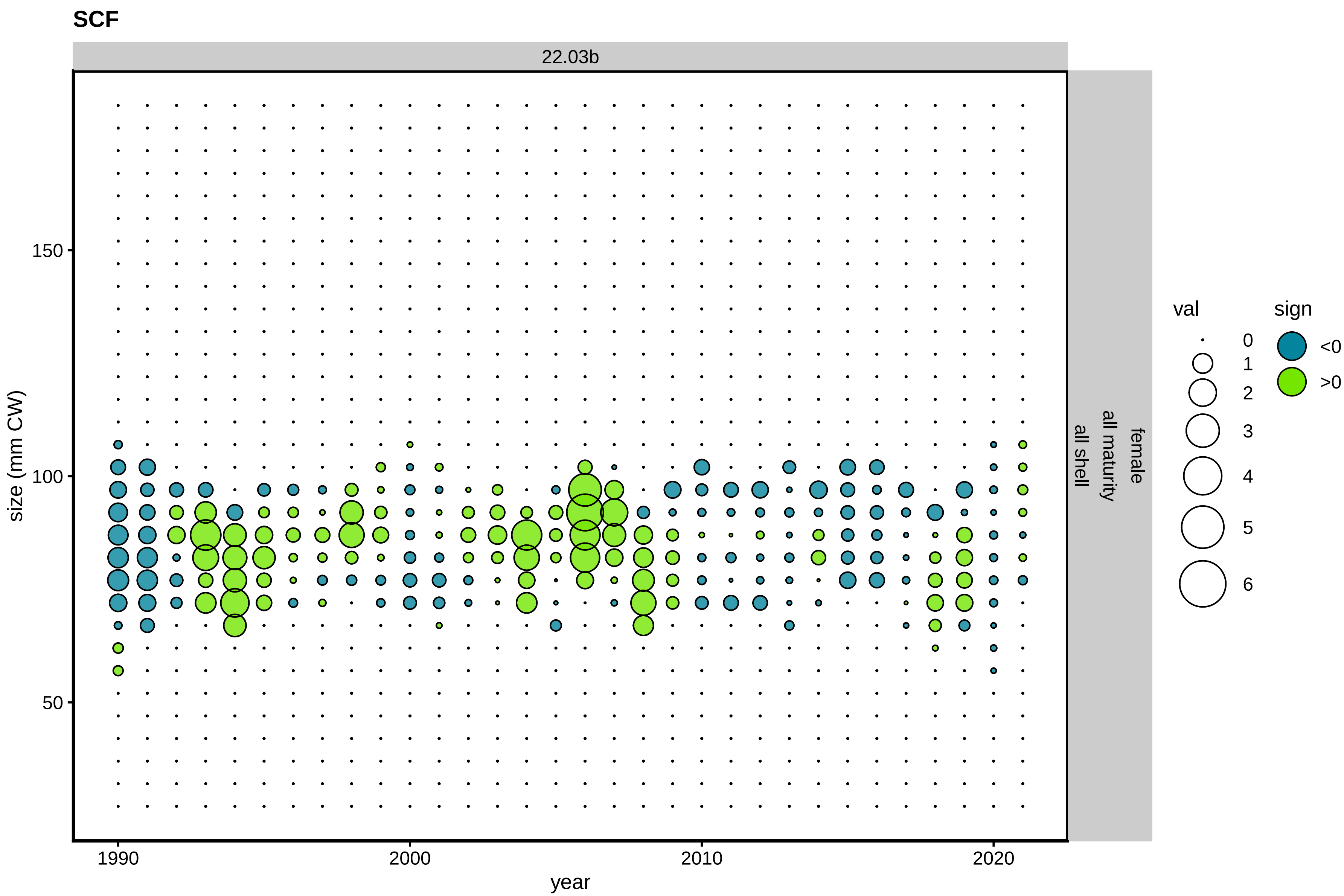

Figure 83. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

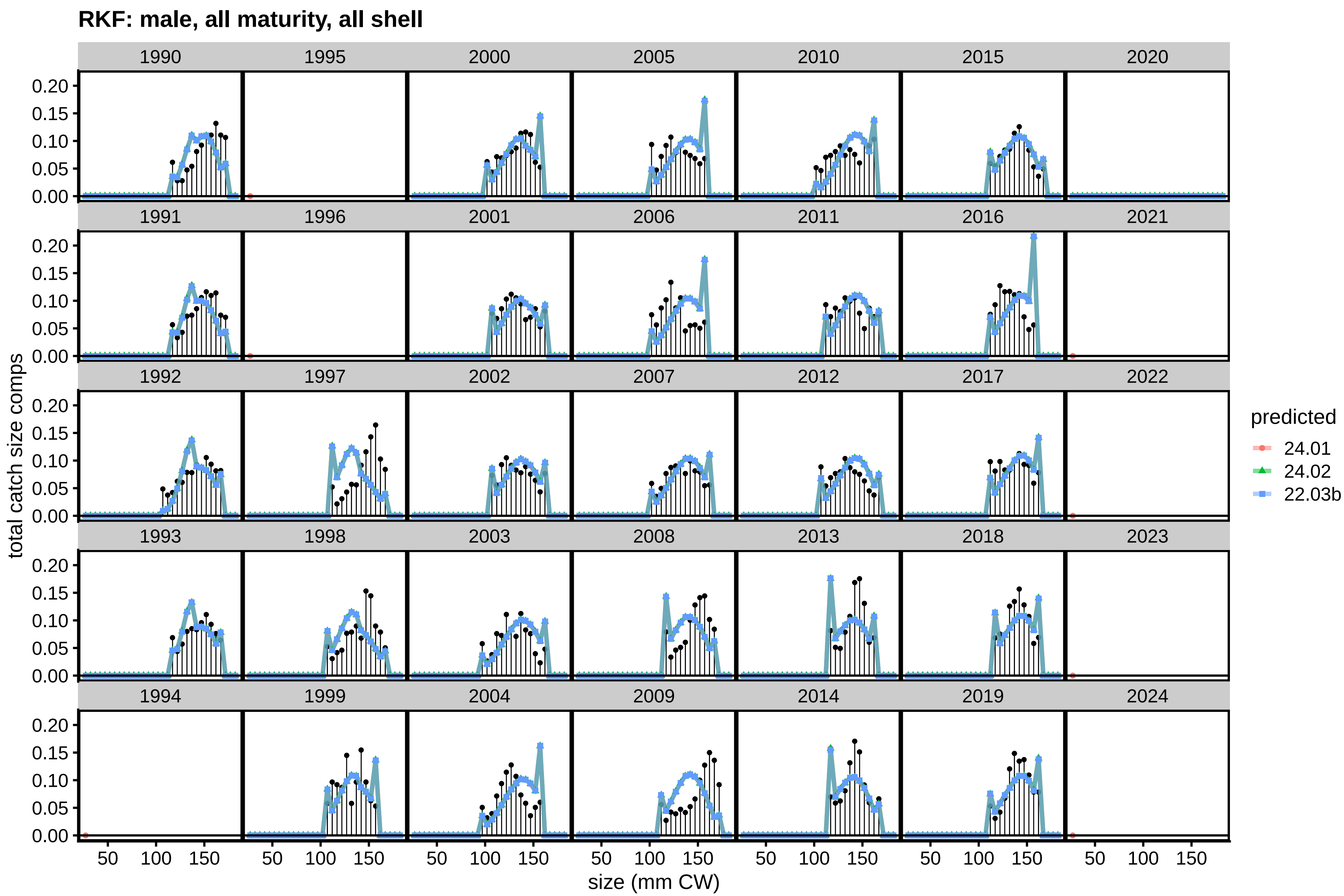

Figure 84. TCSAM02 models fits to total catch size compostiions in the RKF fishery. Preferred model is 24.01.TCSAM02 models fits to total catch size compostiions in the RKF fishery. Preferred model is 24.02.

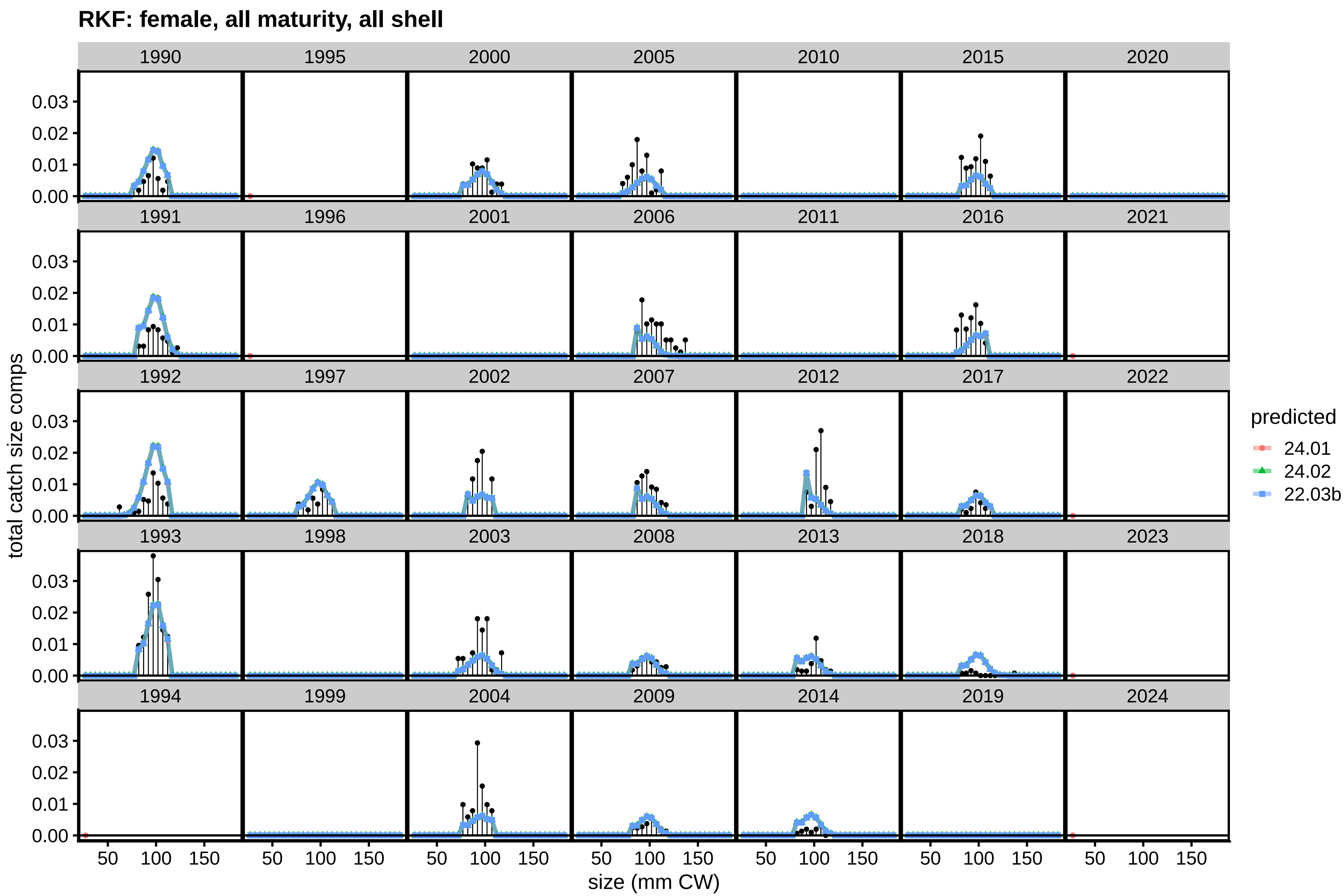

Figure 85. TCSAM02 models fits to total catch size compostiions in the RKF fishery. Preferred model is 24.01.TCSAM02 models fits to total catch size compostiions in the RKF fishery. Preferred model is 24.02.

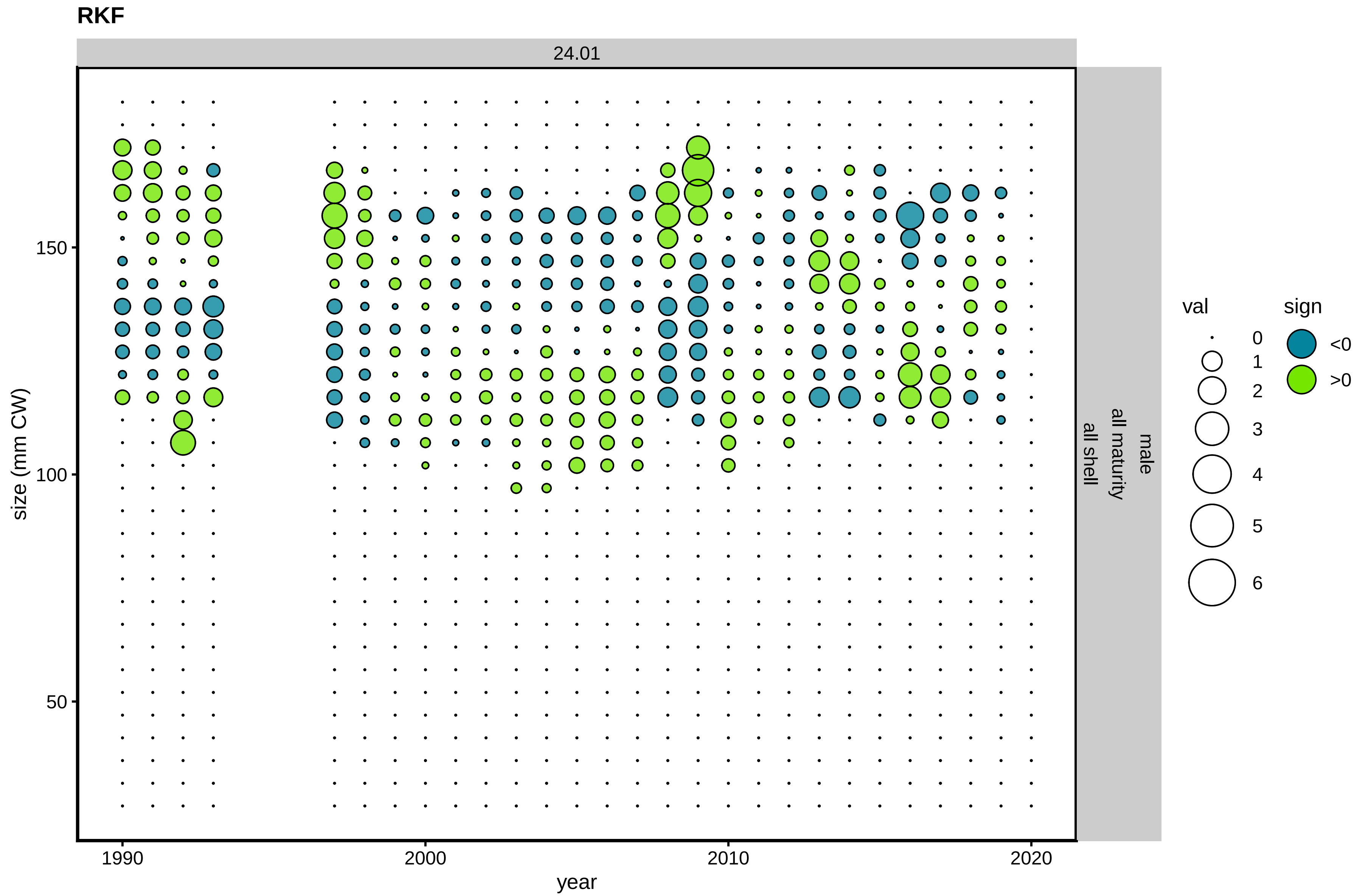

Figure 86. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

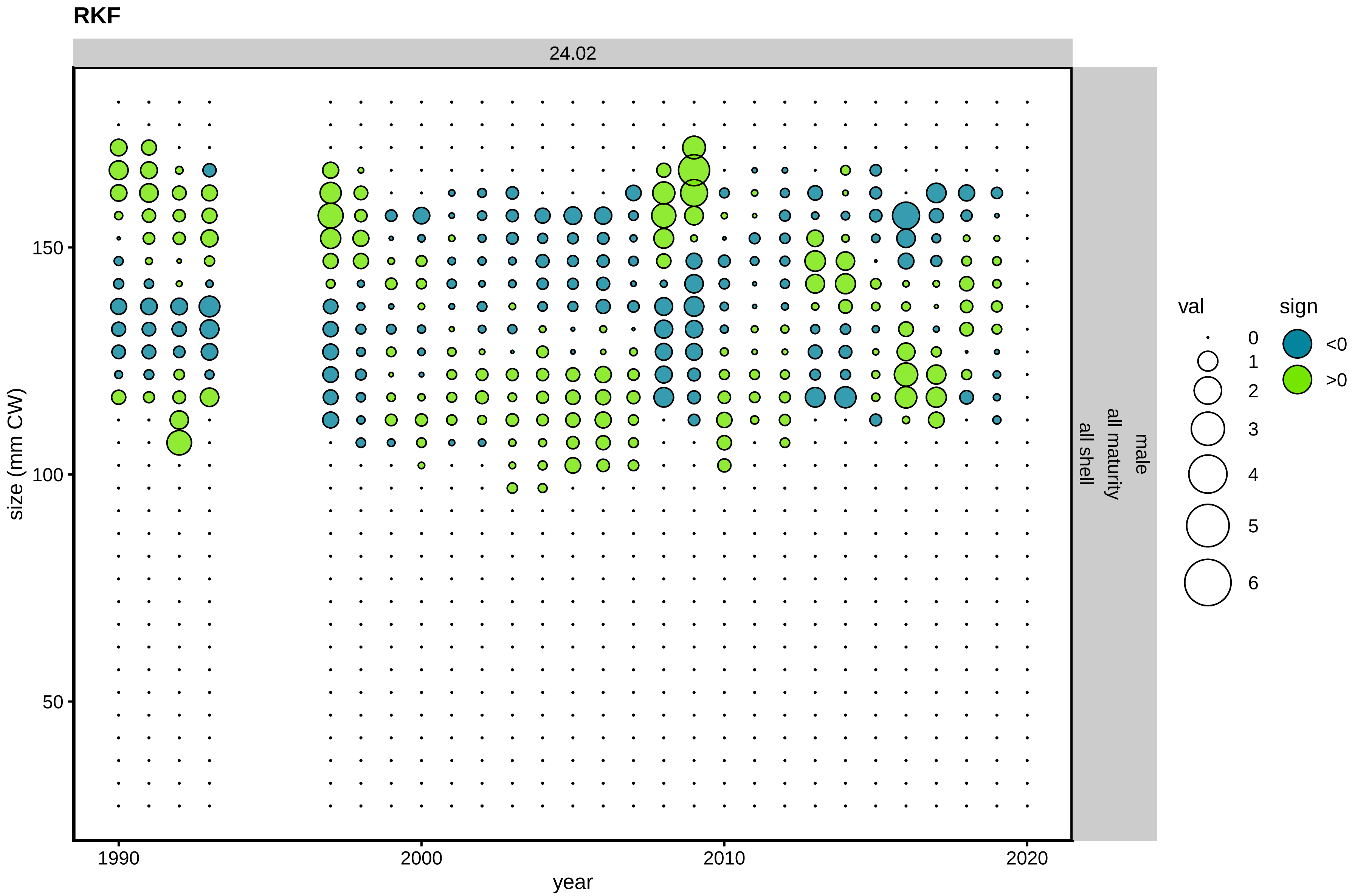

Figure 87. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

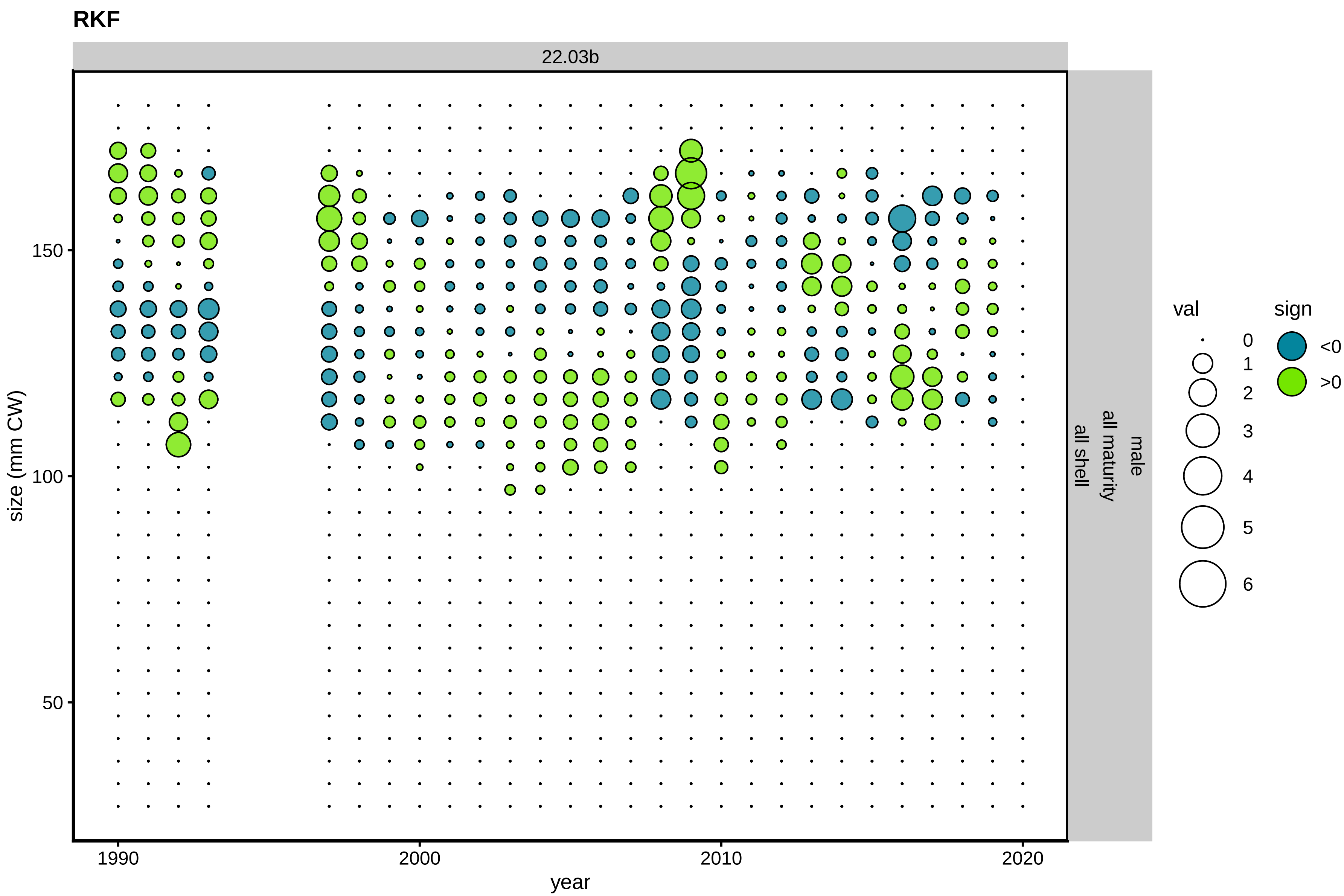

Figure 88. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

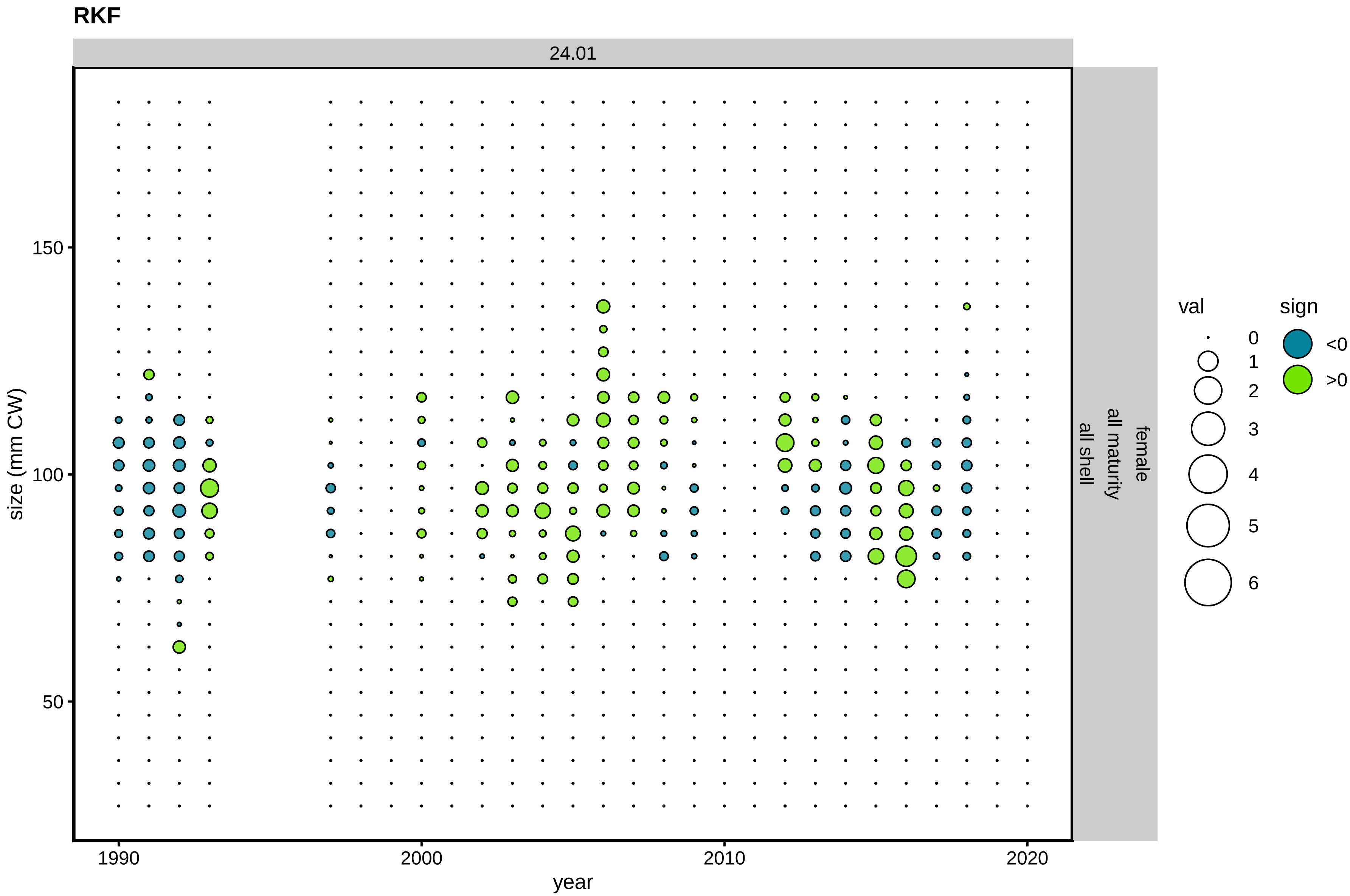

Figure 89. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

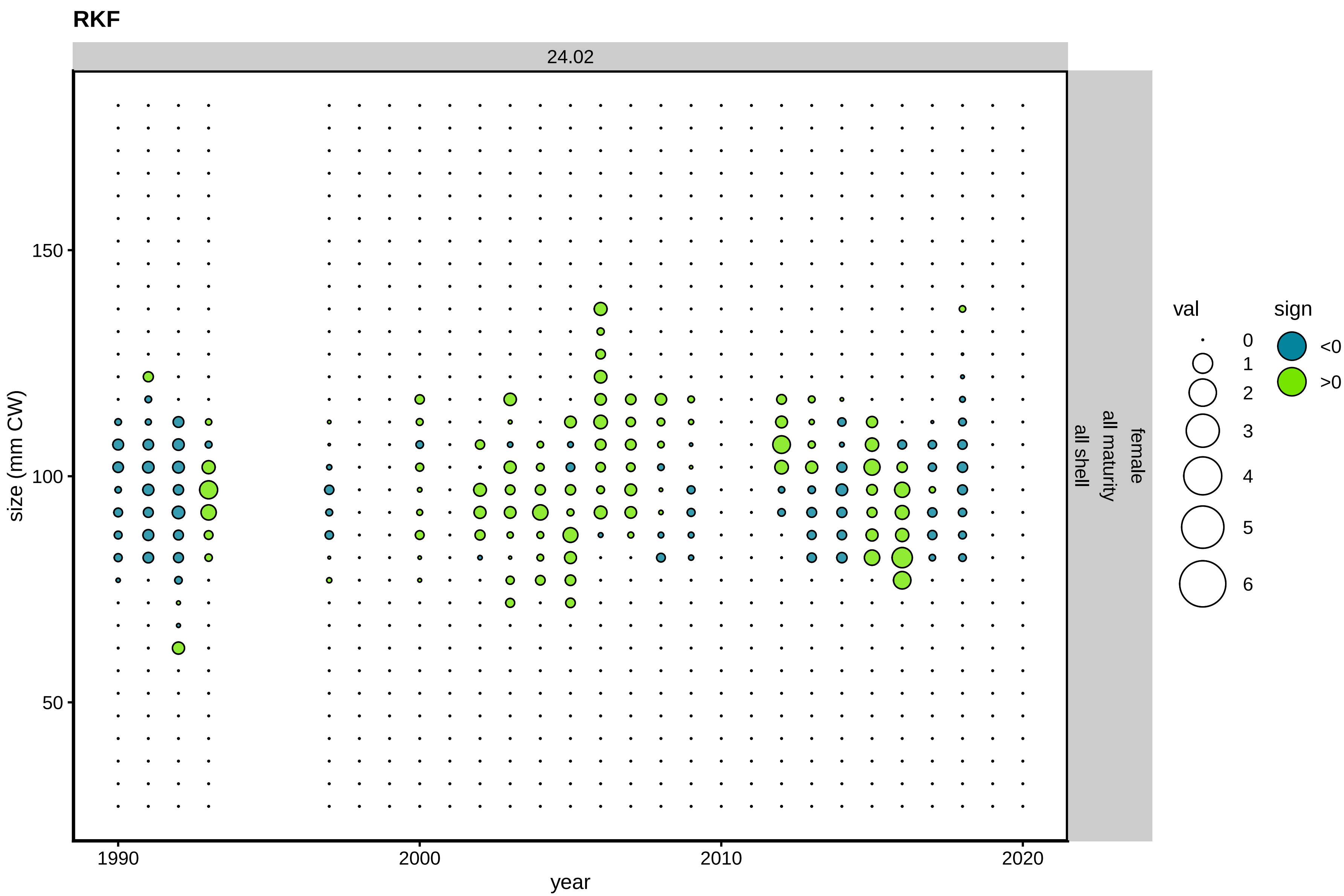

Figure 90. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

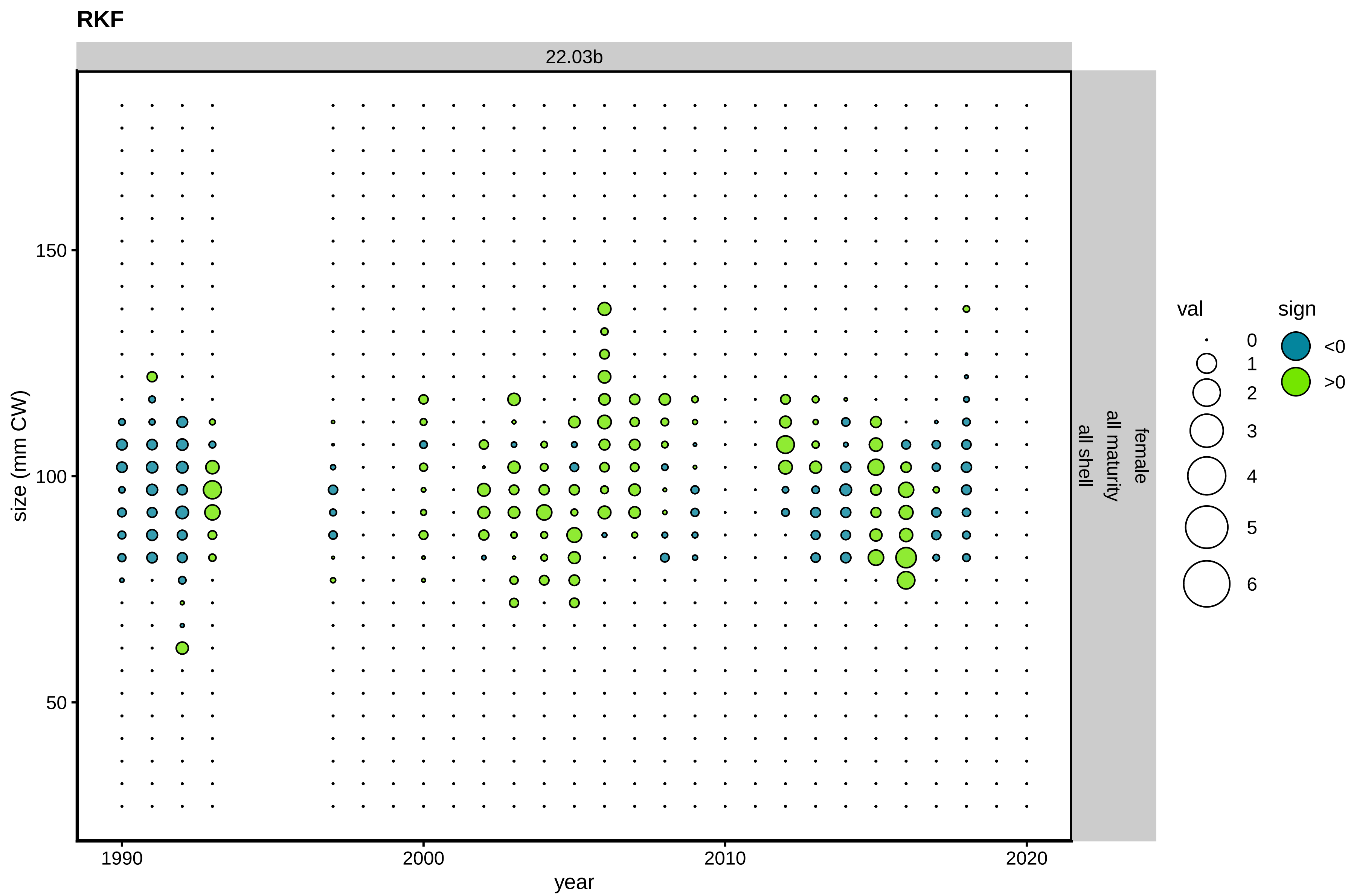

Figure 91. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

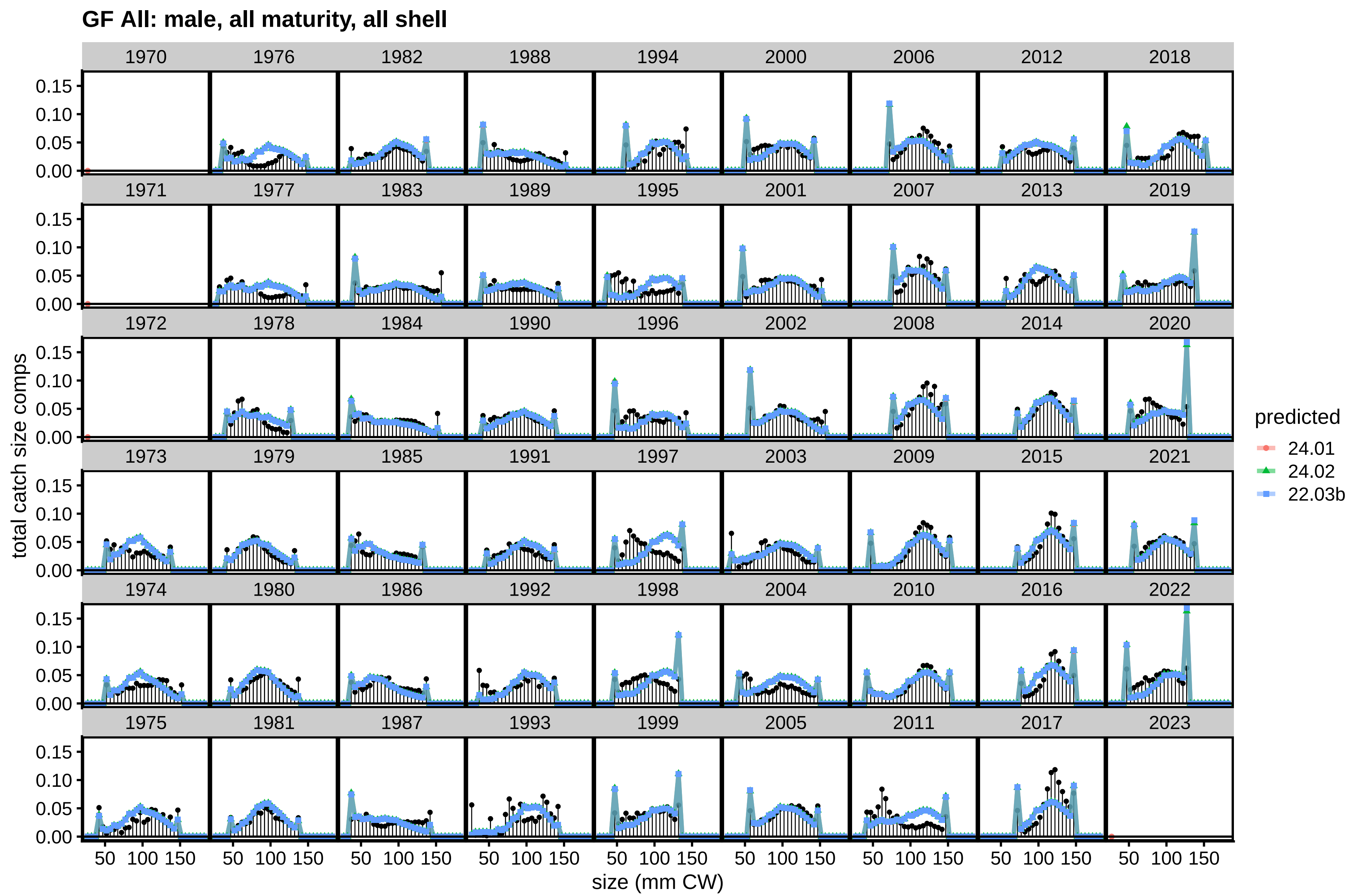

Figure 92. TCSAM02 models fits to total catch size compostiions in the GF All fishery.

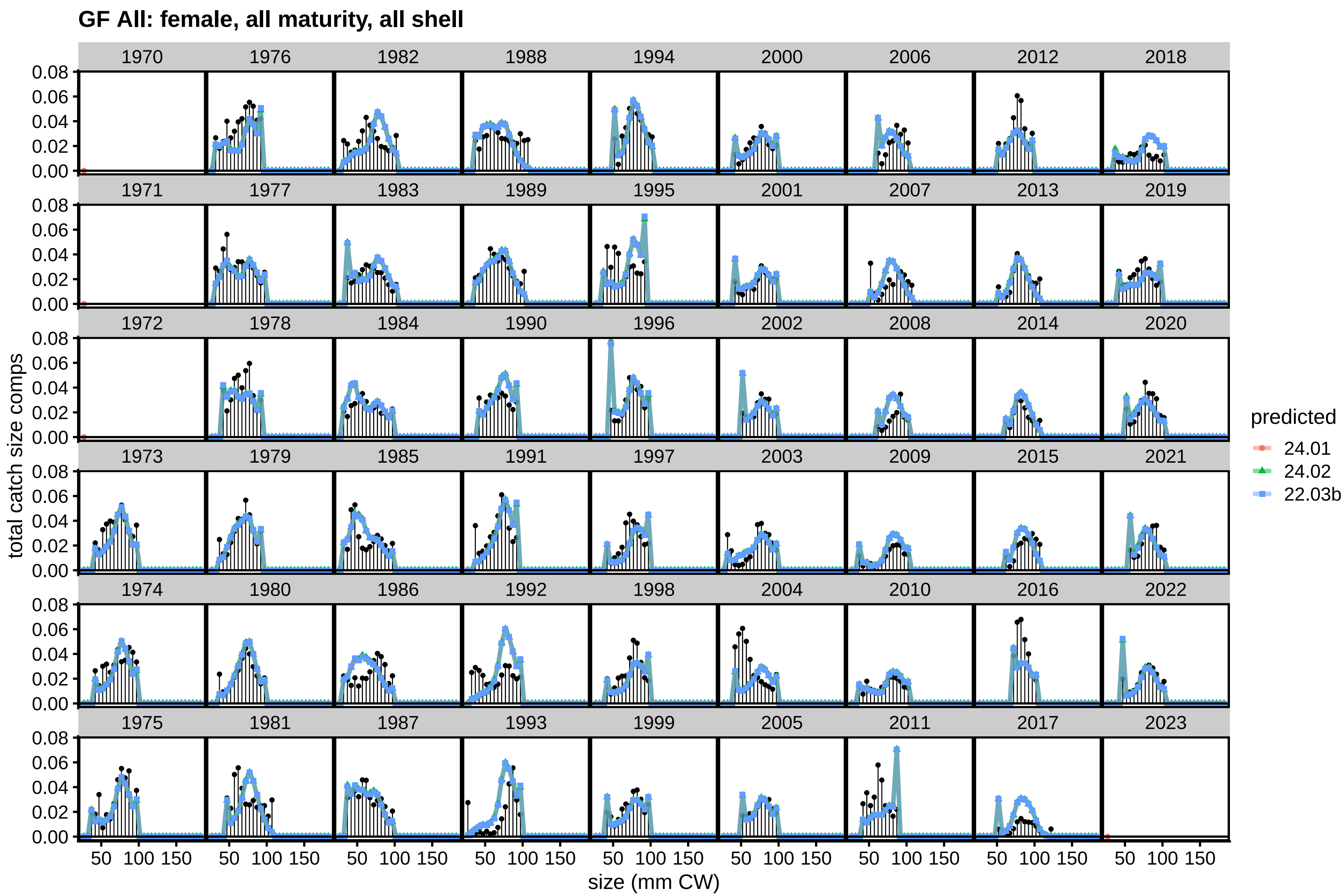

Figure 93. TCSAM02 models fits to total catch size compostiions in the GF All fishery.

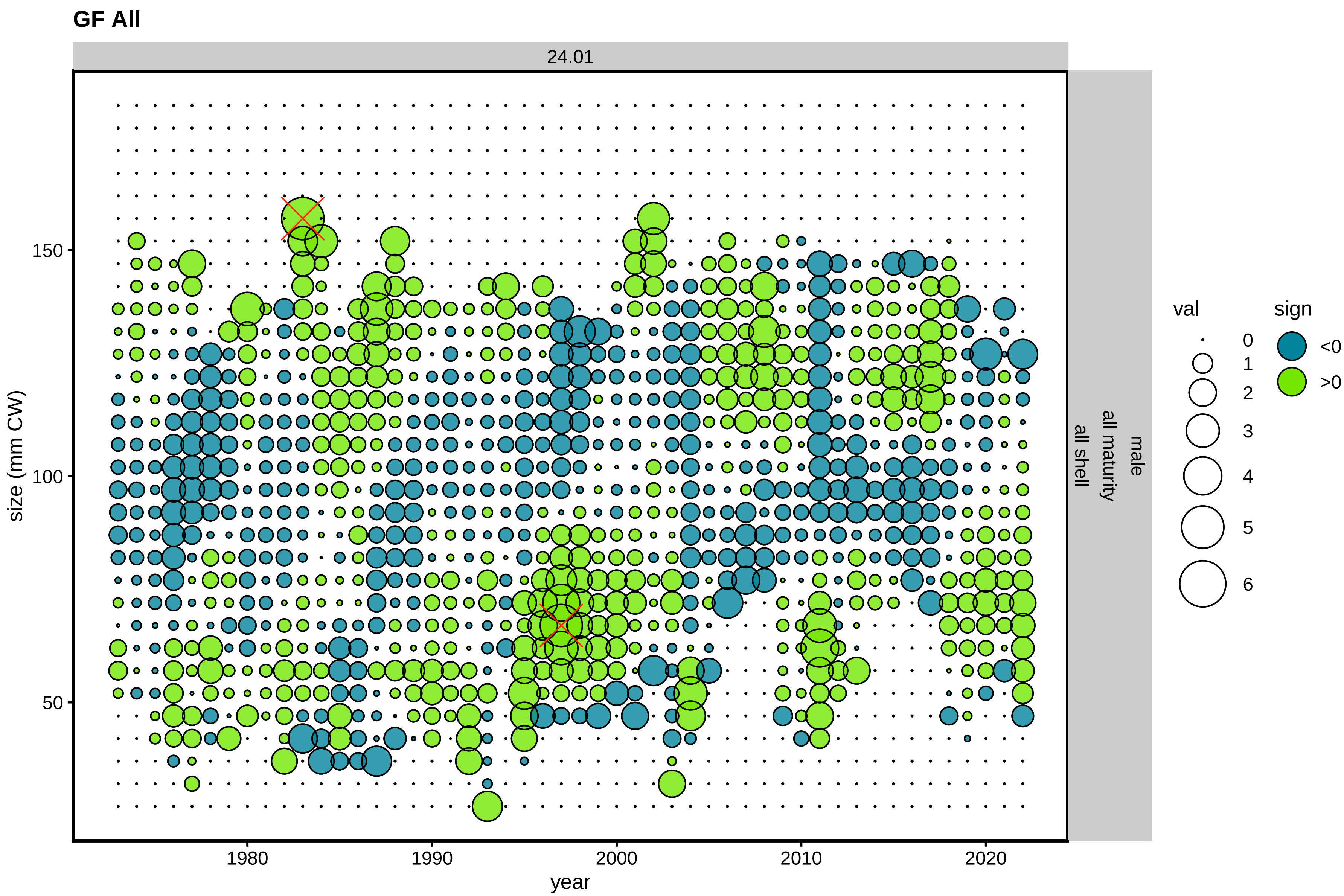

Figure 94. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

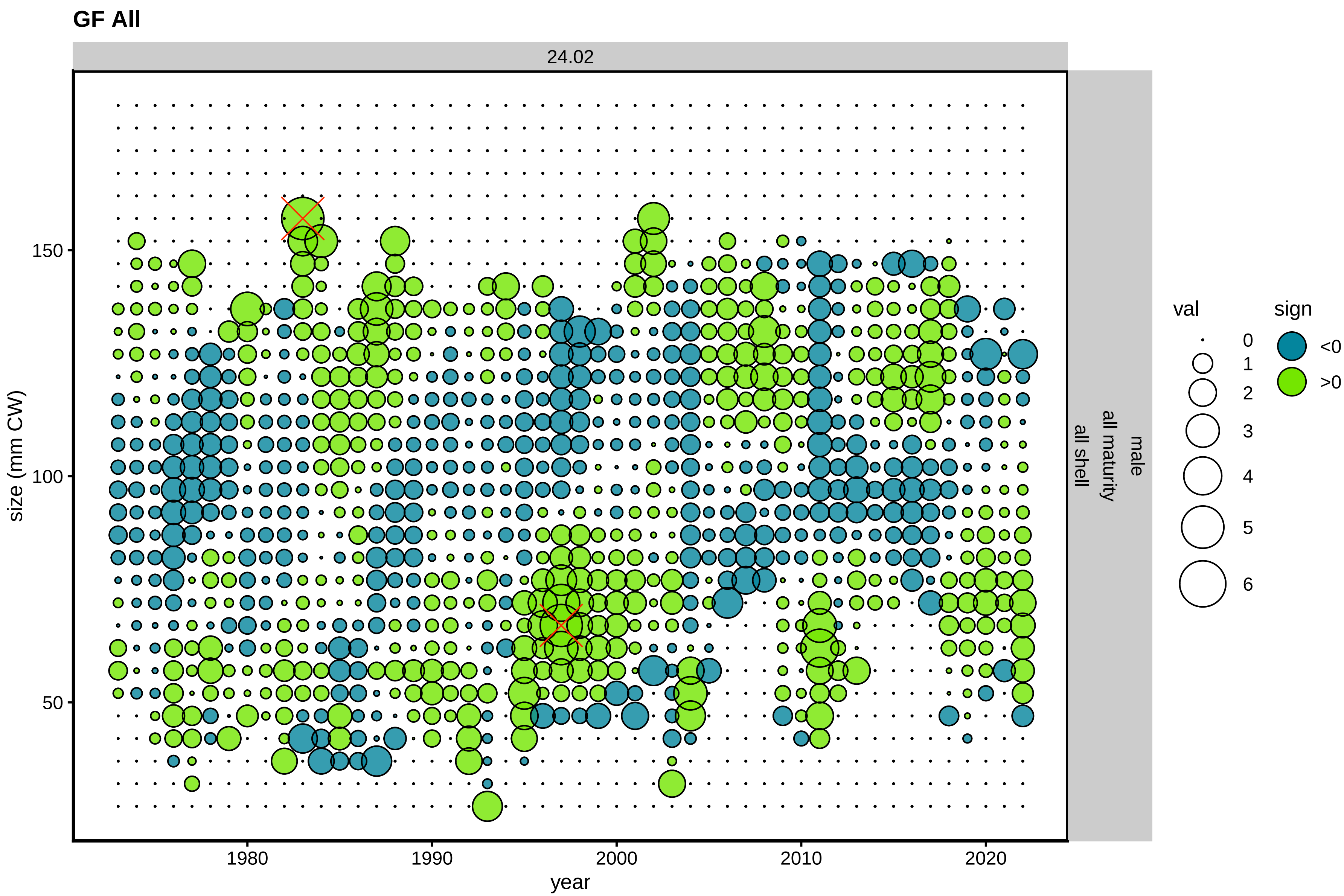

Figure 95. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

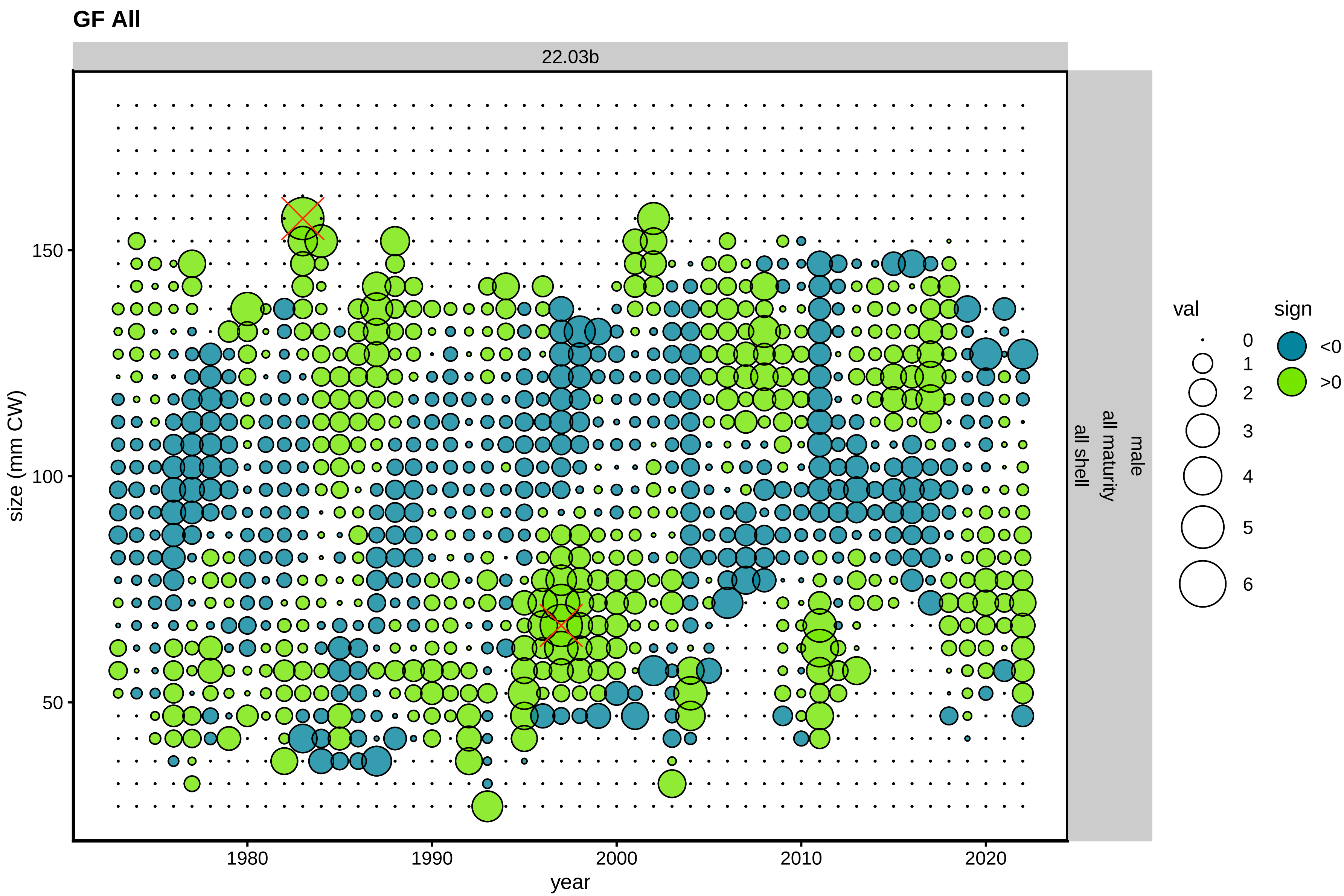

Figure 96. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

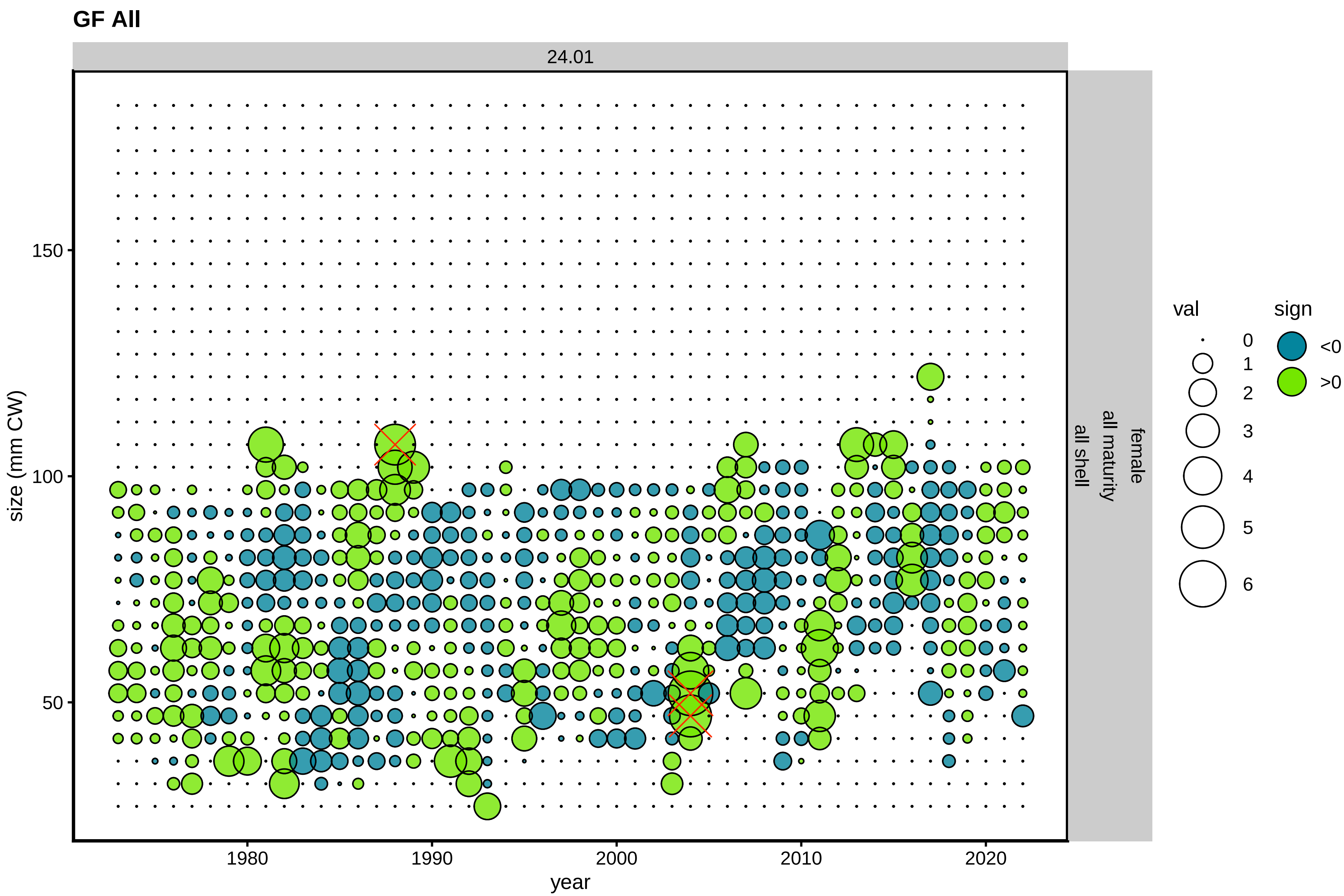

Figure 97. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

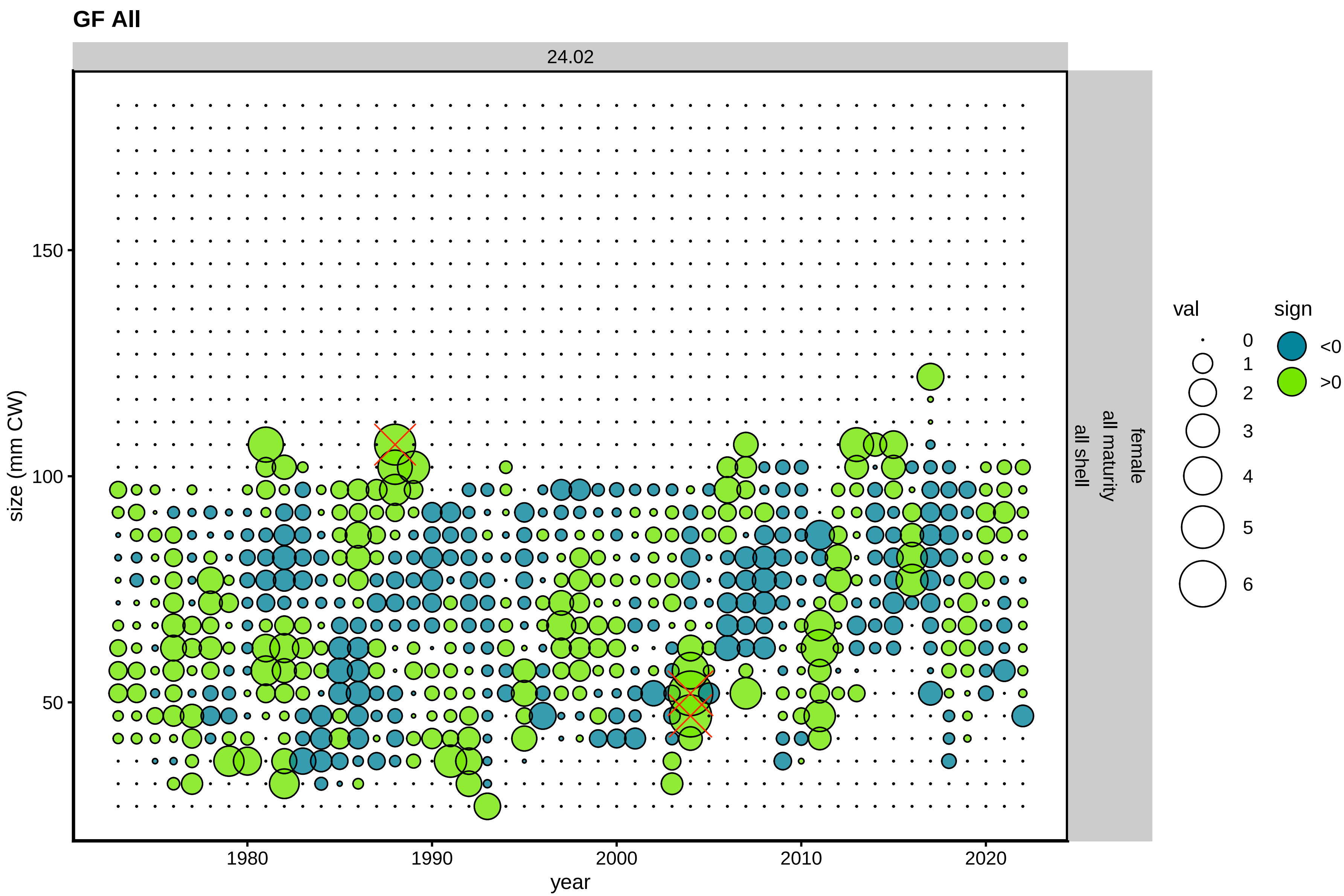

Figure 98. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

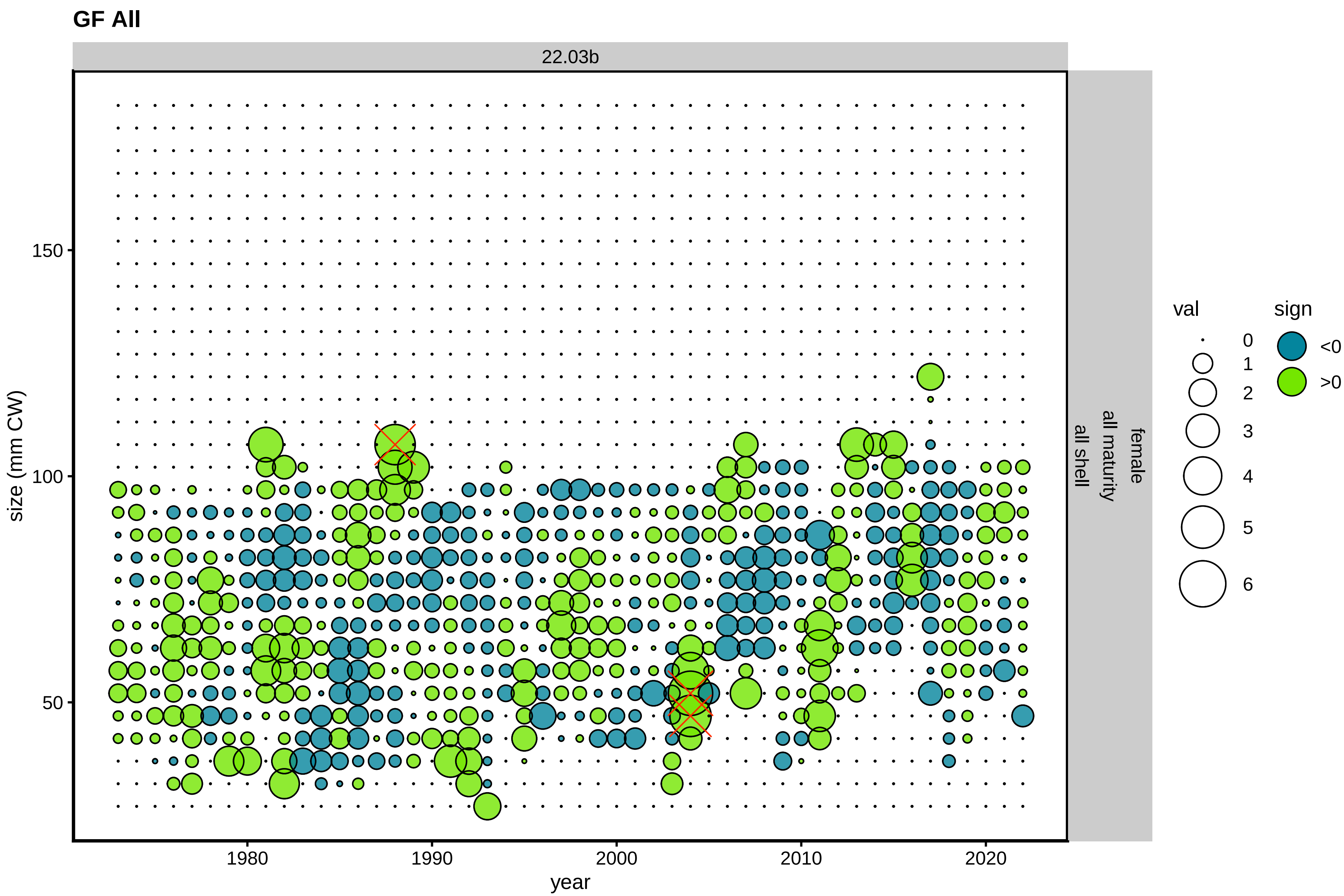

Figure 99. Pearson's residuals for fits to total catch size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

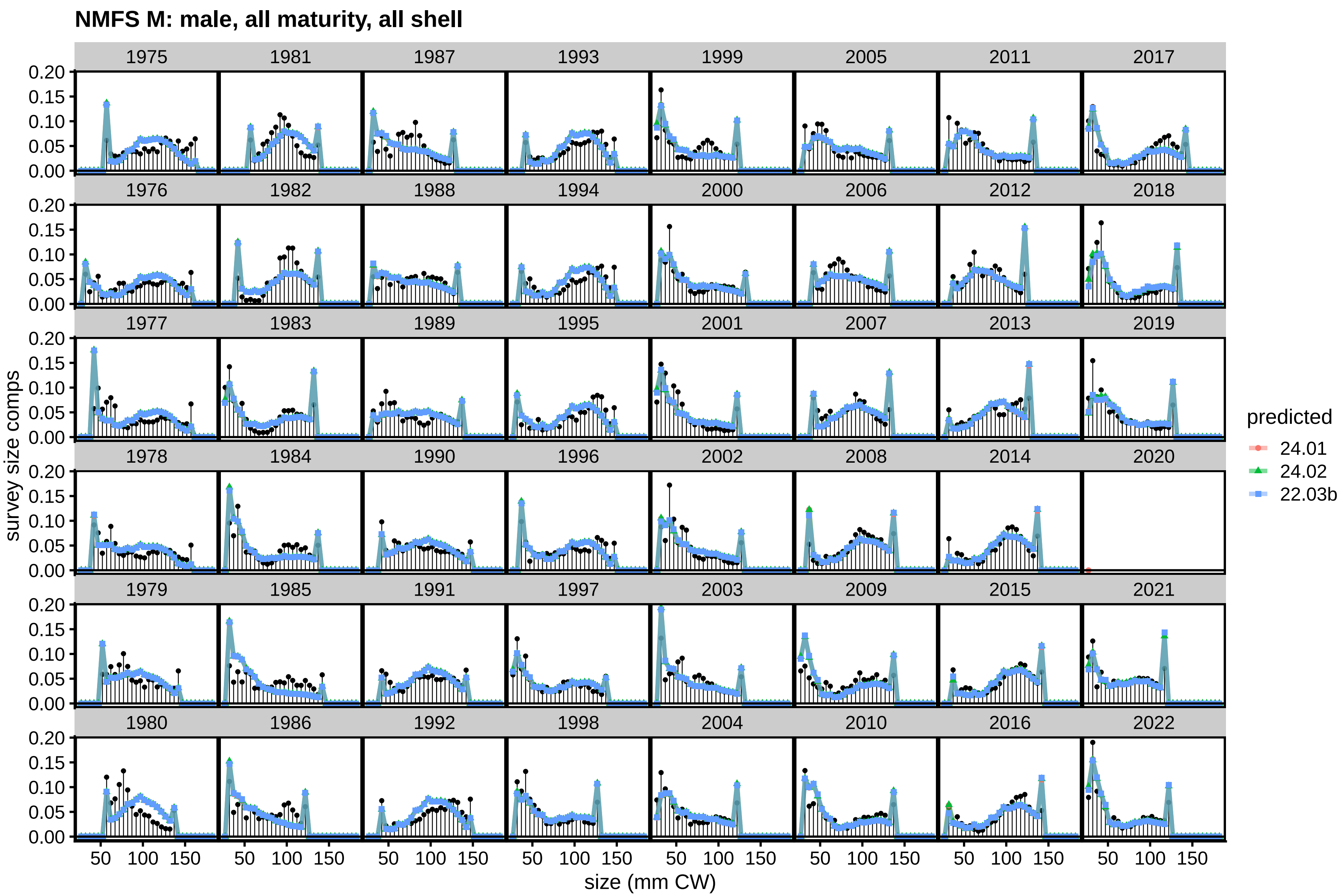

Figure 100. TCSAM02 models fits to survey size compositions in the NMFS M survey. Preferred model is 24.01.TCSAM02 models fits to survey size compositions in the NMFS M survey. Preferred model is 24.02.

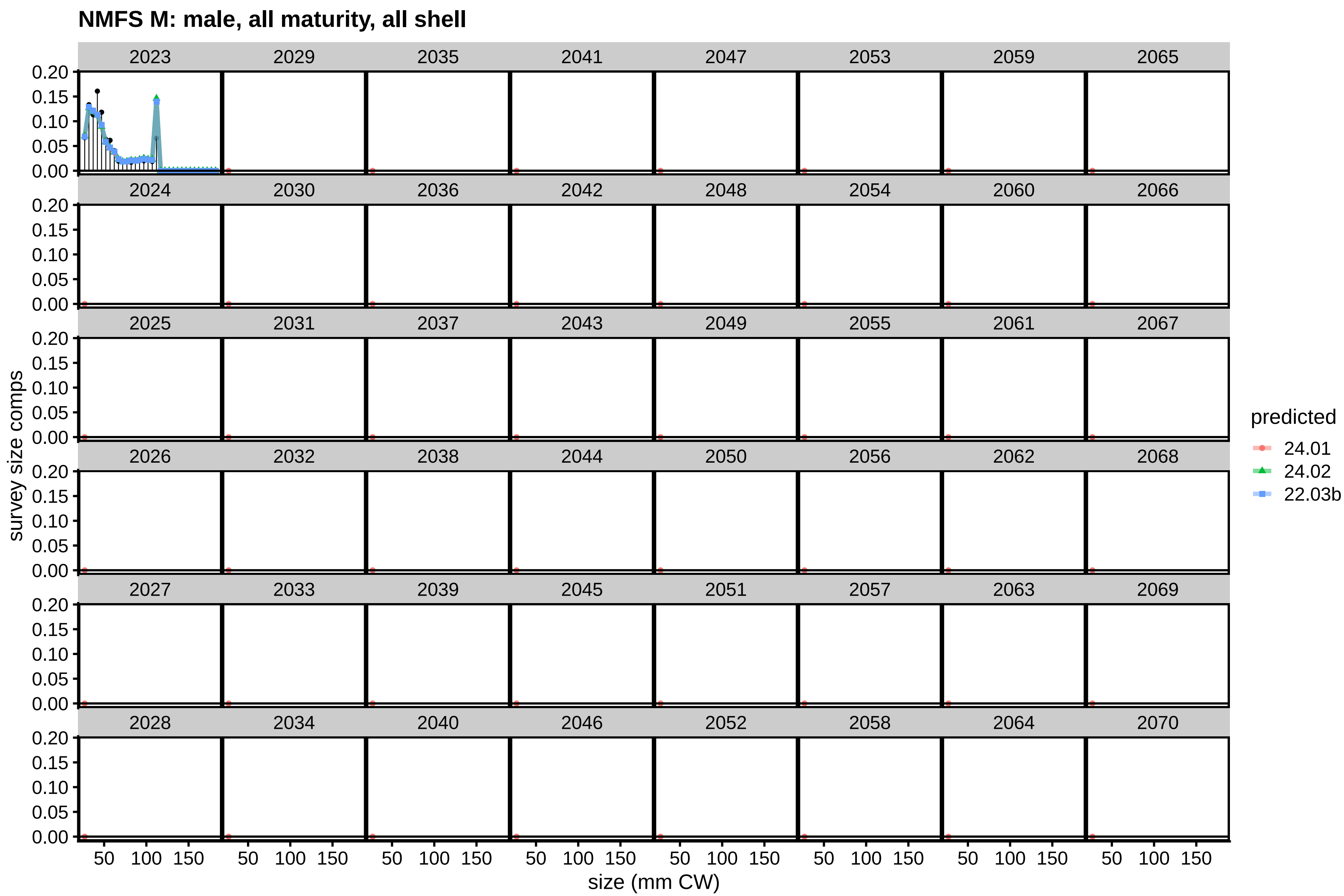

Figure 101. TCSAM02 models fits to survey size compositions in the NMFS M survey. Preferred model is 24.01.TCSAM02 models fits to survey size compositions in the NMFS M survey. Preferred model is 24.02.

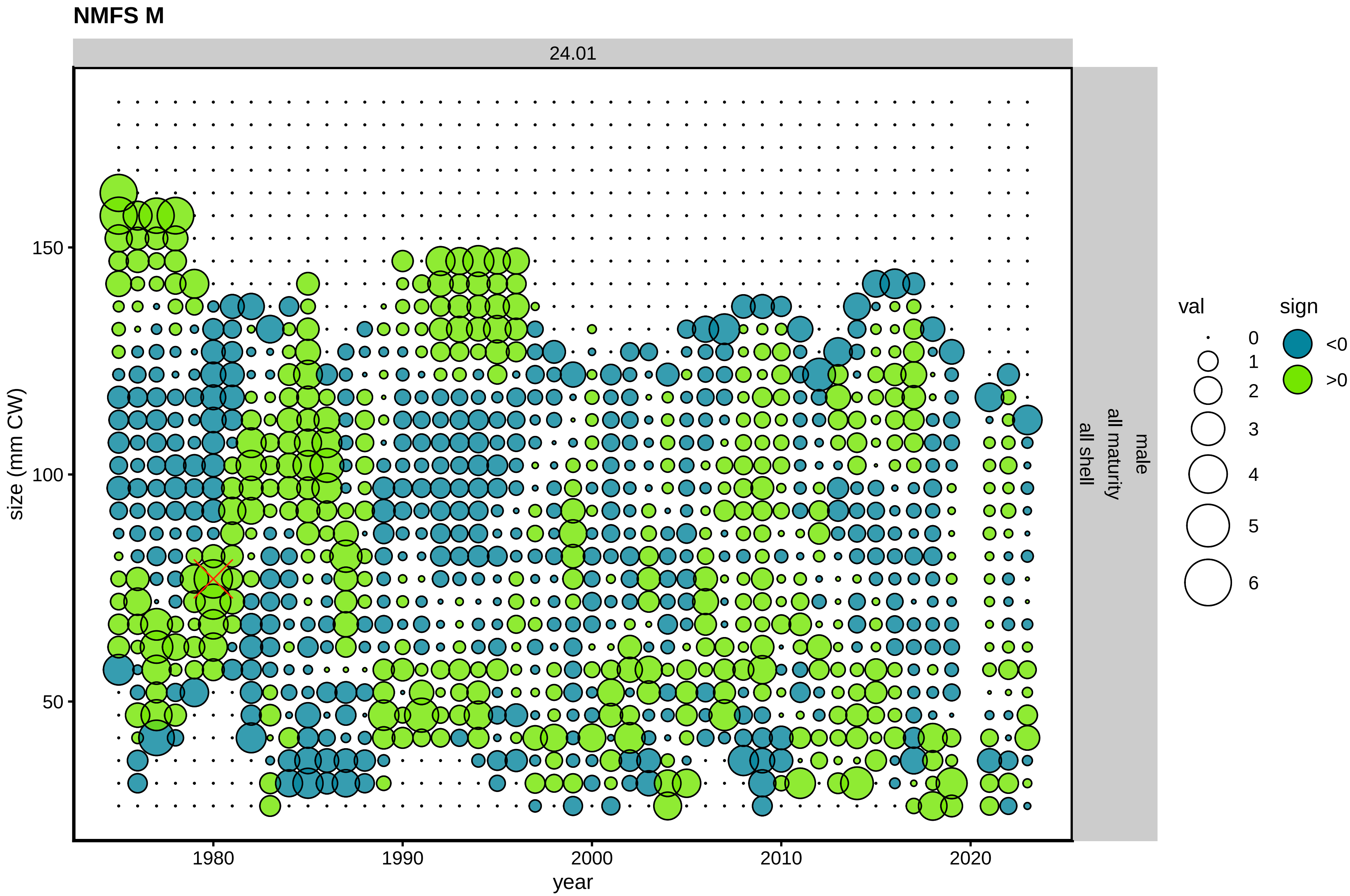

Figure 102. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

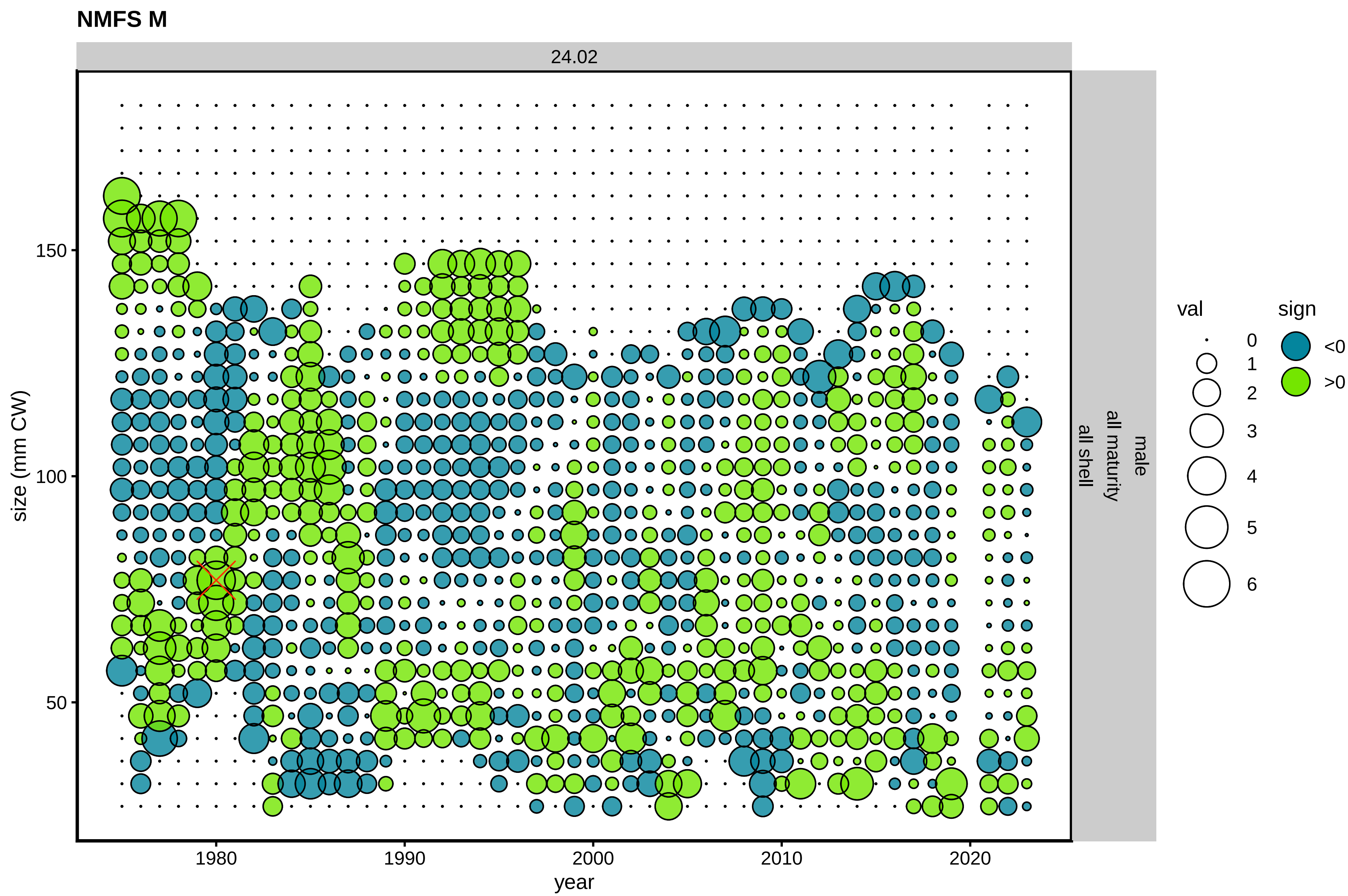

Figure 103. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

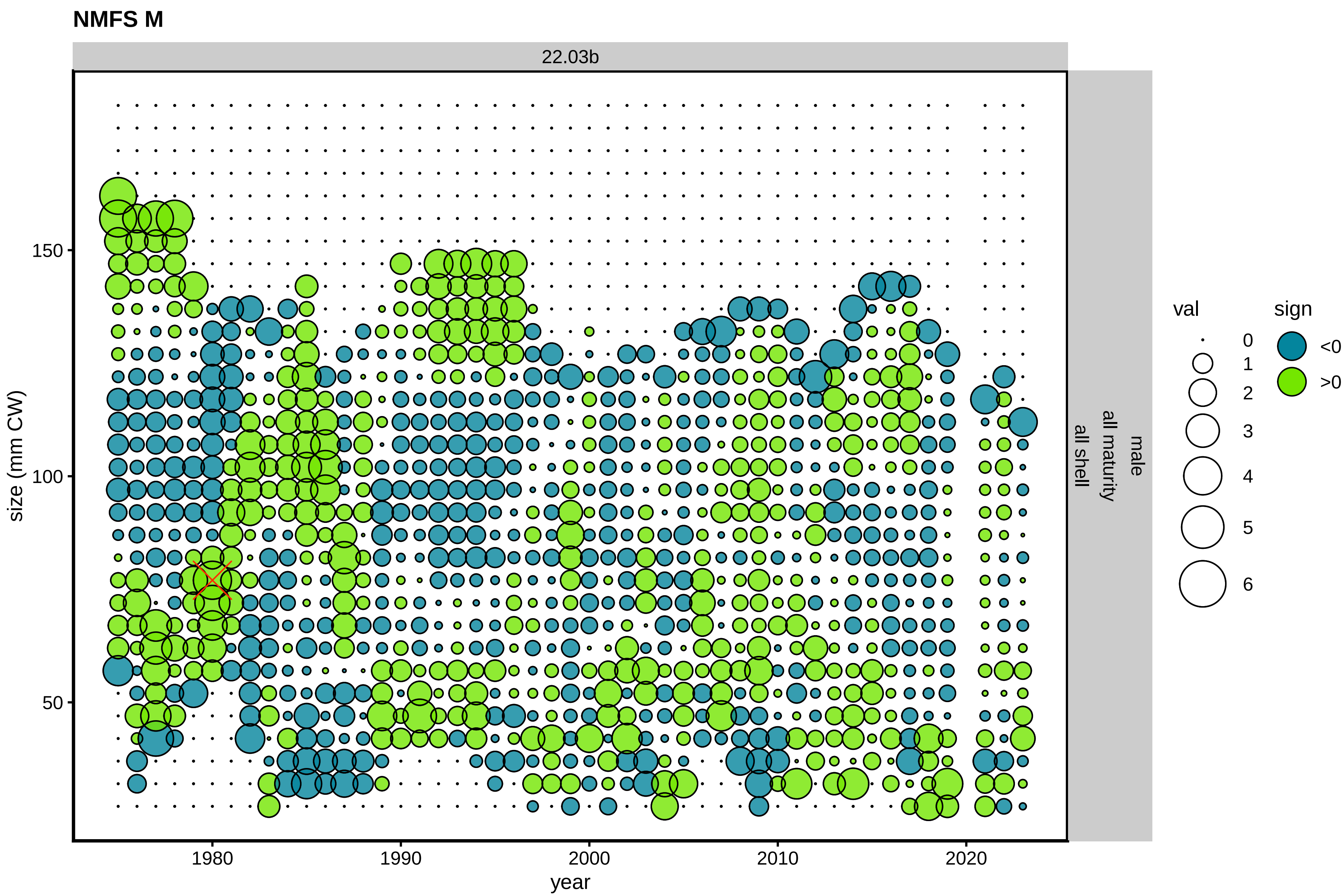

Figure 104. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

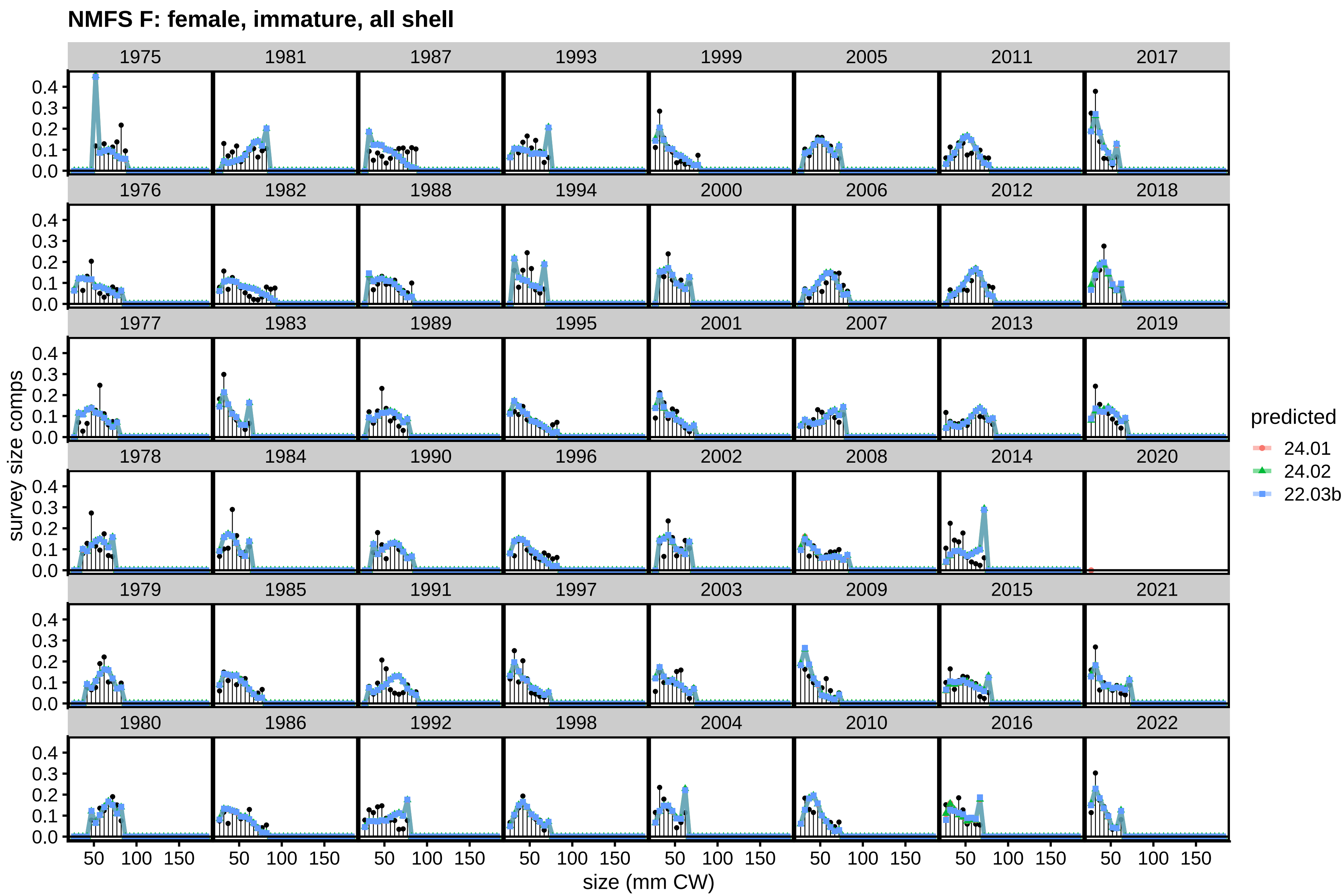

Figure 105. TCSAM02 models fits to survey size compositions in the NMFS F survey. Preferred model is 24.01.TCSAM02 models fits to survey size compositions in the NMFS F survey. Preferred model is 24.02.

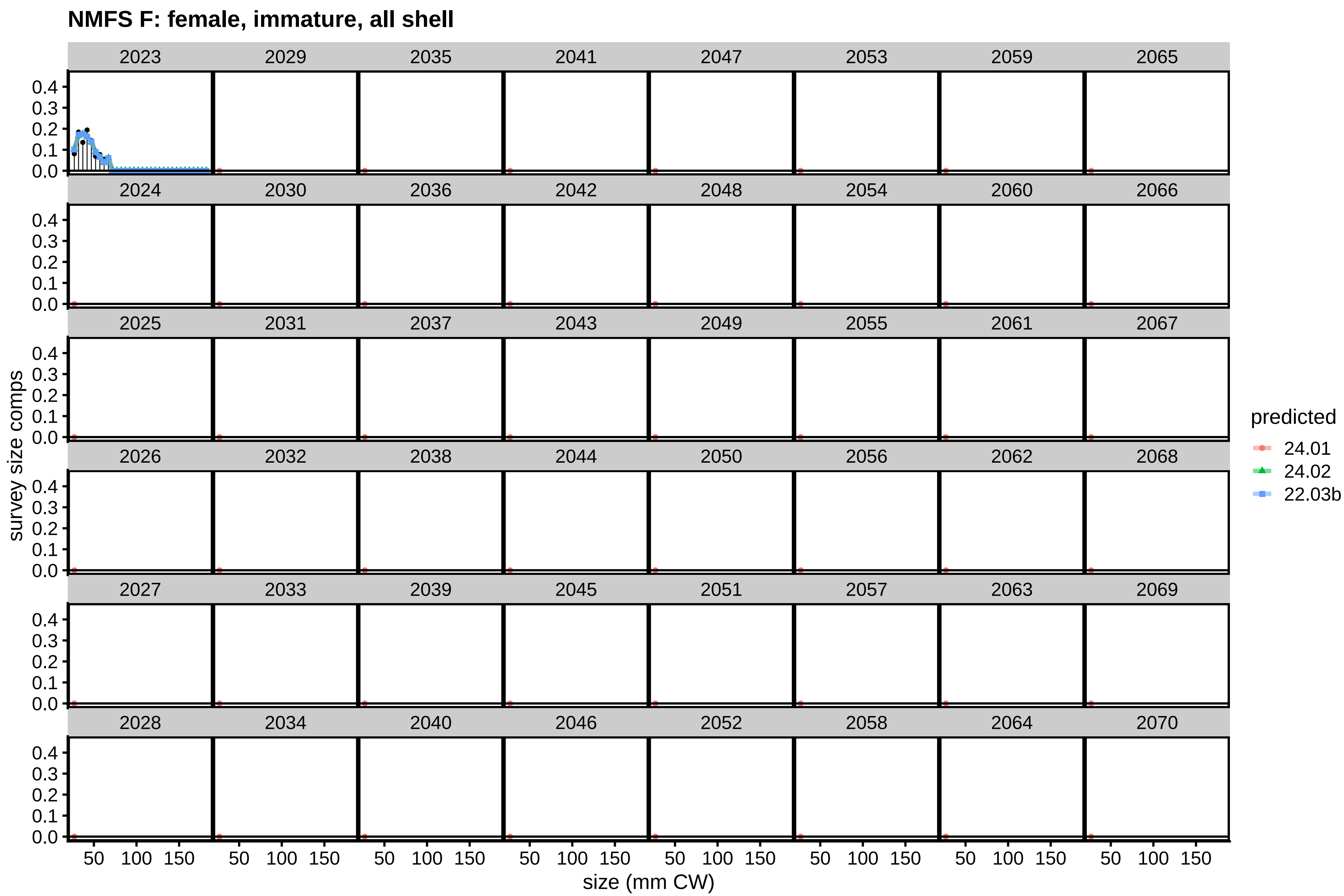

Figure 106. TCSAM02 models fits to survey size compositions in the NMFS F survey. Preferred model is 24.01.TCSAM02 models fits to survey size compositions in the NMFS F survey. Preferred model is 24.02.

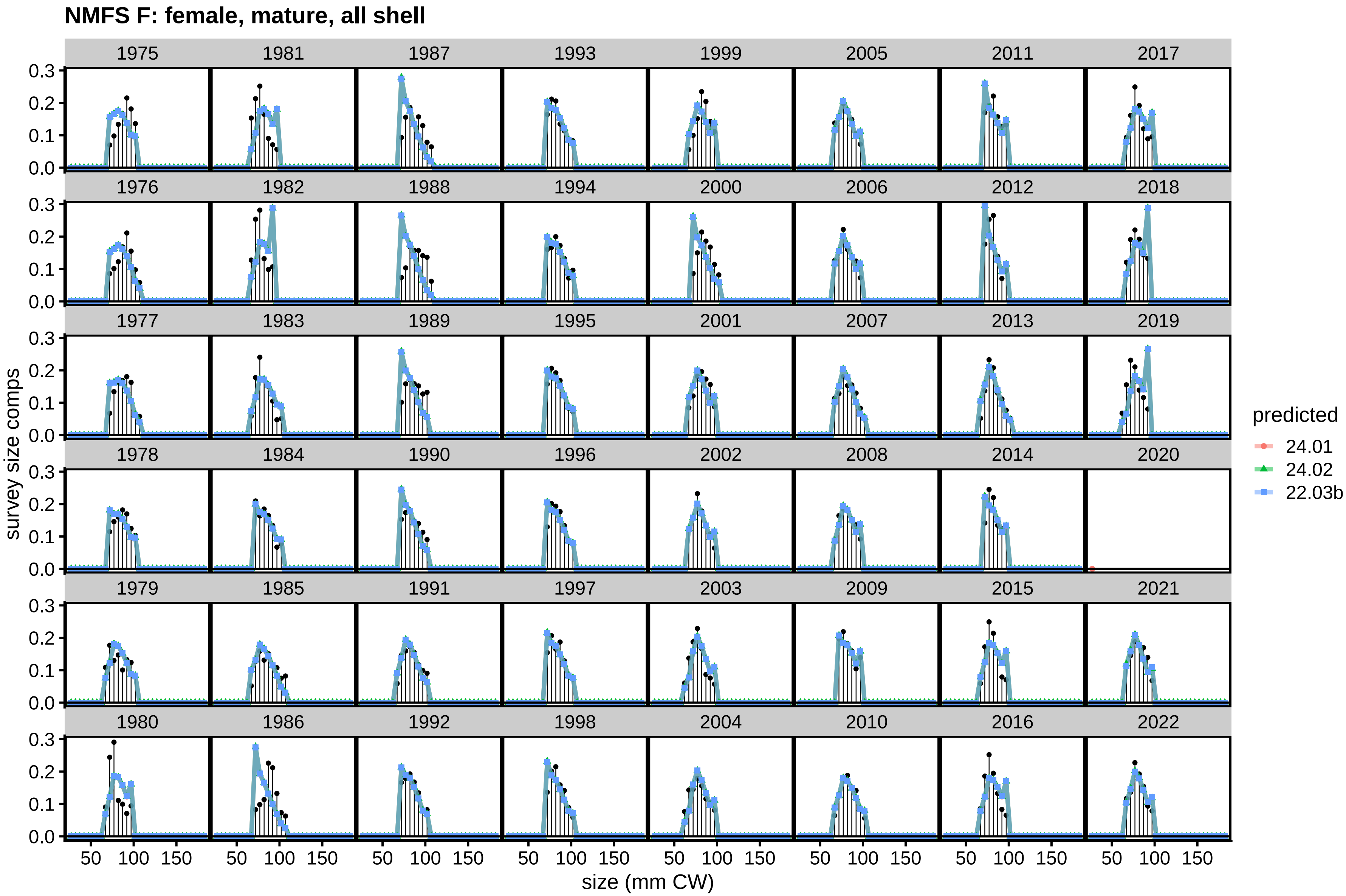

Figure 107. TCSAM02 models fits to survey size compositions in the NMFS F survey. Preferred model is 24.01.TCSAM02 models fits to survey size compositions in the NMFS F survey. Preferred model is 24.02.

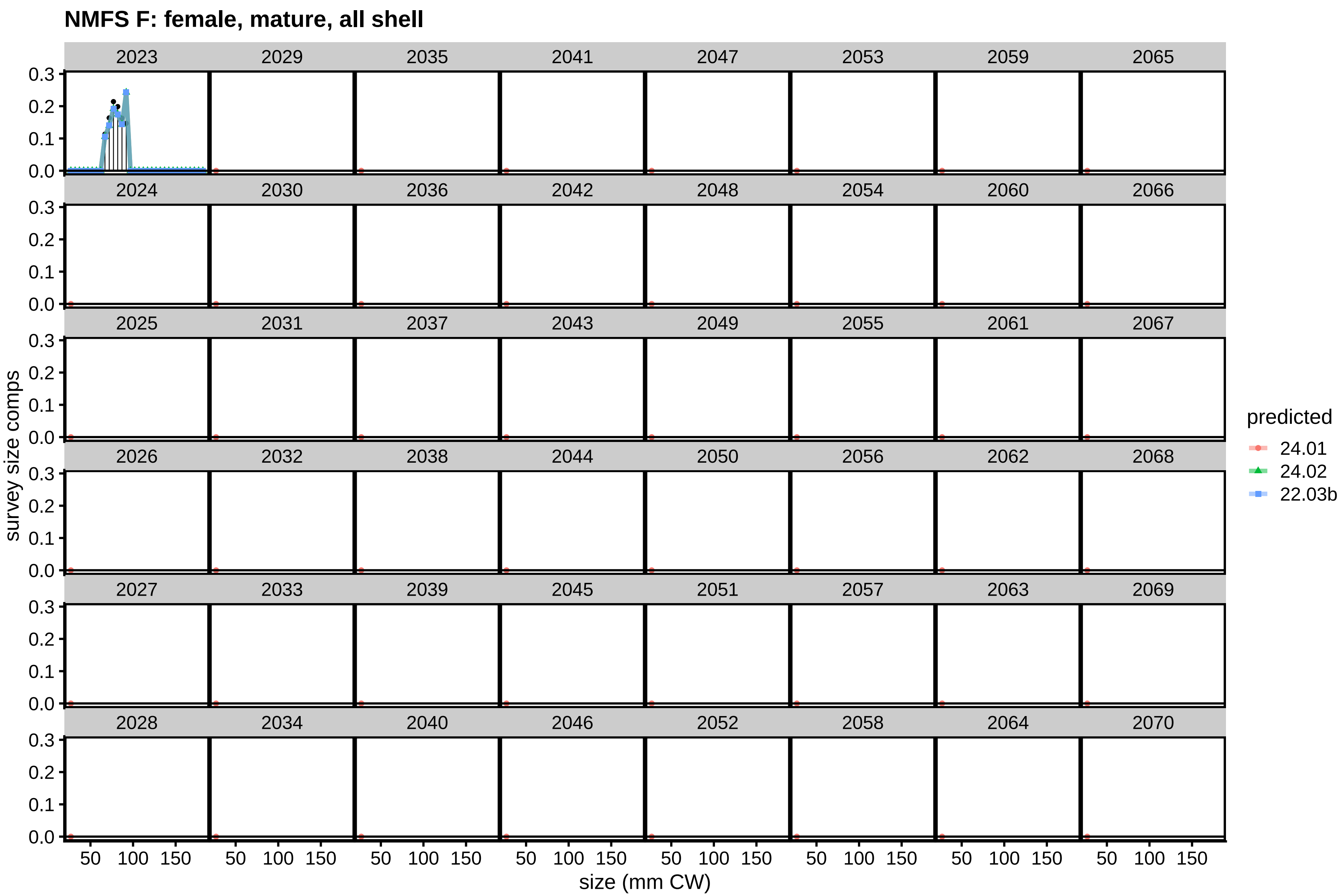

Figure 108. TCSAM02 models fits to survey size compositions in the NMFS F survey. Preferred model is 24.01.TCSAM02 models fits to survey size compositions in the NMFS F survey. Preferred model is 24.02.

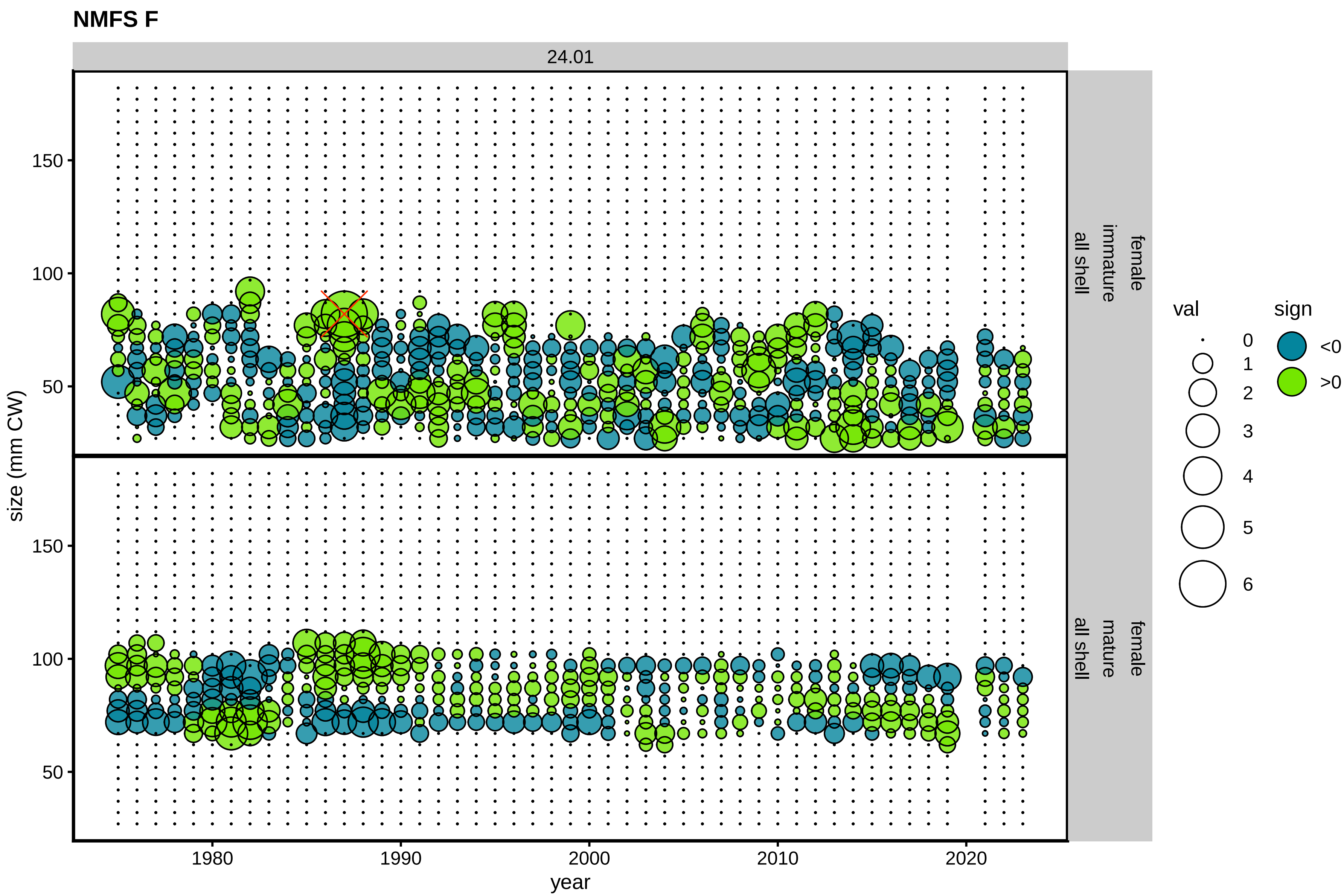

Figure 109. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

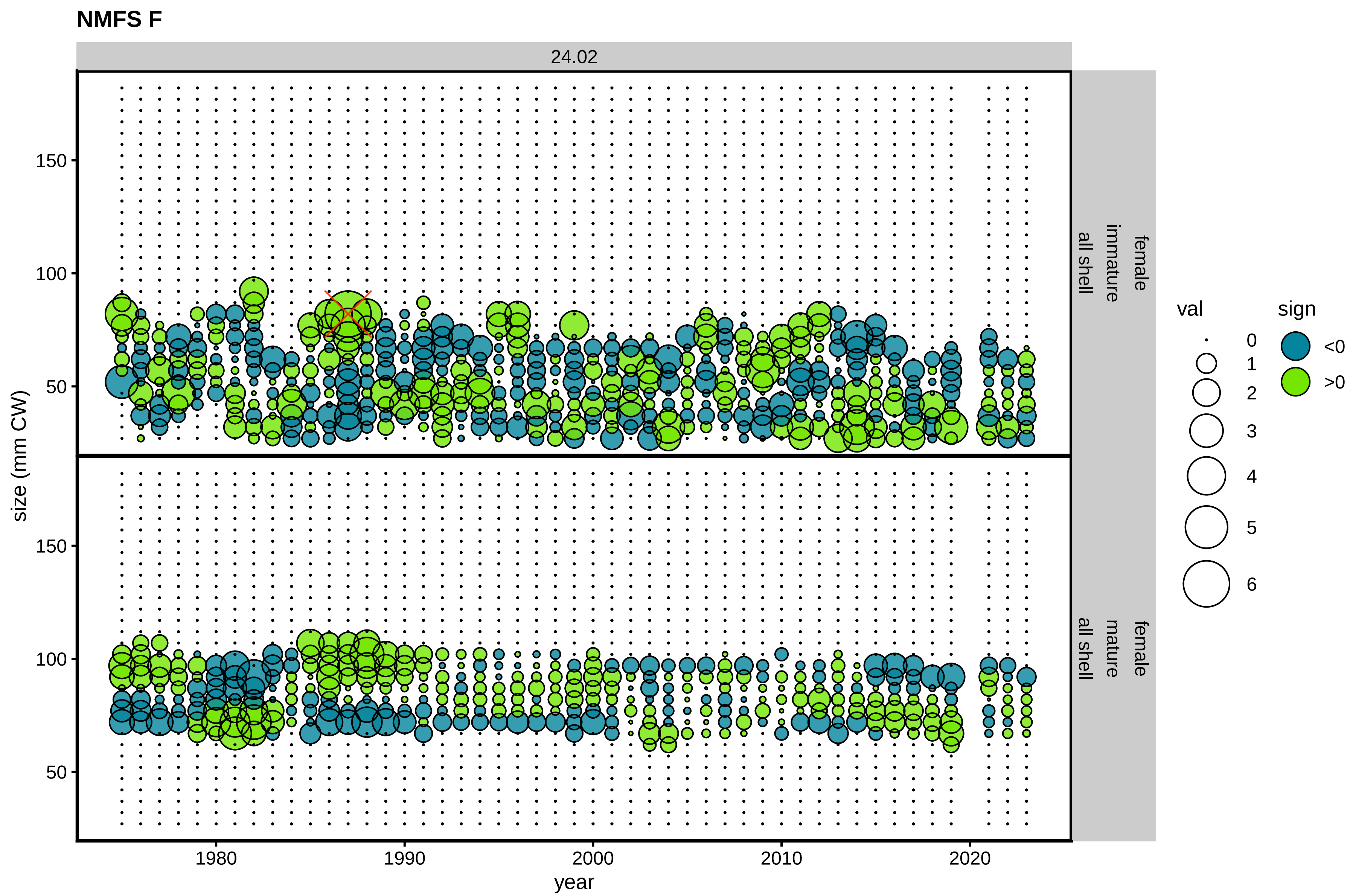

Figure 110. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

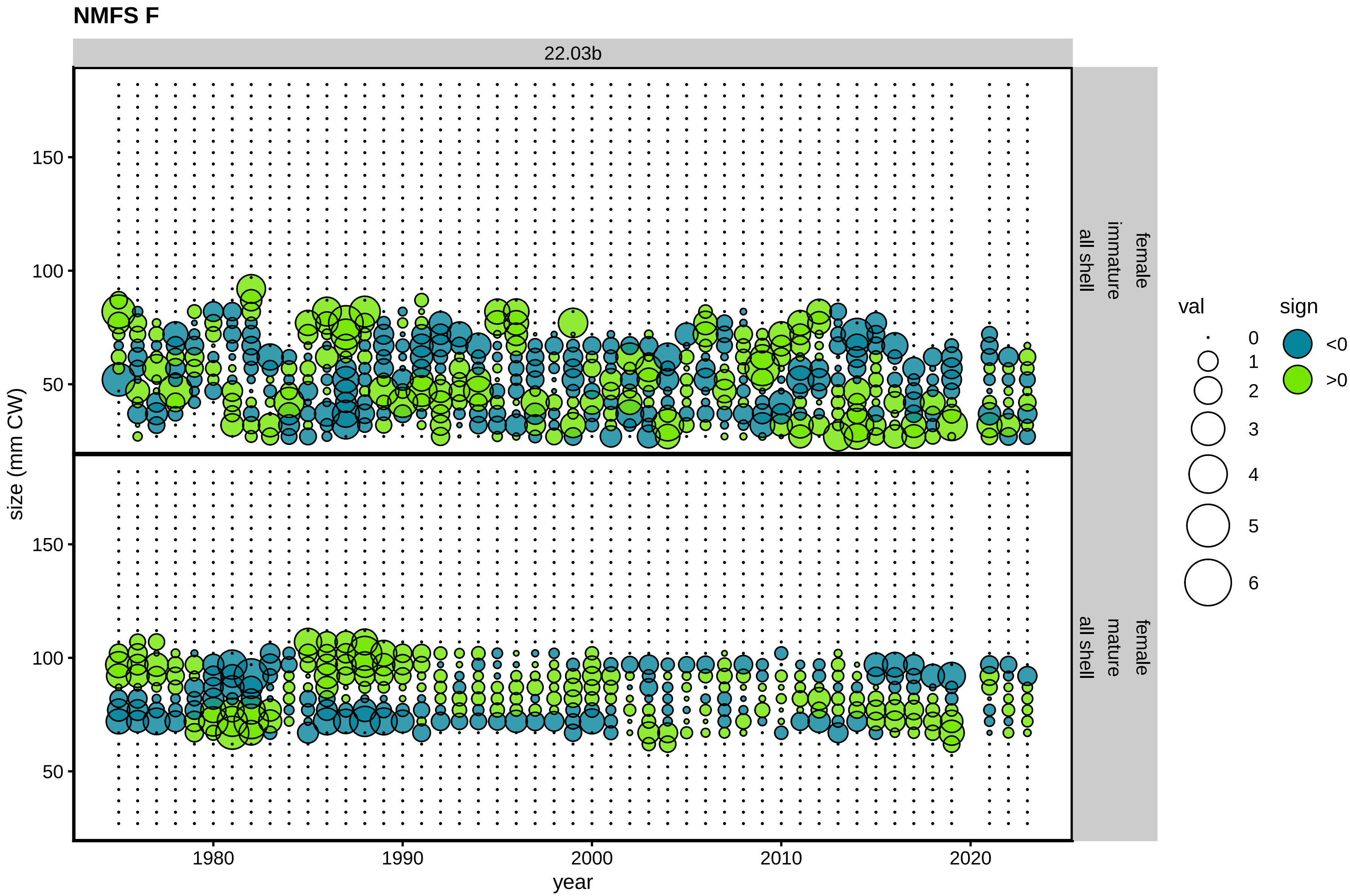

Figure 111. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

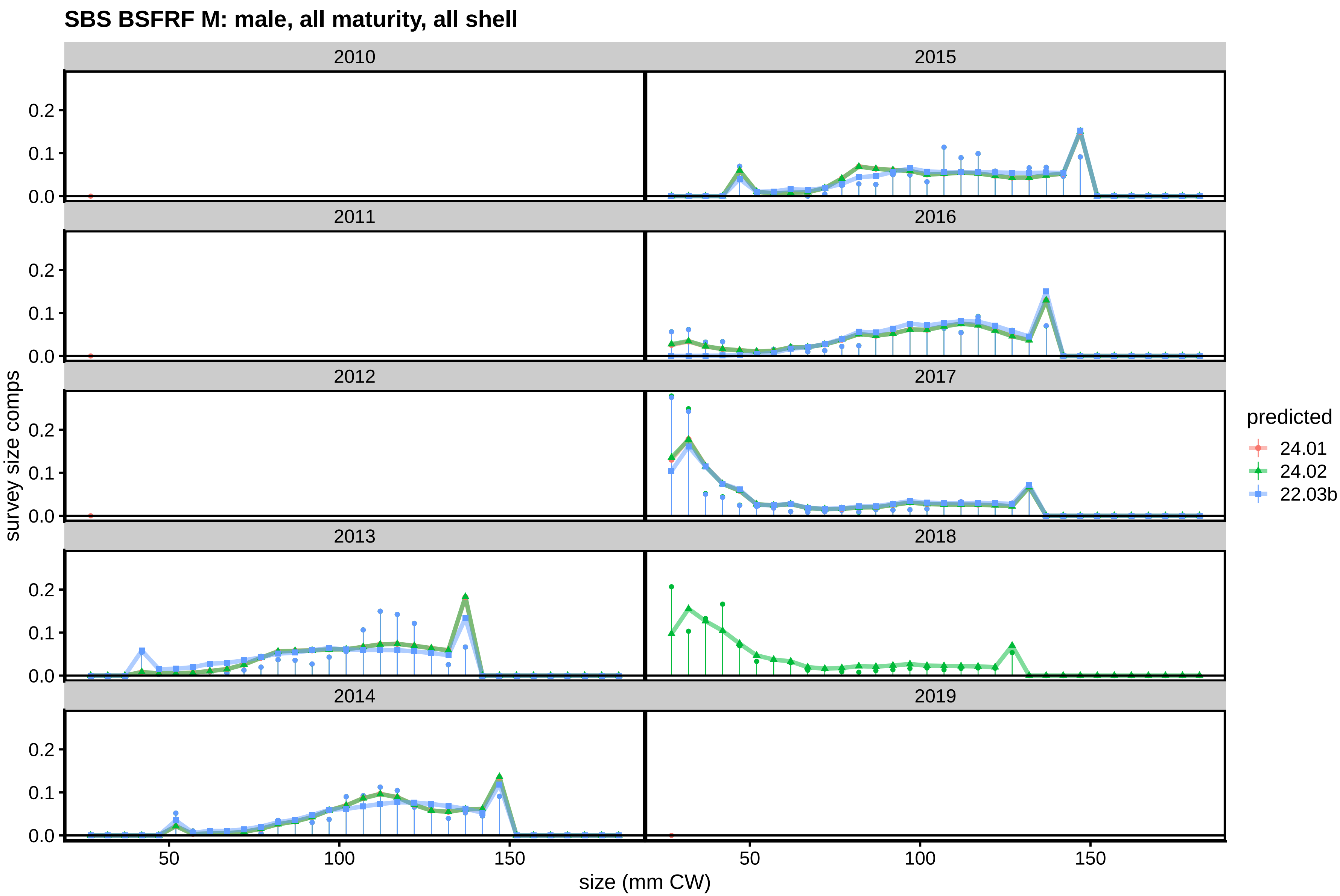

Figure 112. TCSAM02 model fits to survey size compositions in the SBS BSFRF M survey. Preferred model is 24.01.TCSAM02 model fits to survey size compositions in the SBS BSFRF M survey. Preferred model is 24.02.

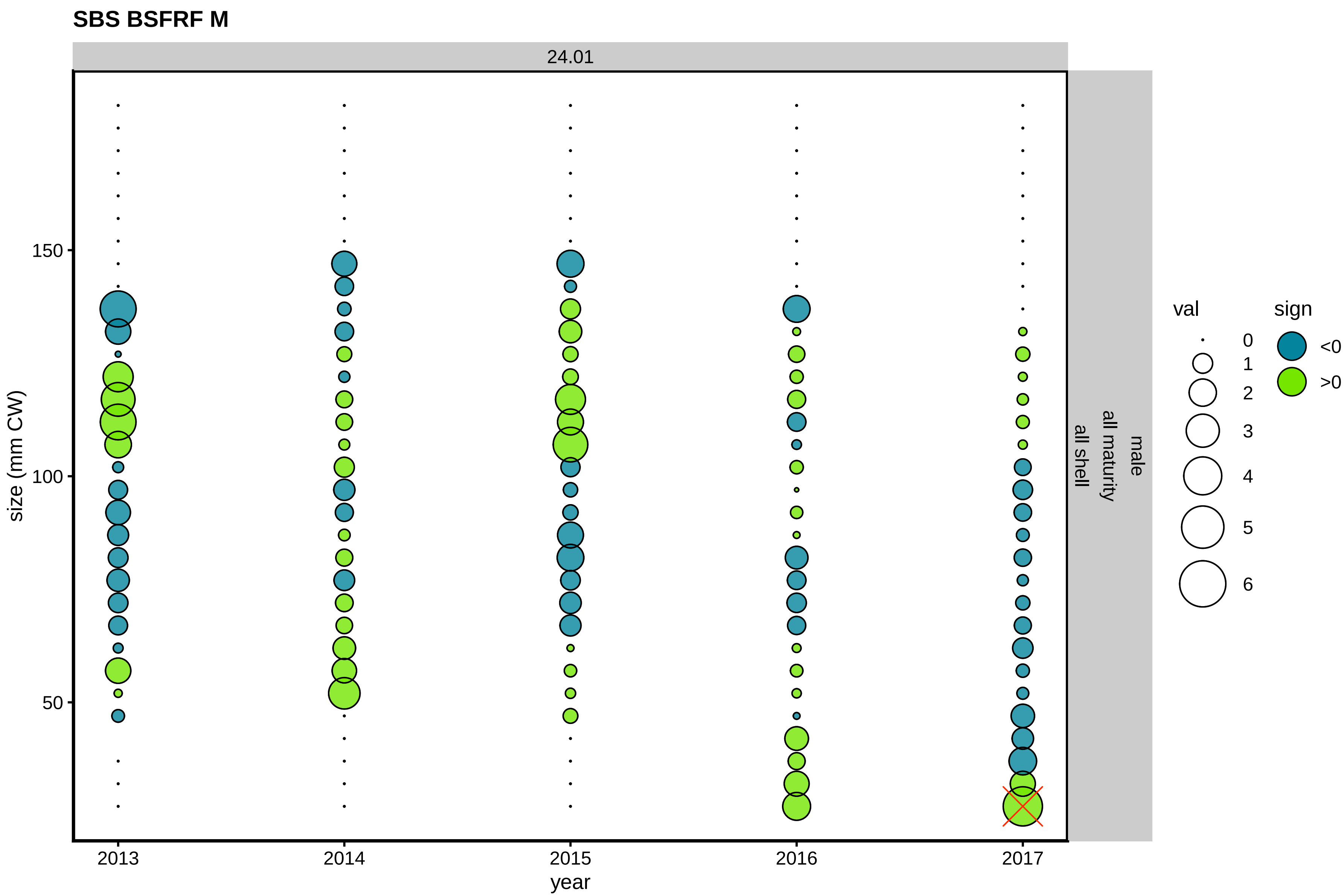

Figure 113. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

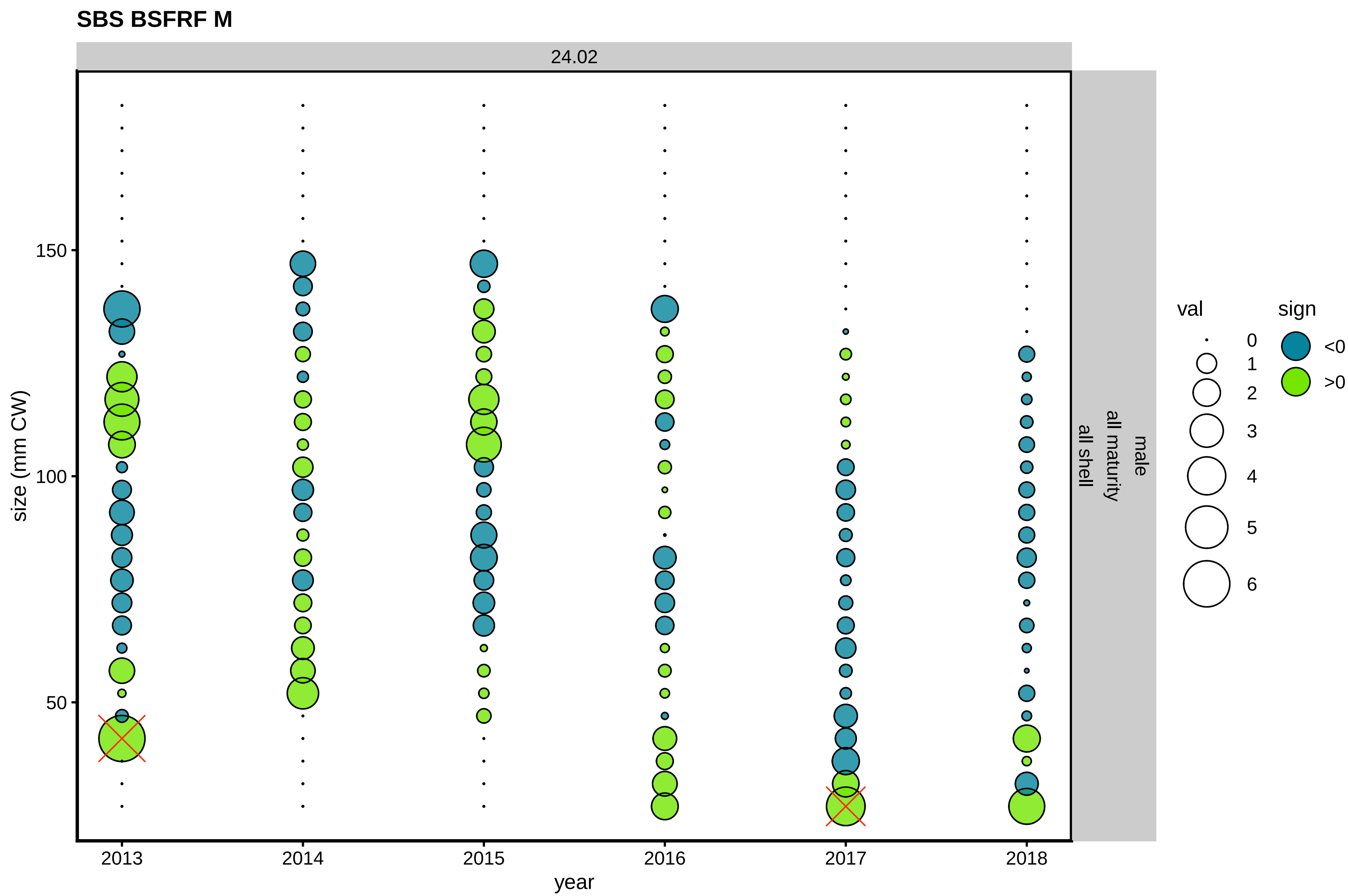

Figure 114. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

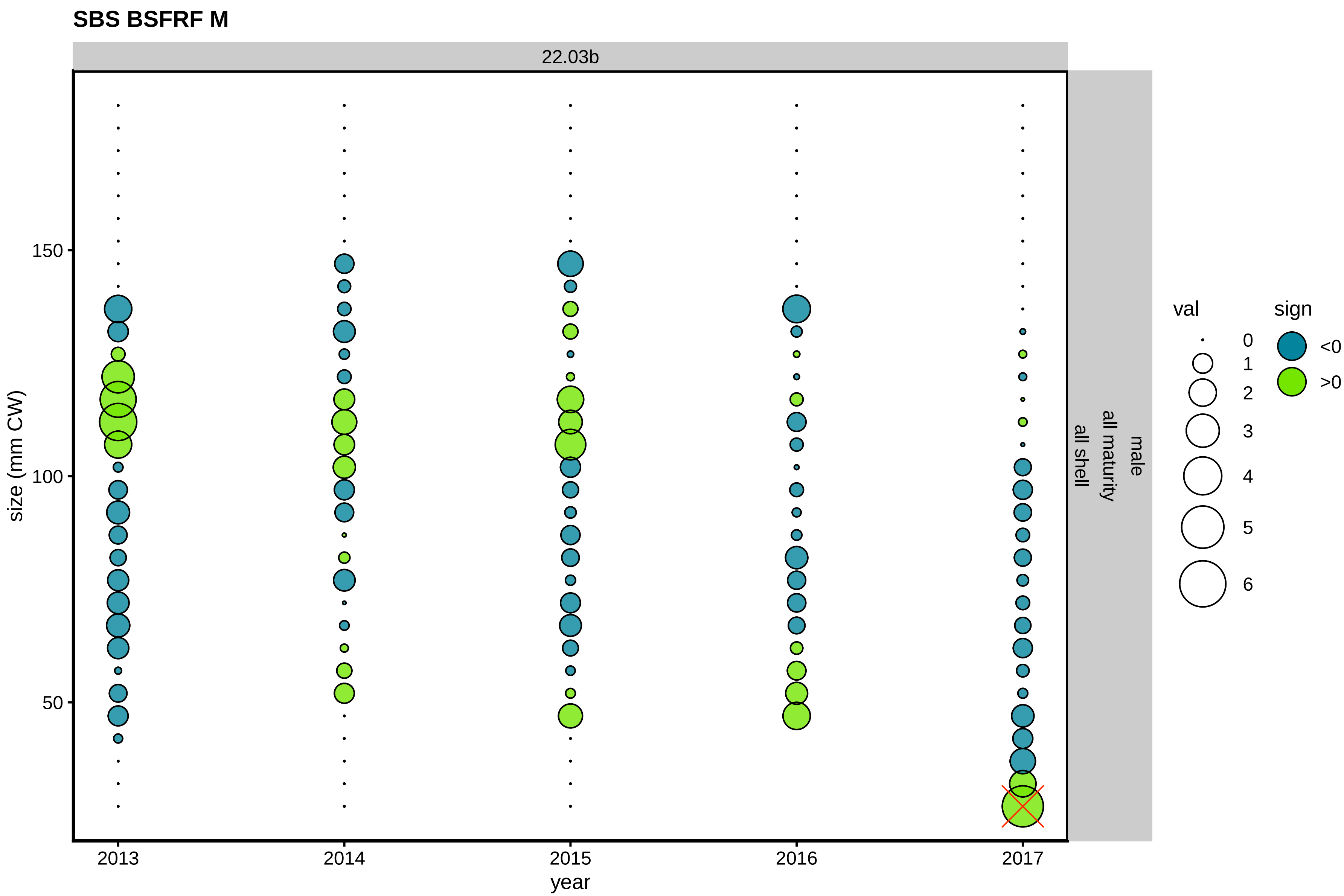

Figure 115. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

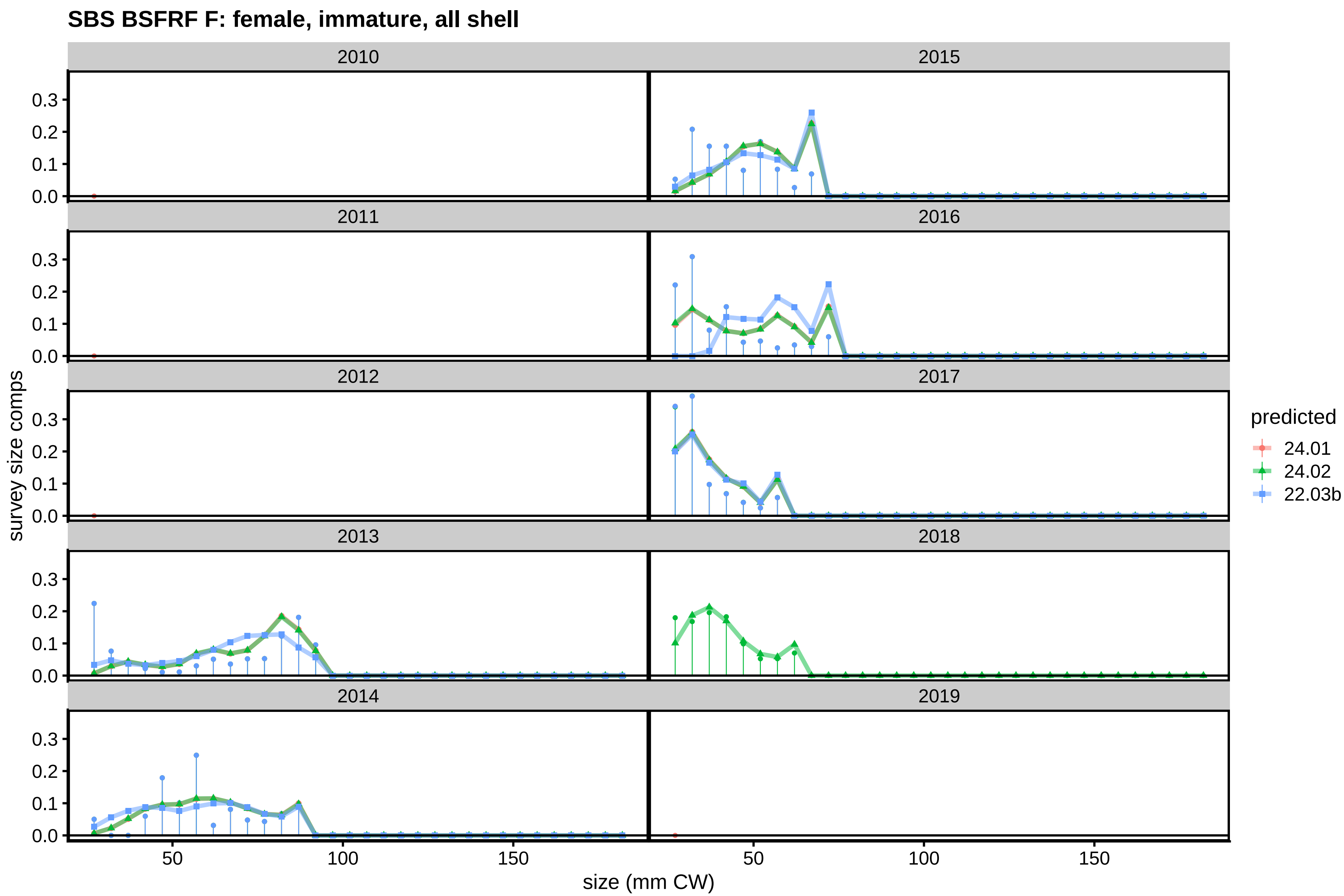

Figure 116. TCSAM02 model fits to survey size compositions in the SBS BSFRF F survey. Preferred model is 24.01.TCSAM02 model fits to survey size compositions in the SBS BSFRF F survey. Preferred model is 24.02.

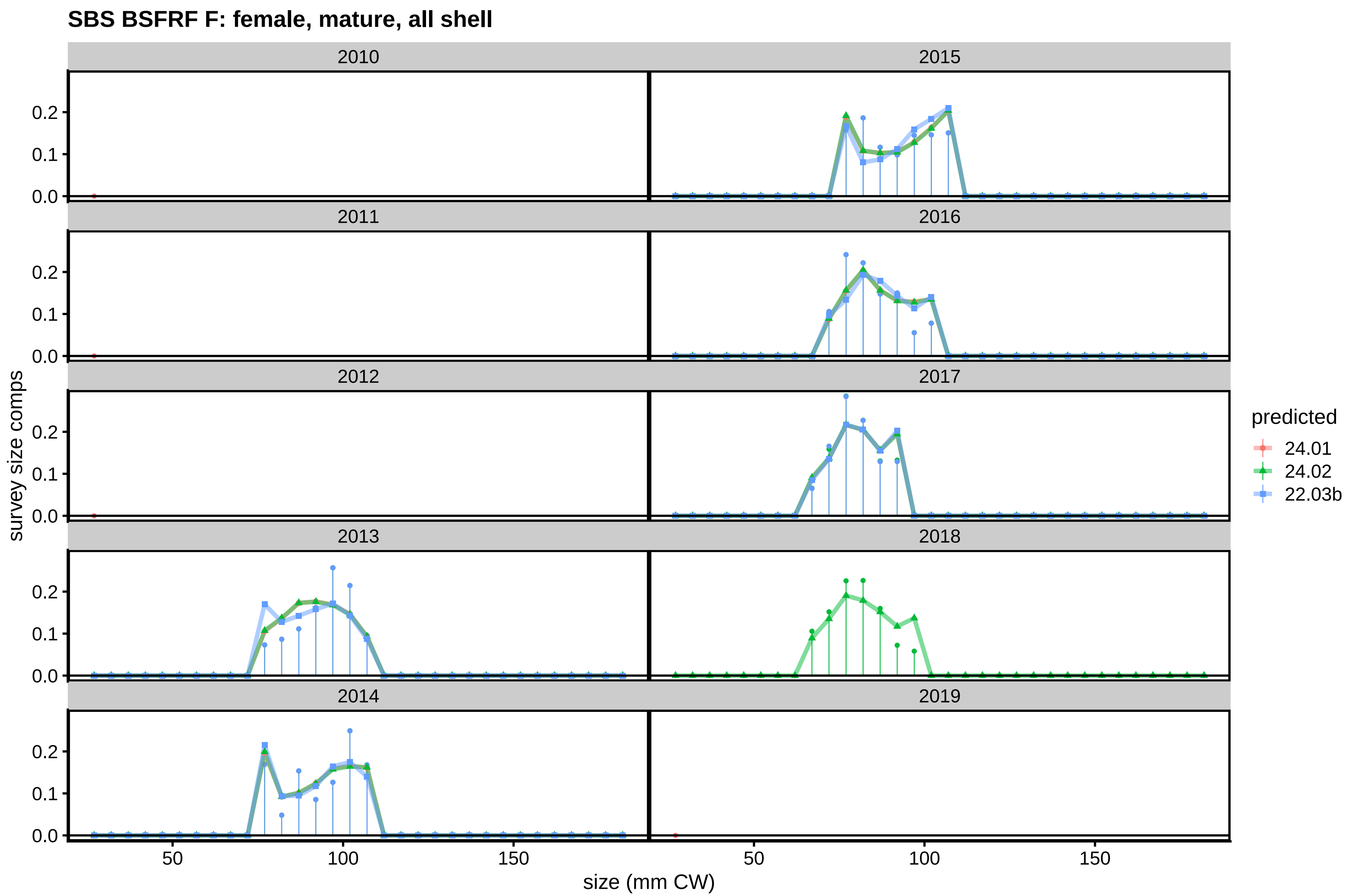

Figure 117. TCSAM02 model fits to survey size compositions in the SBS BSFRF F survey. Preferred model is 24.01.TCSAM02 model fits to survey size compositions in the SBS BSFRF F survey. Preferred model is 24.02.

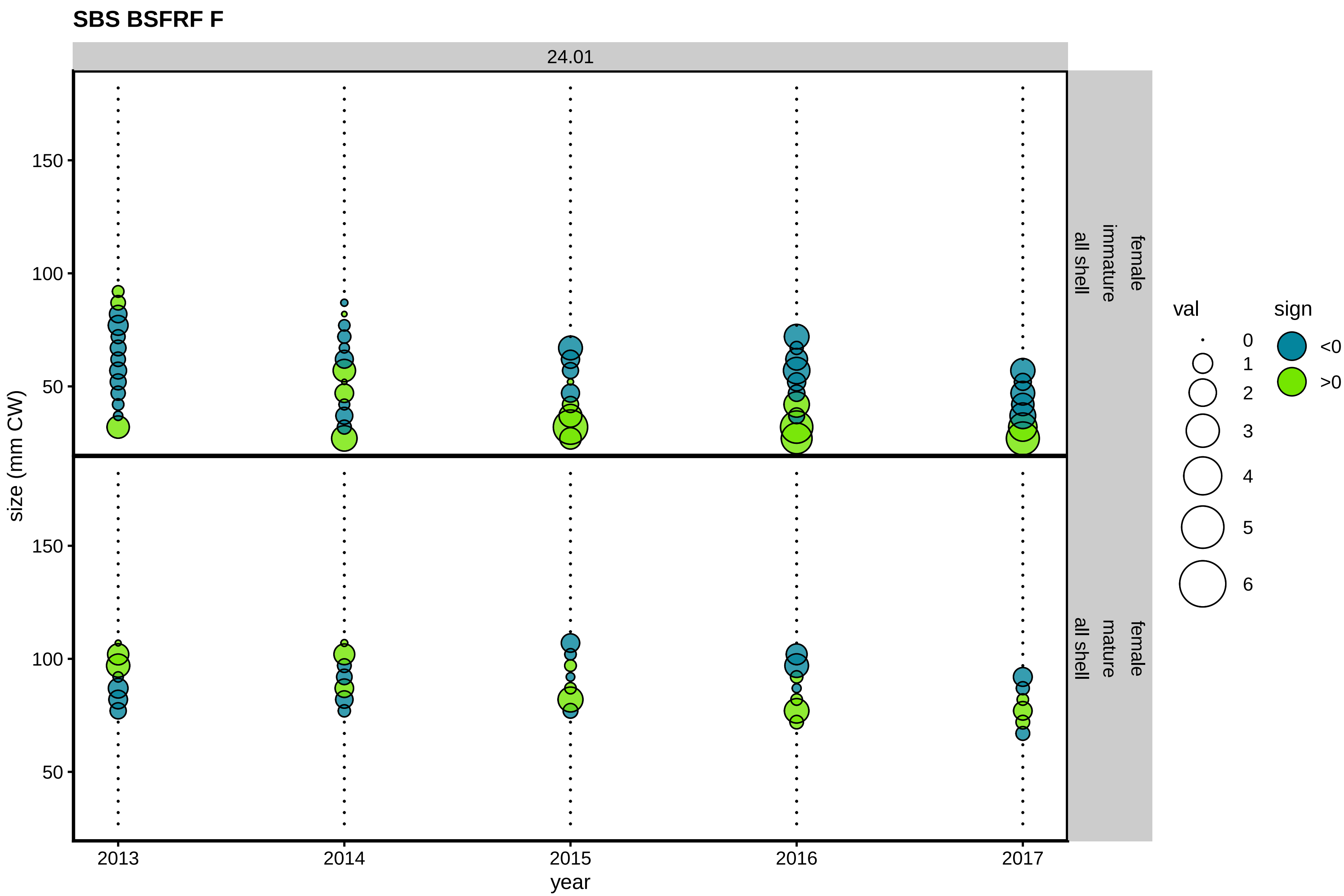

Figure 118. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

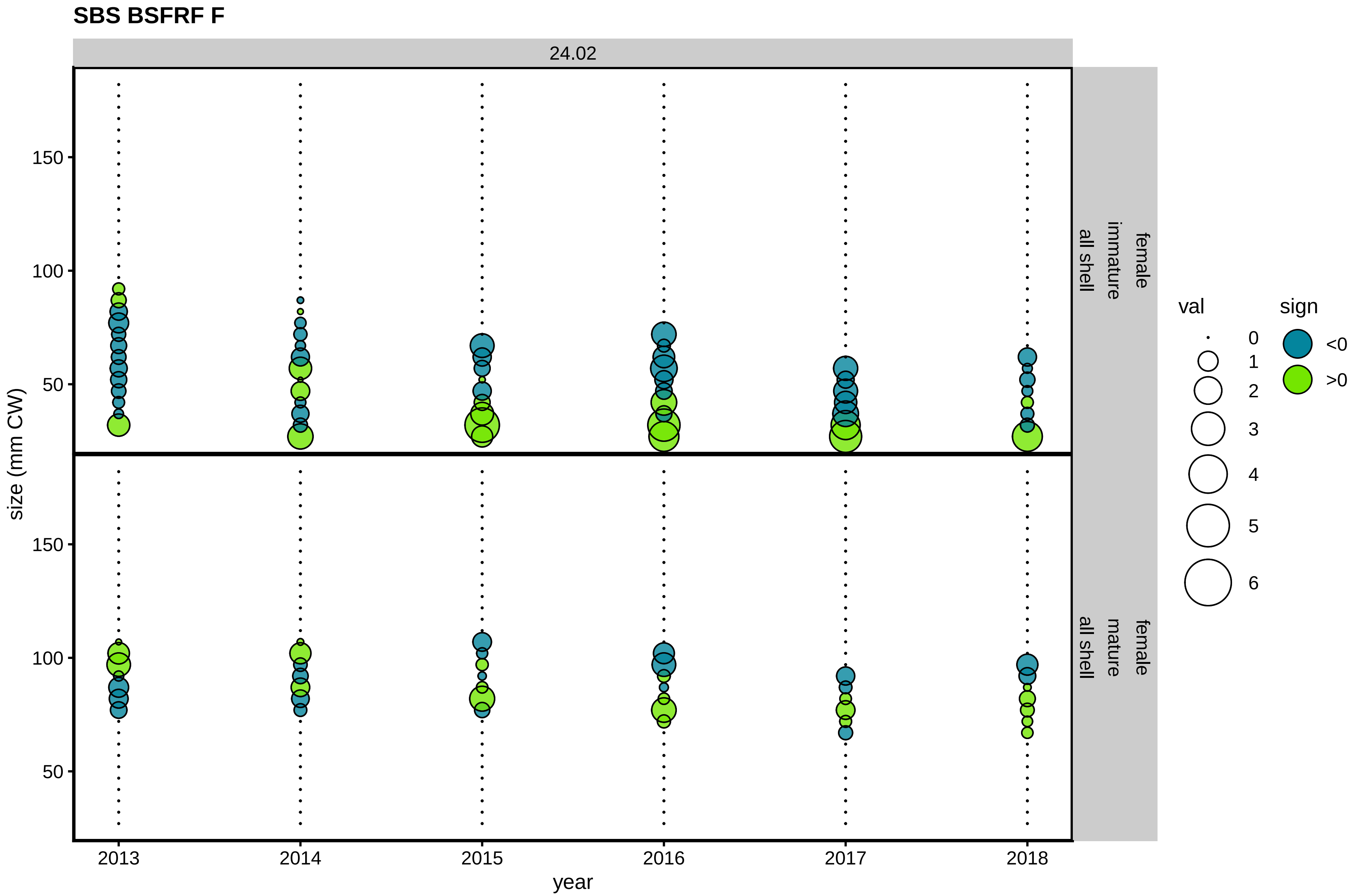

Figure 119. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

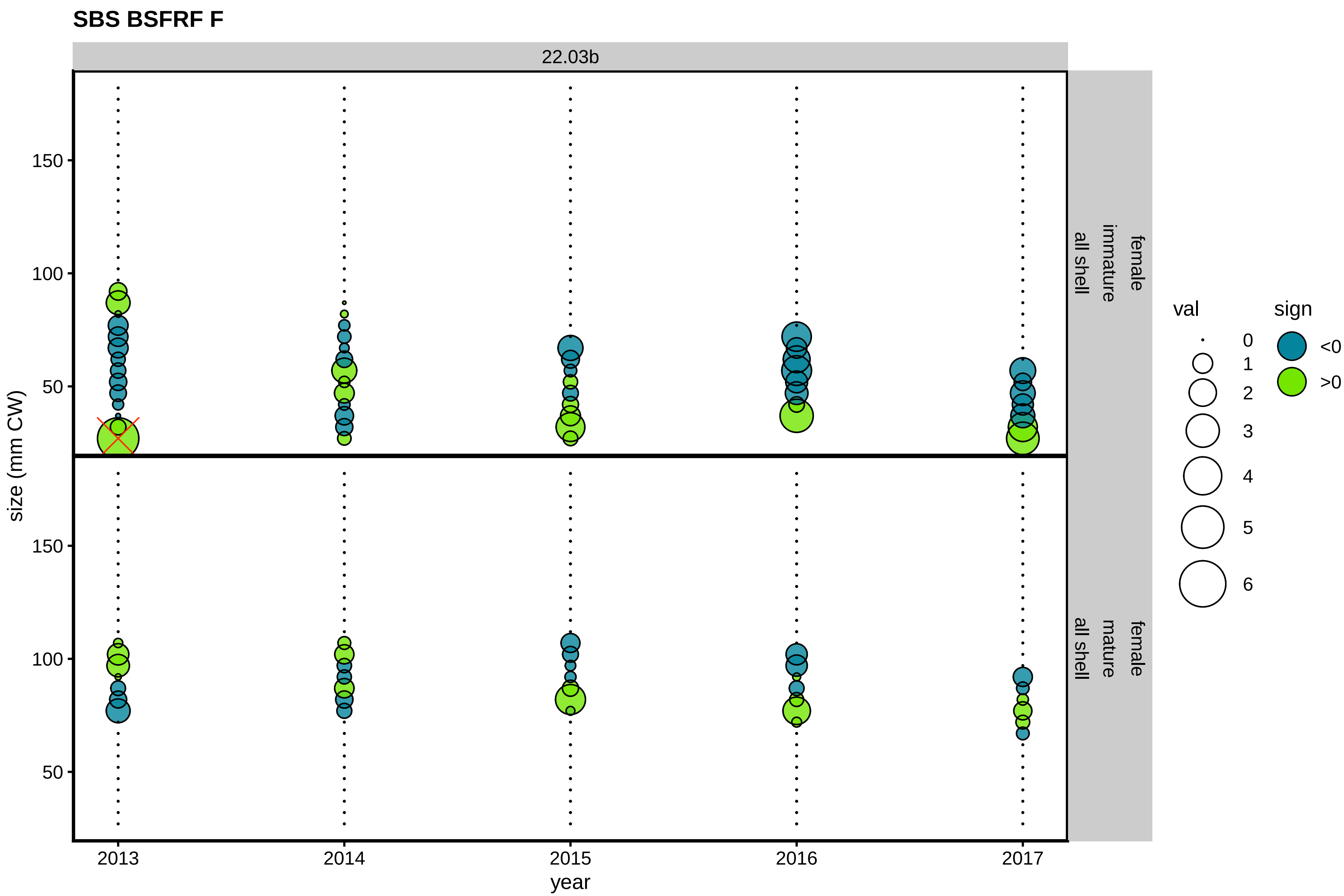

Figure 120. Pearson's residuals for fits to survey size composition data in the TCSAM02 models. Symbol areas reflect the size of each residual, extreme values (residuals larger than 4 in scale) are indicated with a red 'X' to facilitate identification.

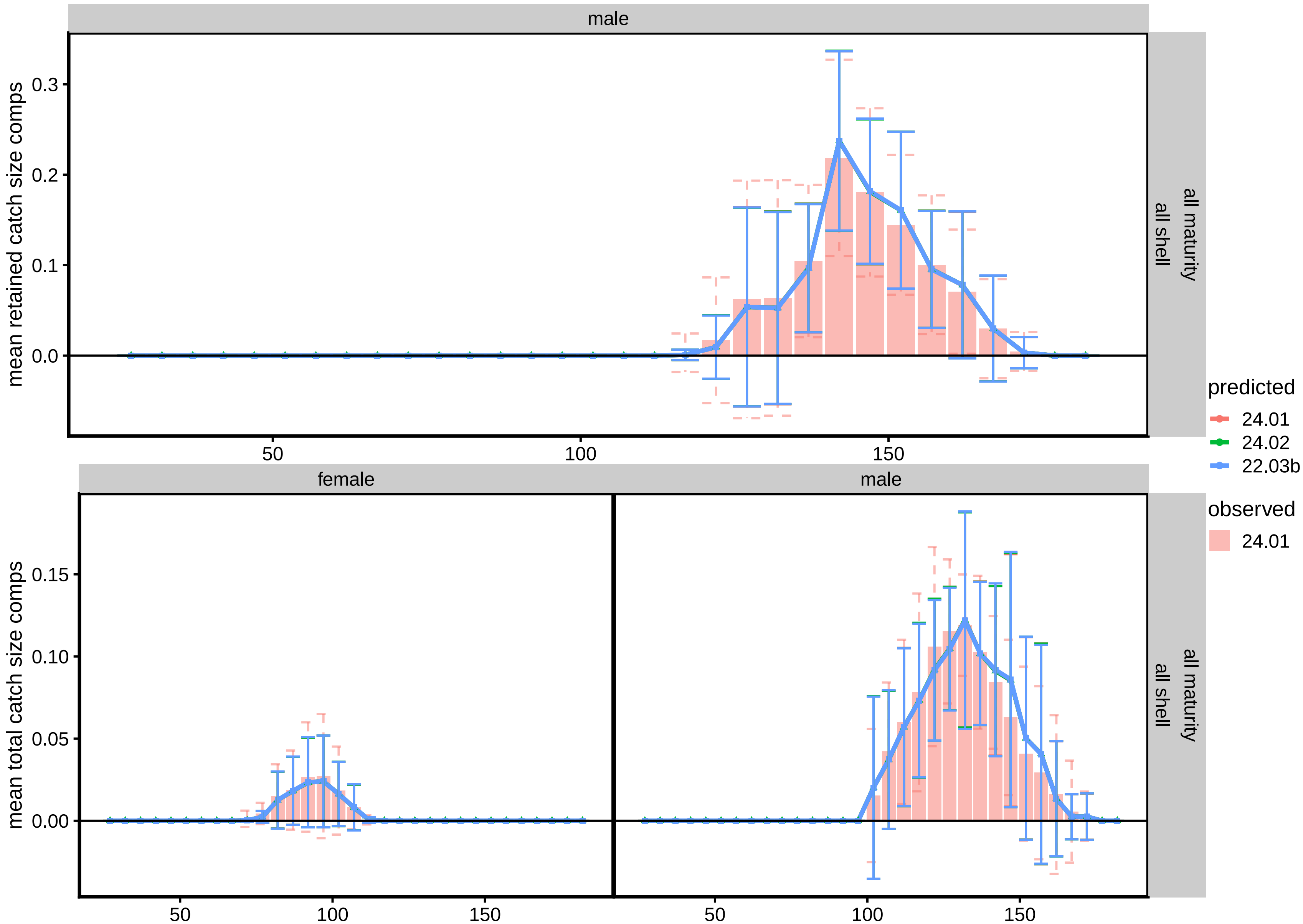

Figure 121. TCSAM02 models fits to directed fishery mean size compositions. Upper plot: retained catch; lower plot: total catch. Model 24.01 is the preferred model.TCSAM02 models fits to directed fishery mean size compositions. Upper plot: retained catch; lower plot: total catch. Model 24.02 is the preferred model.

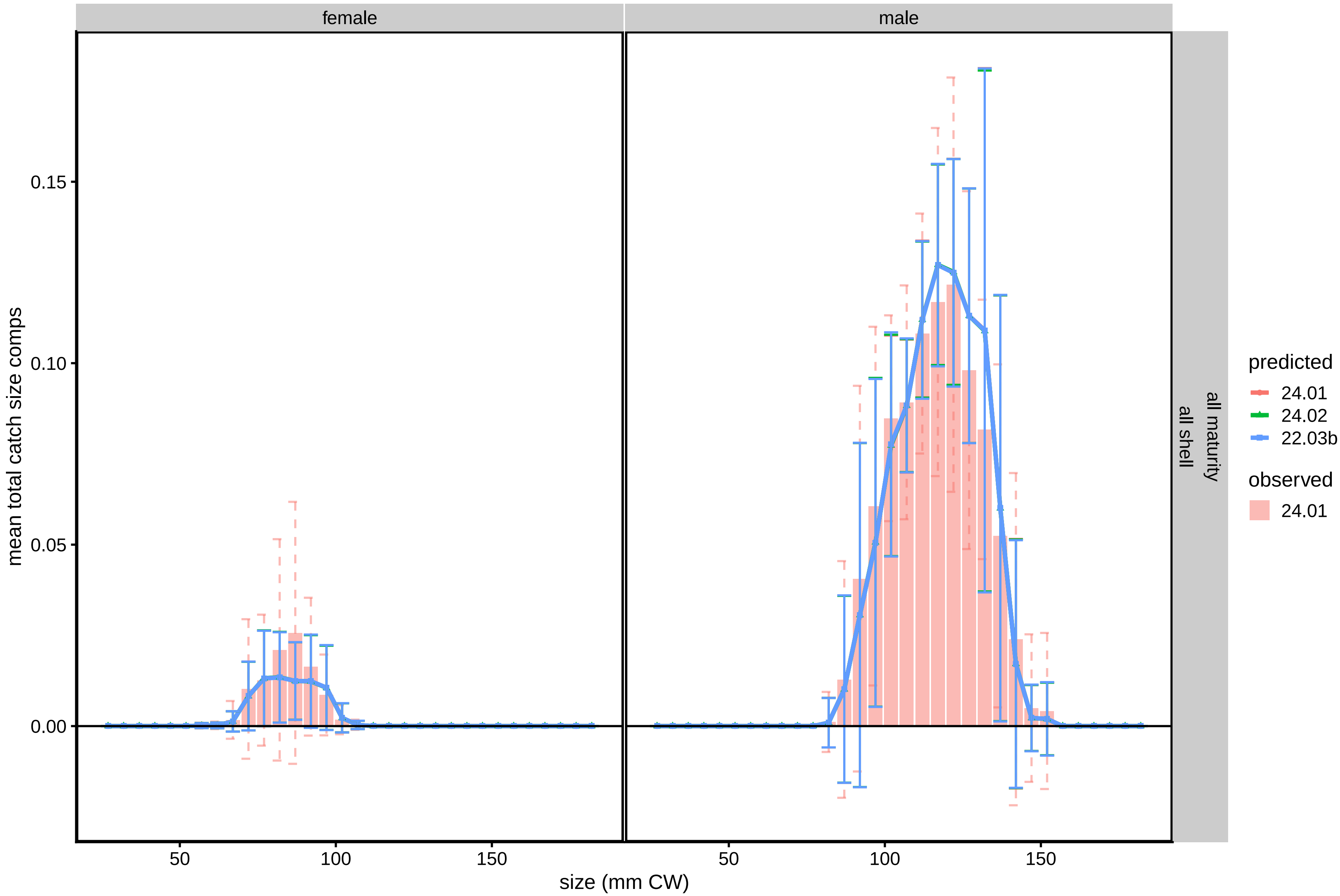

Figure 122. TCSAM02 models fits to mean bycatch size compositions from the snow crab fishery. Model 24.01 is the preferred model.TCSAM02 models fits to mean bycatch size compositions from the snow crab fishery. Model 24.02 is the preferred model.

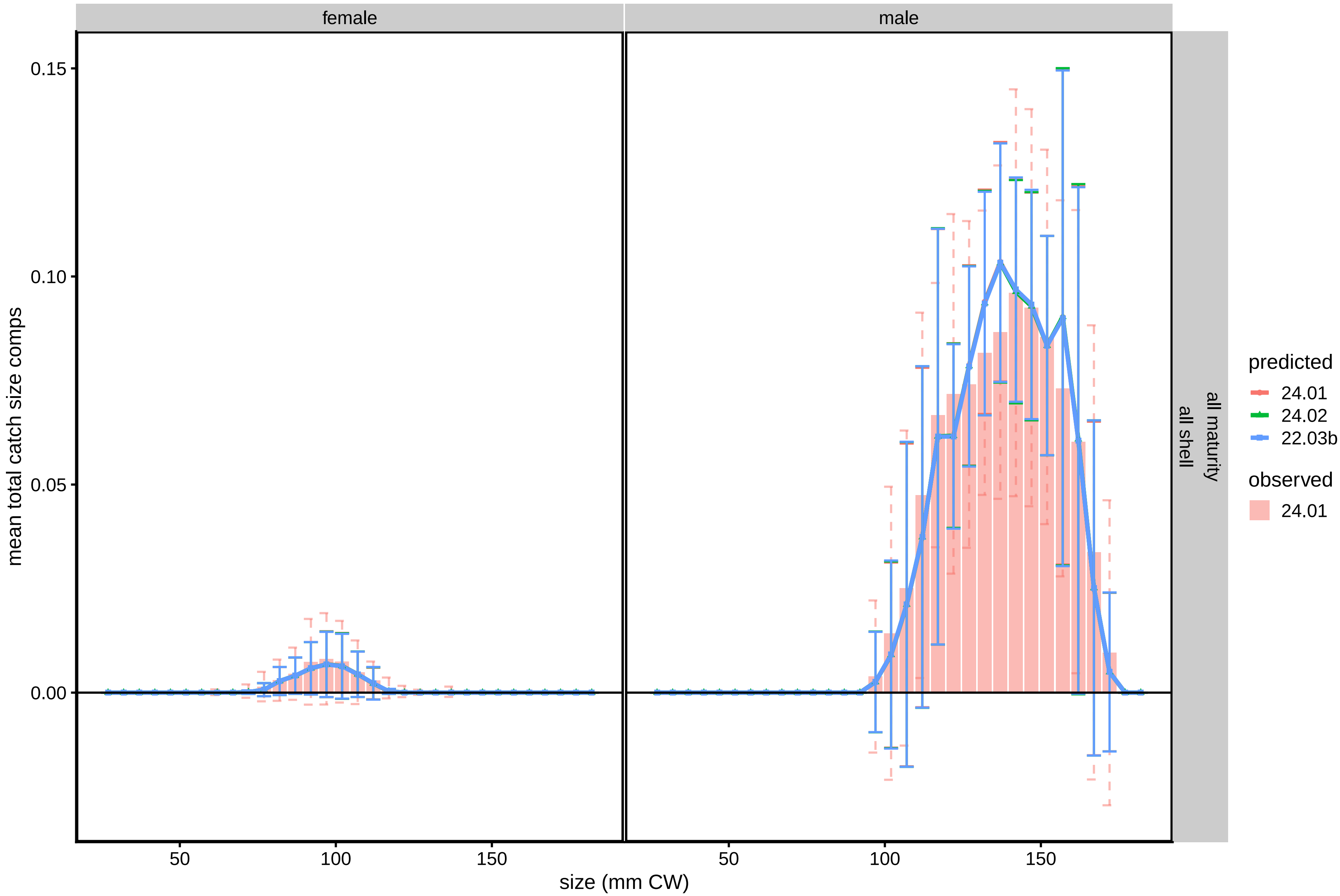

Figure 123. TCSAM02 models fits to mean bycatch size compositions from the BBRKC fishery. Model 24.01 is the preferred model.TCSAM02 models fits to mean bycatch size compositions from the BBRKC fishery. Model 24.02 is the preferred model.

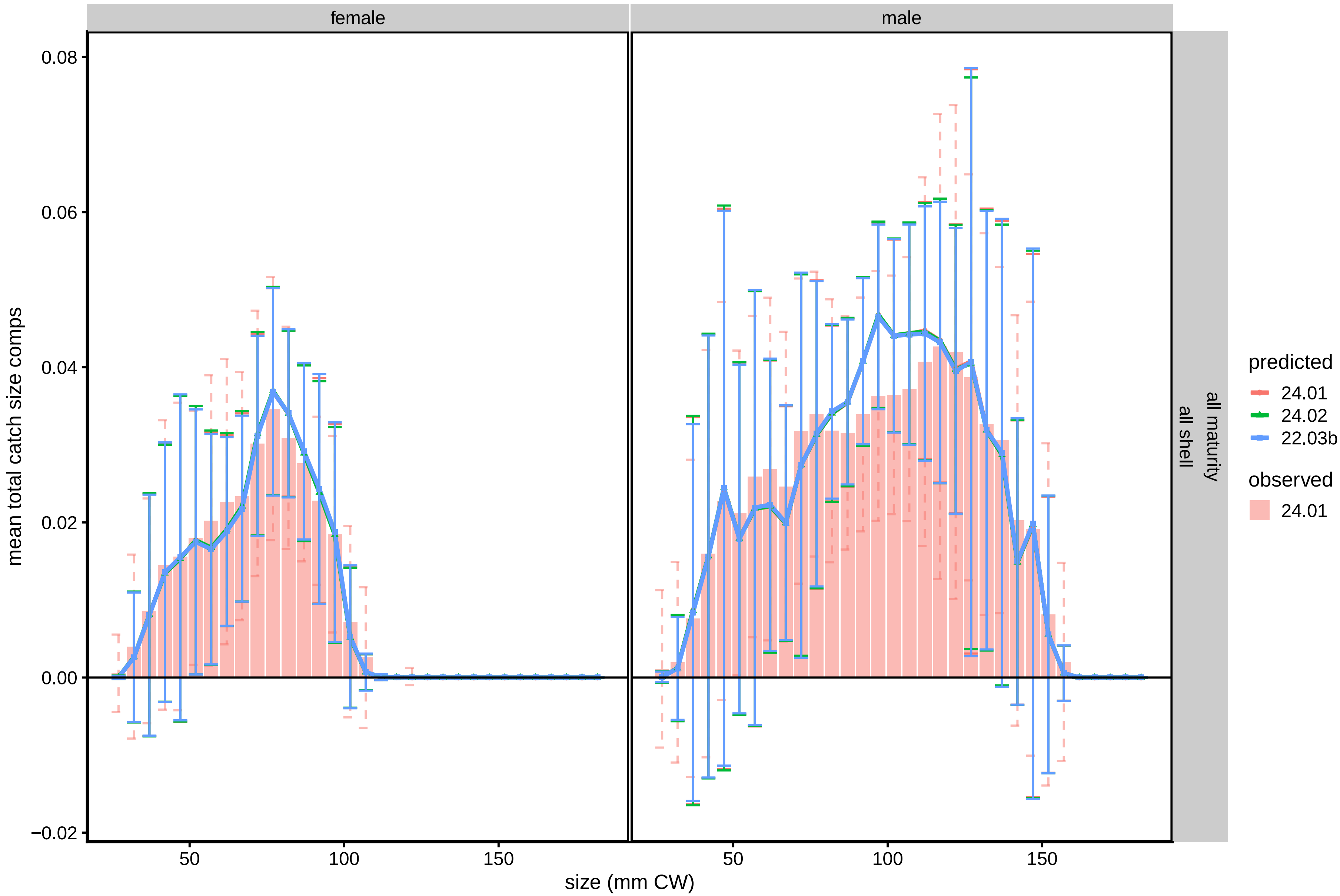

Figure 124. TCSAM02 models fits to mean bycatch size compositions from the groundfish fisheries. The total catch size compositions were normalized similarly for all model scenarios. Model 24.01 is the preferred model.TCSAM02 models fits to mean bycatch size compositions from the groundfish fisheries. The total catch size compositions were normalized similarly for all model scenarios. Model 24.02 is the preferred model.

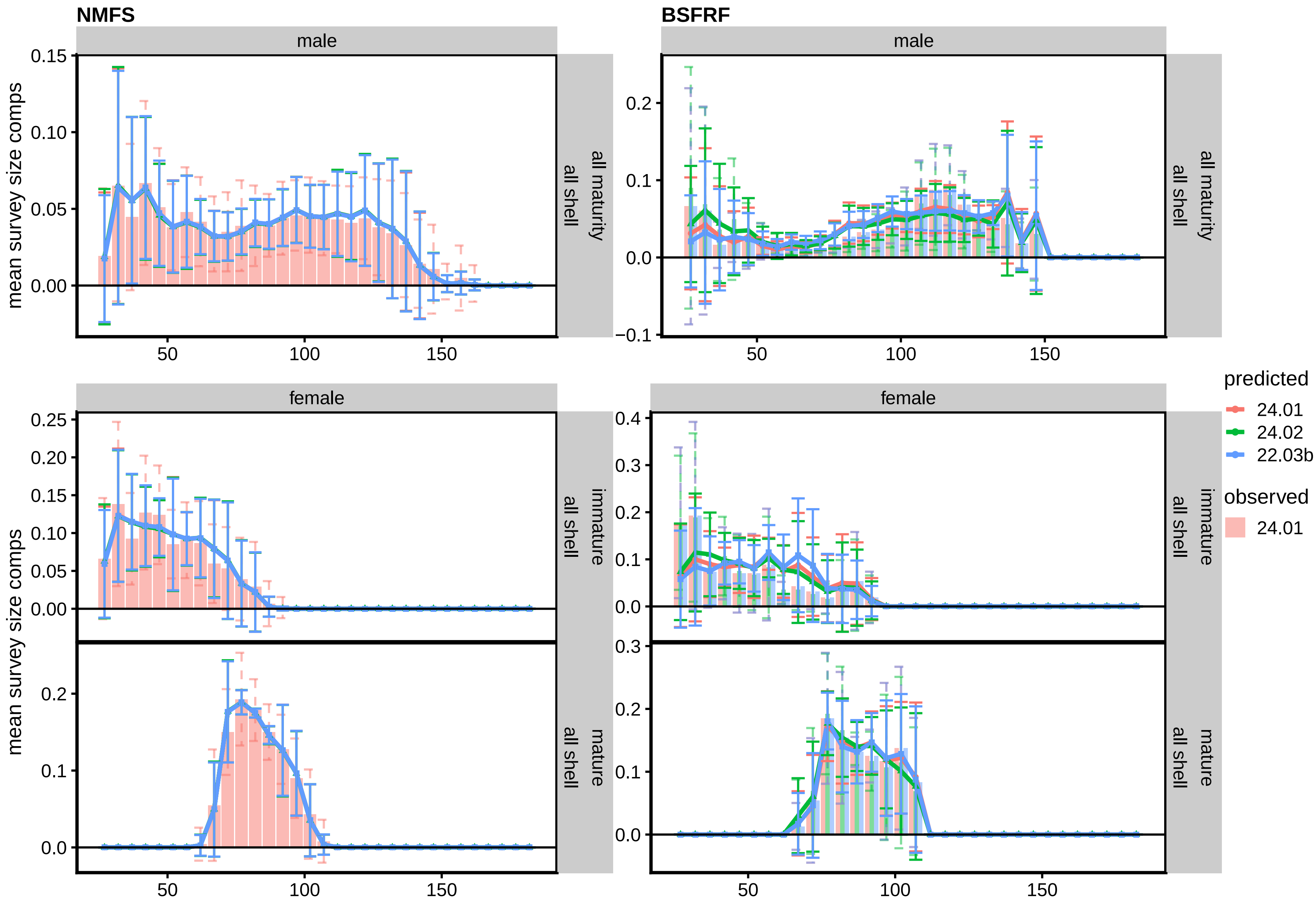

Figure 125. TCSAM02 models fits to mean survey size compositions from the NMFS EBS (left column) and BSFRF SBS (right column) surveys. The total catch size compositions were normalized similarly for all model scenarios.

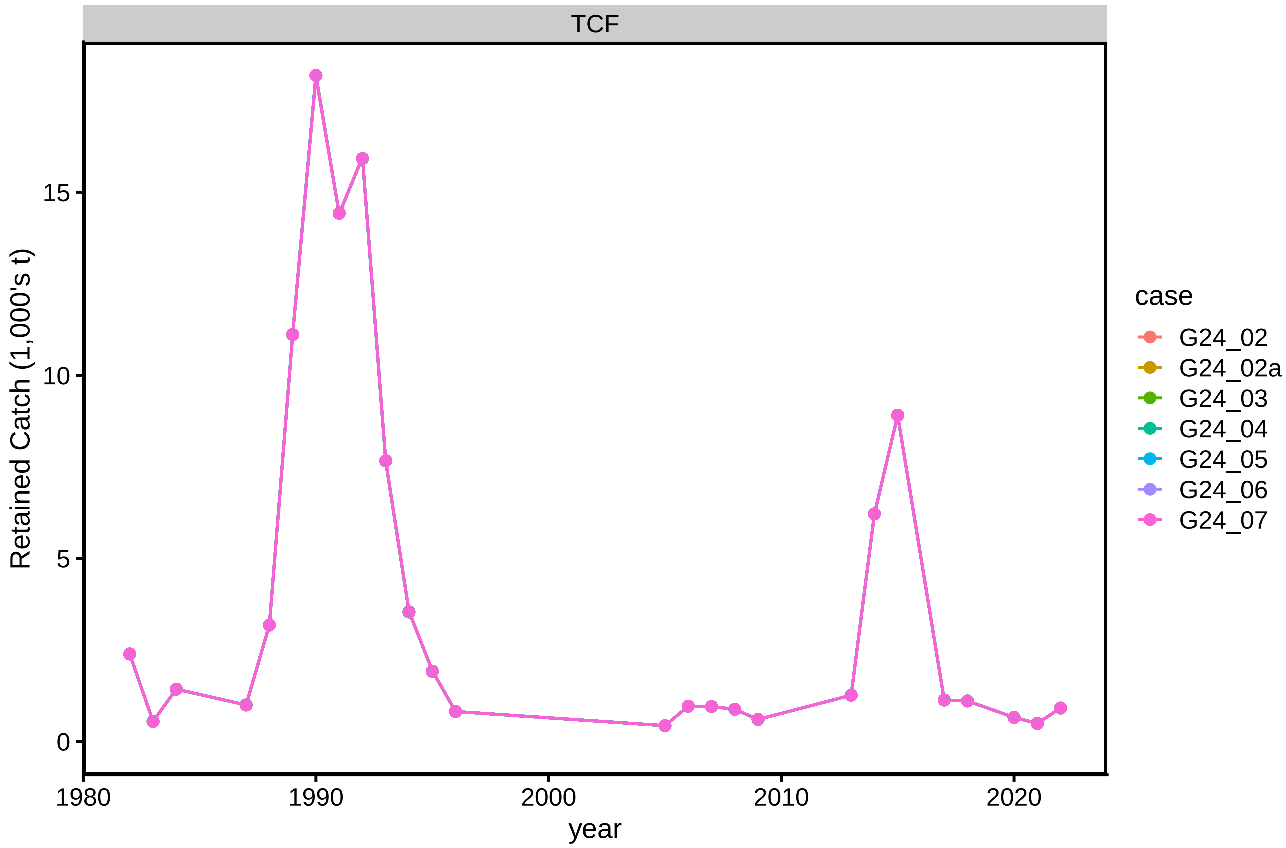

Figure 126. Fits of GMACS models to retained catch biomass, colored by model case.

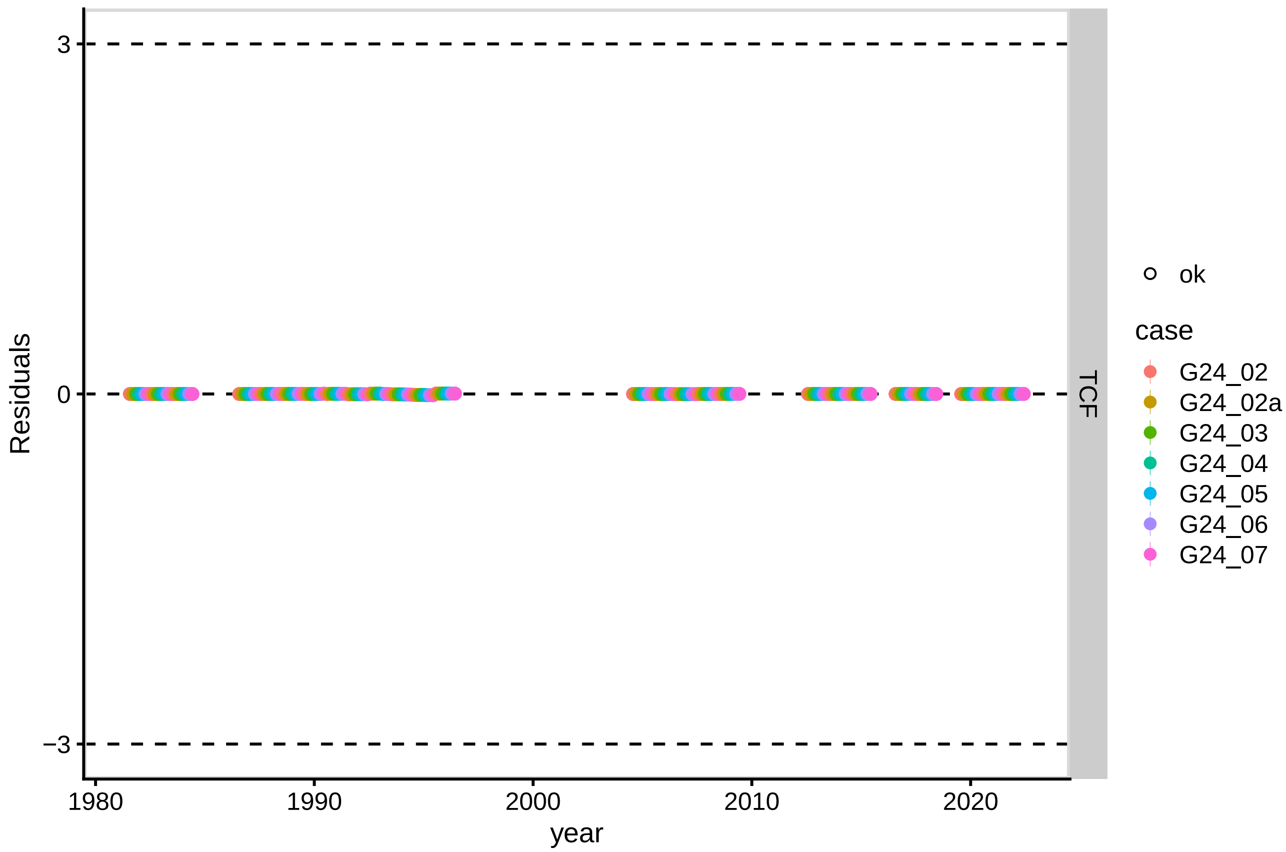

Figure 127. Residuals for GMACS models from fits to the retained catch biomass data, colored by model case (lines: predicted; points: observed; envelopes: confidence intervals on observations).

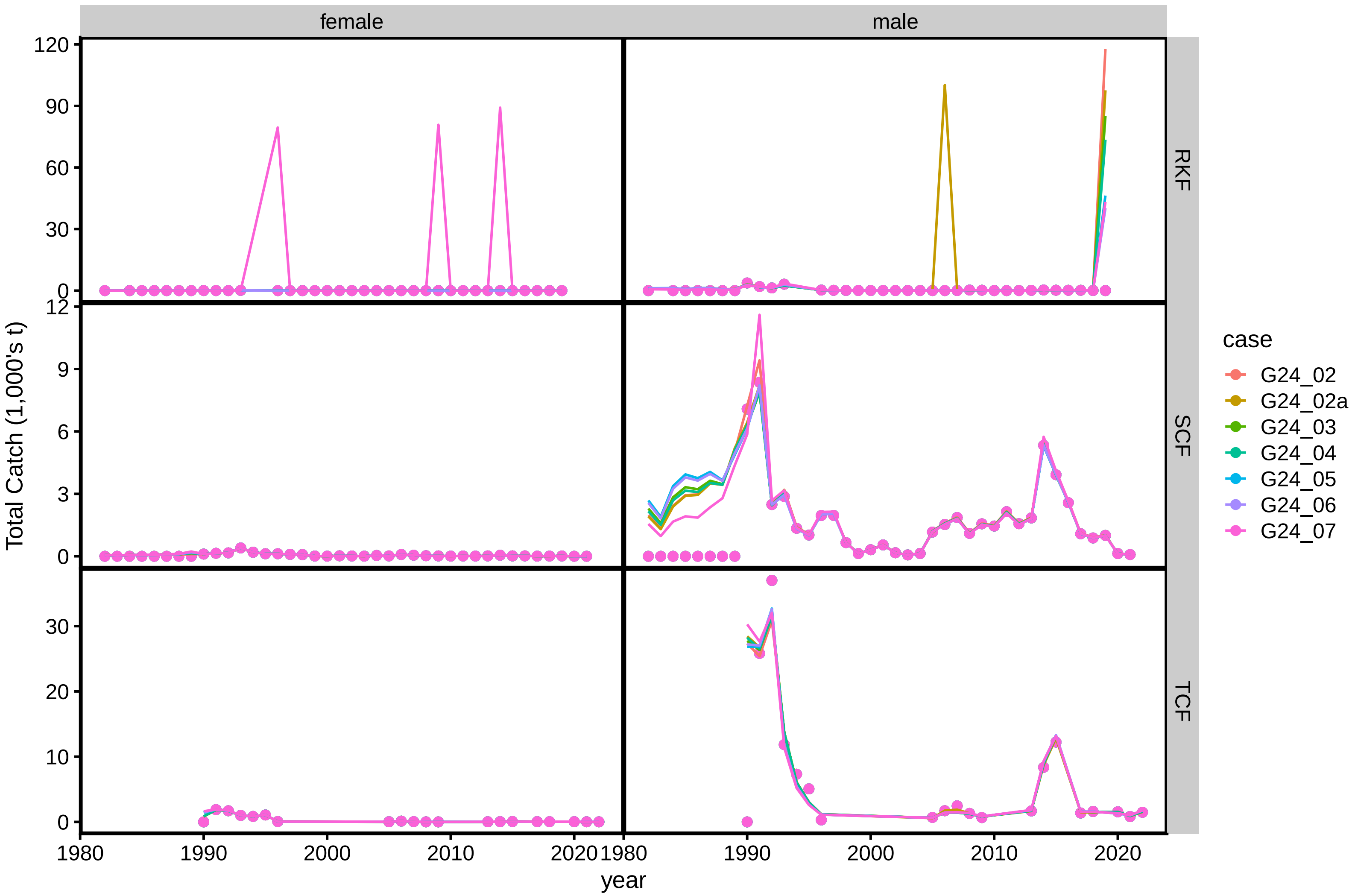

Figure 128. Fits of GMACS models to total catch biomass in the crab fisheries, colored by model case.

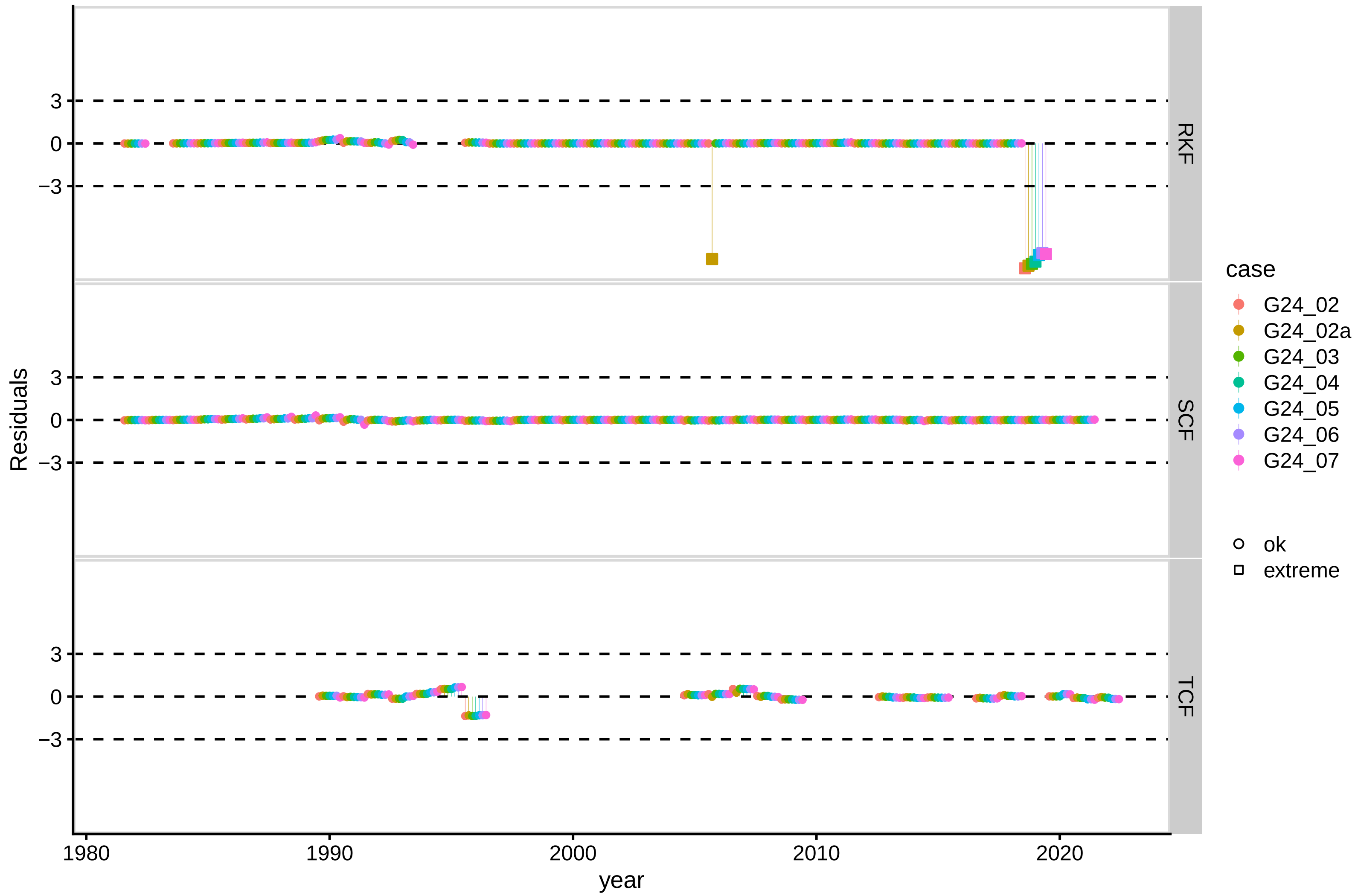

Figure 129. Residuals for GMACS models from fits to the total catch biomass data by crab fishery for males, colored by model case (lines: predicted; points: observed; envelopes: confidence intervals on observations).

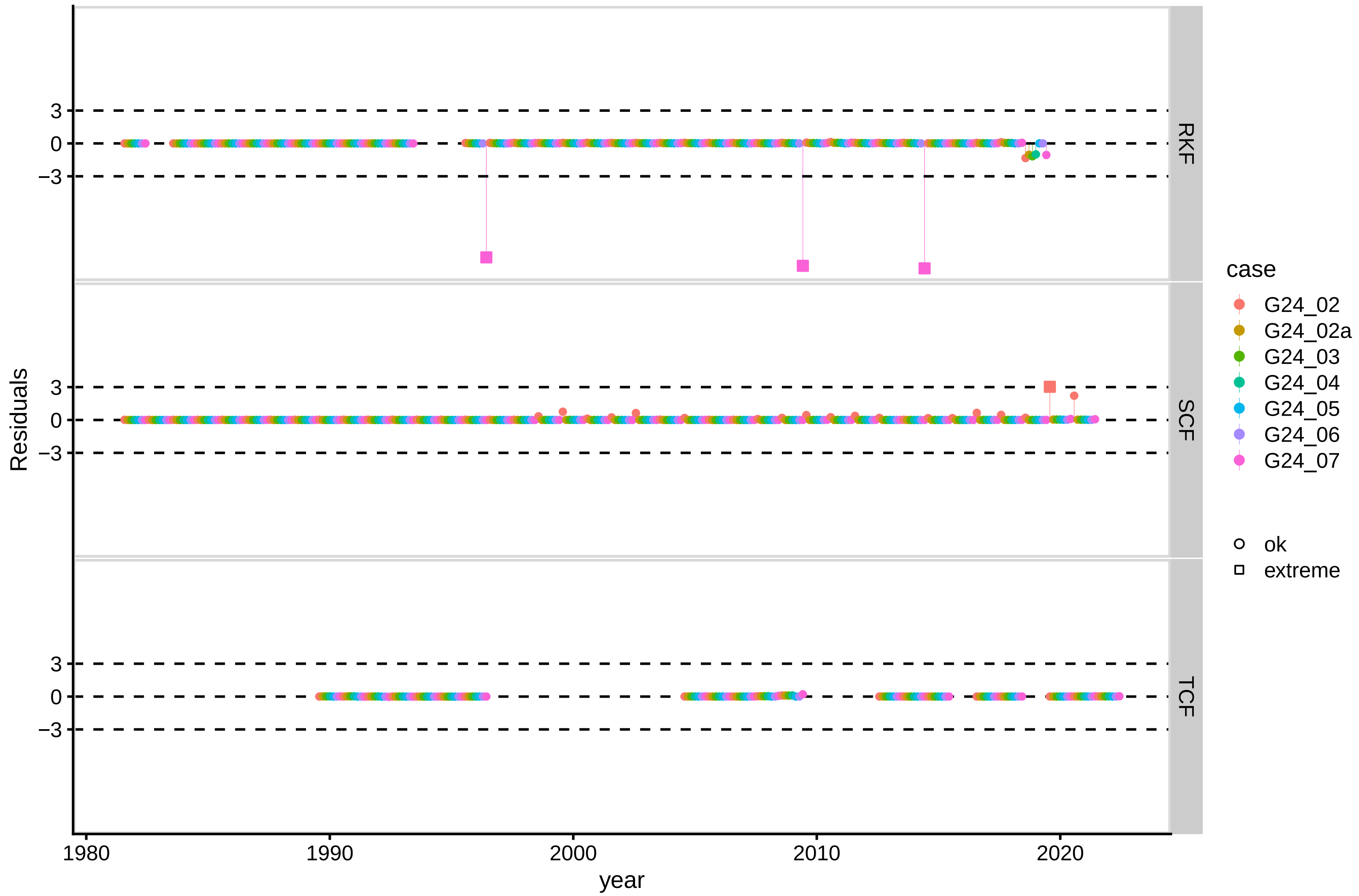

Figure 130. Residuals for GMACS models from fits to the total catch biomass data by crab fishery for females, colored by model case (lines: predicted; points: observed; envelopes: confidence intervals on observations).

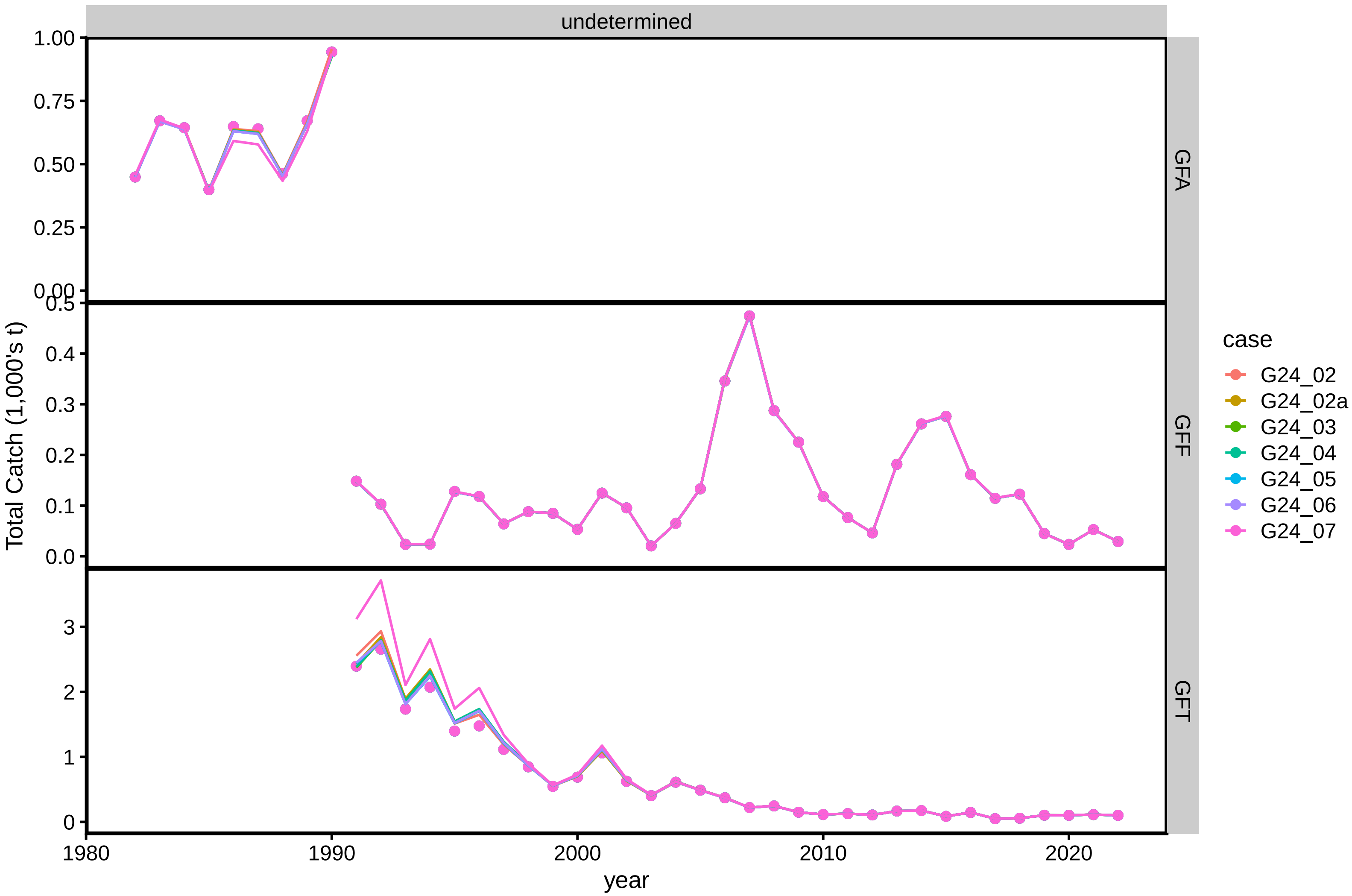

Figure 131. Fits of GMACS models to total catch biomass in the groundfish fisheries, colored by model case.

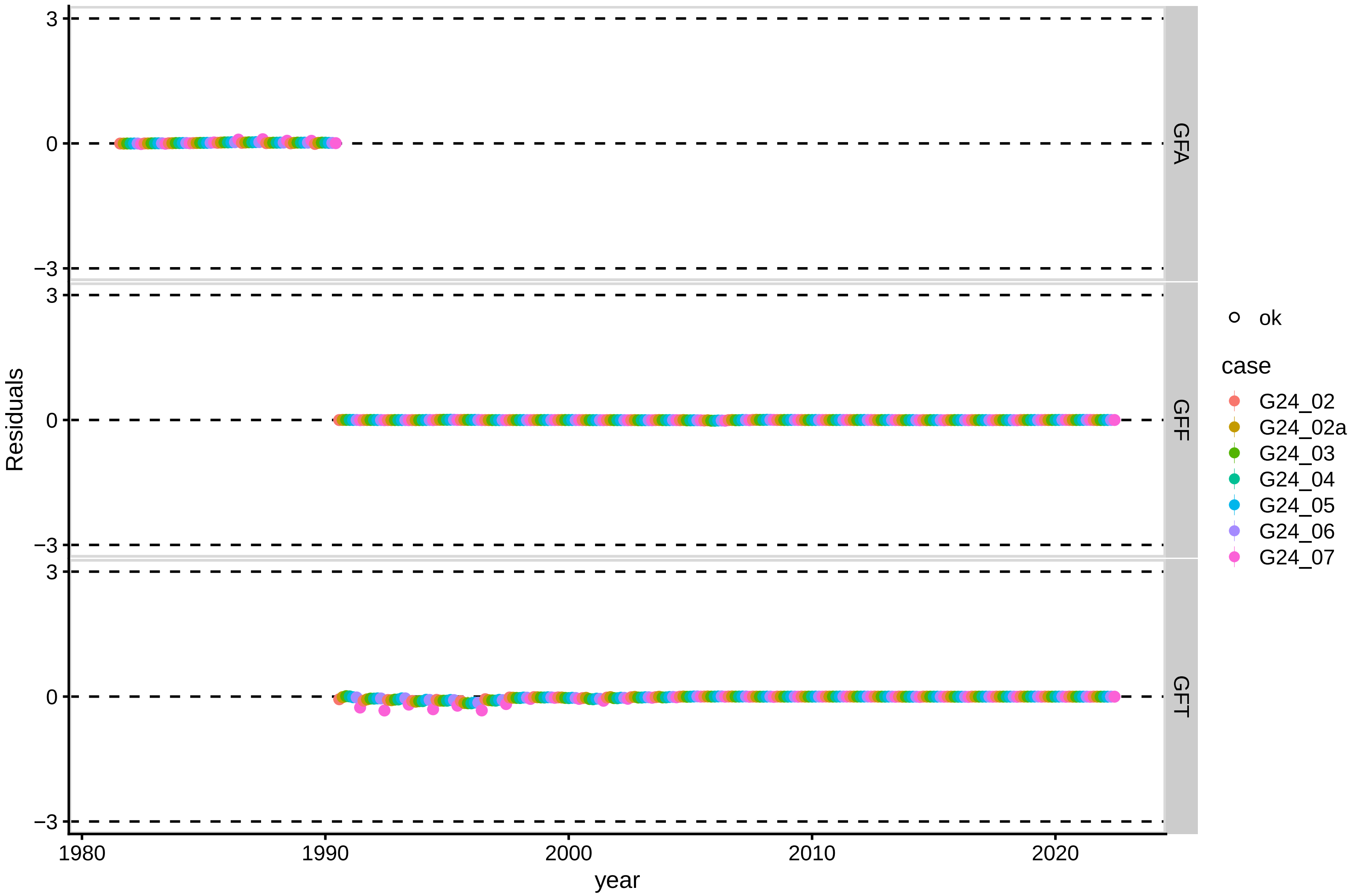

Figure 132. Residuals for GMACS models from fits to the total catch biomass data by groundfish fishery gear type for combined sexes, colored by model case (lines: predicted; points: observed; envelopes: confidence intervals on observations).

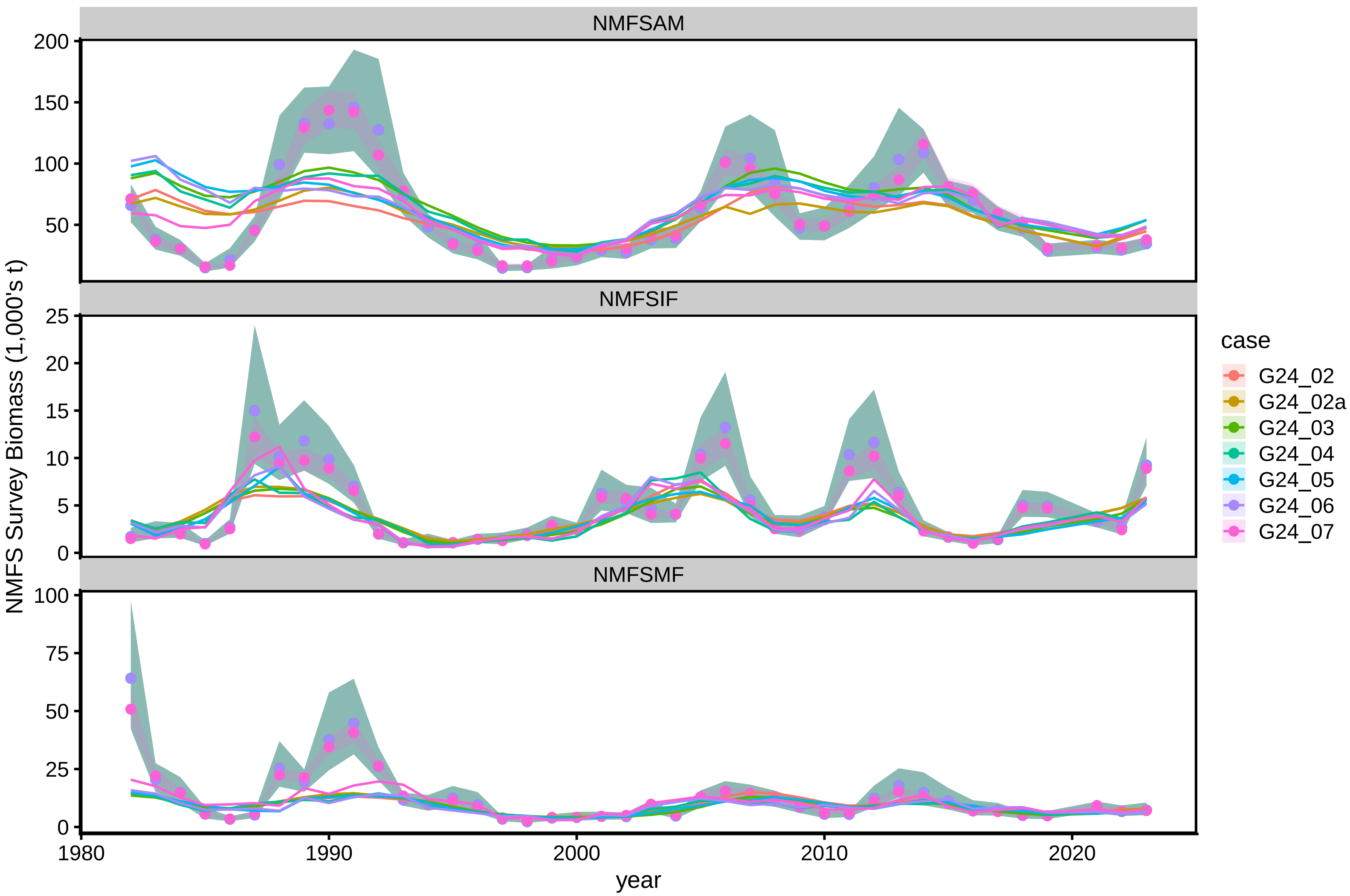

Figure 133. Fits of GMACS models to the biomass indices, colored by model case (lines: predicted; points: observed; envelopes: confidence intervals on observations). Note that all models fit to design-based indices, except G24.07 which fits to VAST-based indices.

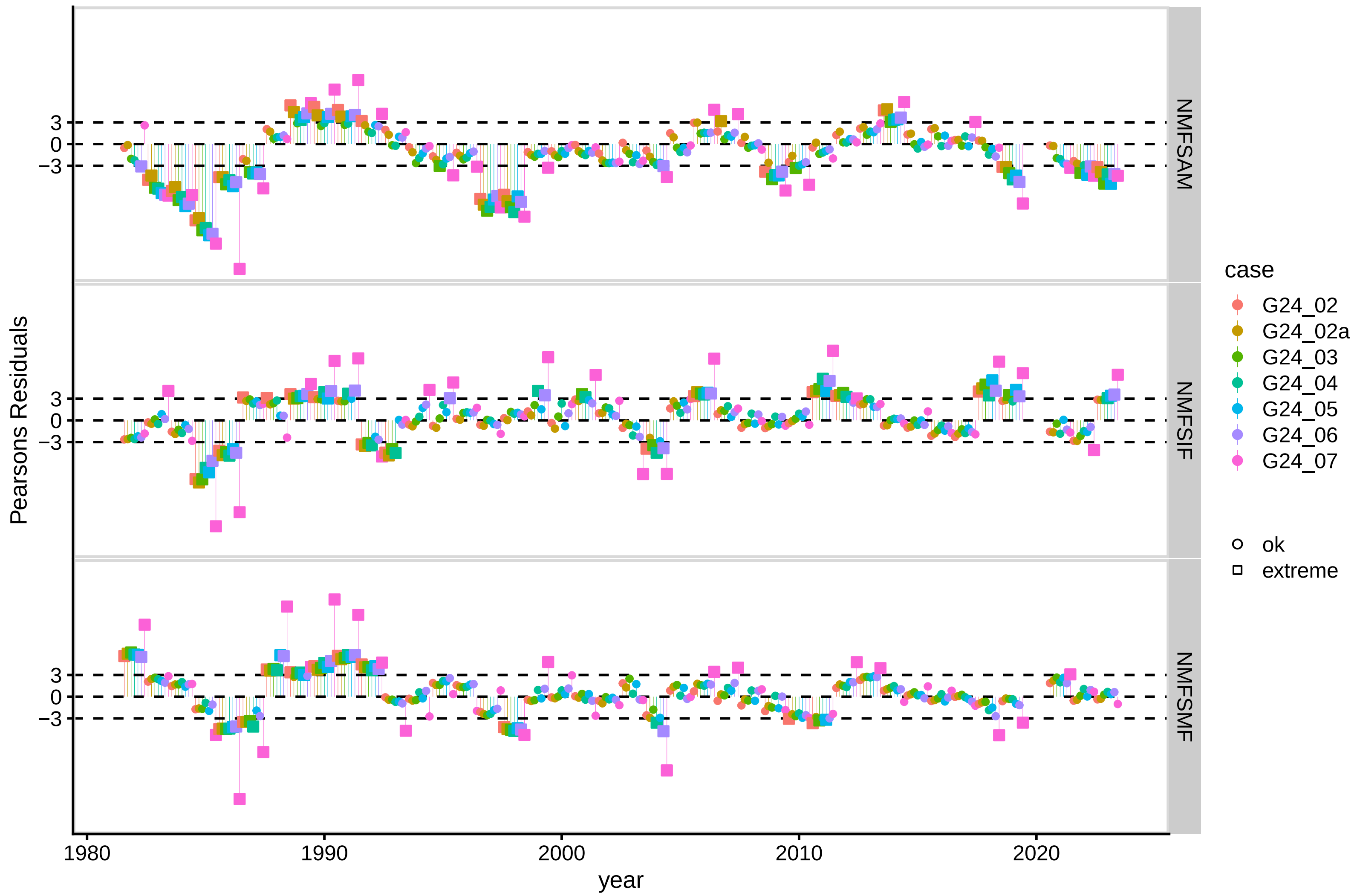

Figure 134. Residuals for GMACS models from fits to the biomass indices, colored by model case (lines: predicted; points: observed; envelopes: confidence intervals on observations). Note that all models fit to design-based indices, except G24.07 which fits to VAST-based indices.

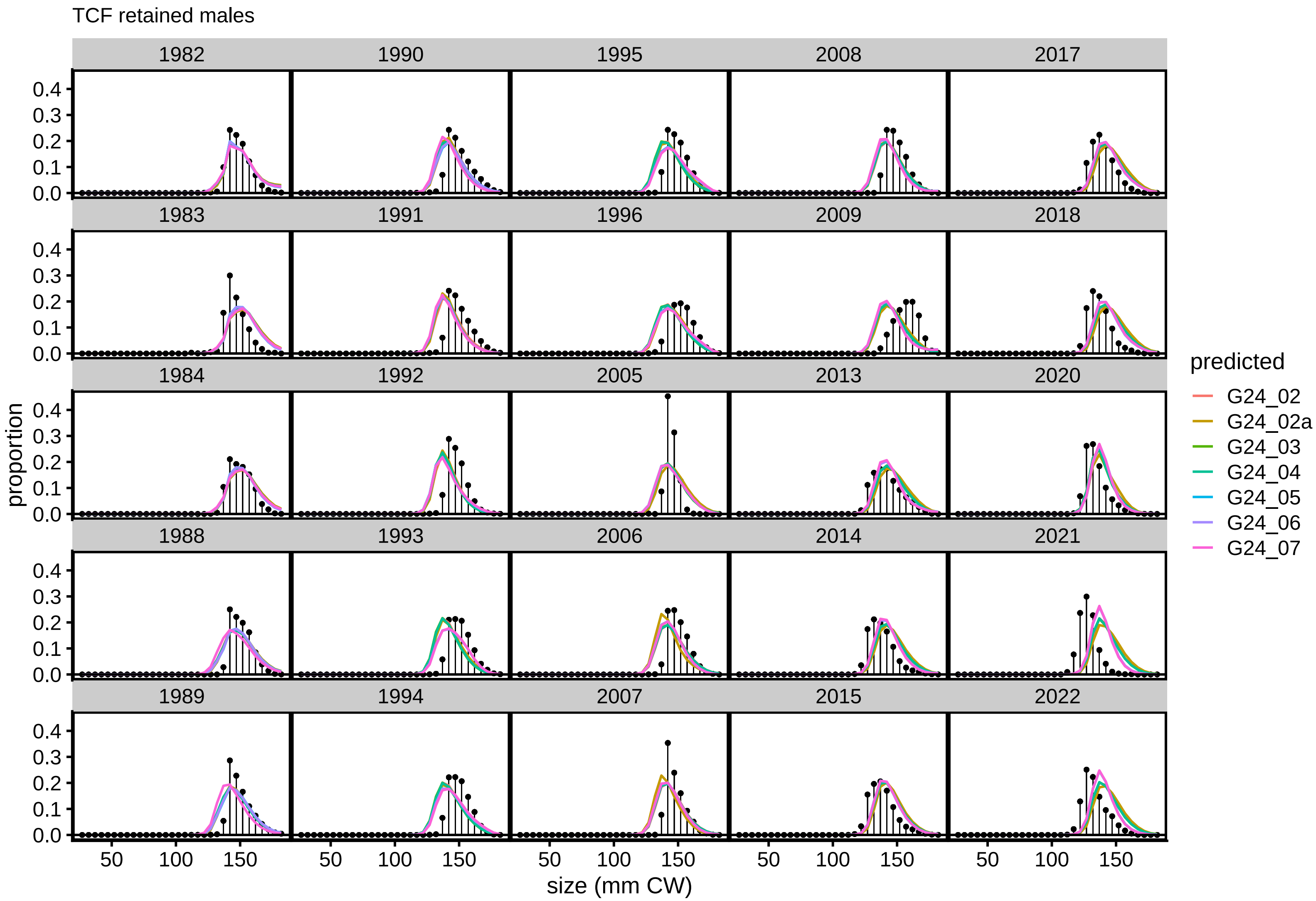

Figure 135. Fits to size comps for TCF retained males. Pins: observed proportions; lines: predicted proprtions, colored by case.

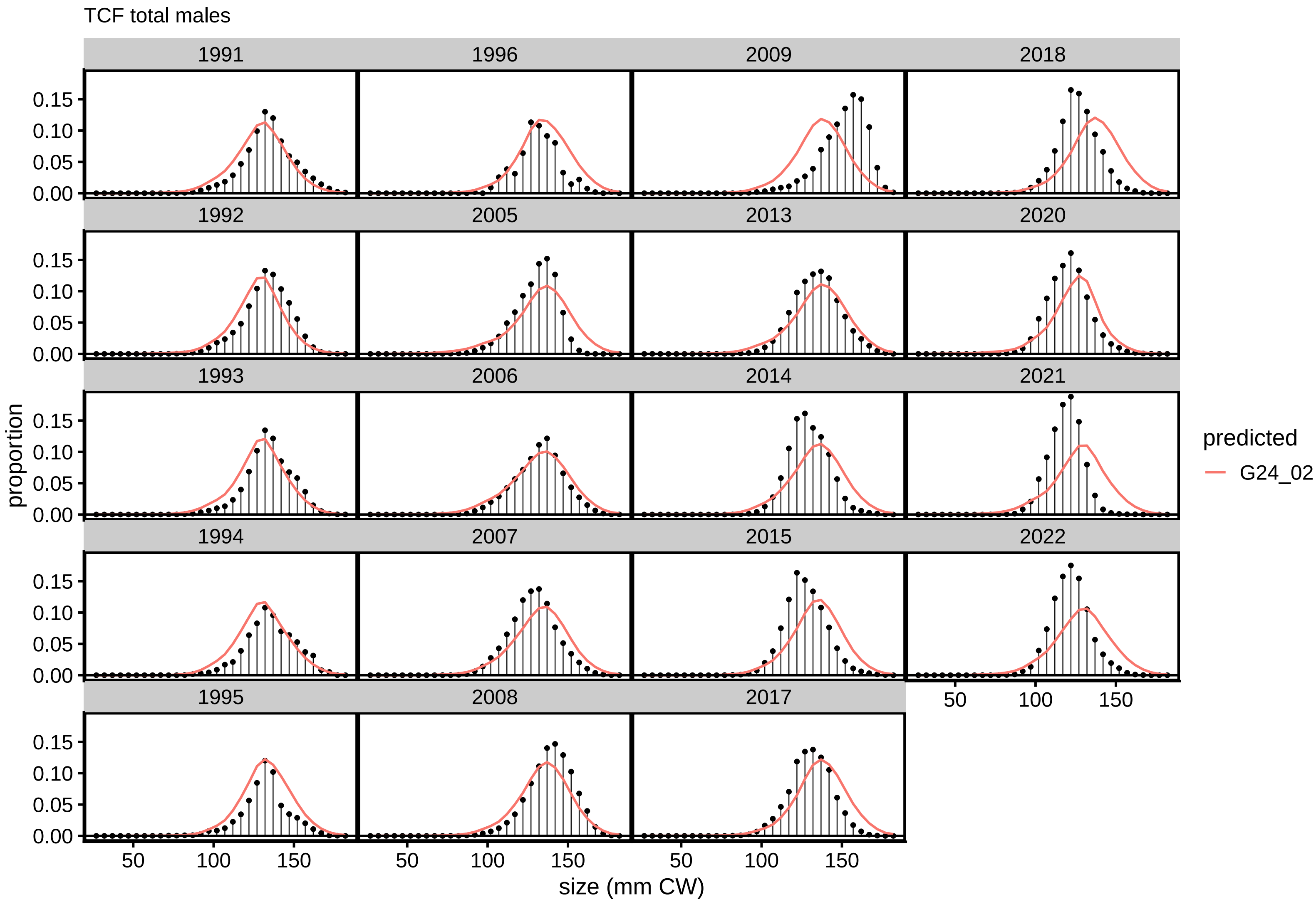

Figure 136. Fits to size comps for TCF total males. Pins: observed proportions; lines: predicted proprtions, colored by case.

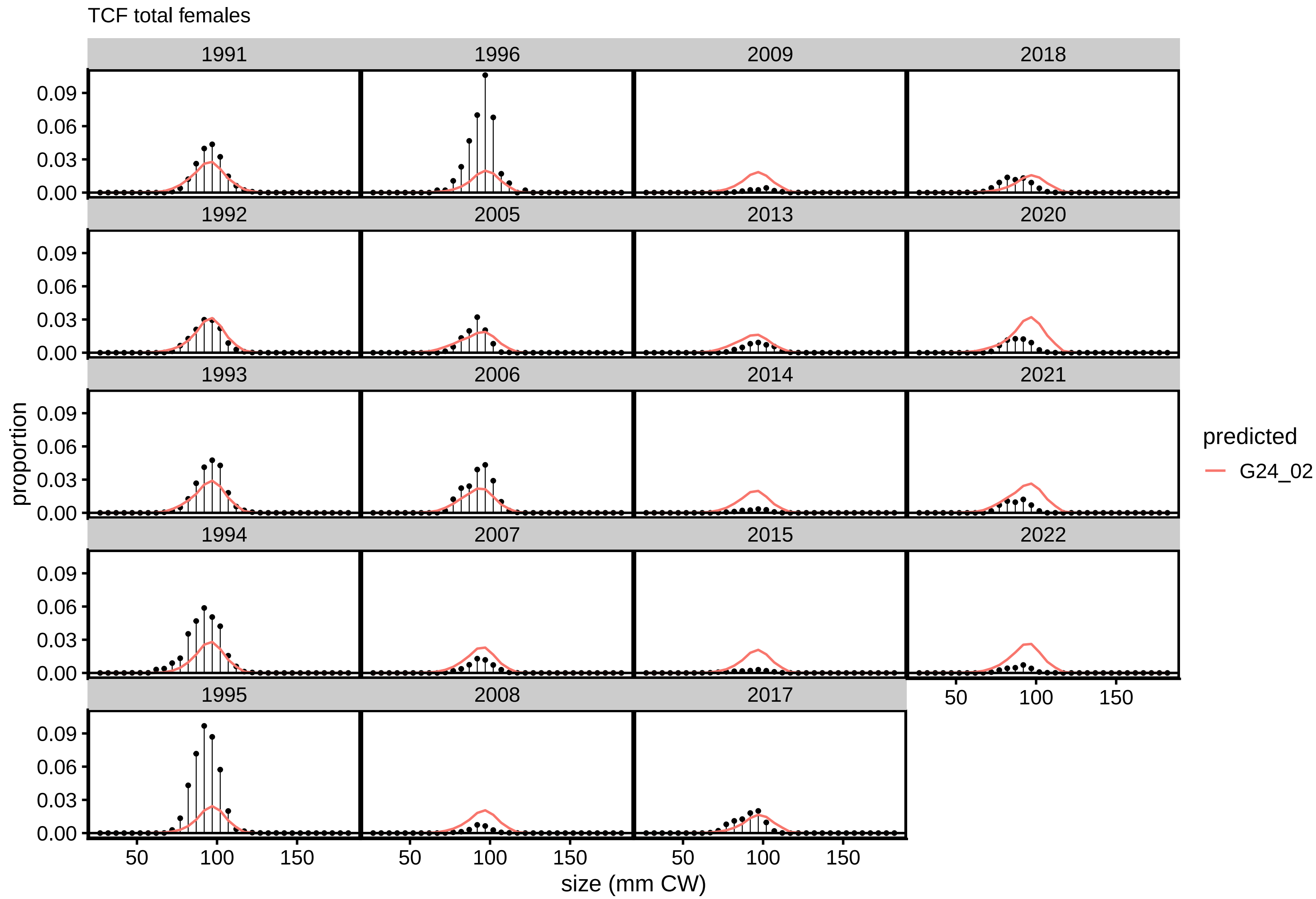

Figure 137. Fits to size comps for TCF total females. Pins: observed proportions; lines: predicted proprtions, colored by case.

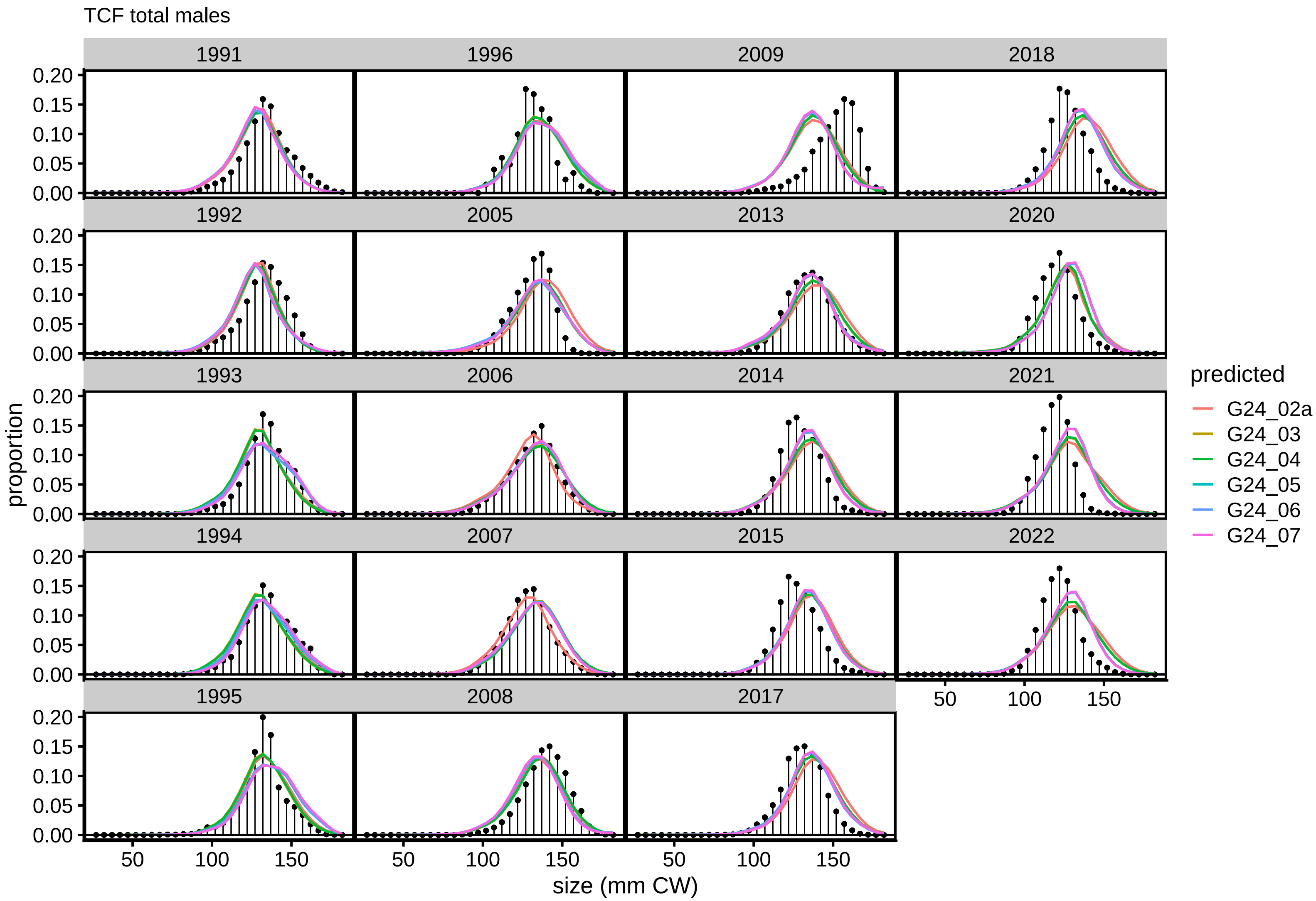

Figure 138. Fits to size comps for TCF total males. Pins: observed proportions; lines: predicted proprtions, colored by case.

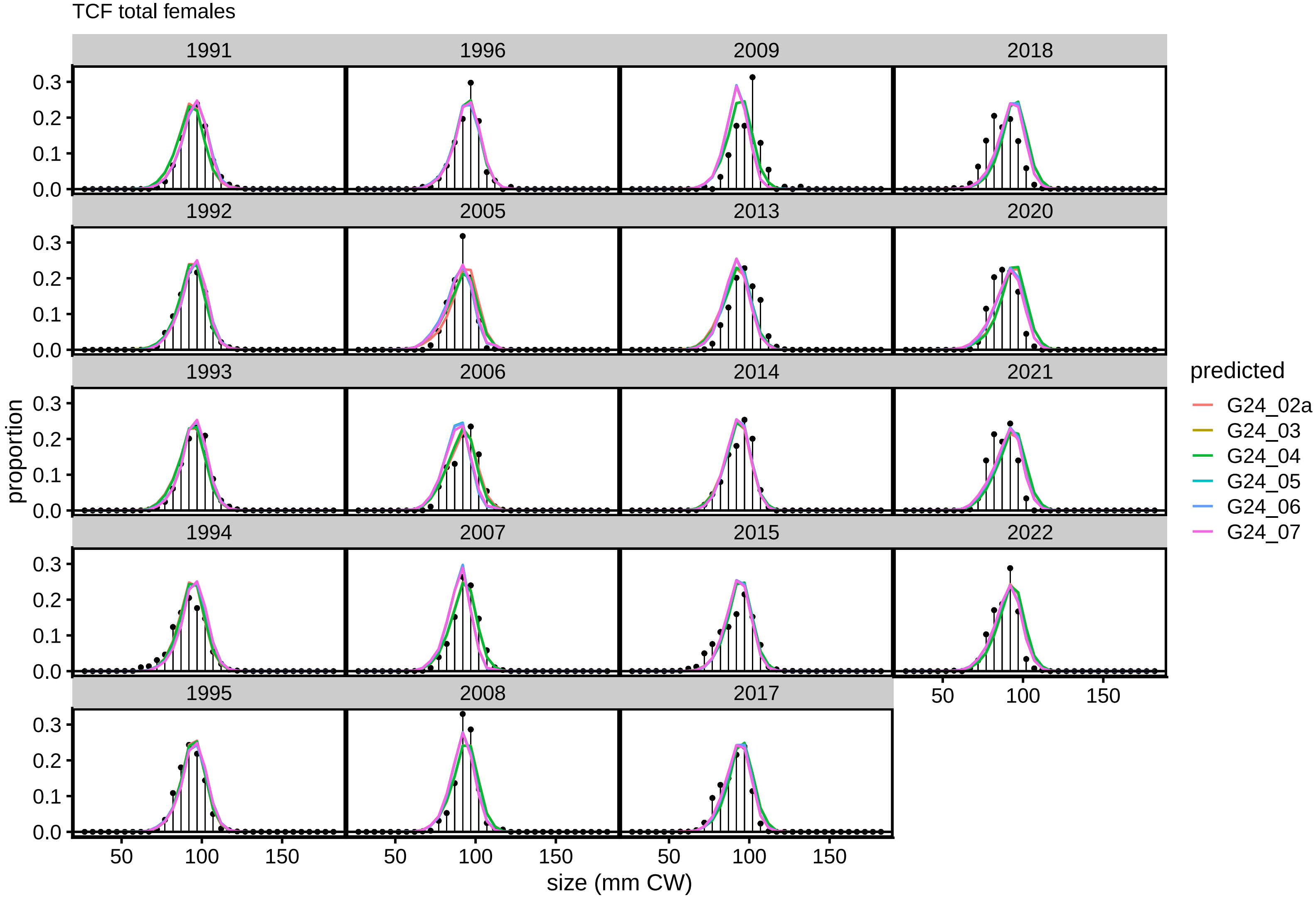

Figure 139. Fits to size comps for TCF total females. Pins: observed proportions; lines: predicted proprtions, colored by case.

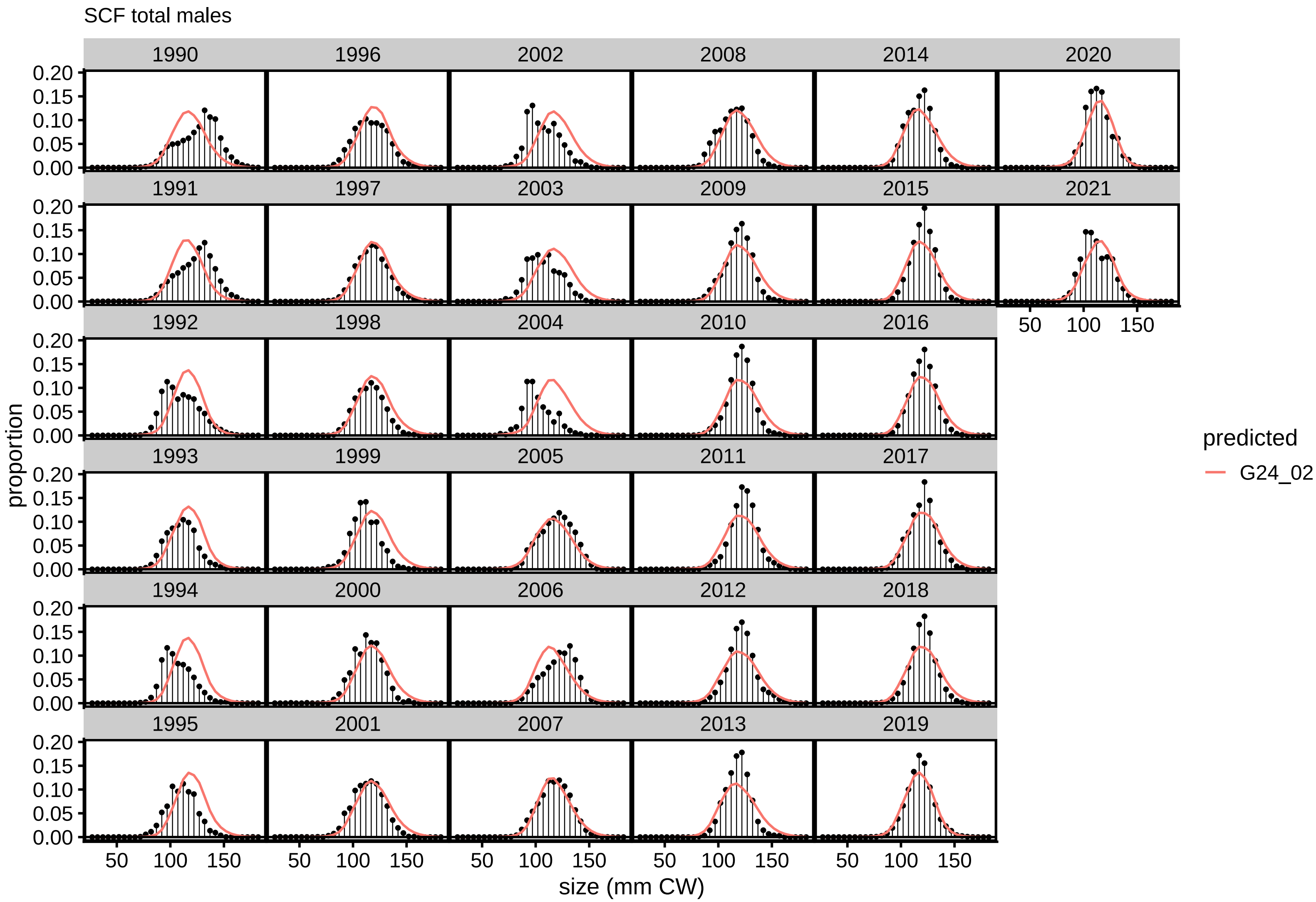

Figure 140. Fits to size comps for SCF total males. Pins: observed proportions; lines: predicted proprtions, colored by case.

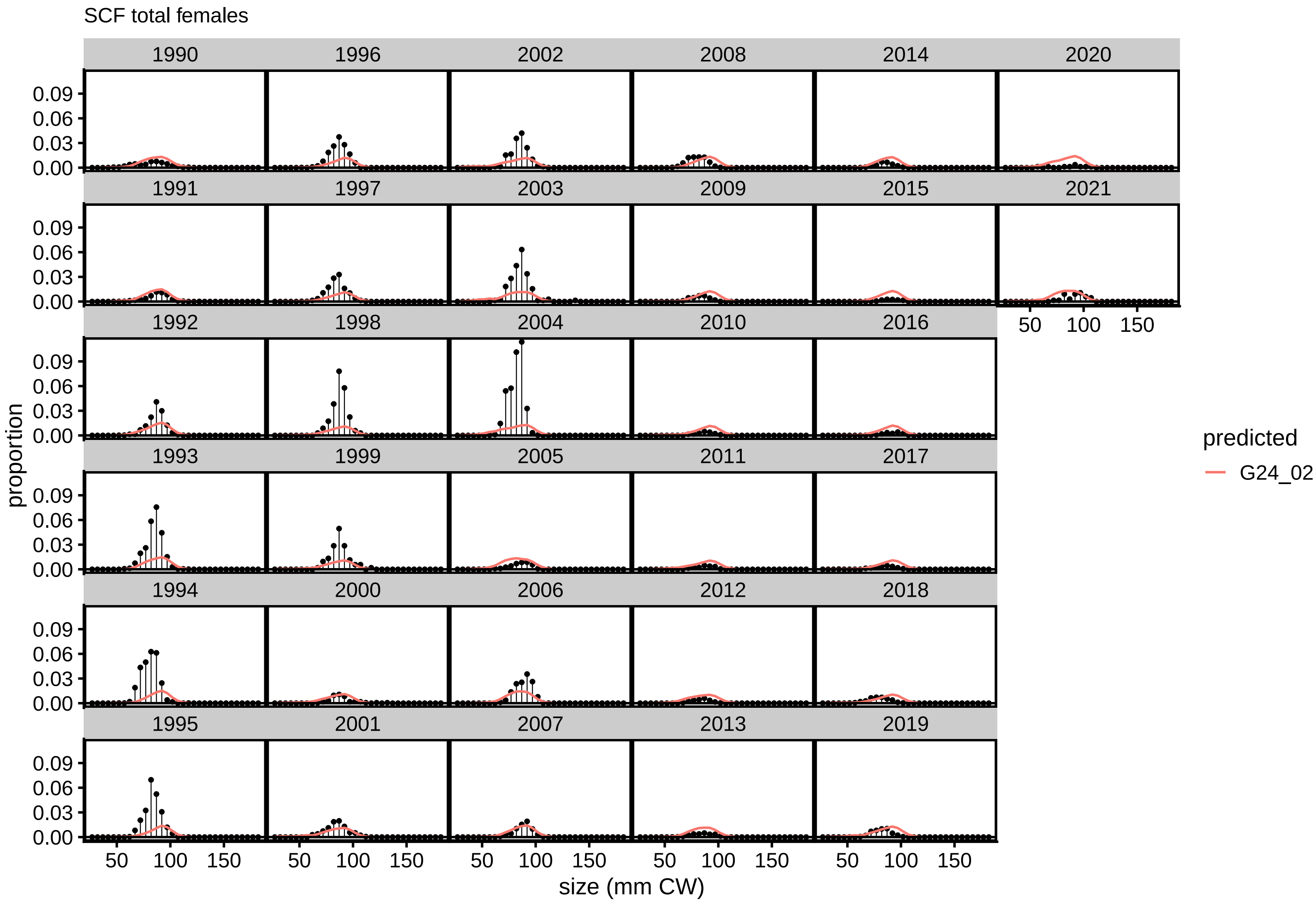

Figure 141. Fits to size comps for SCF total females. Pins: observed proportions; lines: predicted proprtions, colored by case.

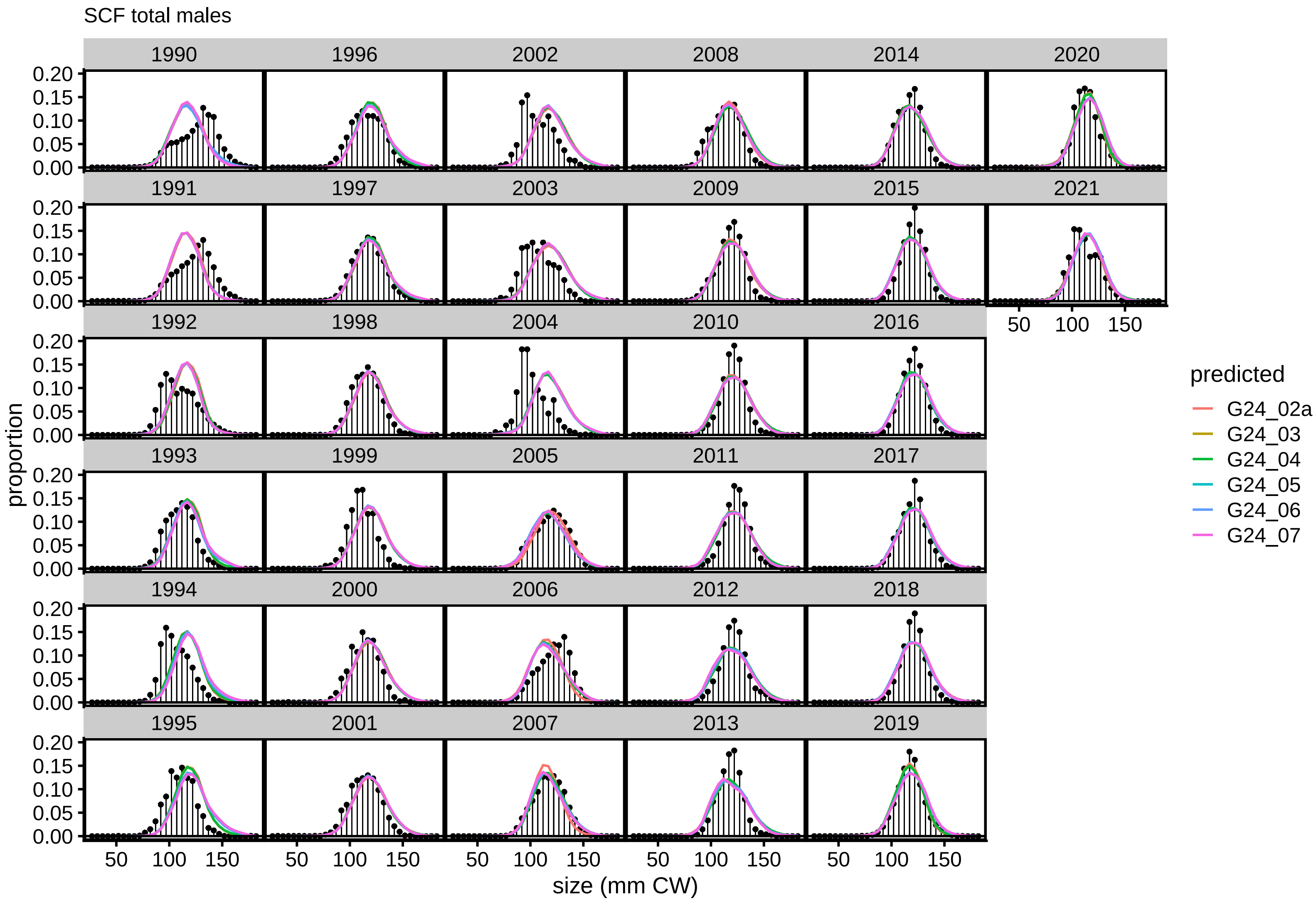

Figure 142. Fits to size comps for SCF total males. Pins: observed proportions; lines: predicted proprtions, colored by case.

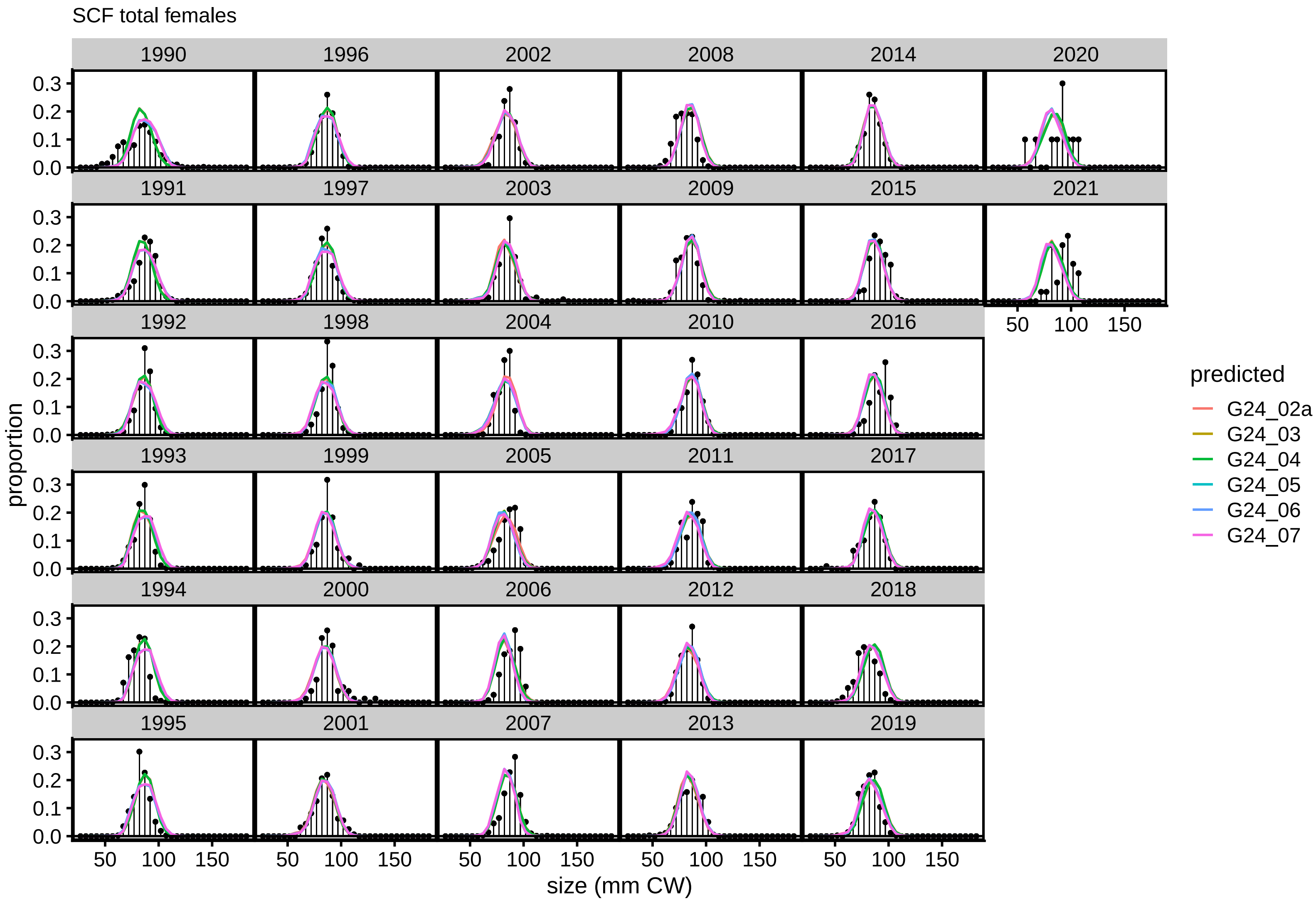

Figure 143. Fits to size comps for SCF total females. Pins: observed proportions; lines: predicted proprtions, colored by case.

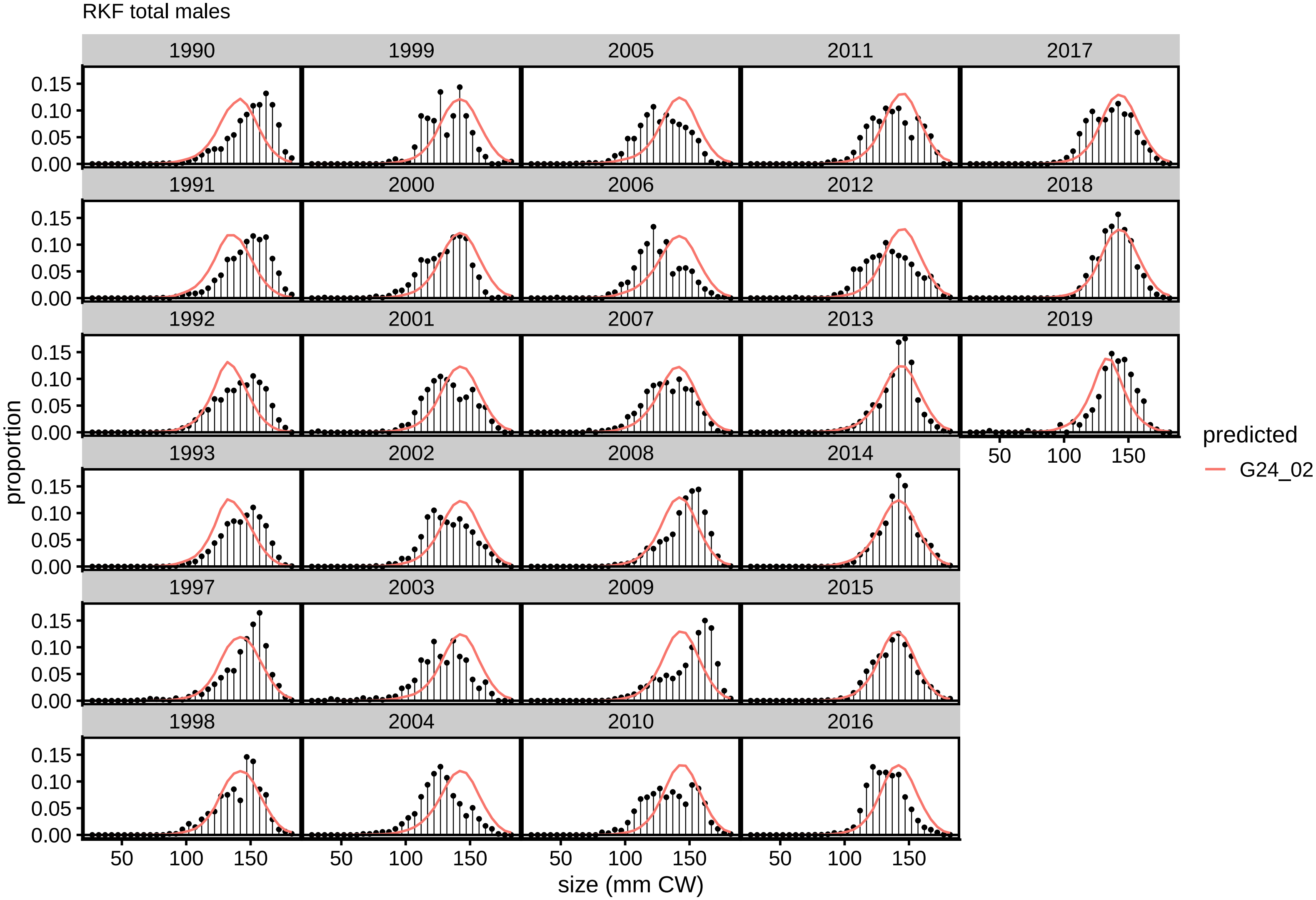

Figure 144. Fits to size comps for RKF total males. Pins: observed proportions; lines: predicted proprtions, colored by case.

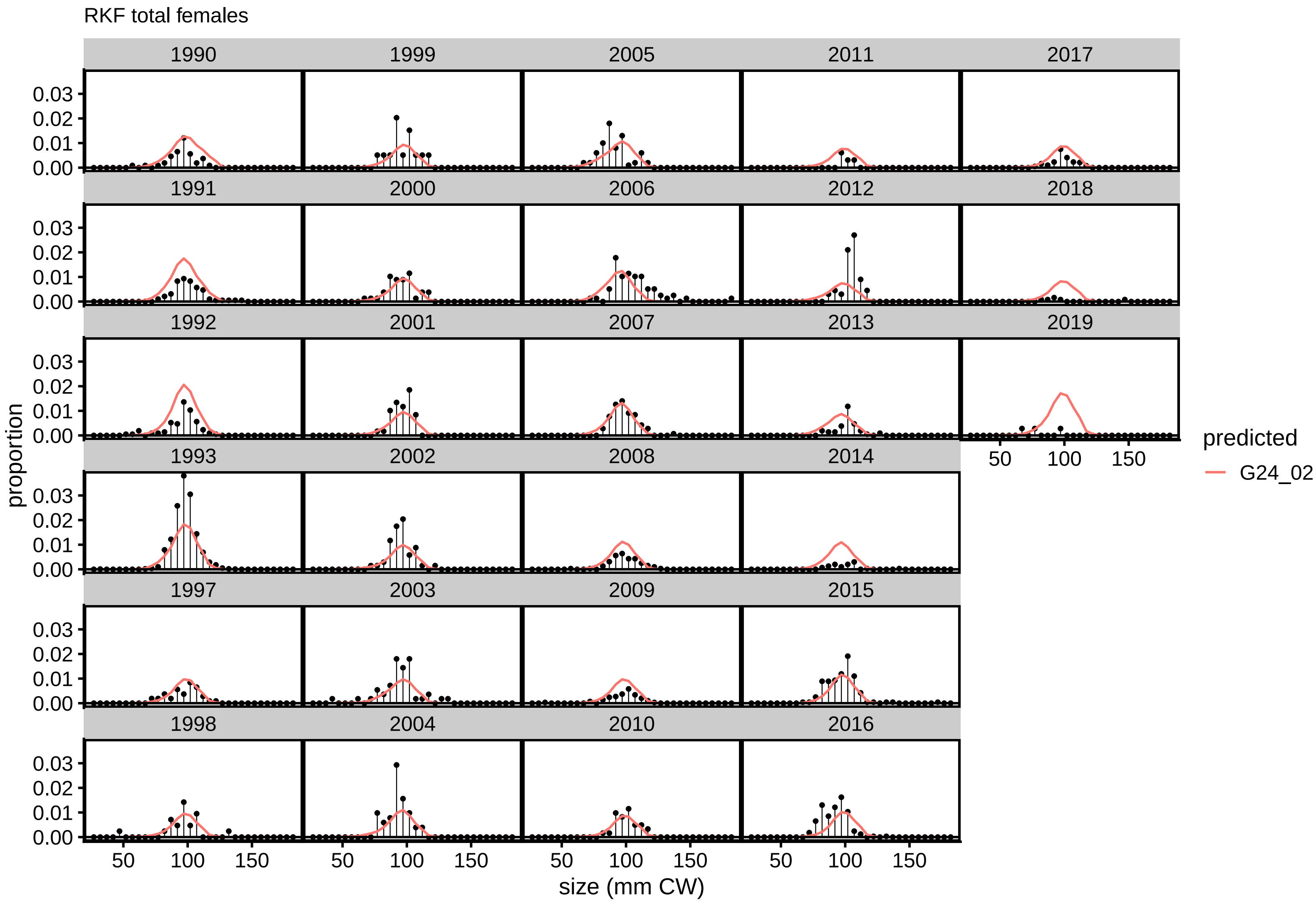

Figure 145. Fits to size comps for RKF total females. Pins: observed proportions; lines: predicted proprtions, colored by case.

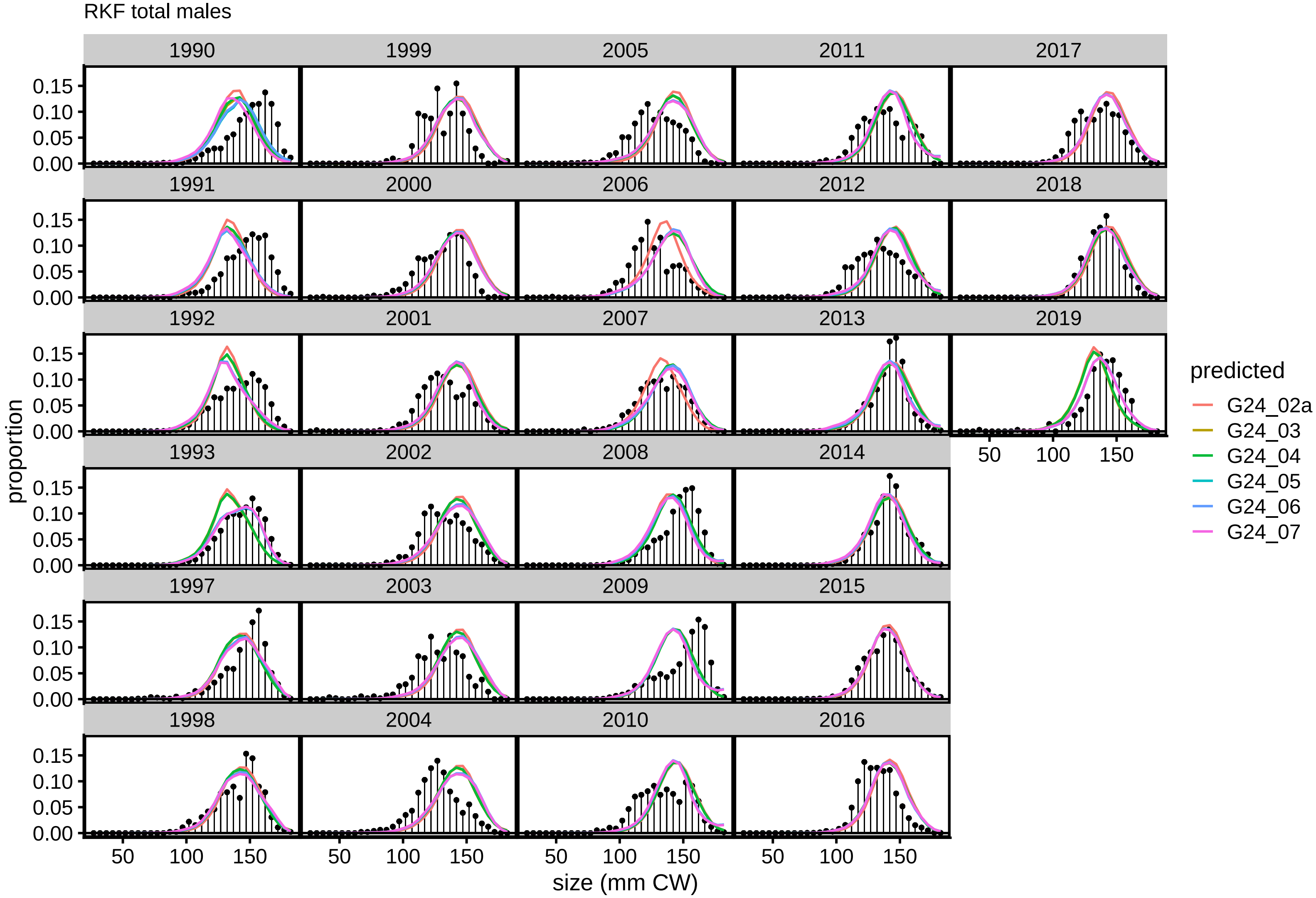

Figure 146. Fits to size comps for RKF total males. Pins: observed proportions; lines: predicted proprtions, colored by case.

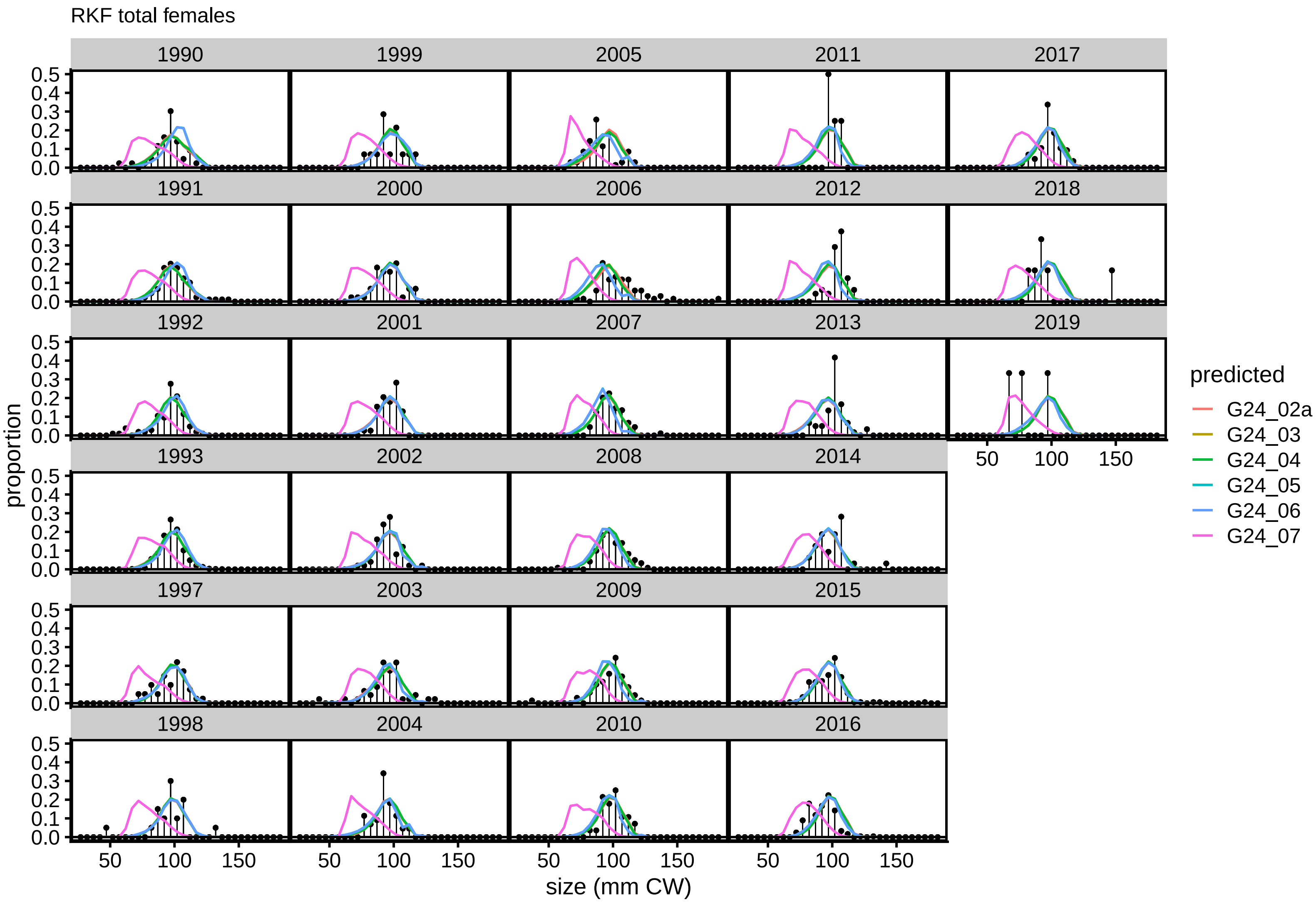

Figure 147. Fits to size comps for RKF total females. Pins: observed proportions; lines: predicted proprtions, colored by case.

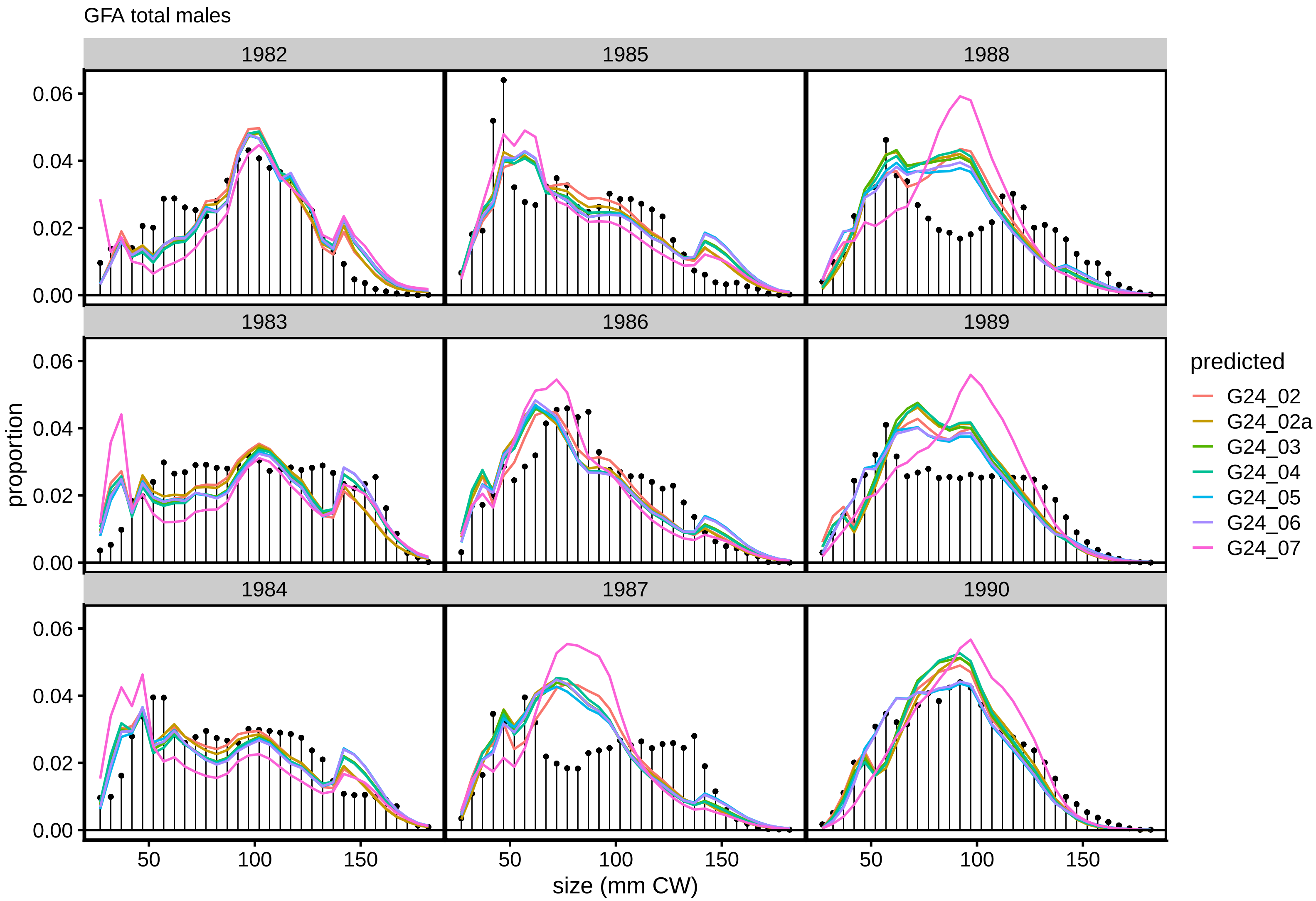

Figure 148. Fits to size comps for GFA total males. Pins: observed proportions; lines: predicted proprtions, colored by case.

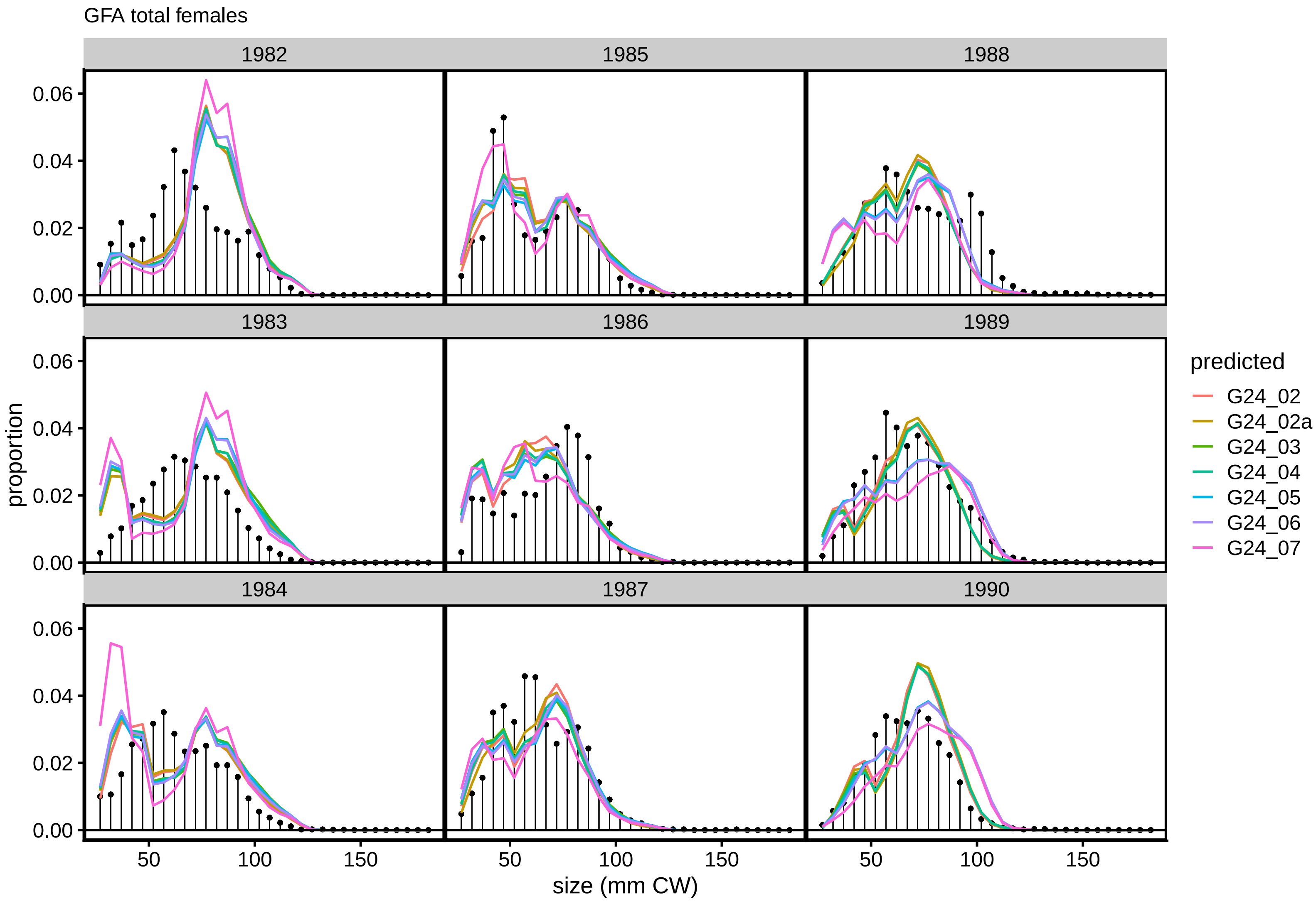

Figure 149. Fits to size comps for GFA total females. Pins: observed proportions; lines: predicted proprtions, colored by case.

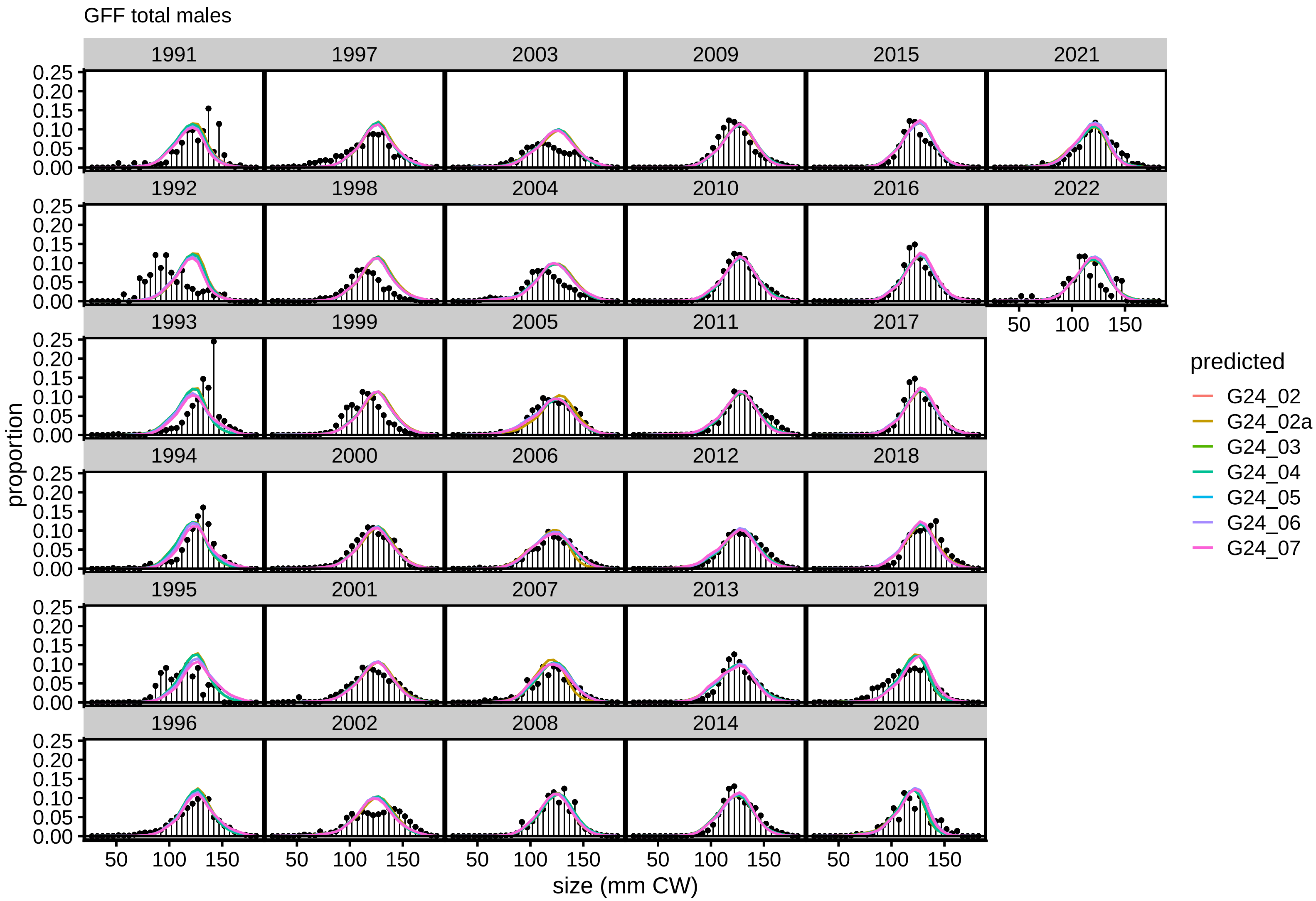

Figure 150. Fits to size comps for GFF total males. Pins: observed proportions; lines: predicted proprtions, colored by case.

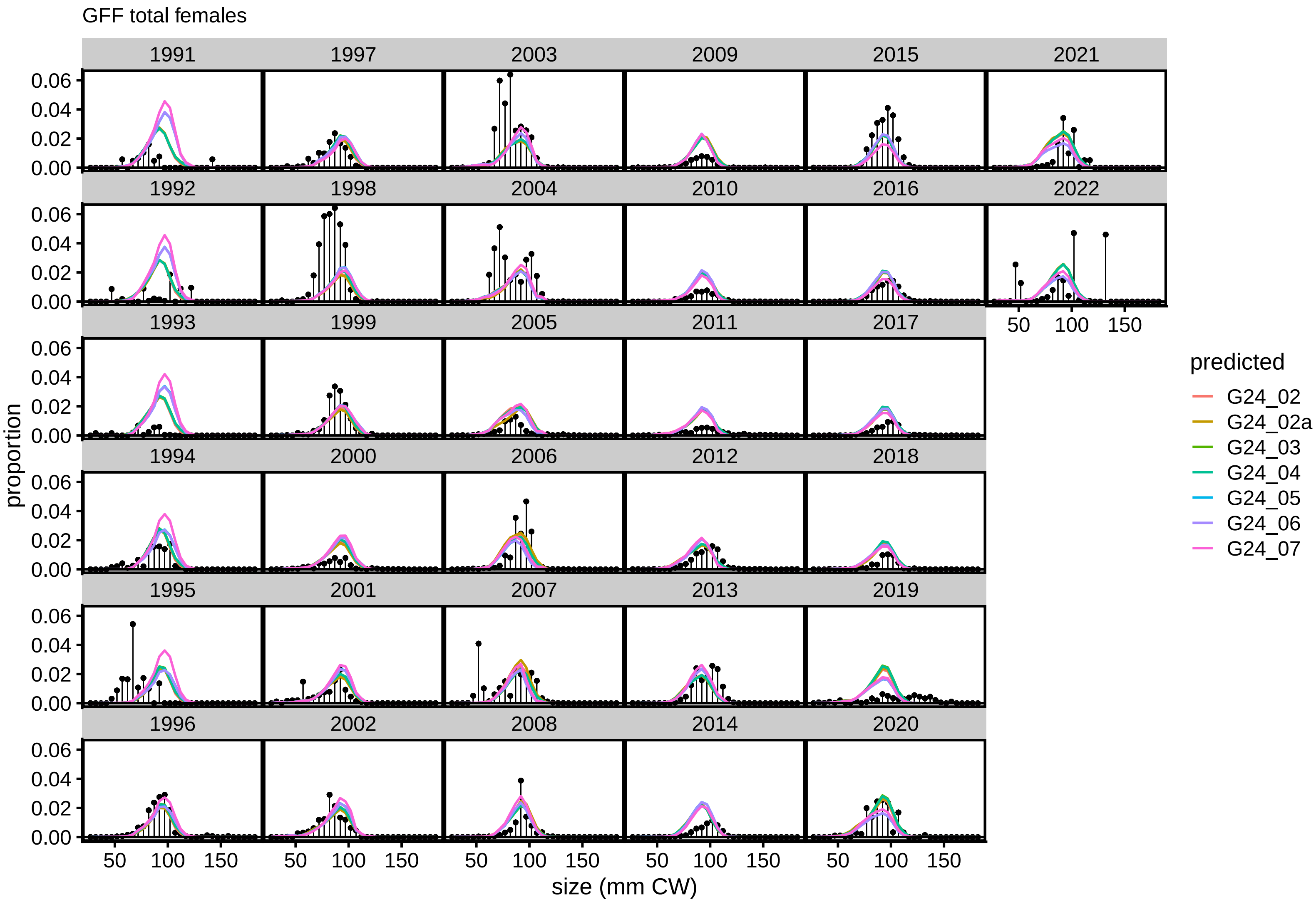

Figure 151. Fits to size comps for GFF total females. Pins: observed proportions; lines: predicted proprtions, colored by case.

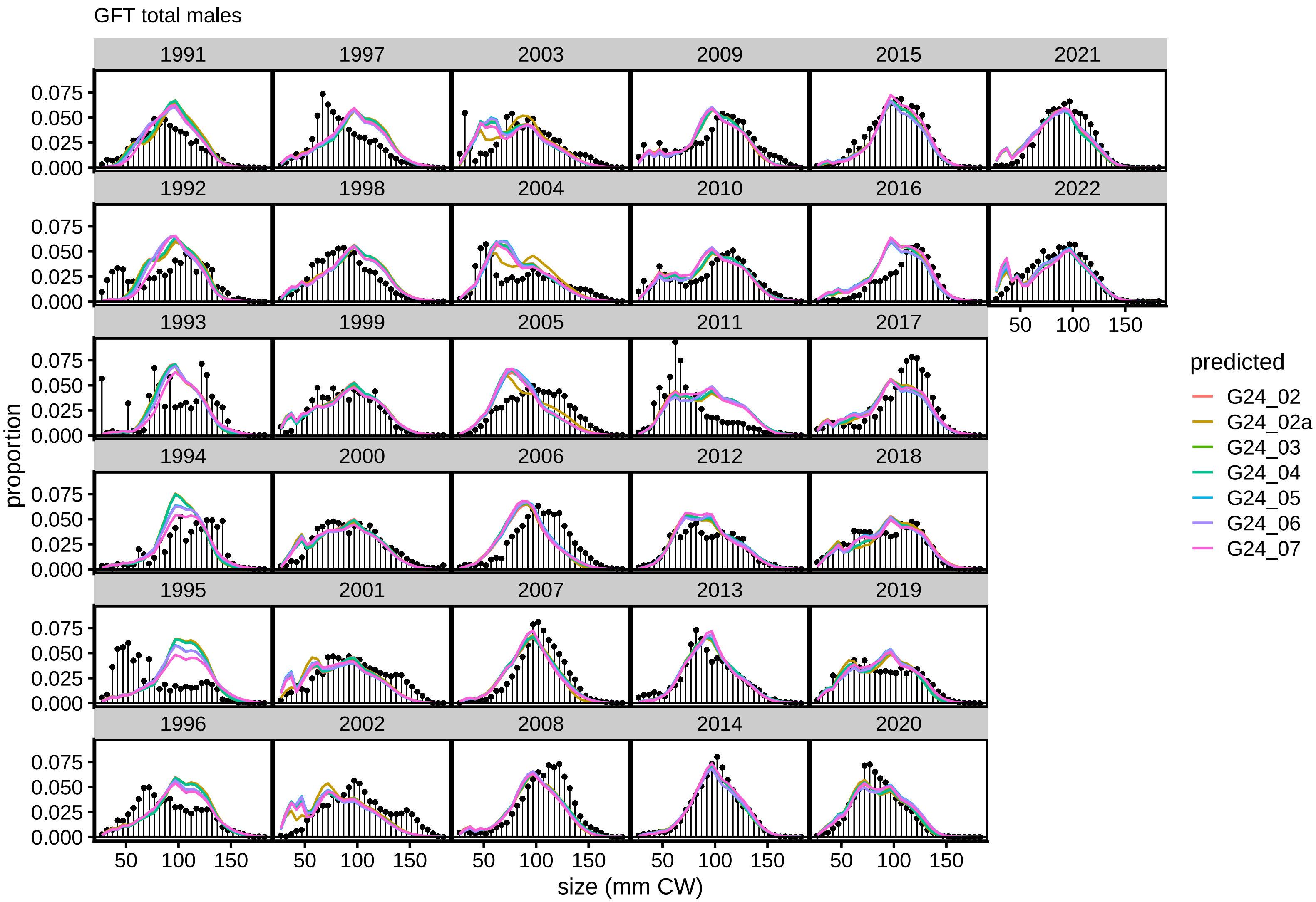

Figure 152. Fits to size comps for GFT total males. Pins: observed proportions; lines: predicted proprtions, colored by case.

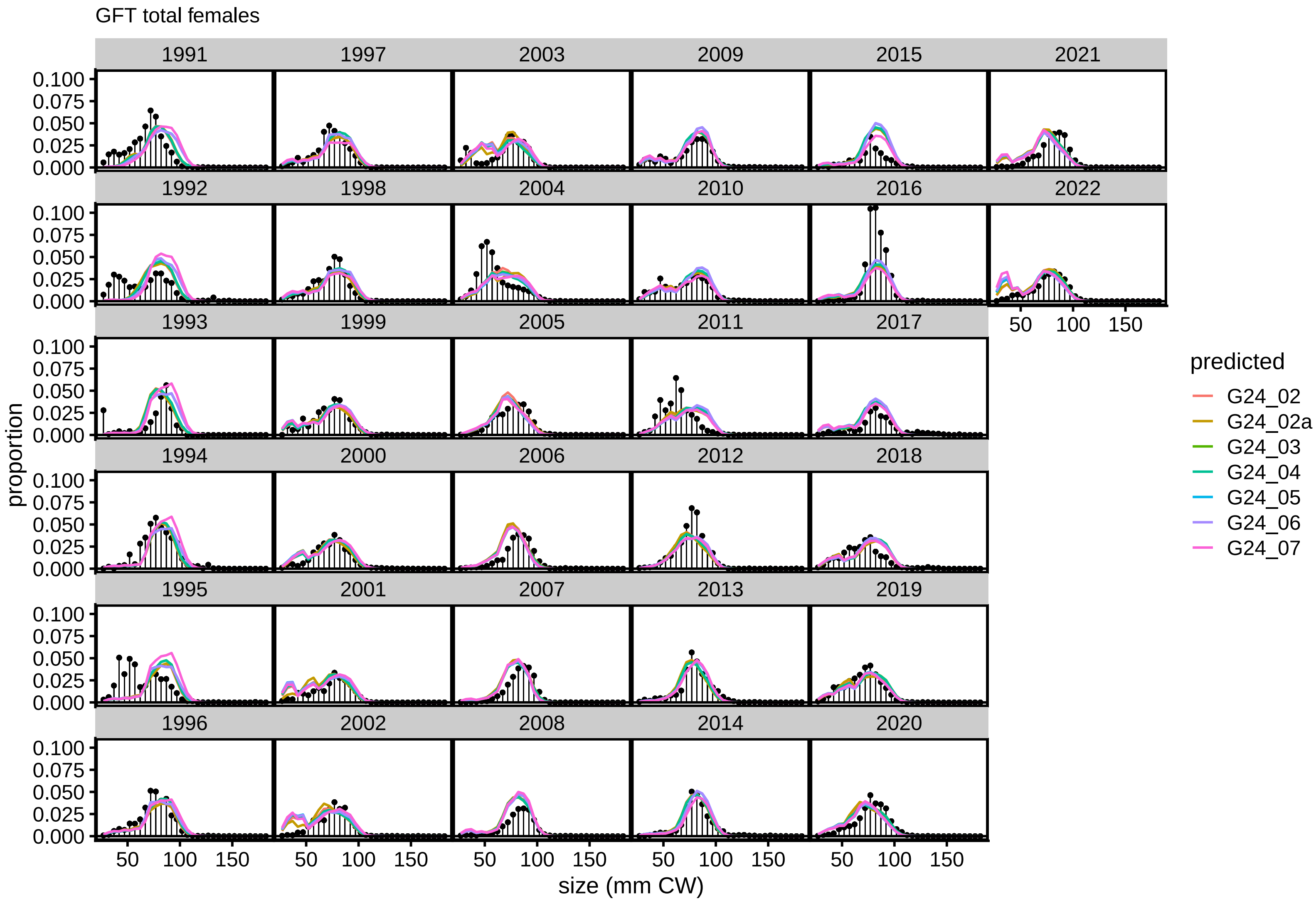

Figure 153. Fits to size comps for GFT total females. Pins: observed proportions; lines: predicted proprtions, colored by case.

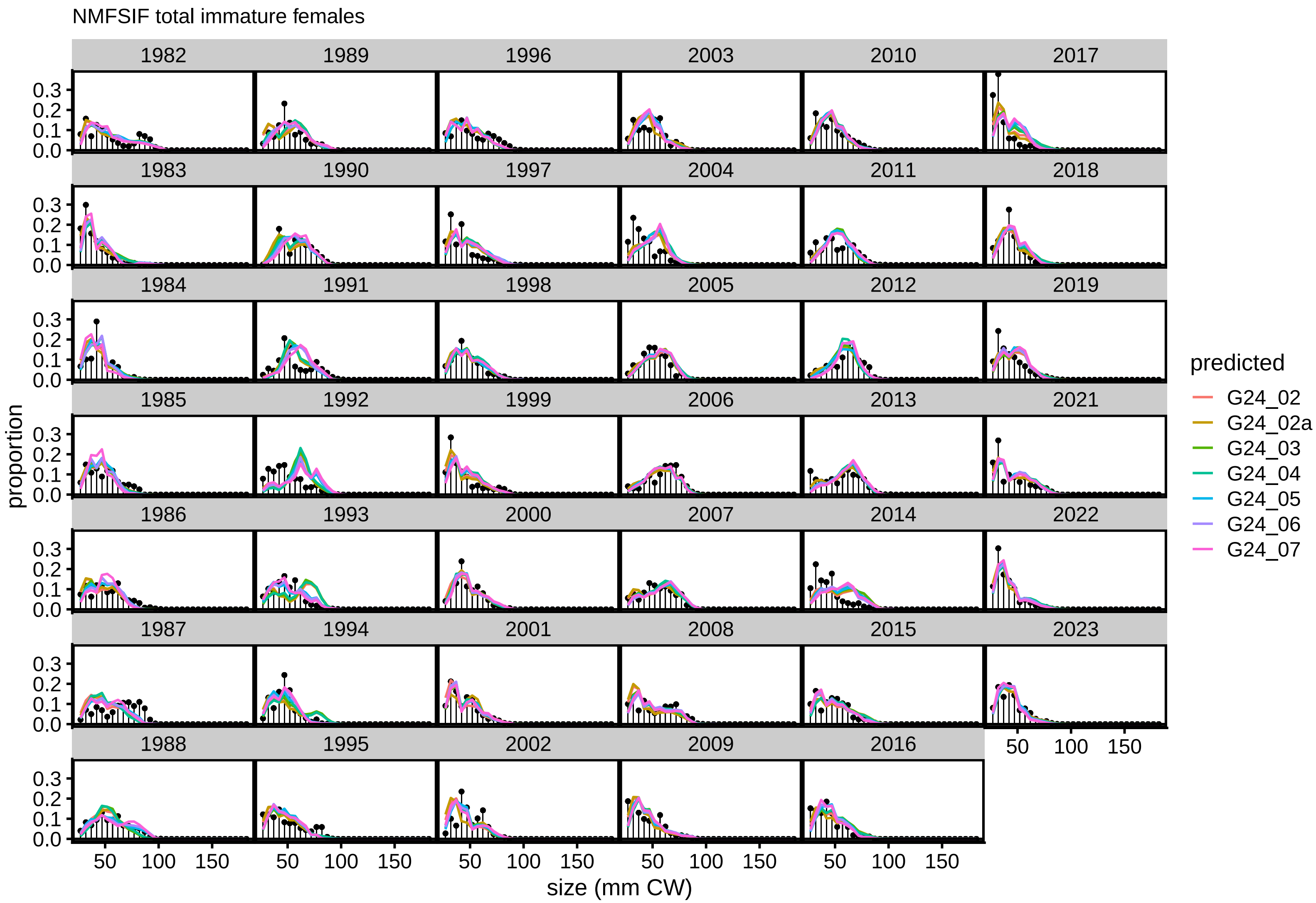

Figure 154. Fits to size comps for NMFSIF total immature females. Pins: observed proportions; lines: predicted proprtions, colored by case.

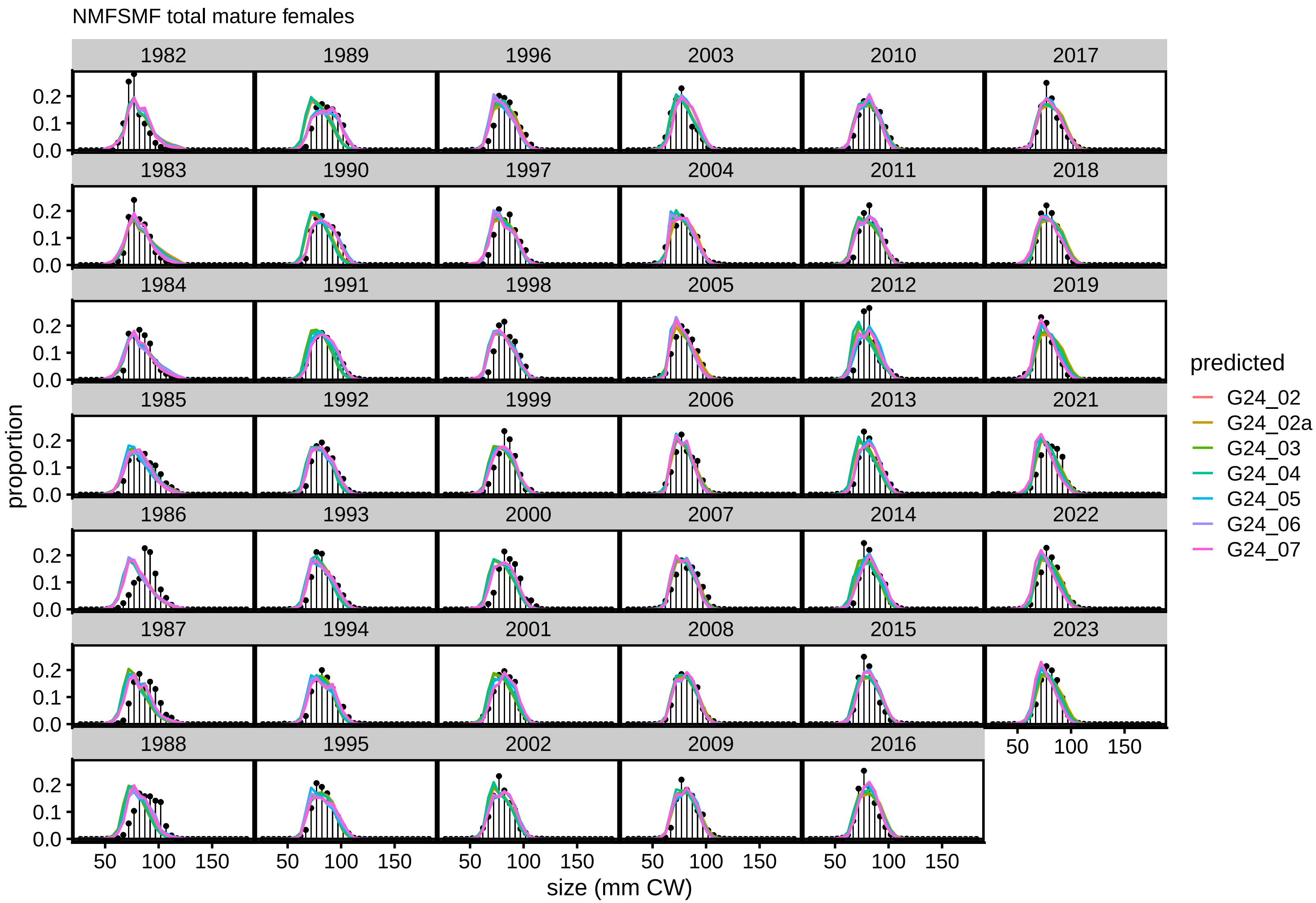

Figure 155. Fits to size comps for NMFSMF total mature females. Pins: observed proportions; lines: predicted proprtions, colored by case.

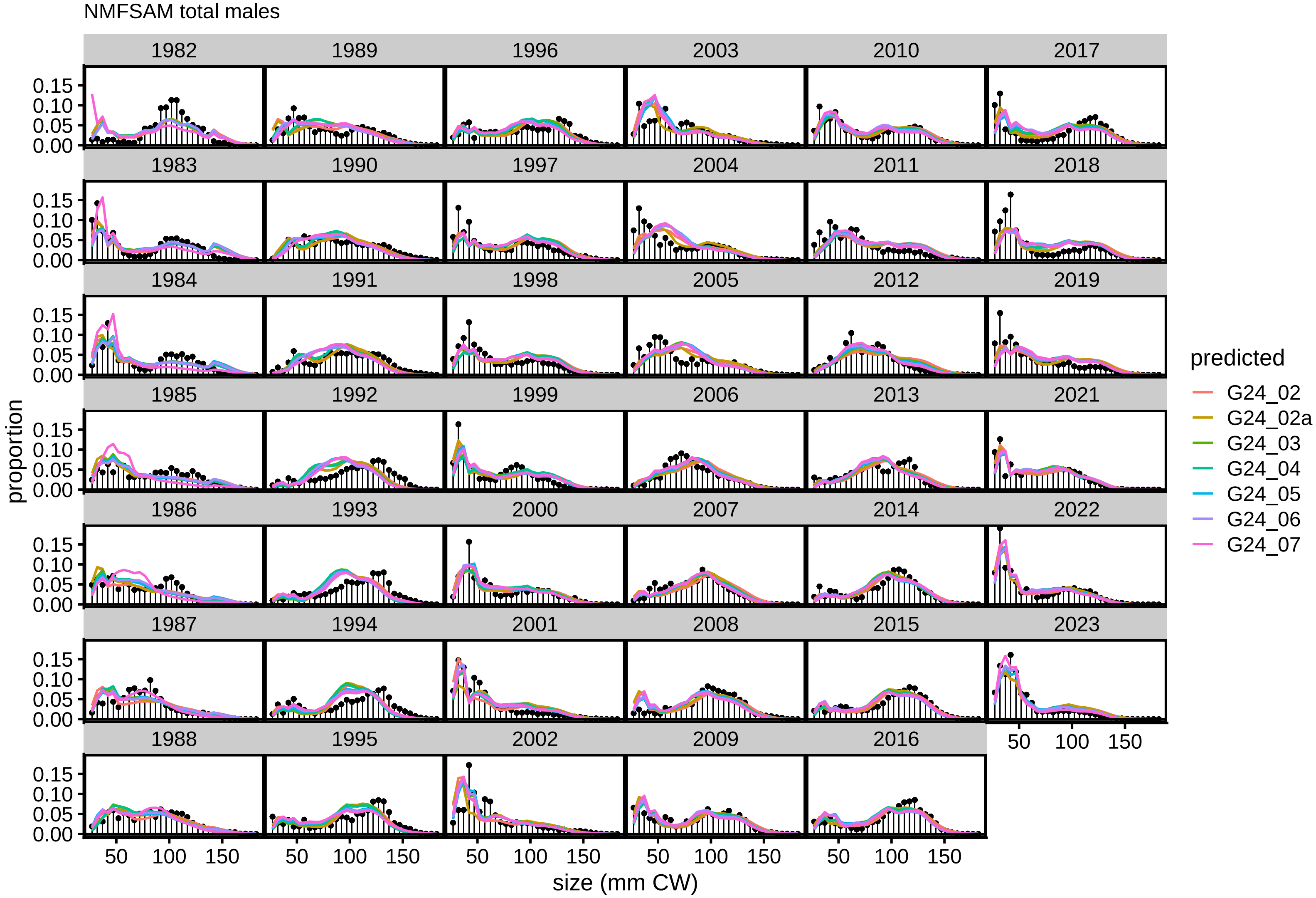

Figure 156. Fits to size comps for NMFSAM total males. Pins: observed proportions; lines: predicted proprtions, colored by case.

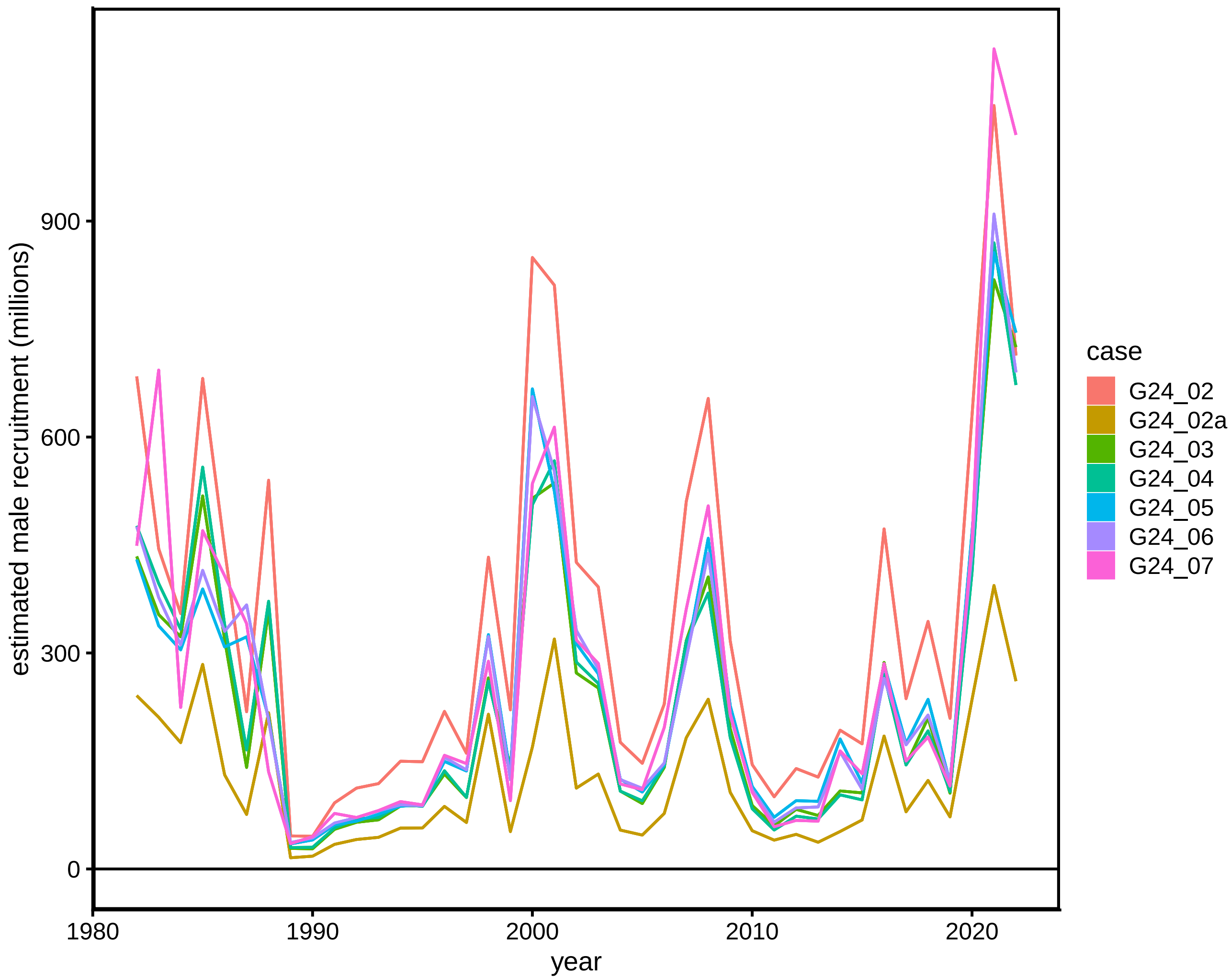

Figure 157. Time series estimates from GMACS models for recruitment.

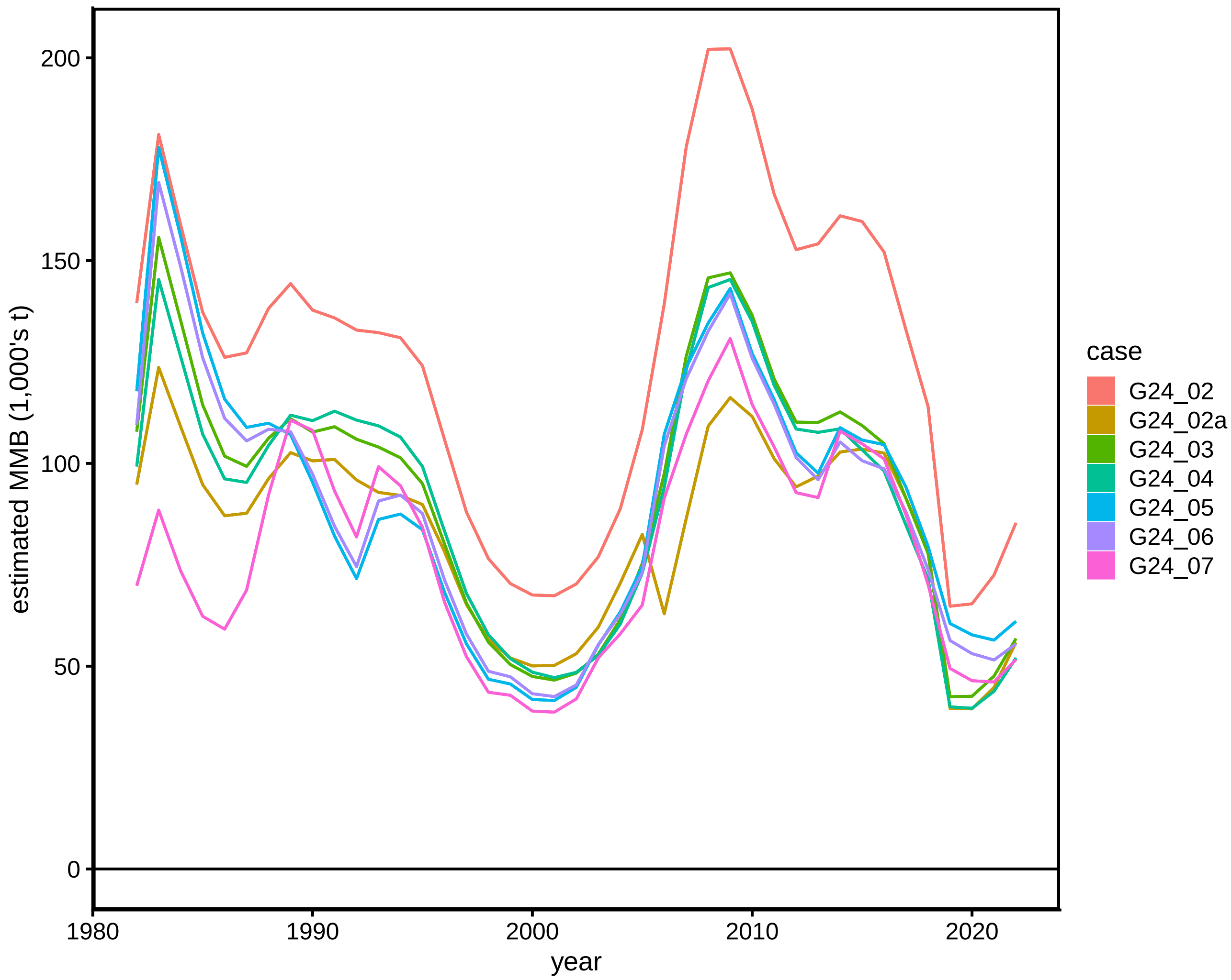

Figure 158. Time series estimates from GMACS models for MMB.

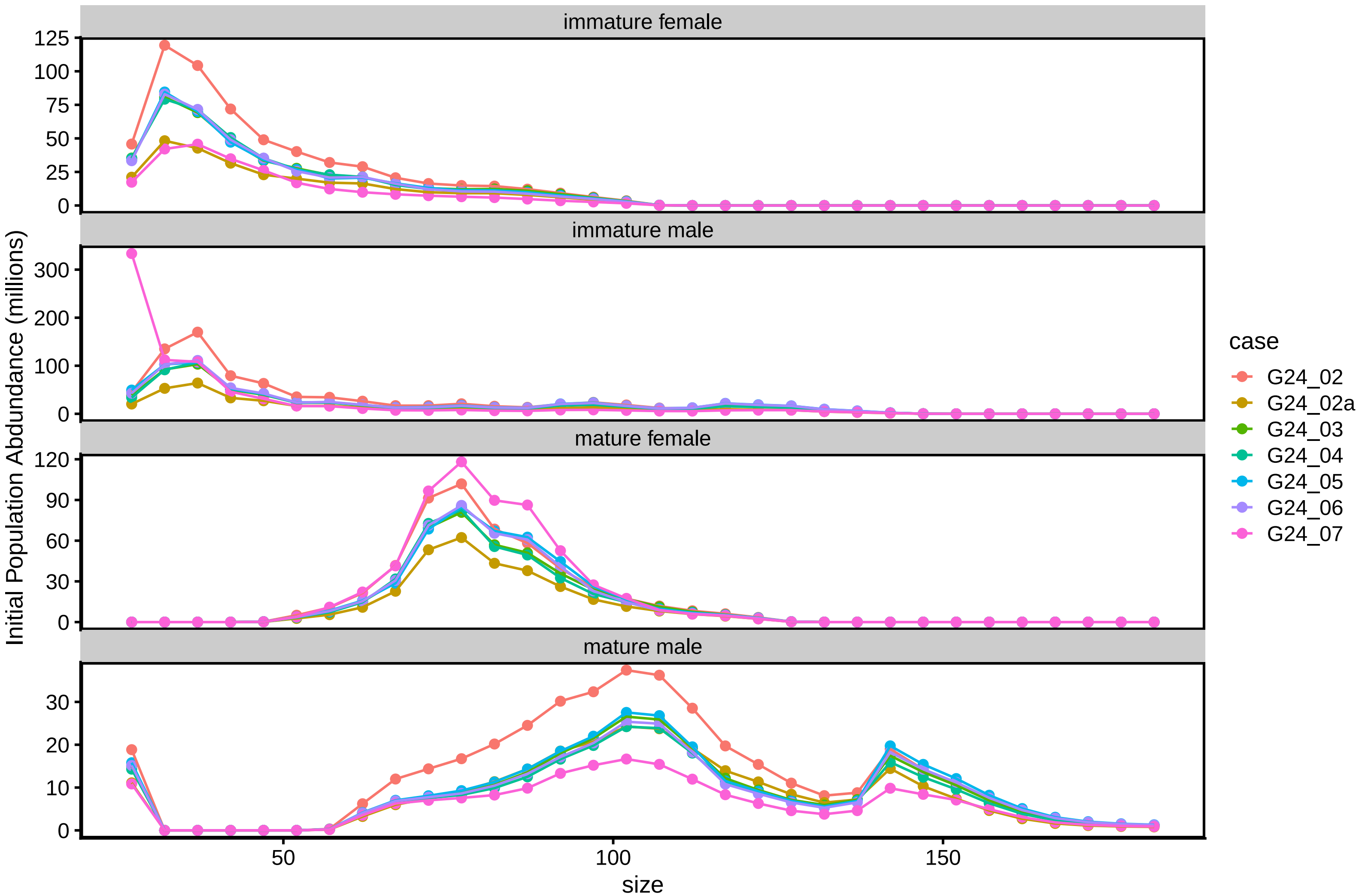

Figure 159. Initial population abundance from GMACS models, by category and size.

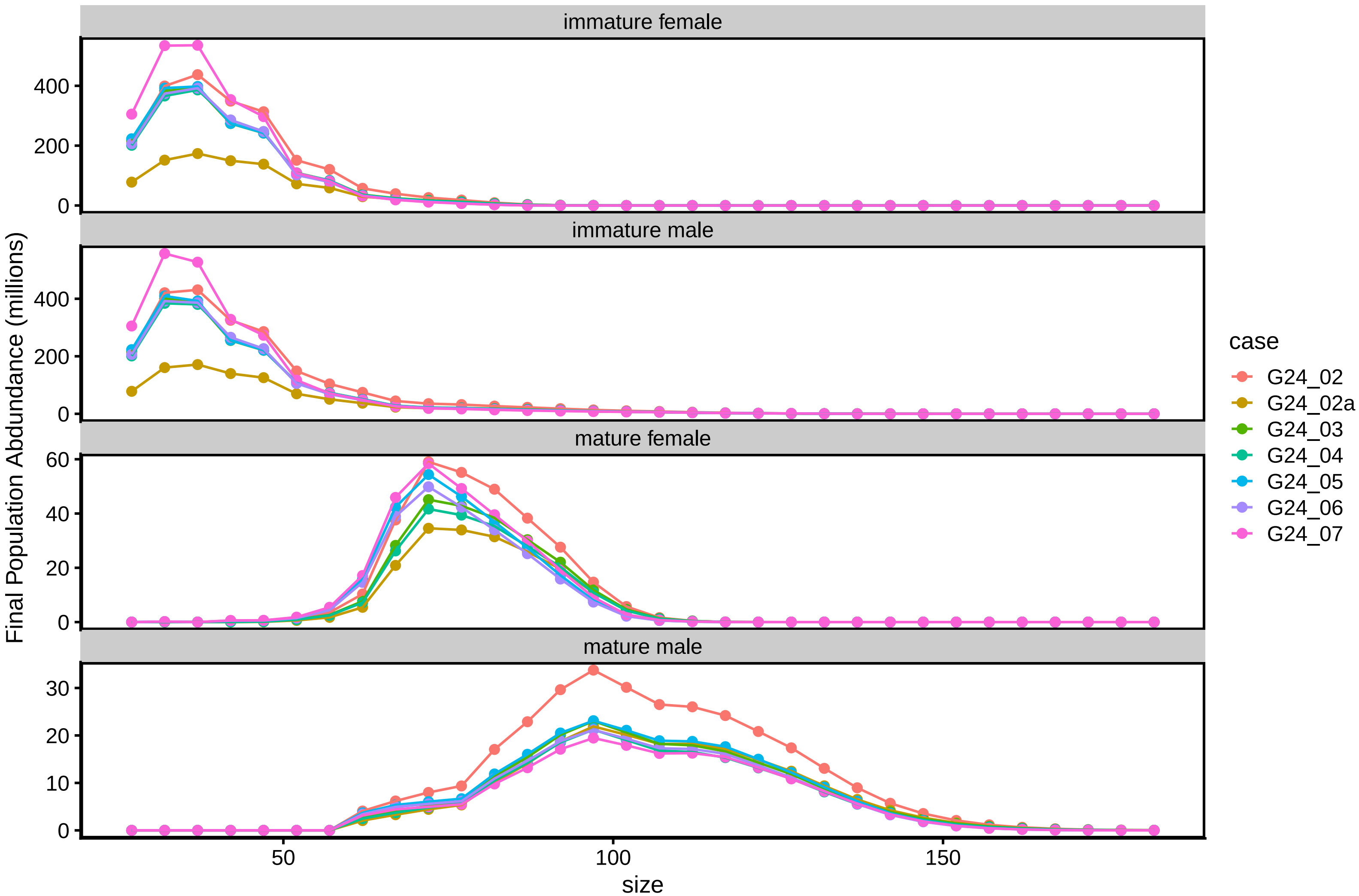

Figure 160. Final population abundance from GMACS models, by category and size.

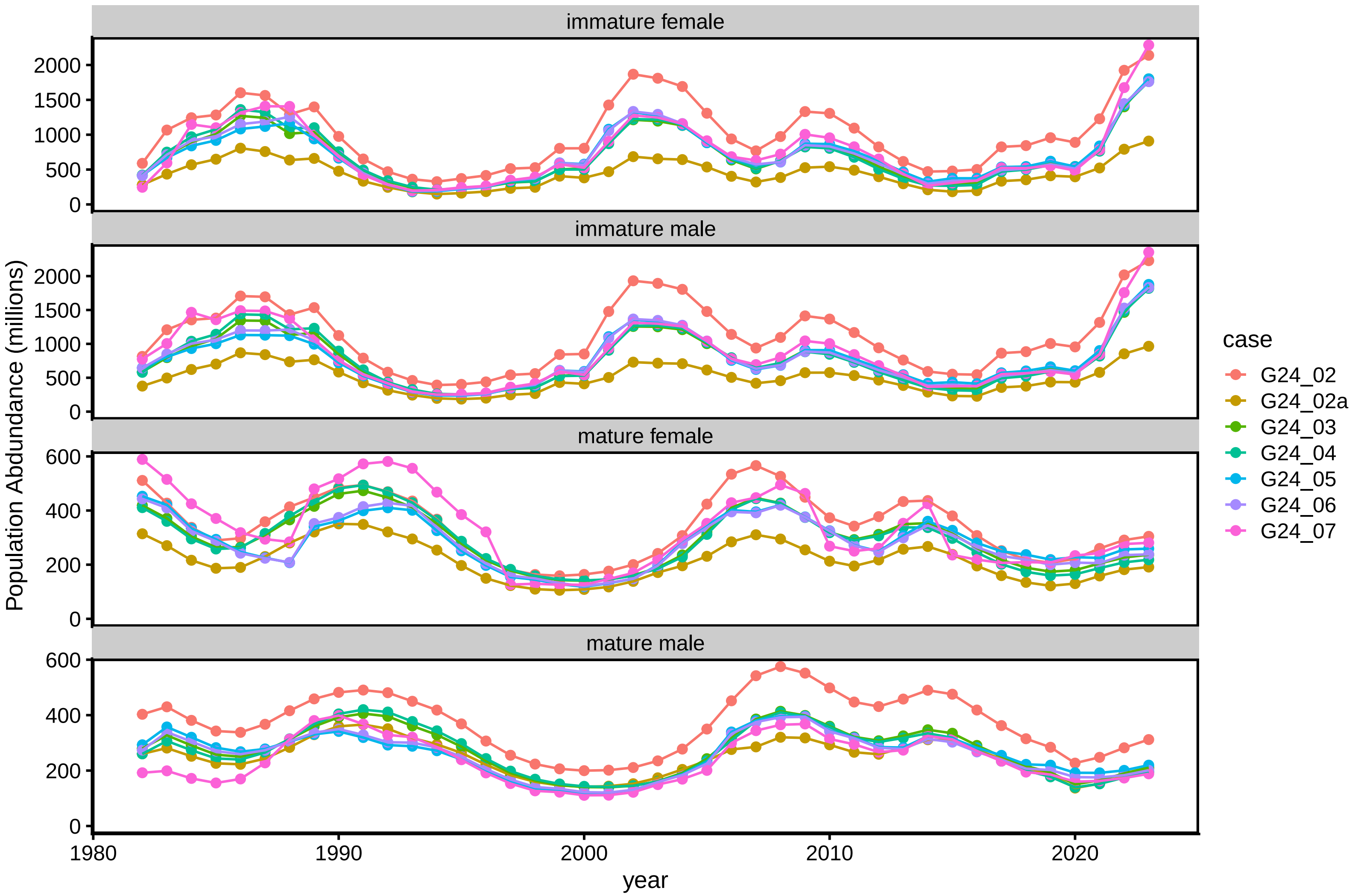

Figure 161. Time series of population abundance from GMACS models, by category.

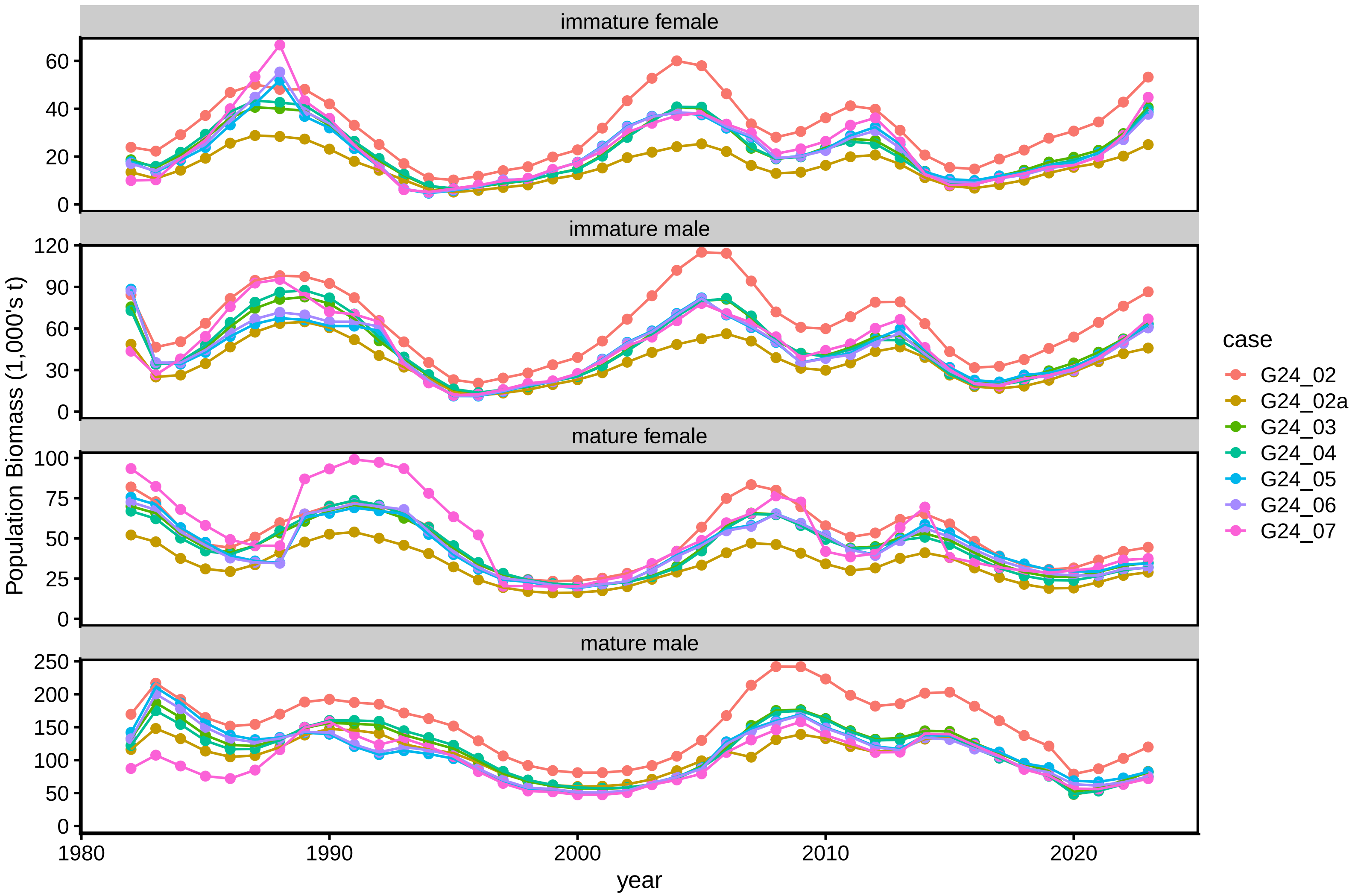

Figure 162. Time series of population biomass from GMACS models, by category.

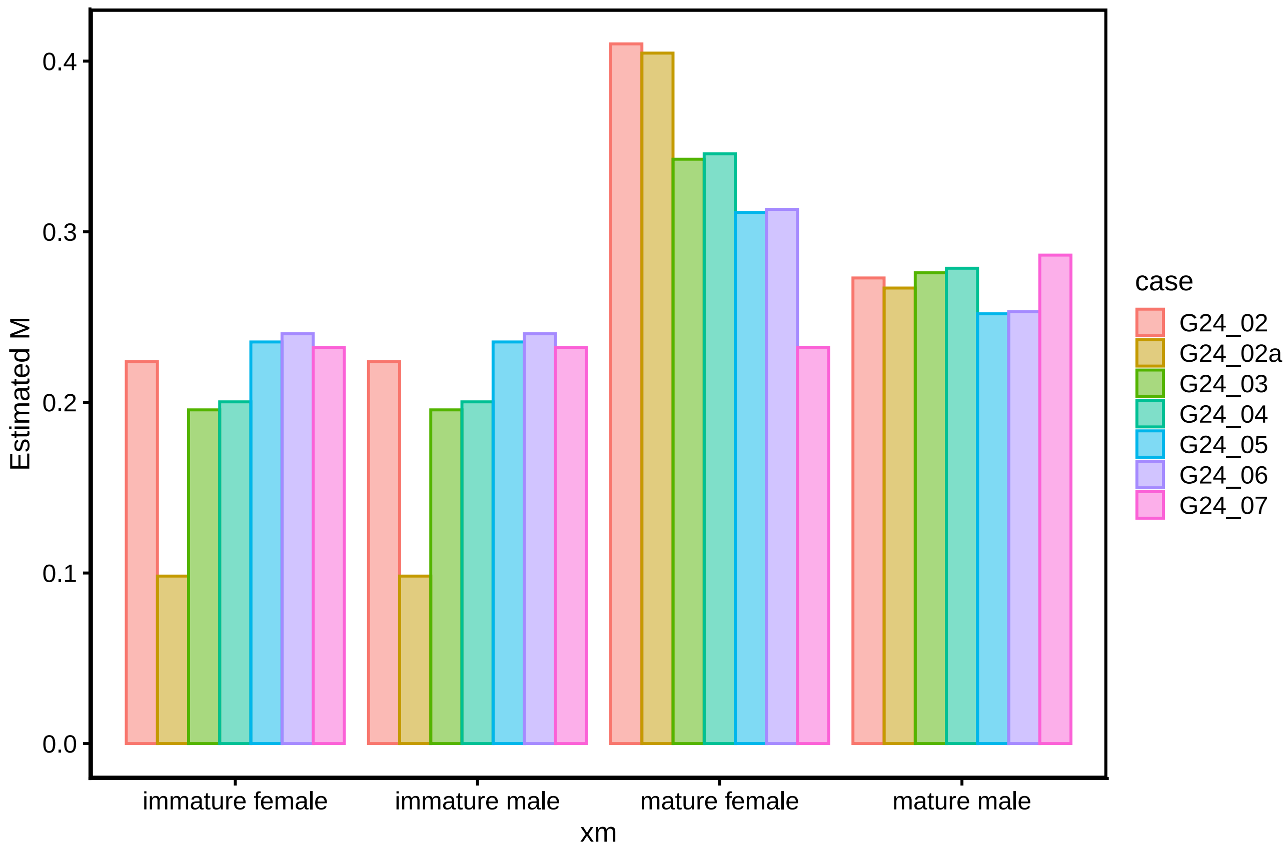

Figure 163. Estimated natural mortality rates from GMACS models, by population category. Colored by model case.

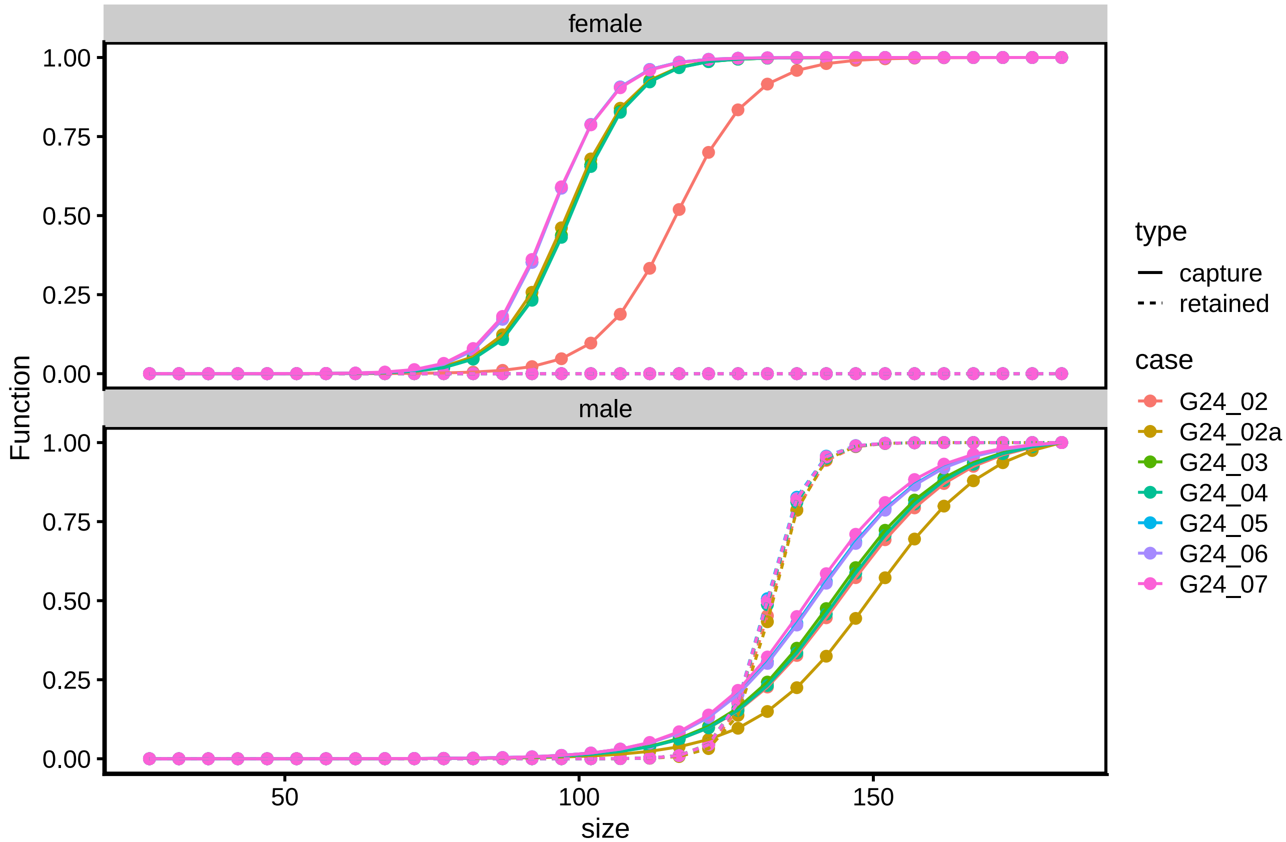

Figure 164. Estimated fishery selectivity and retention curves in the directed fishery from GMACS models. Color: model case.

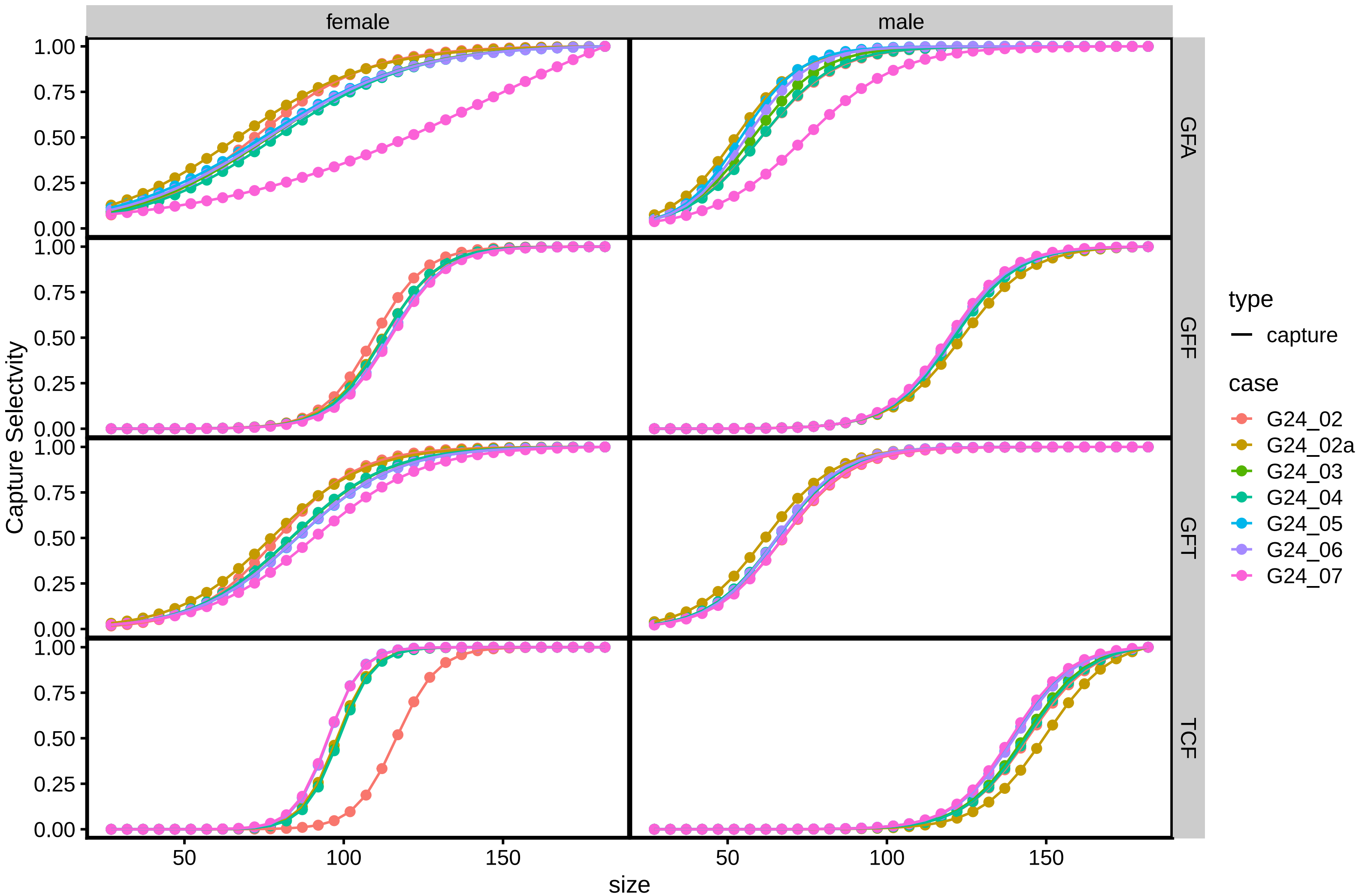

Figure 165. Estimated fishery capture selectivity by sex in the non-directed crab fisheries from GMACS models. Color: model case.

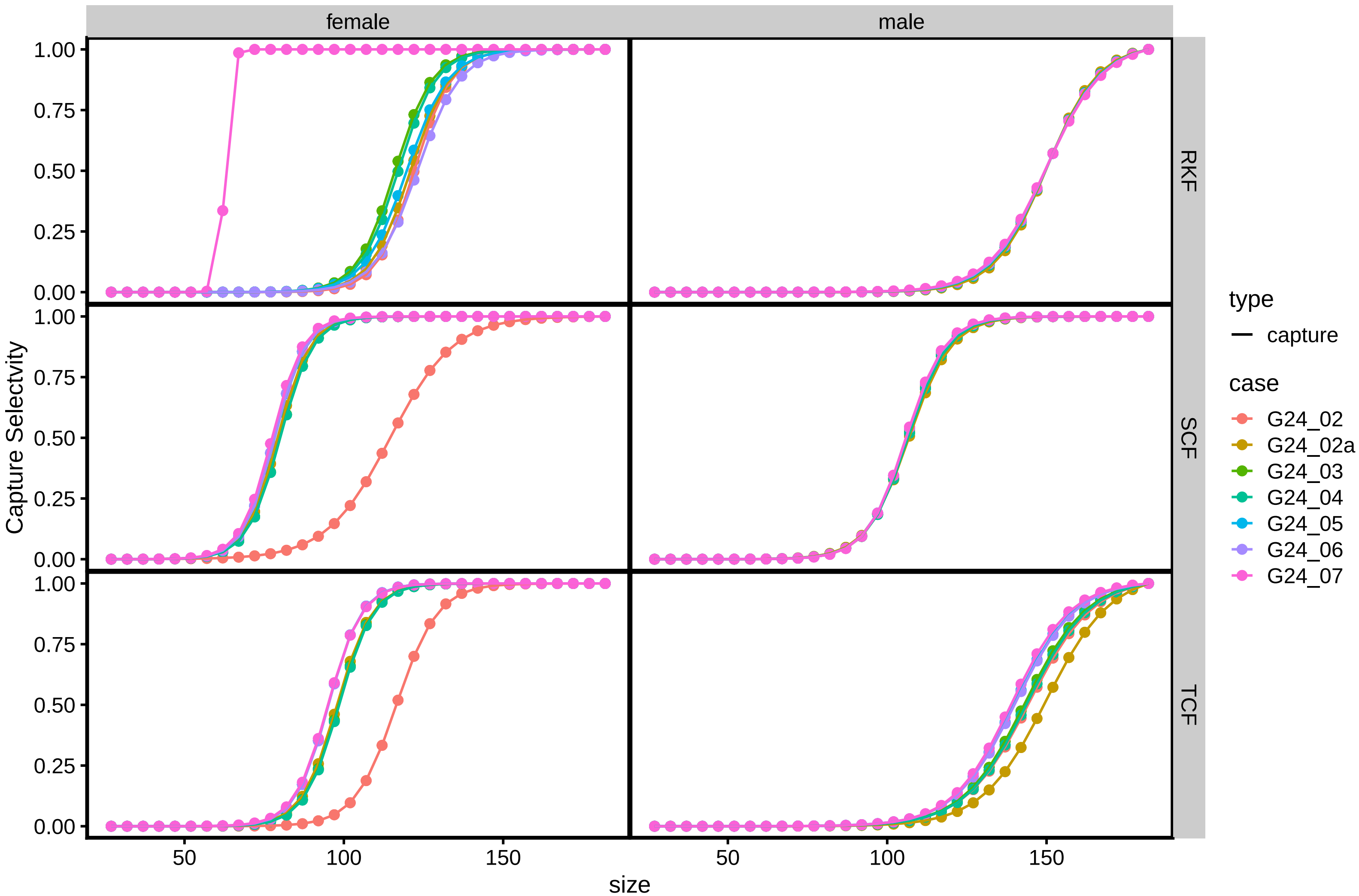

Figure 166. Estimated fishery capture selectivity by sex in the groundfish fisheries from GMACS models. Color: model case.

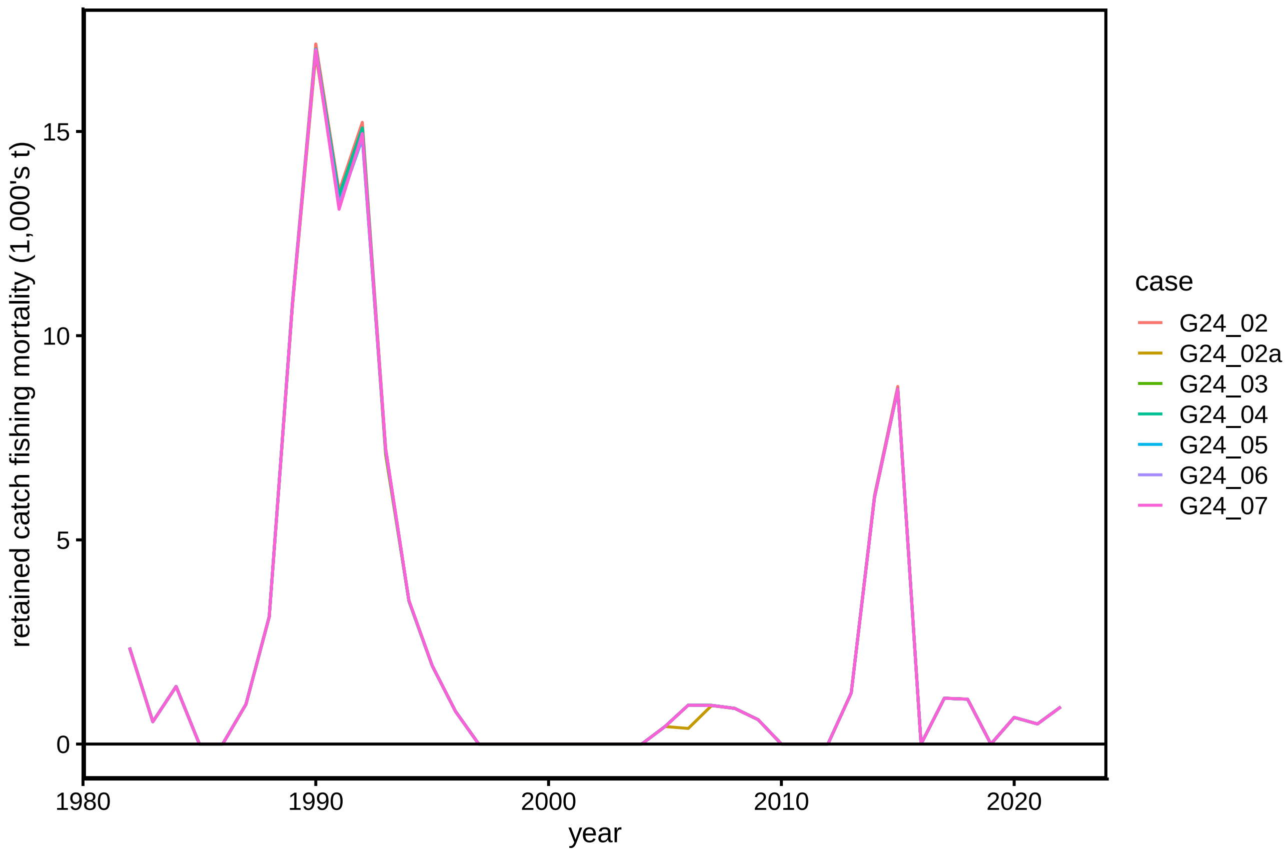

Figure 167. Time series estimates for retained catch mortality from GMACS models.

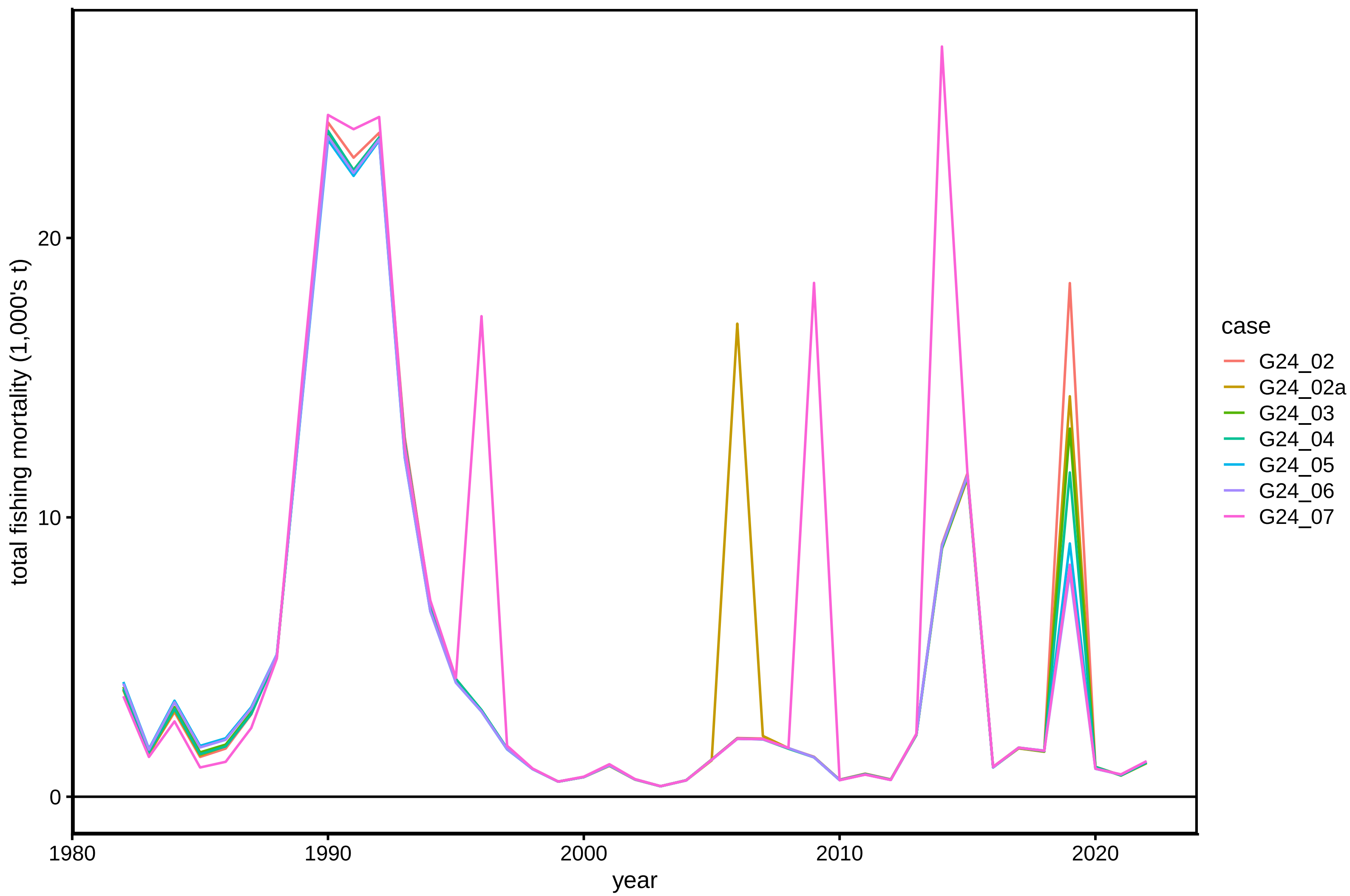

Figure 168. Time series estimates for total fishing mortality from GMACS models.

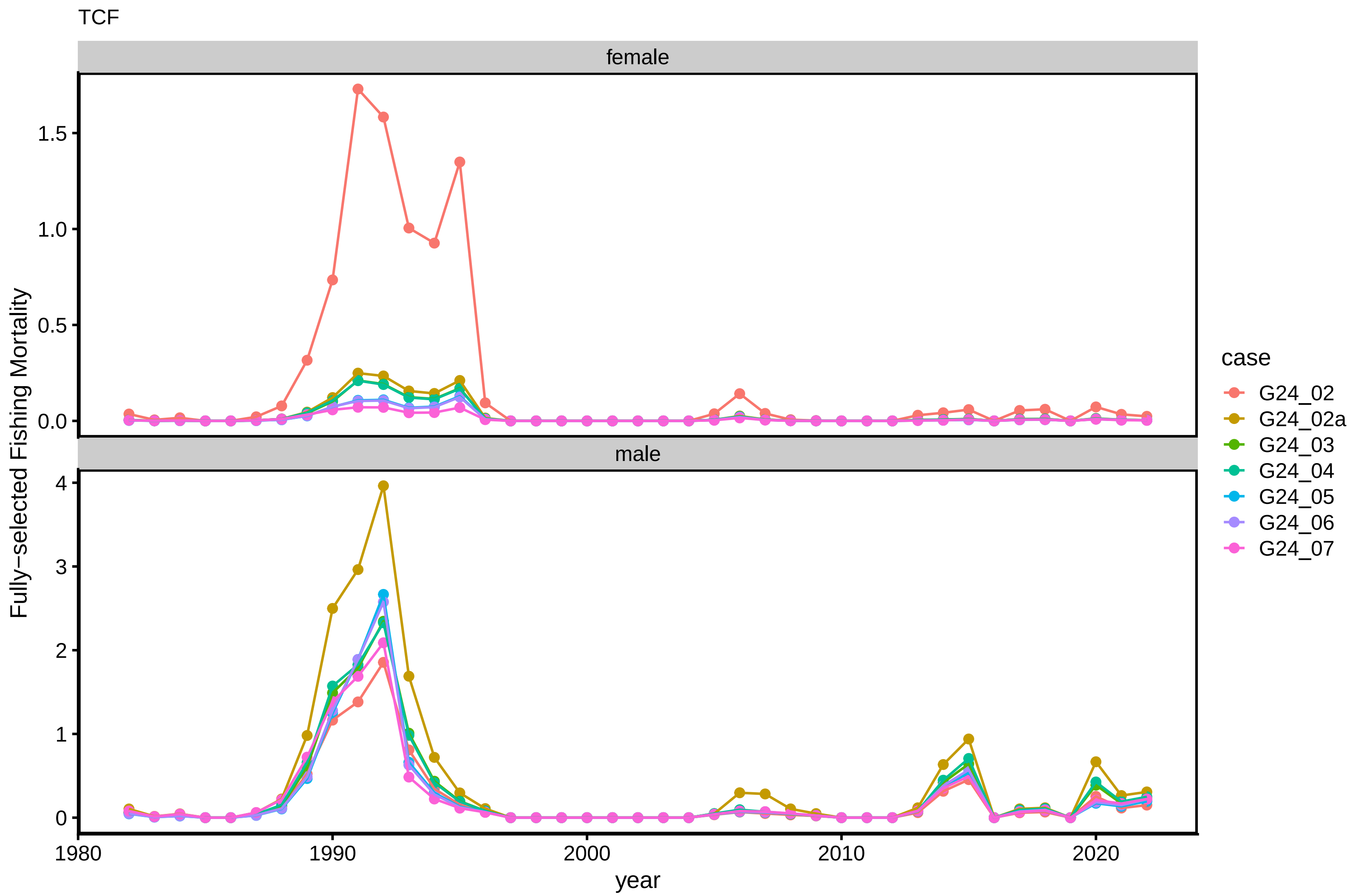

Figure 169. Estimated fully-selected fishing mortality in the directed fishery from GMACS models, colored by case.

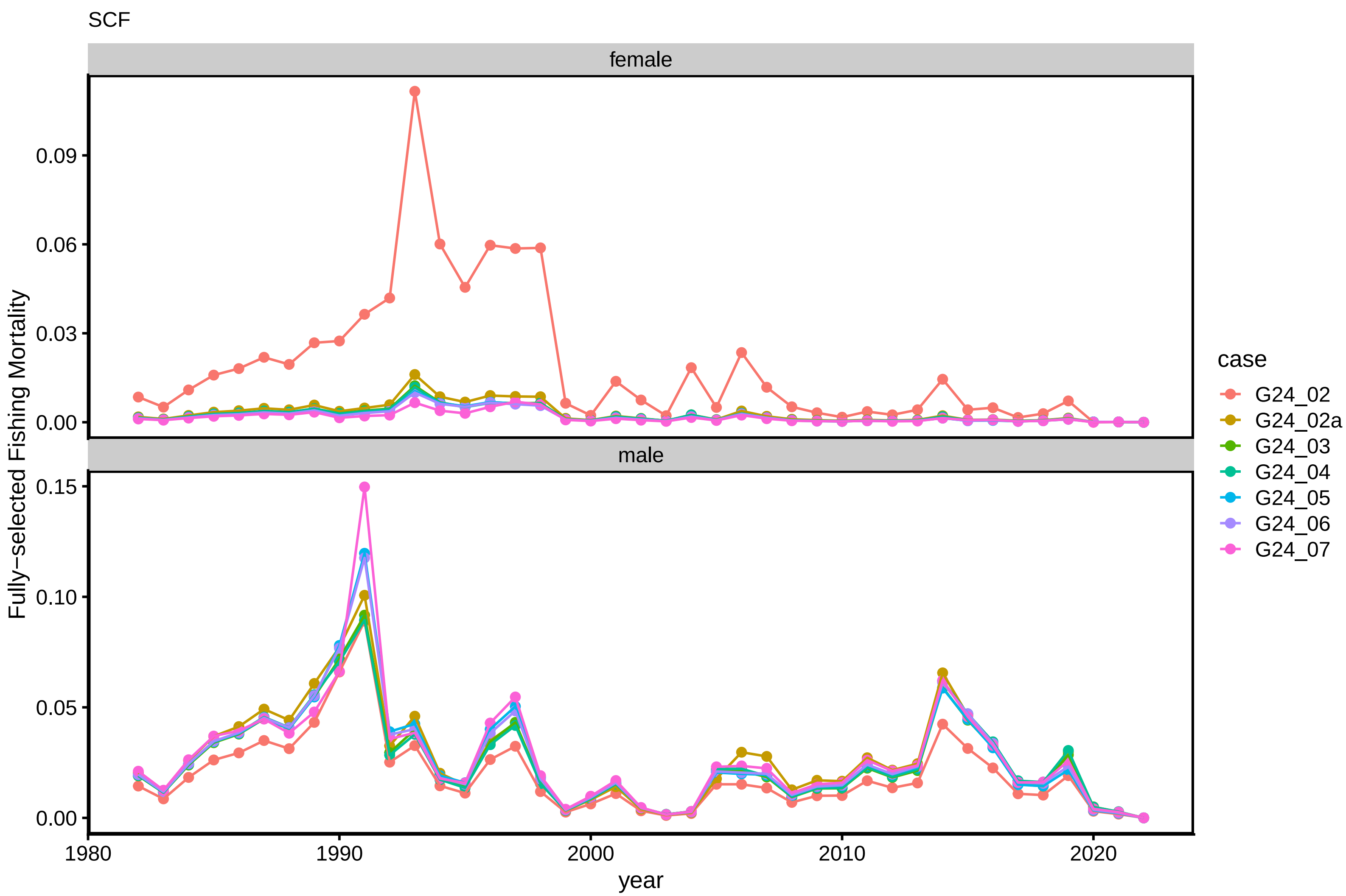

Figure 170. Estimated fully-selected fishing mortality in the snow crab fishery from GMACS models, colored by case.

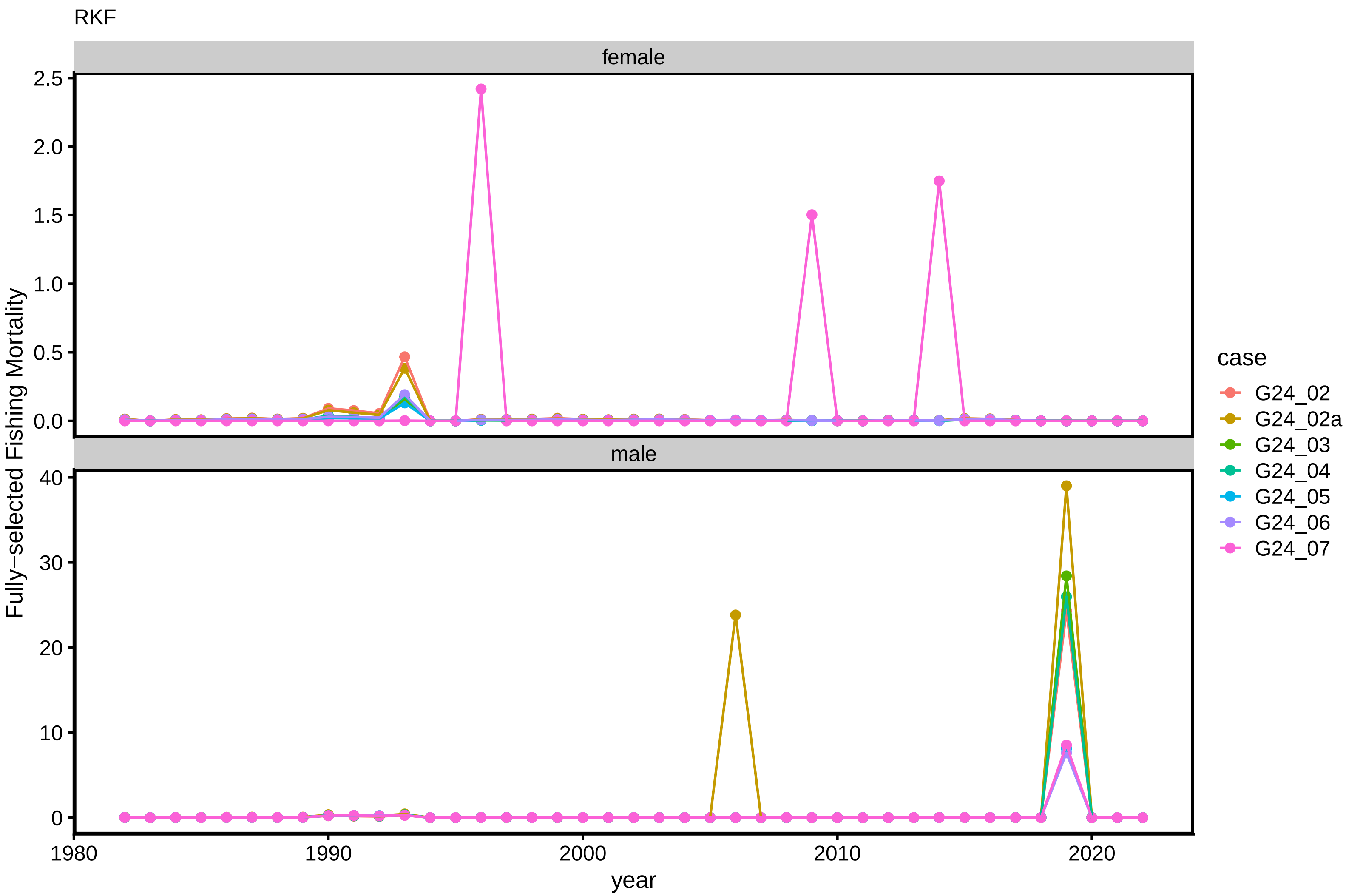

Figure 171. Estimated fully-selected fishing mortality in the BBRKC fishery from GMACS models, colored by case.

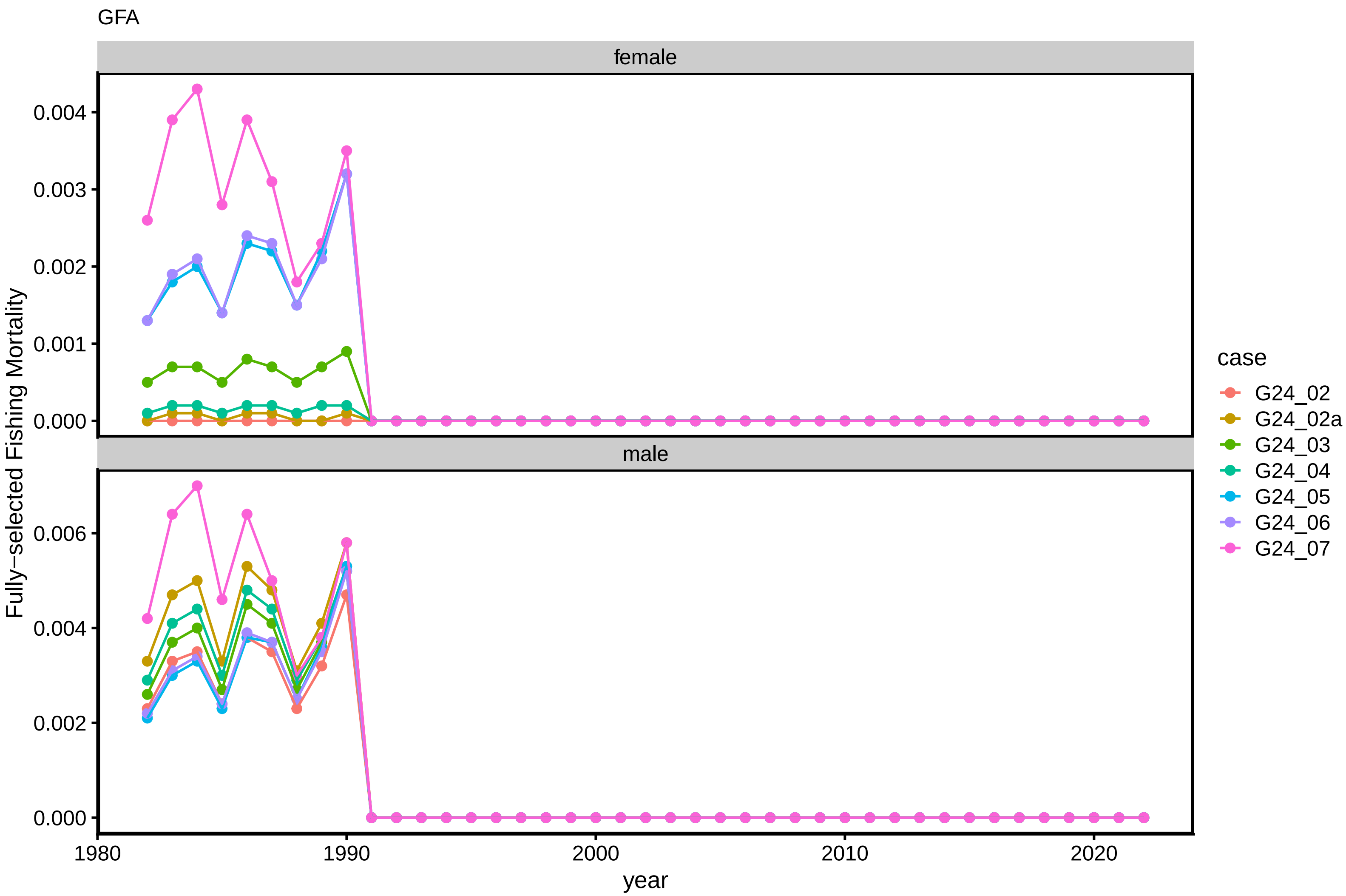

Figure 172. Estimated fully-selected fishing mortality in the combinied-gear groundfish fisheries from GMACS models, colored by case.

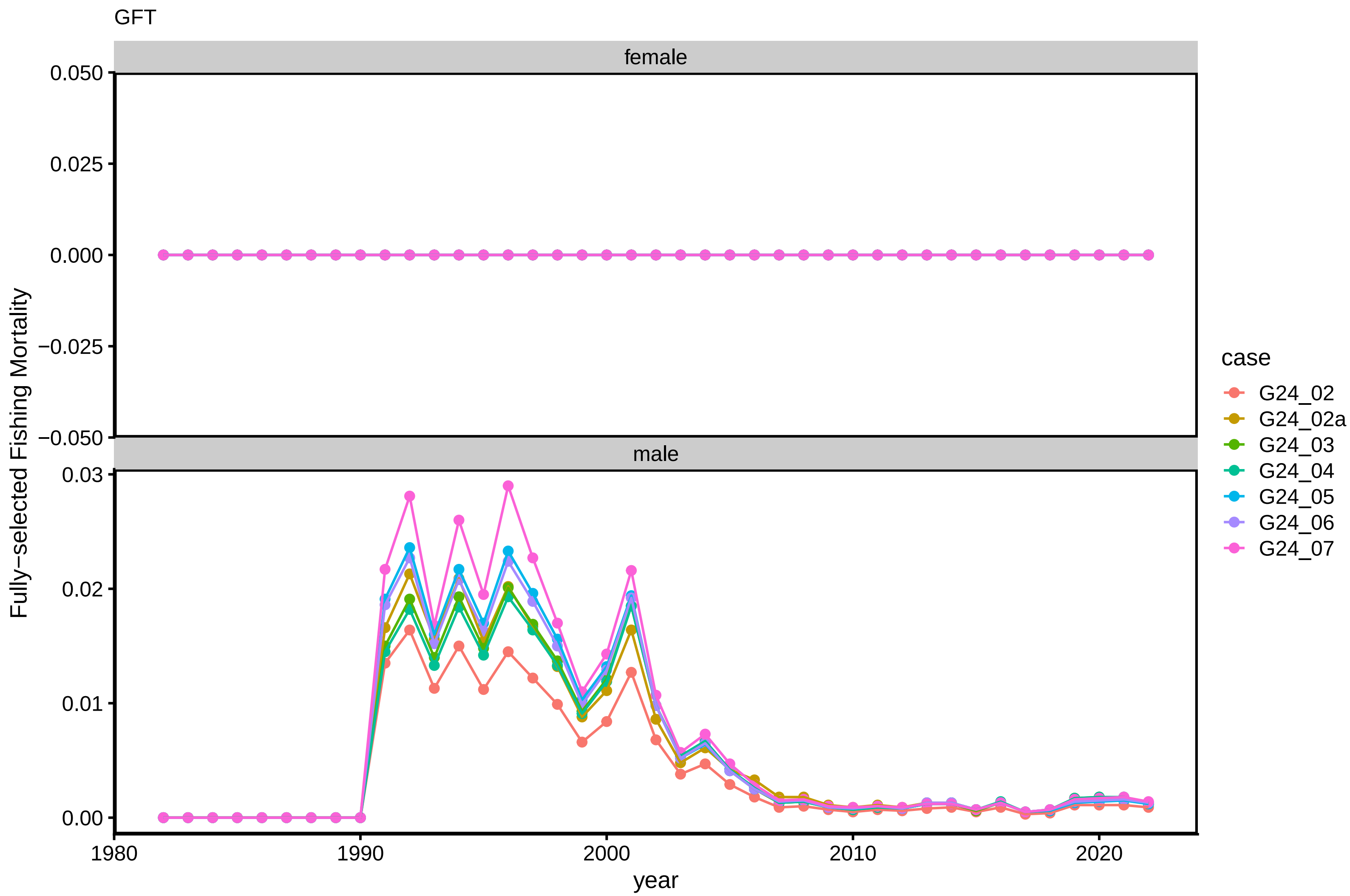

Figure 173. Estimated fully-selected fishing mortality in the groundfish trawl fisheries from GMACS models, colored by case.

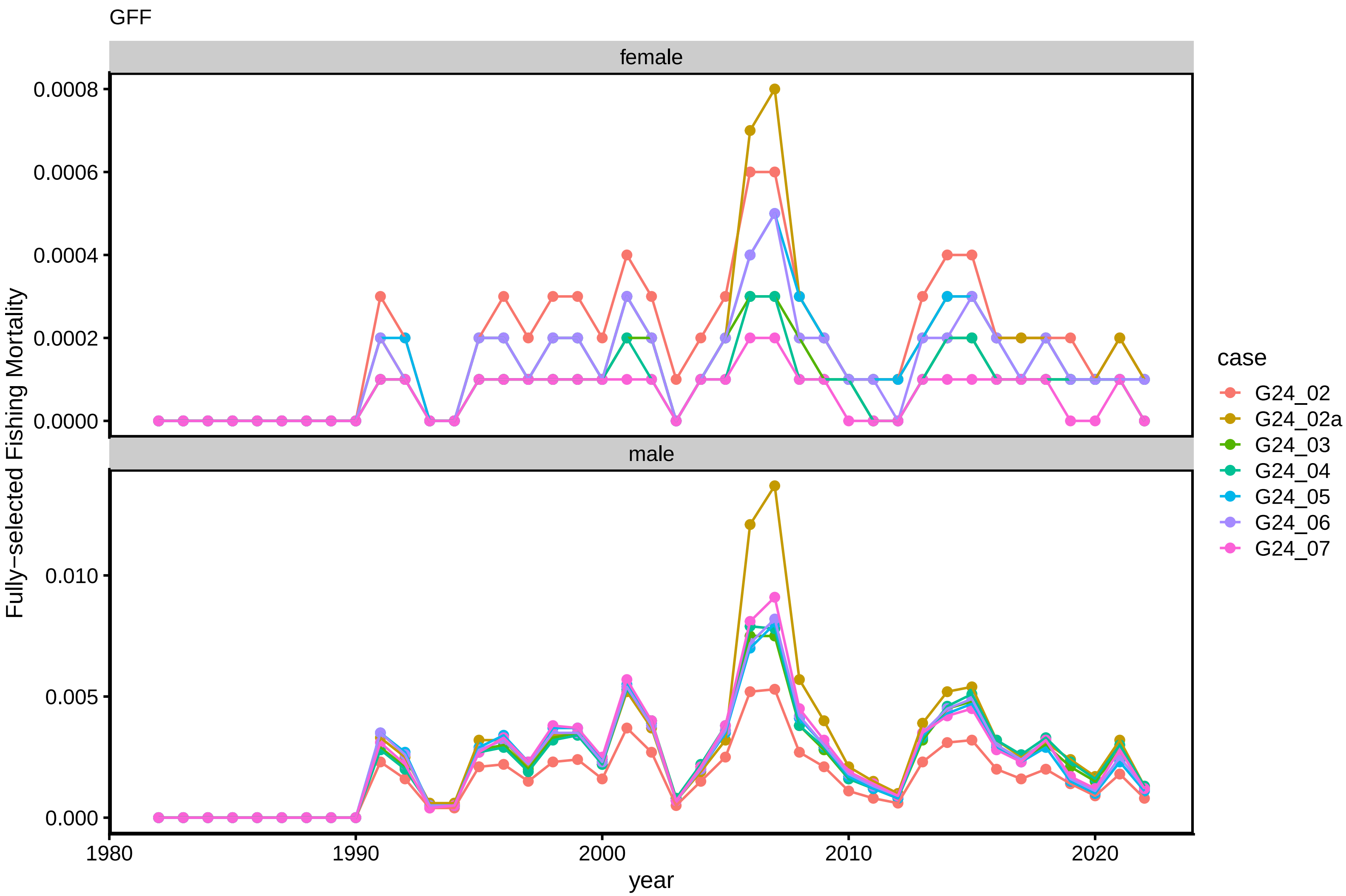

Figure 174. Estimated fully-selected fishing mortality in the fixed-gear groundfish fisheries from GMACS models, colored by case.

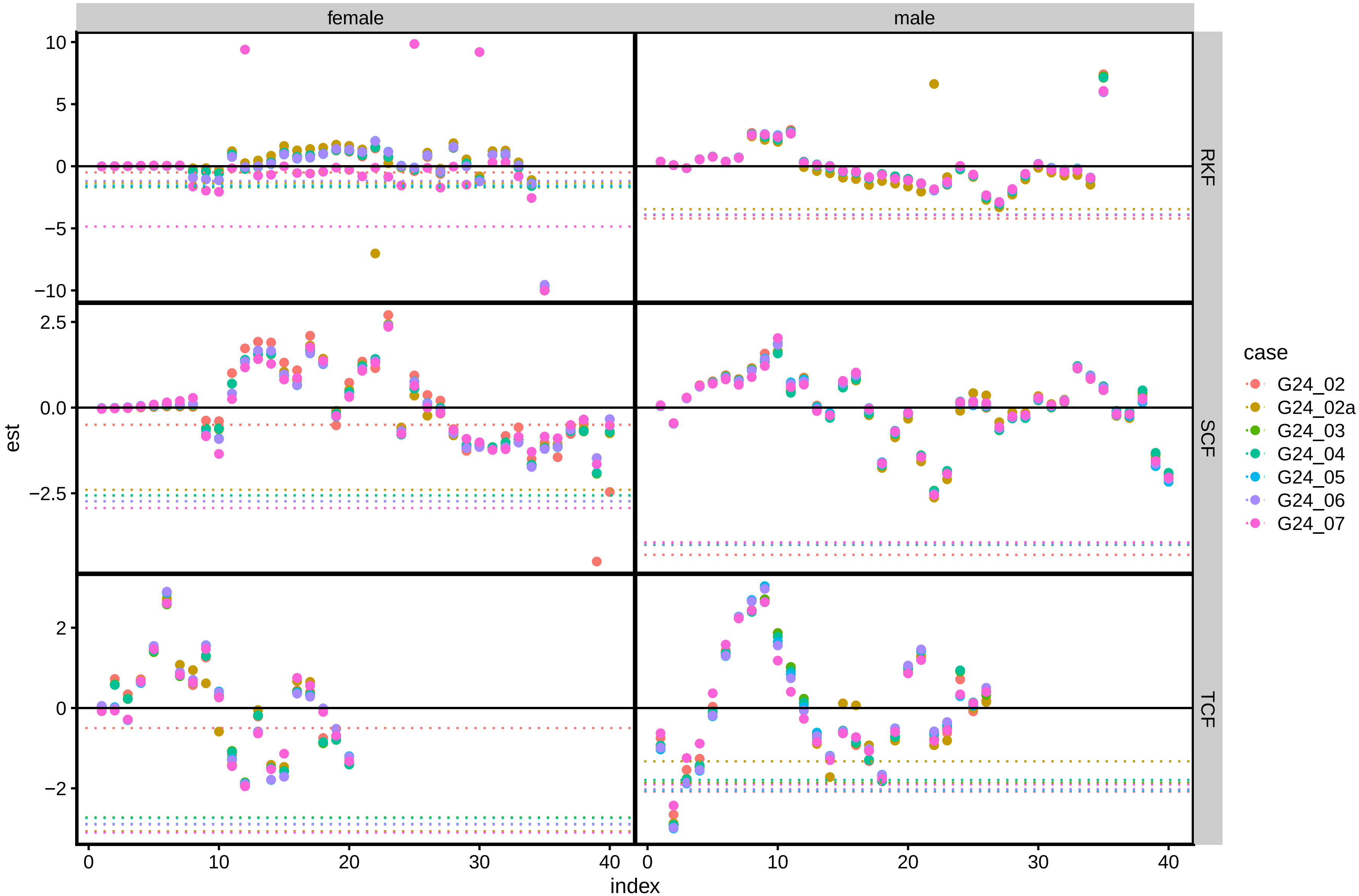

Figure 175. Ln-scale fishing mortality deviations and means for crab fisheries from GMACS models, colored by case.

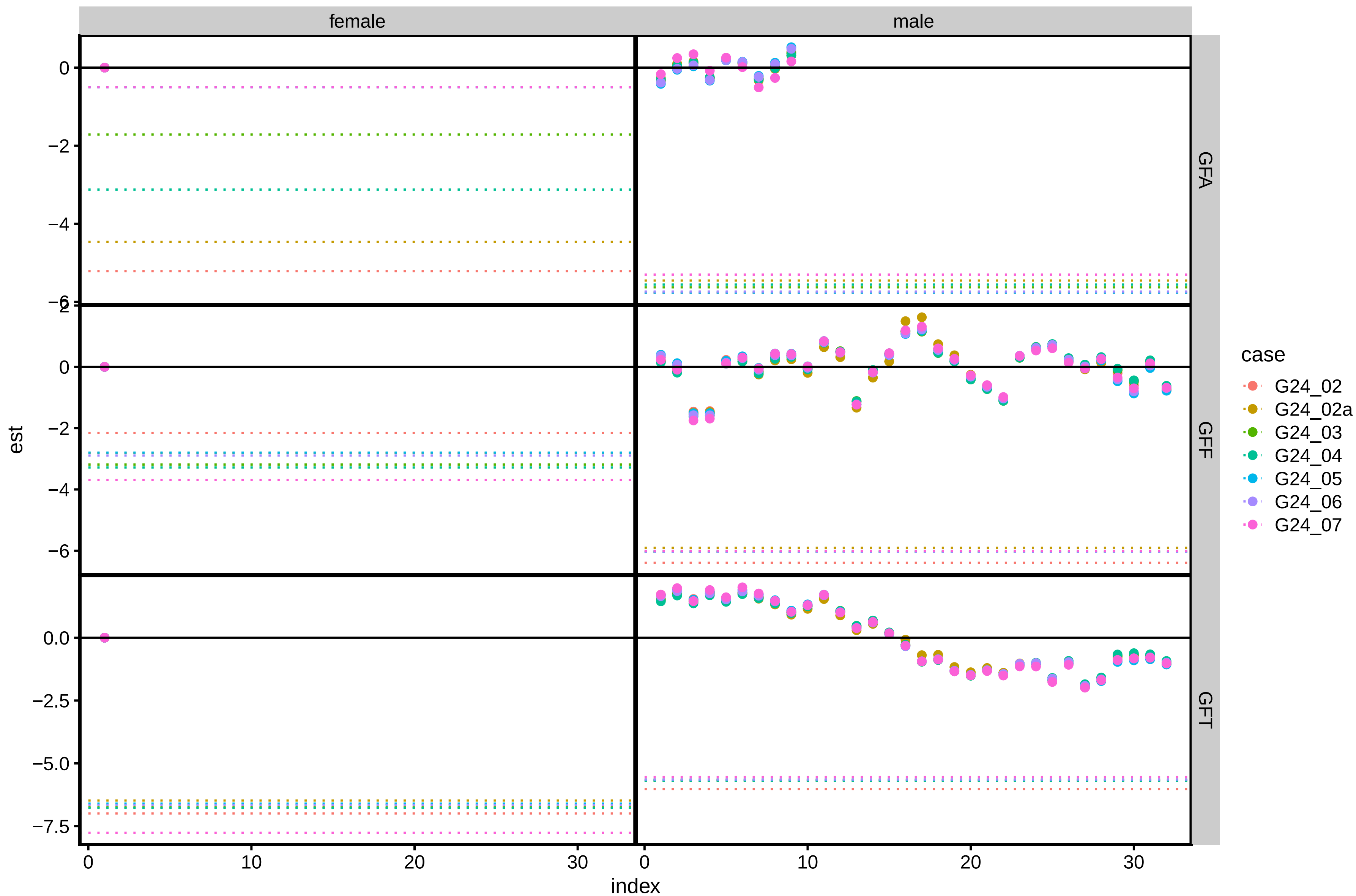

Figure 176. Ln-scale fishing mortality deviations and means for groundfish fisheries from GMACS models, colored by case.

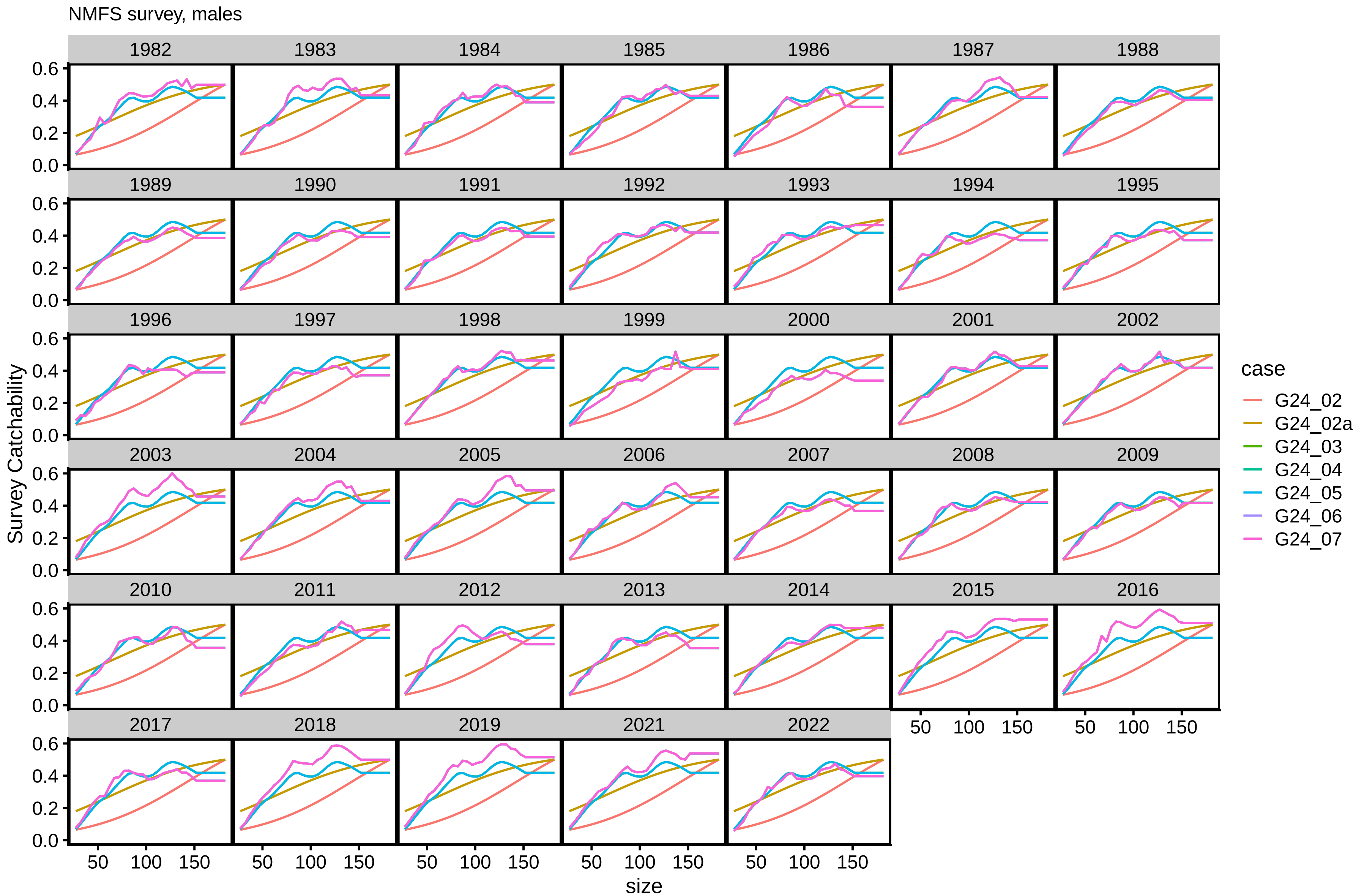

Figure 177. Estimated NMFS survey catchability for males from GMACS models. Survey selectivity is estimated inside the model only for G24.02 and G24.02a. Color: model case.

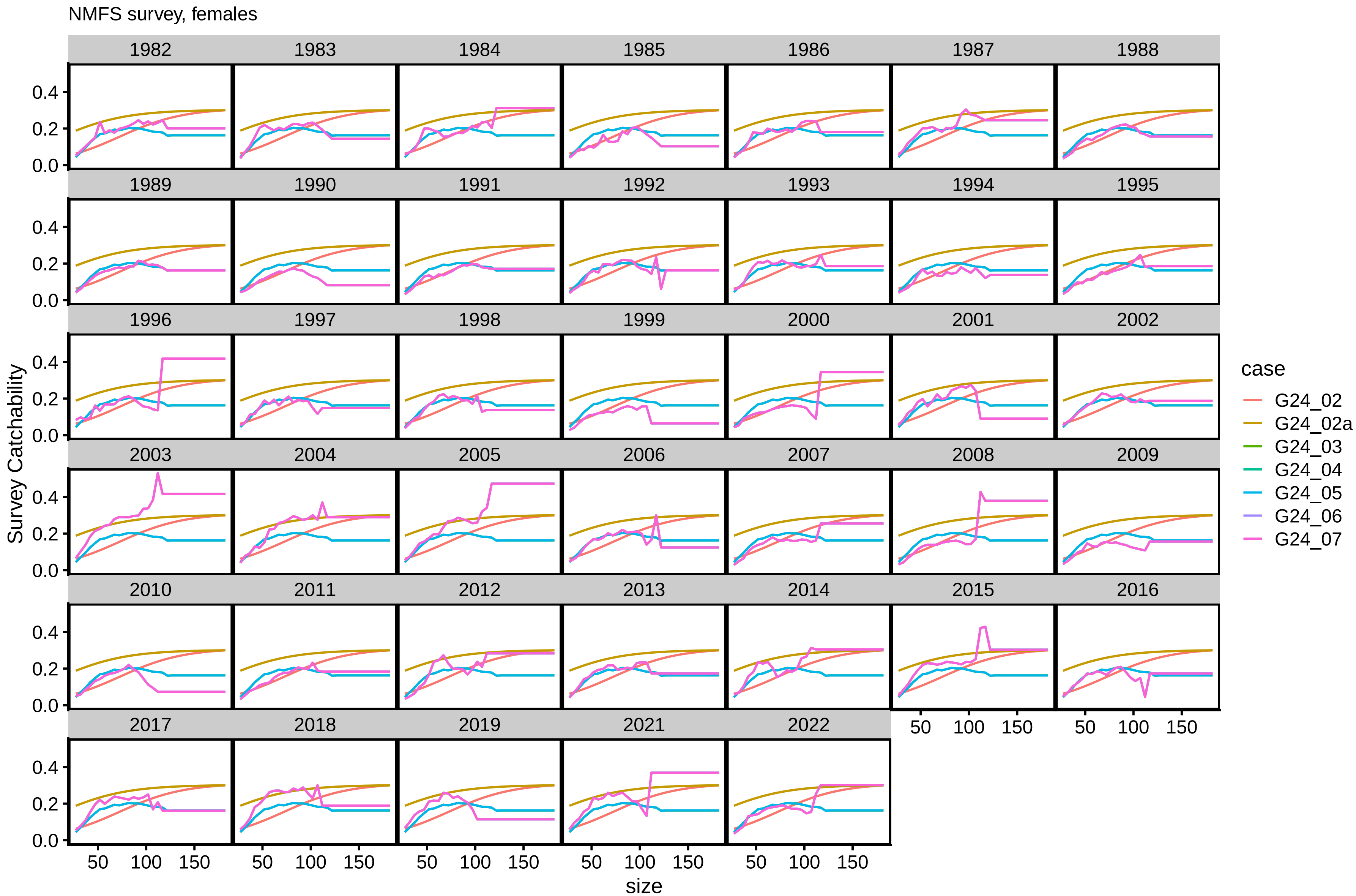

Figure 178. Estimated NMFS survey catchability from GMACS models for females. Survey selectivity is estimated inside the model only for G24.02 and G24.02a. Color: model case.

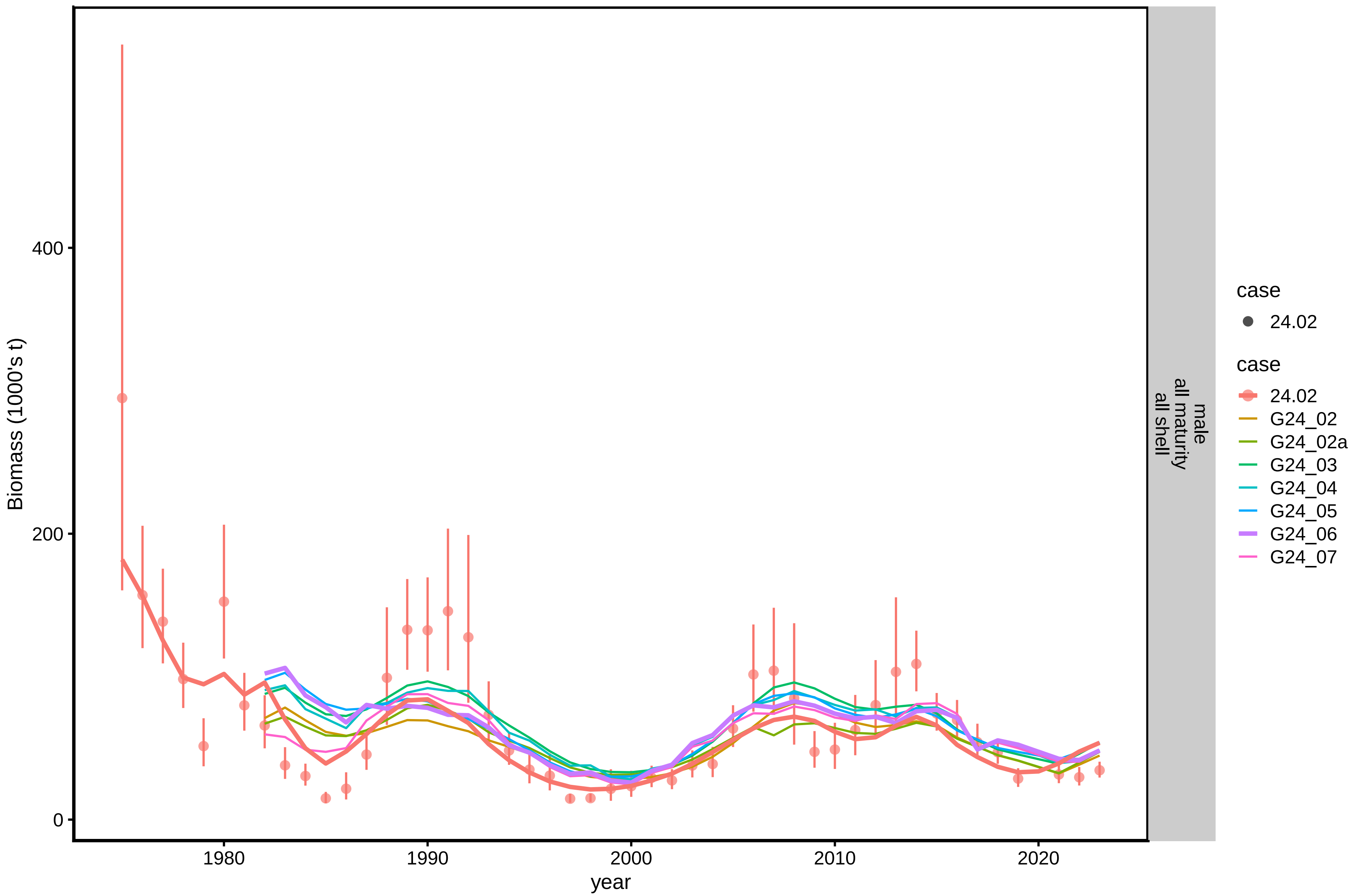

Figure 179. Comparison of TCSAM02 (24.02) and GMACS models (G24...) fits to NMFS survey biomass for males. Results from models 24.02 and G24.06 are highlighted using thicker lines.

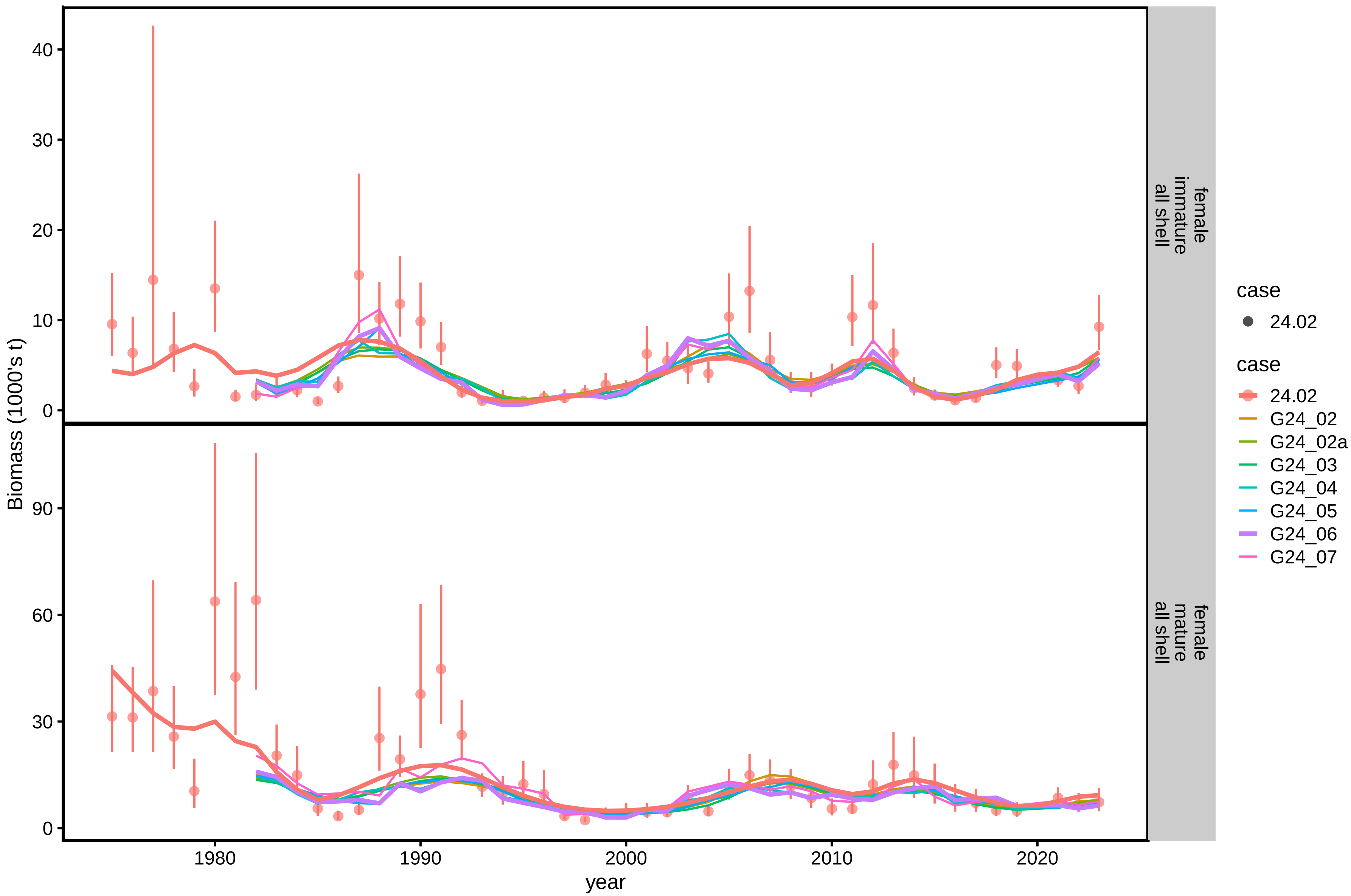

Figure 180. Comparison of TCSAM02 (24.02) and GMACS models (G24...) fits to NMFS survey female biomass, by maturity state. Results from models 24.02 and G24.06 are highlighted using thicker lines.

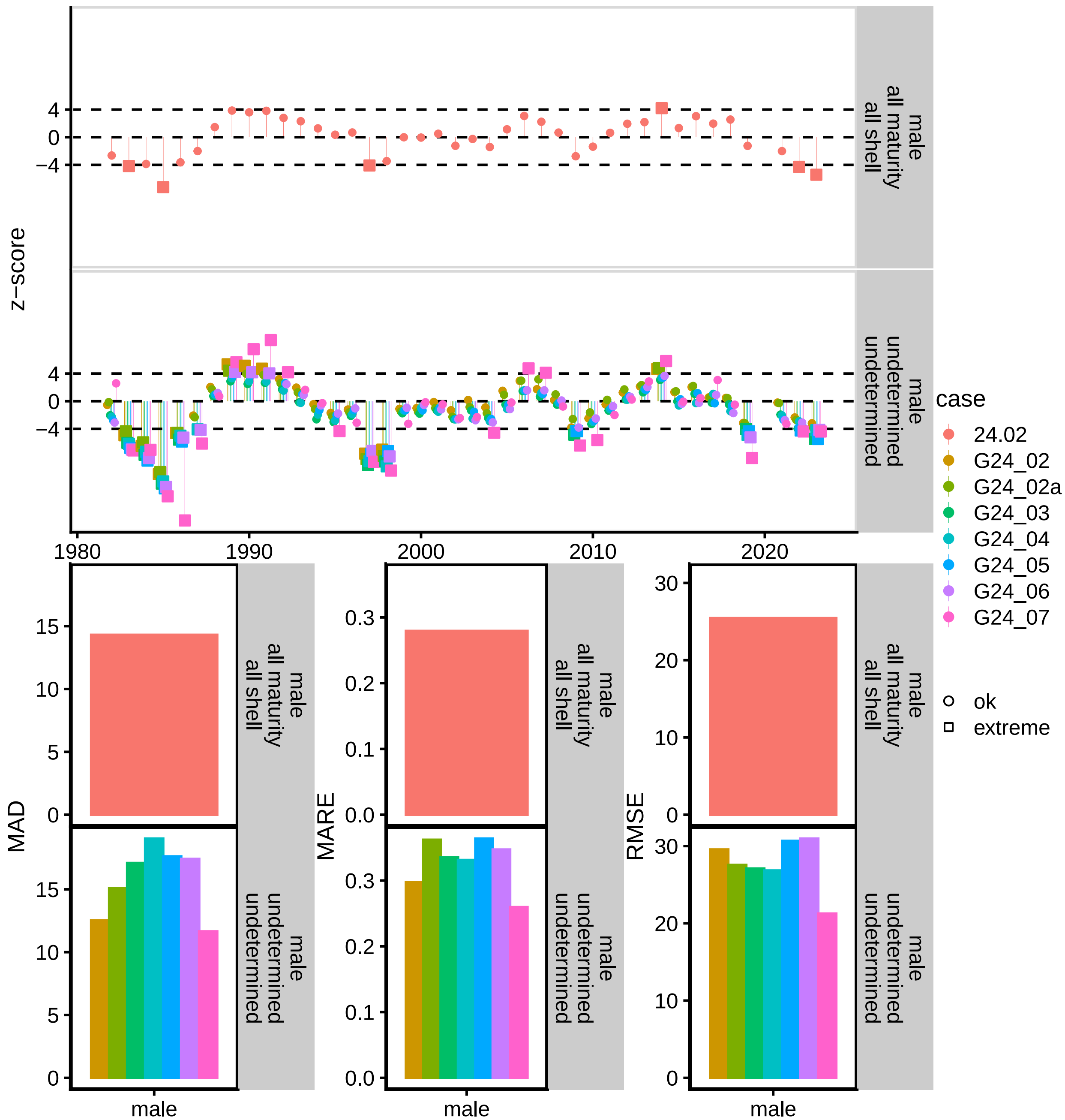

Figure 181. Comparison of TCSAM02 (24.02) and GMACS models (G24...) residuals diagnostics for fits to NMFS survey biomass for males.

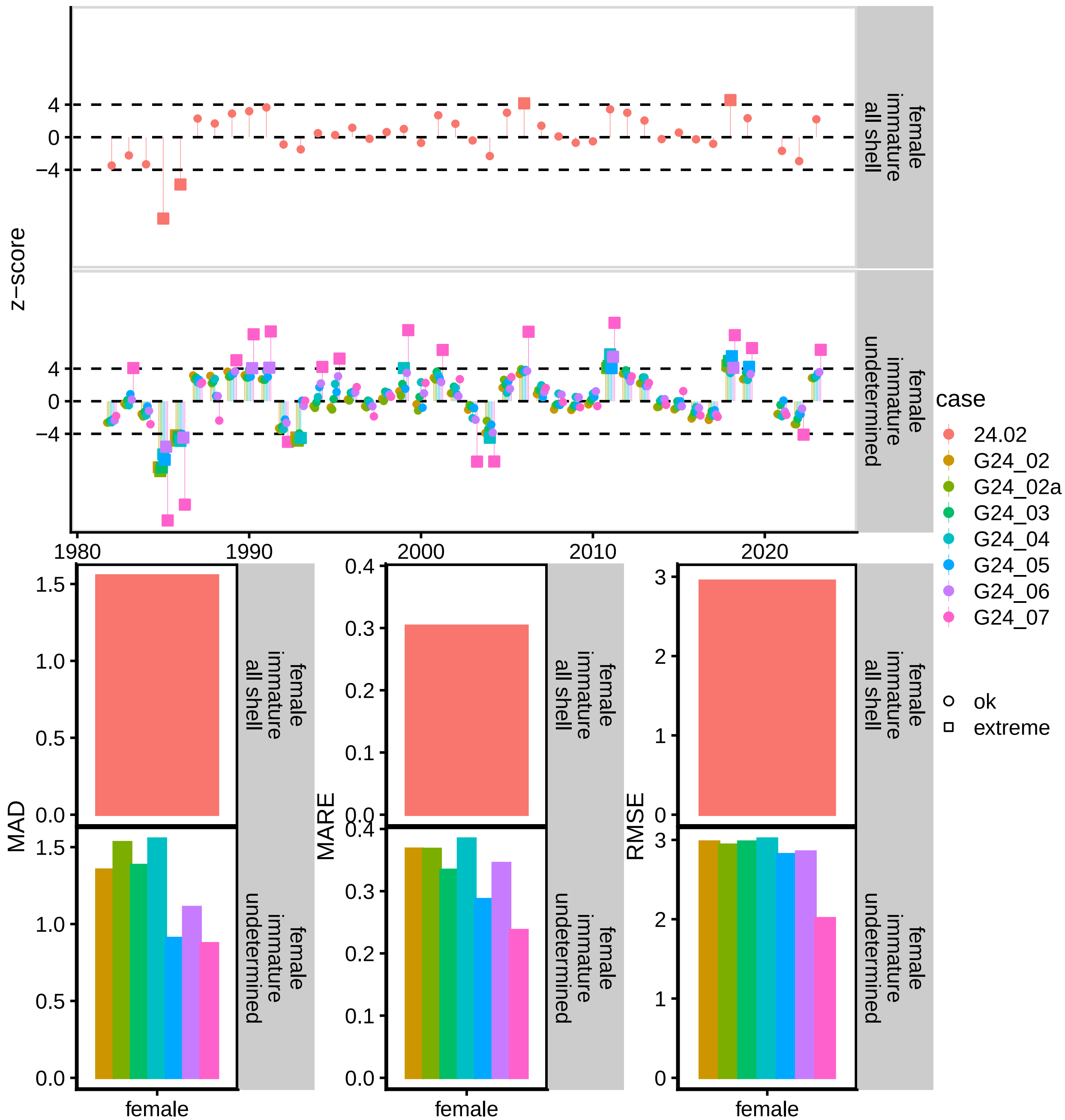

Figure 182. Comparison of TCSAM02 (24.02) and GMACS models (G24...) residuals diagnostics for fits to NMFS survey biomass for immature females.

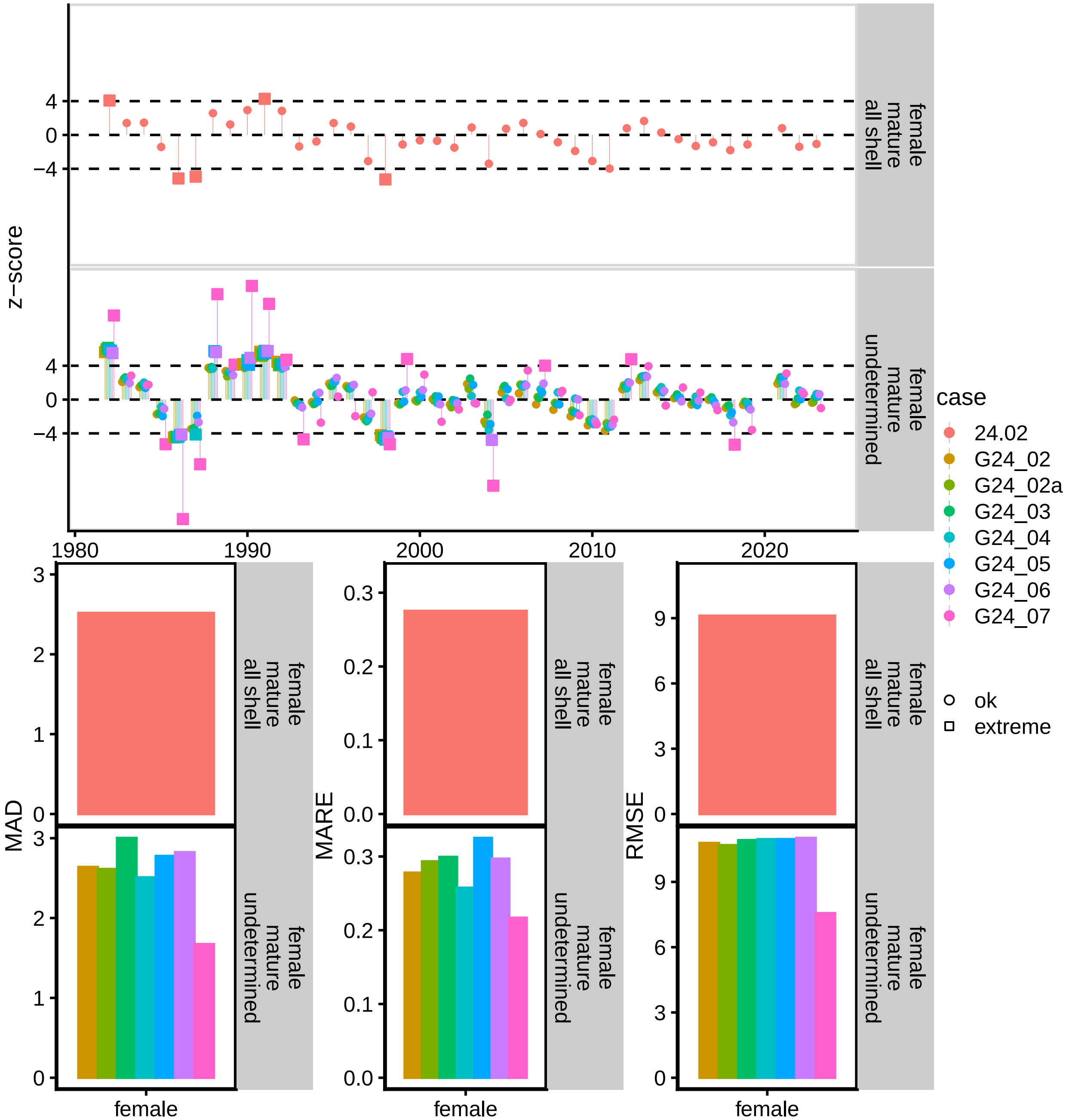

Figure 183. Comparison of TCSAM02 (24.02) and GMACS models (G24...) residuals diagnostics for fits to NMFS survey biomass for mature females.

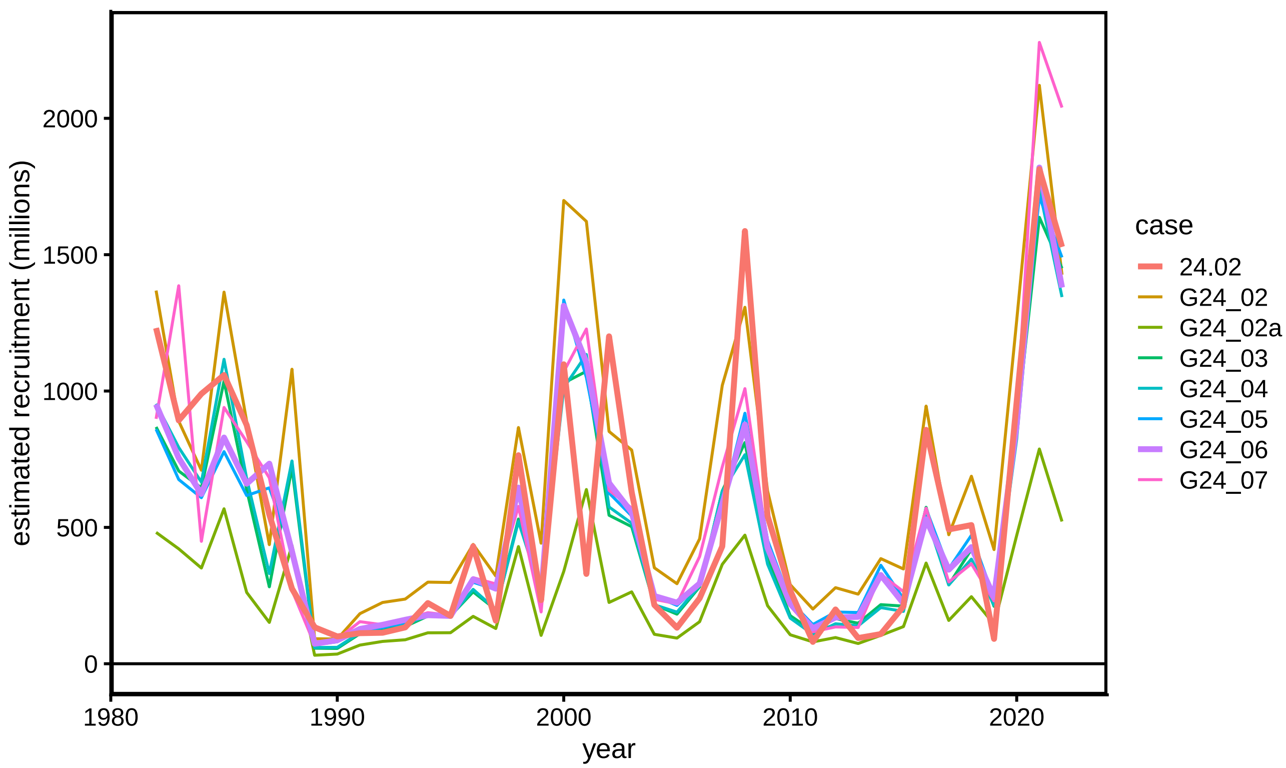

Figure 184. Comparison of TCSAM02 (24.02) and GMACS models (G24...) predicted recruitment time series. Results from models 24.02 and G24.06 are highlighted using thicker lines.

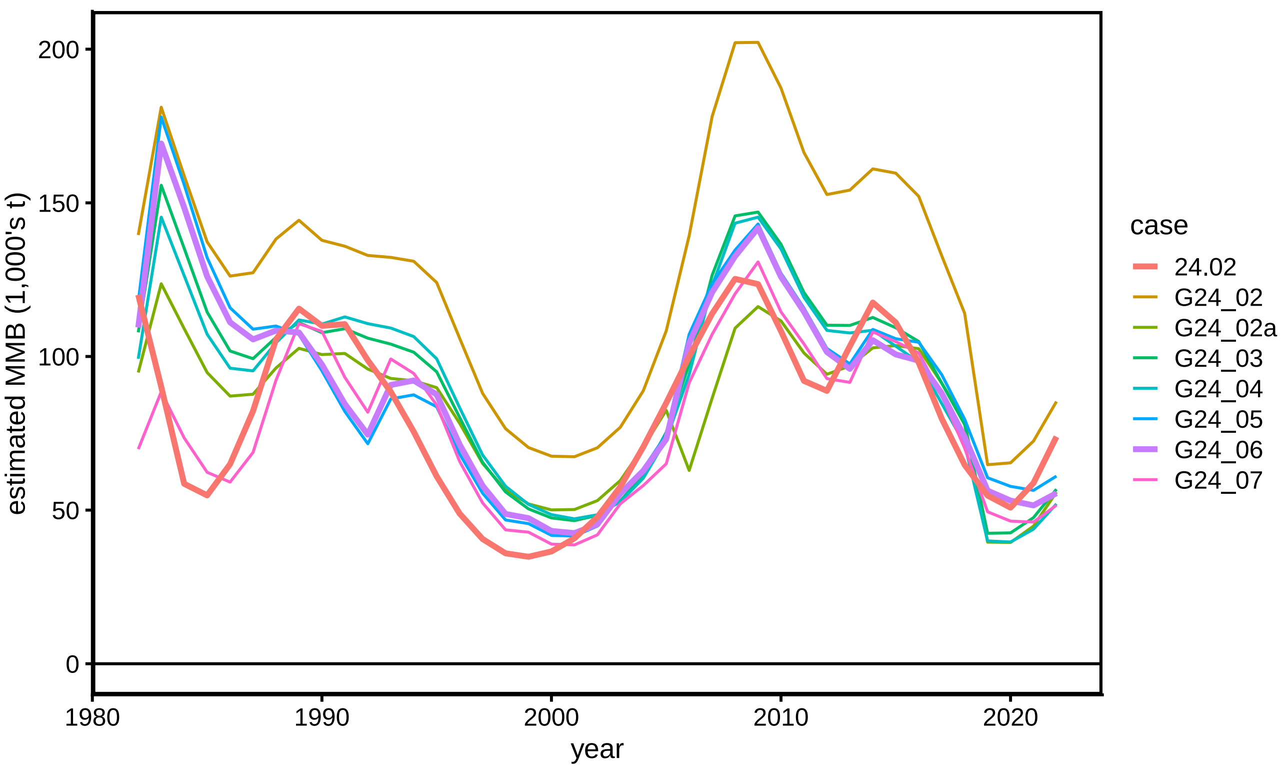

Figure 185. Comparison of TCSAM02 (24.02) and GMACS models (G24…) predicted MMB trend. Results from models 24.02 and G24.06 are highlighted using thicker lines.

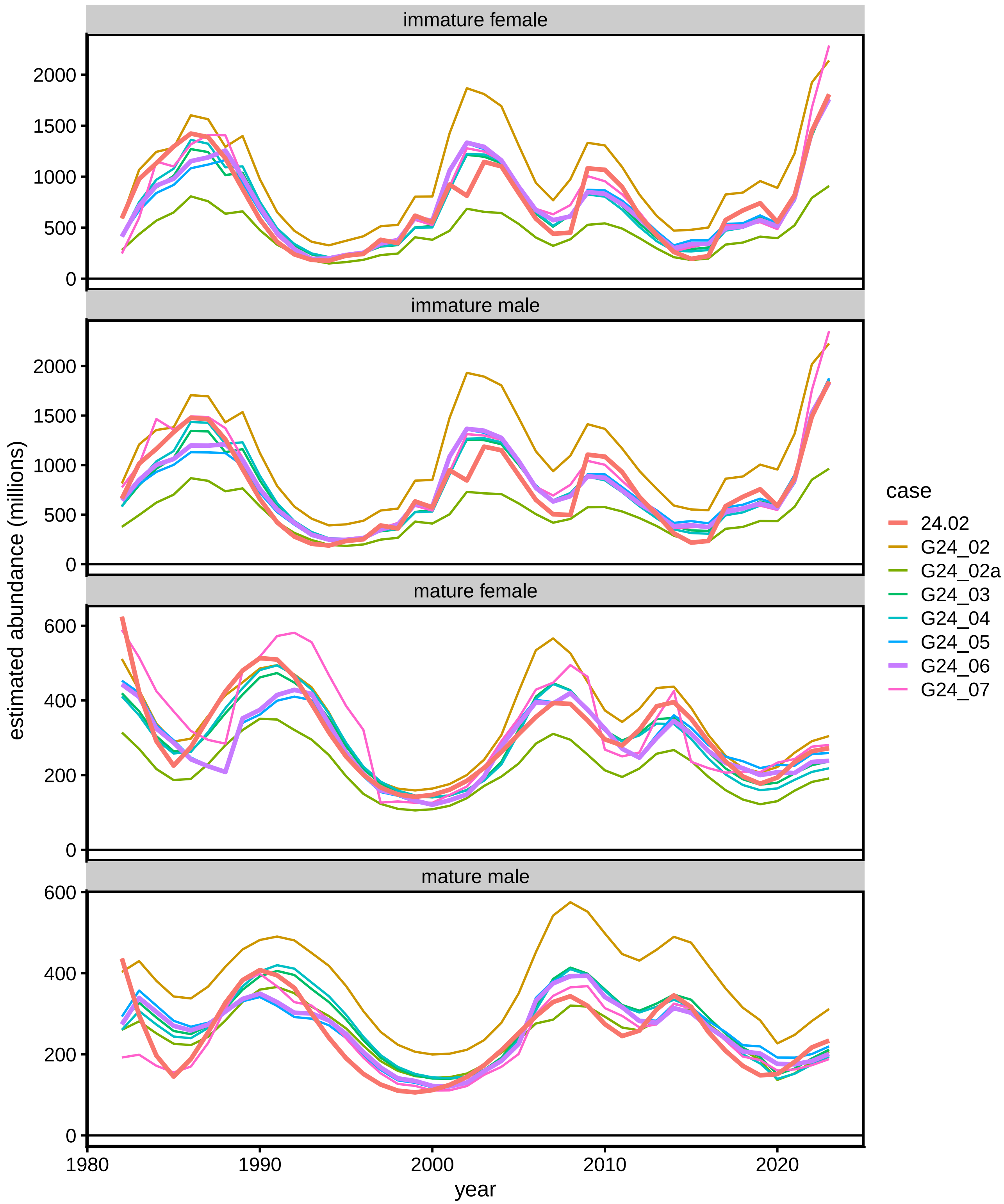

Figure 186. Comparison of TCSAM02 (24.02) and GMACS models (G24...) predicted population abundance trends by sex and maturity state. Results from models 24.02 and G24.06 are highlighted using thicker lines.

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