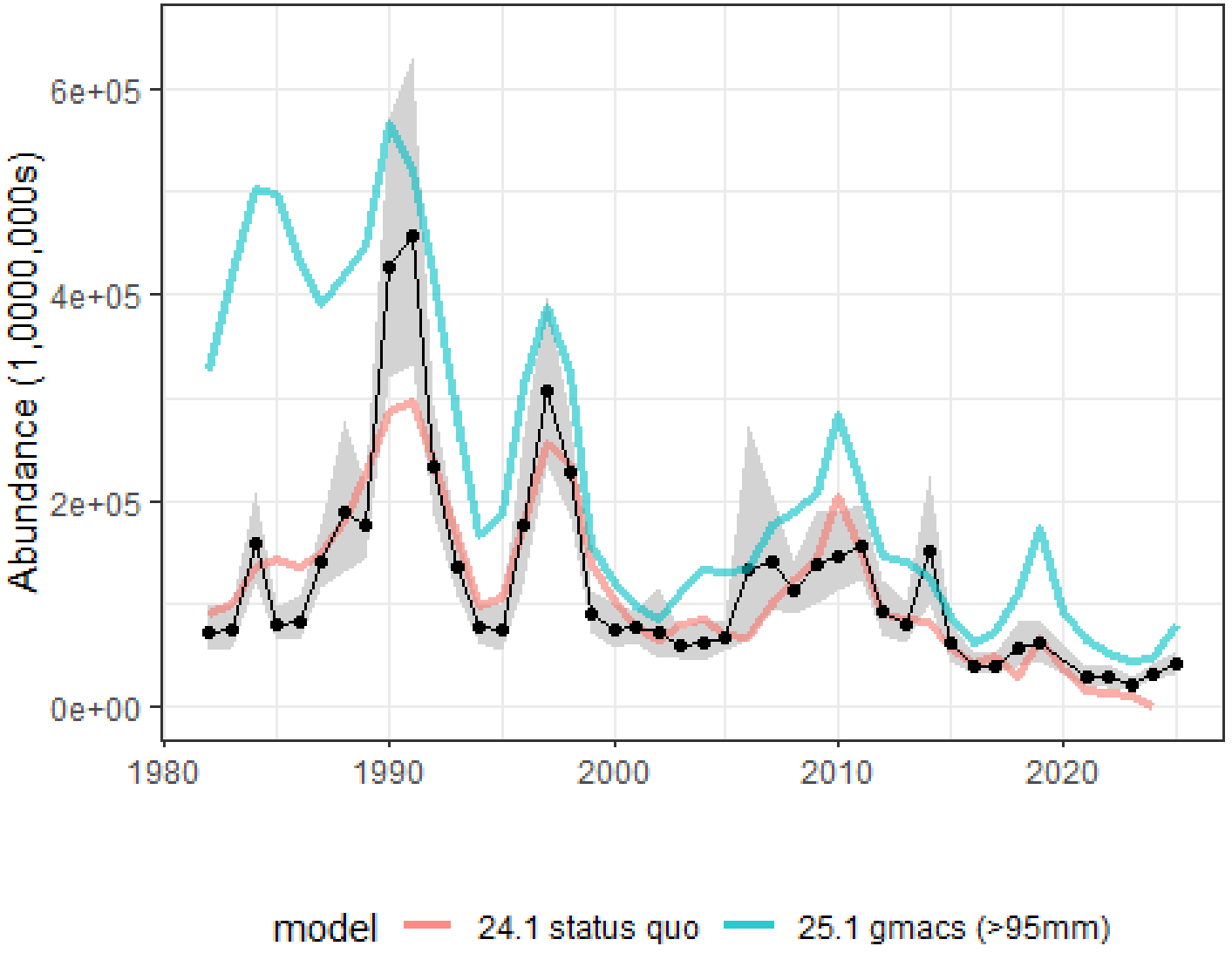
Eastern Bering Sea snow crab assessment draft

Cody Szuwalski

September 11, 2025

Big picture

- Small increase in preferred males
  - 7th lowest on record
  - 8% of the maximum observed
- Last 9 years are the lowest on record
  - In order: 2023, 2021, 2022, 2024, 2017, 2016, 2025, 2018, 2019
- Large numbers of medium sized males
- Terminal molt issues



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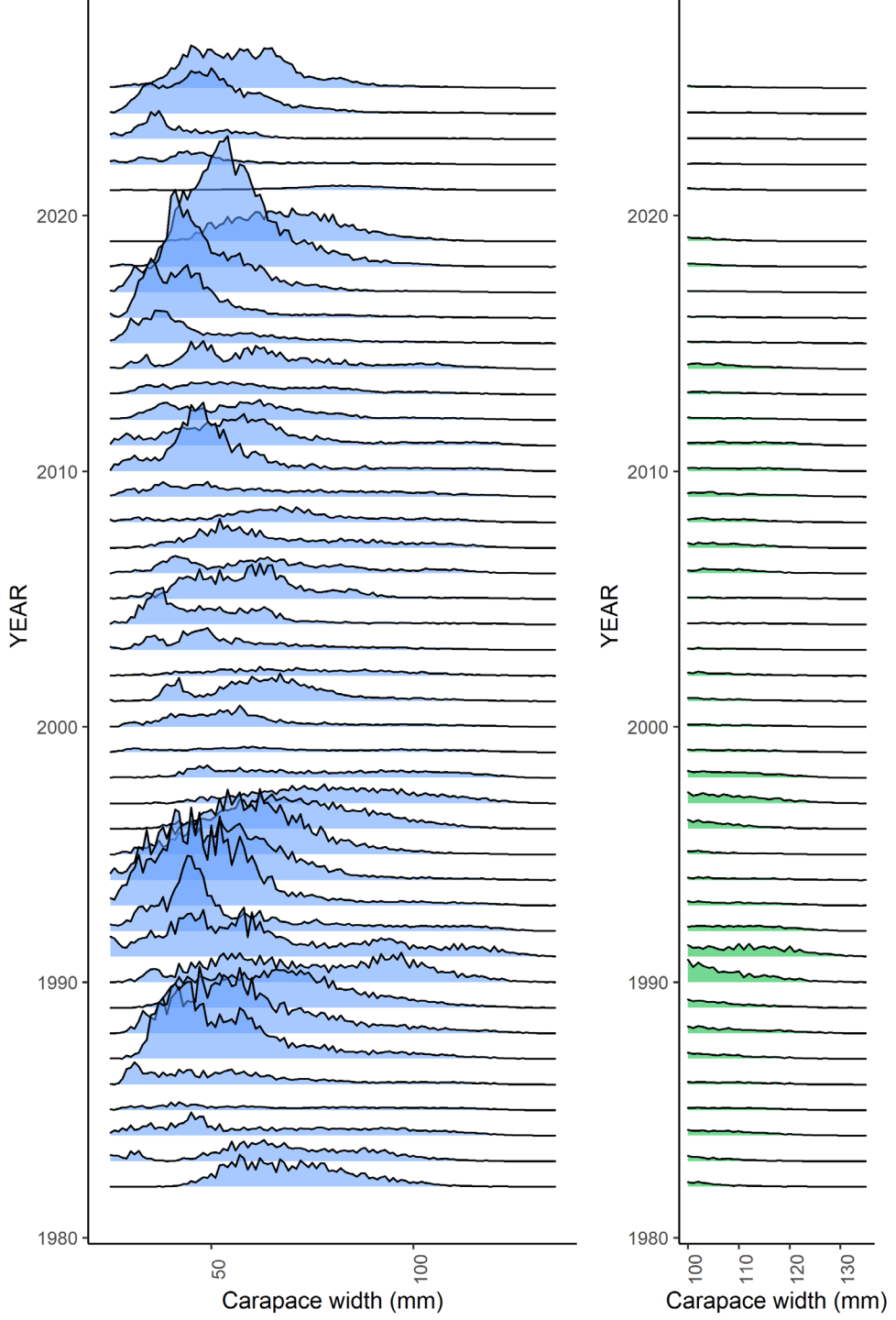

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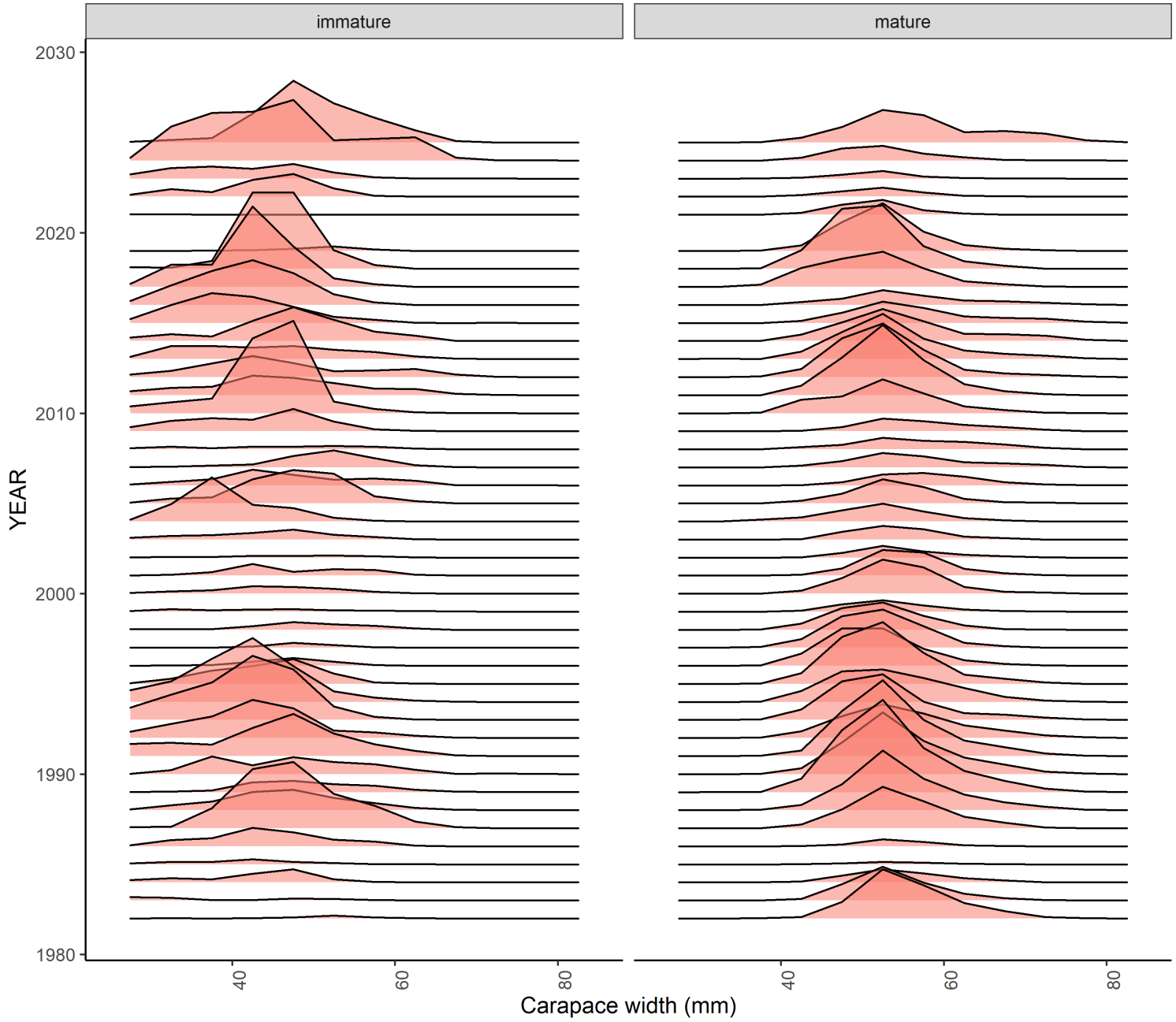

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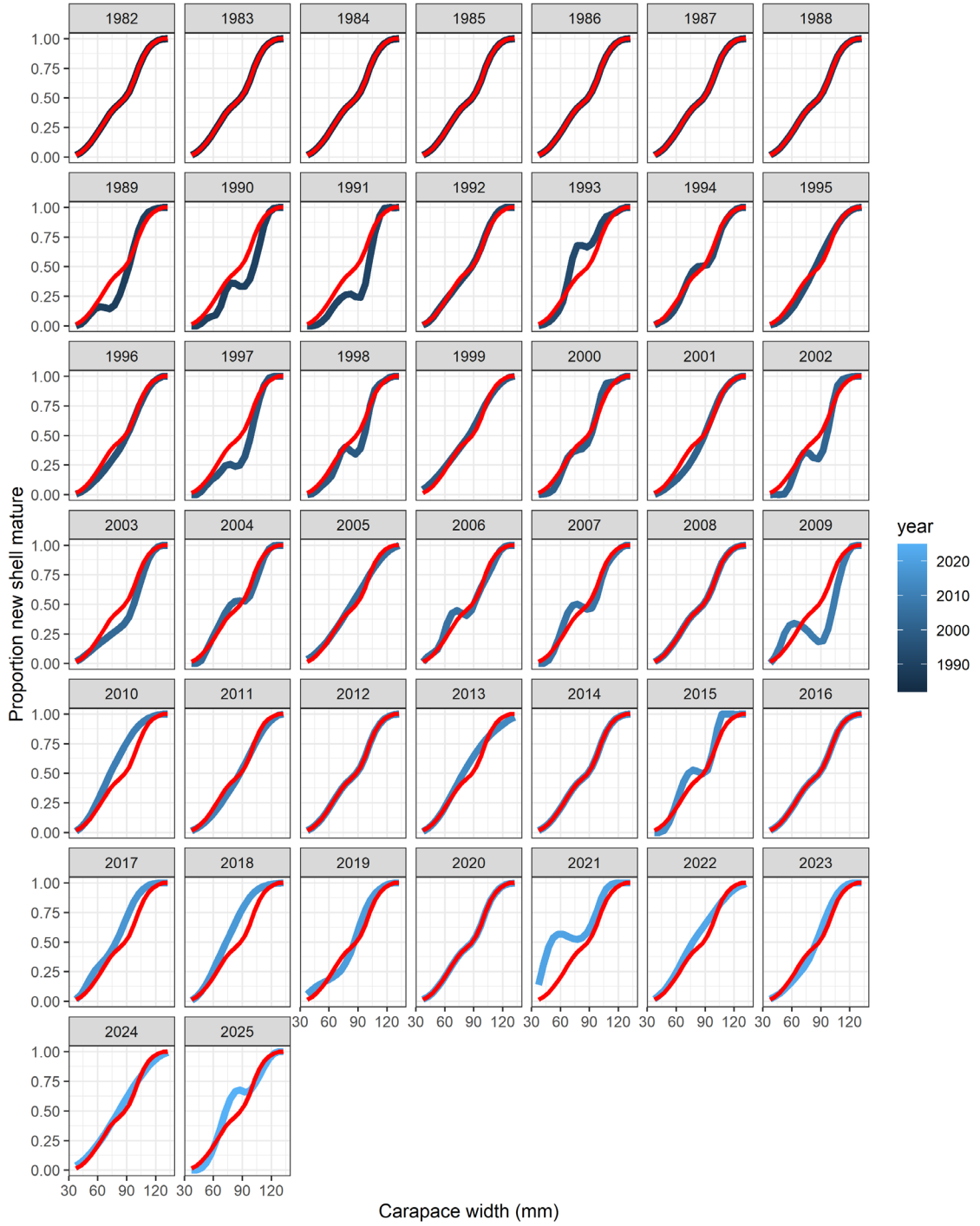

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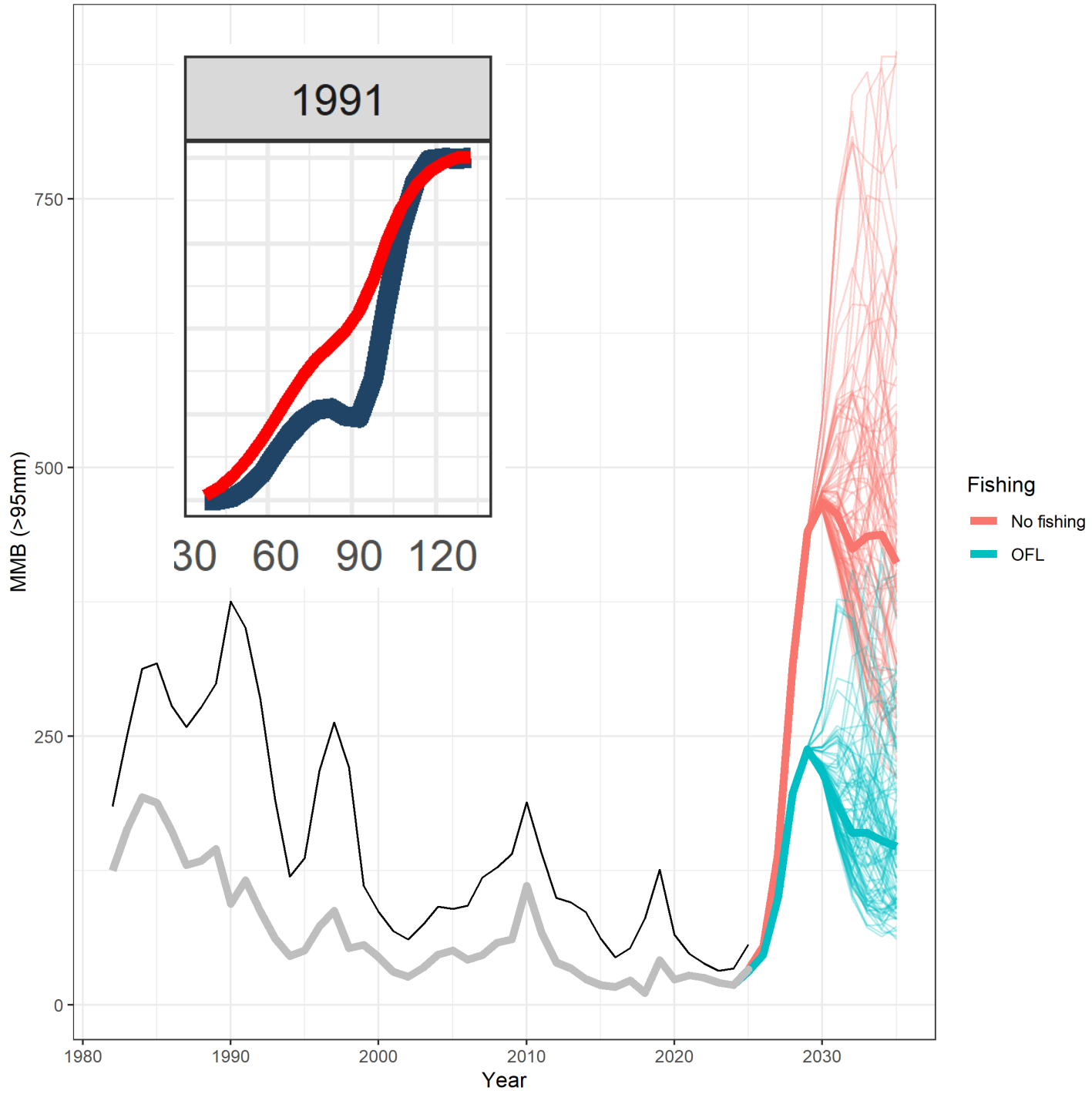

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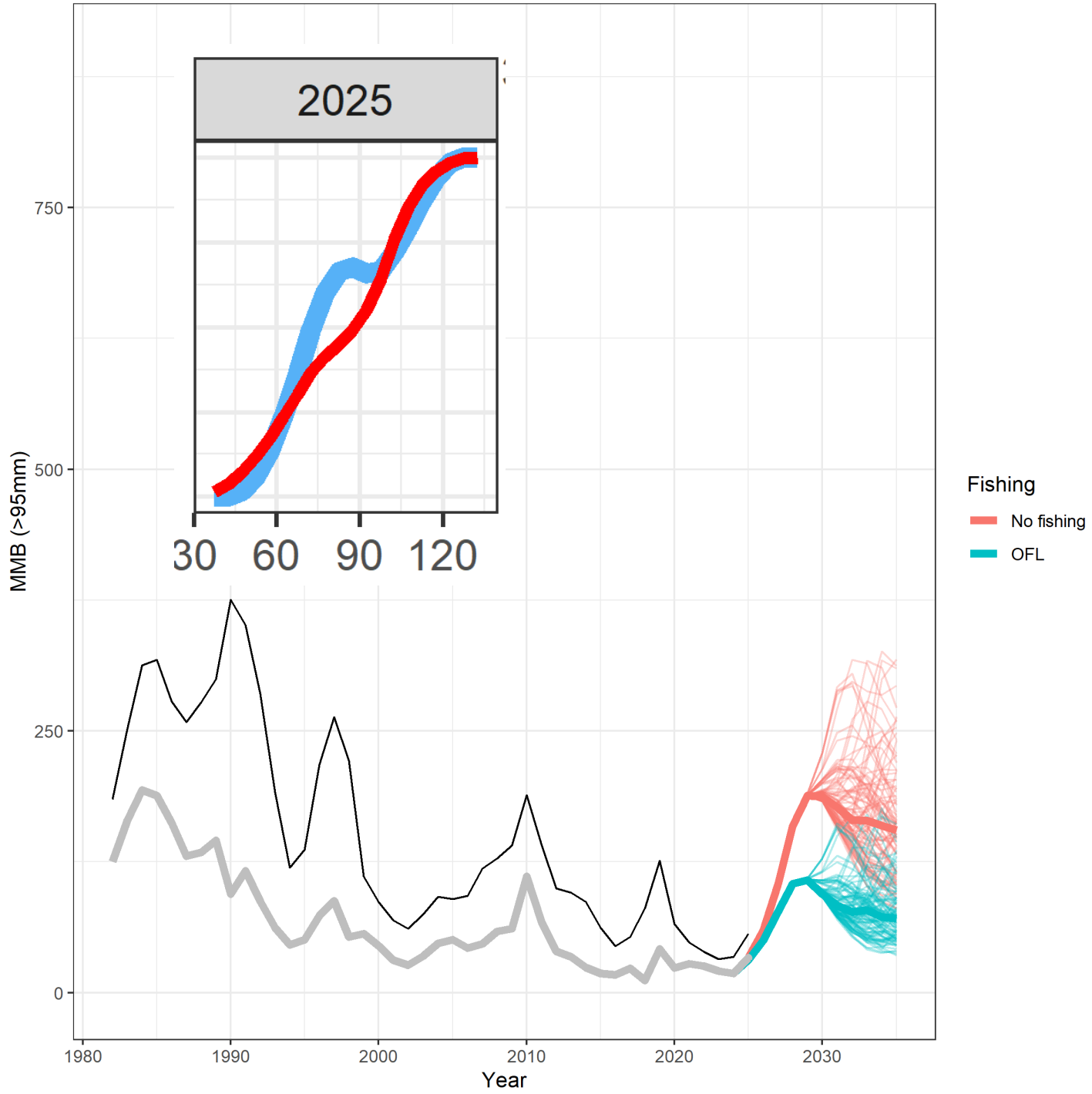
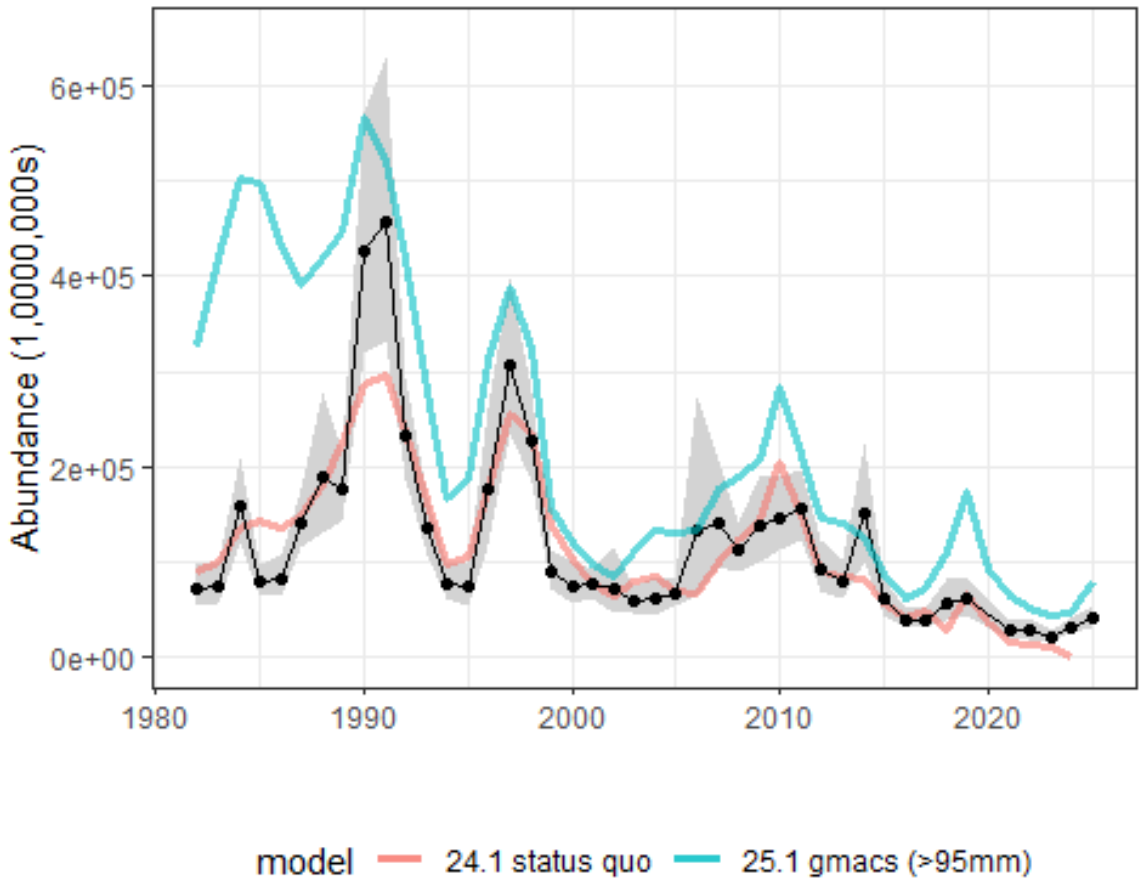
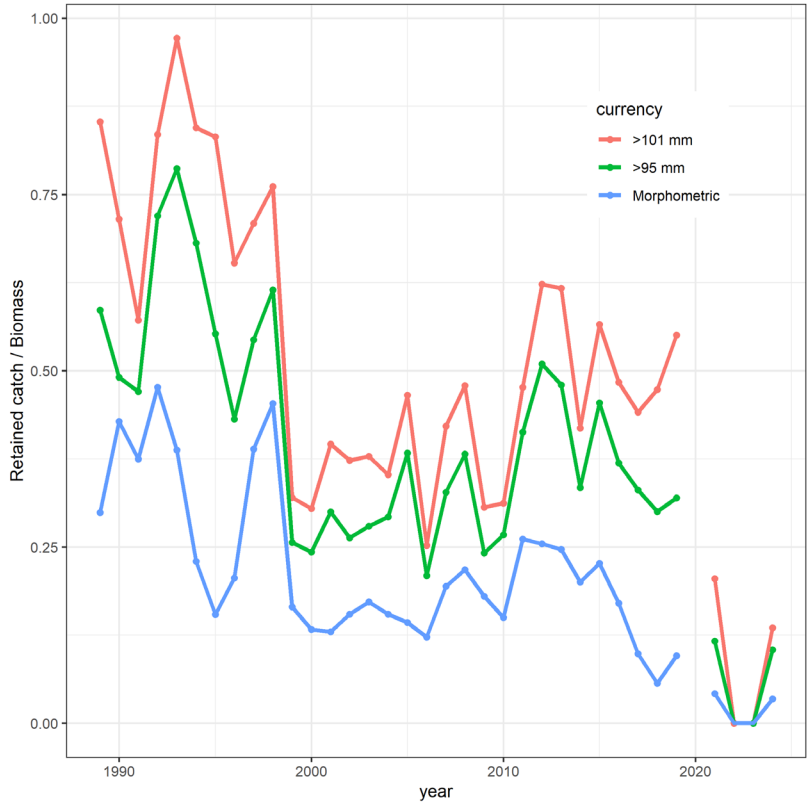


Recommendations

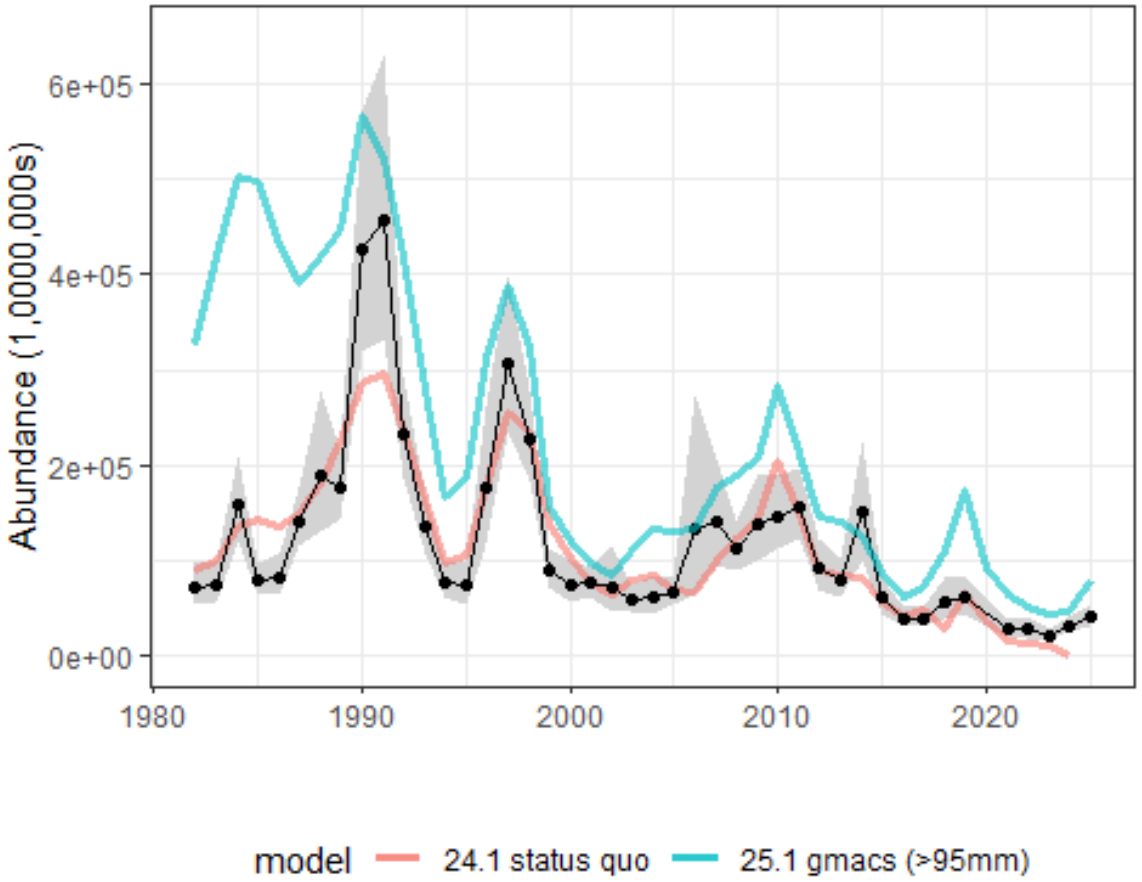
- Tier 3: B35% + large males currency (>95 mm)
- **OFL = 3.26 kt**
- **ABC = 2.63 kt (20% buffer)**

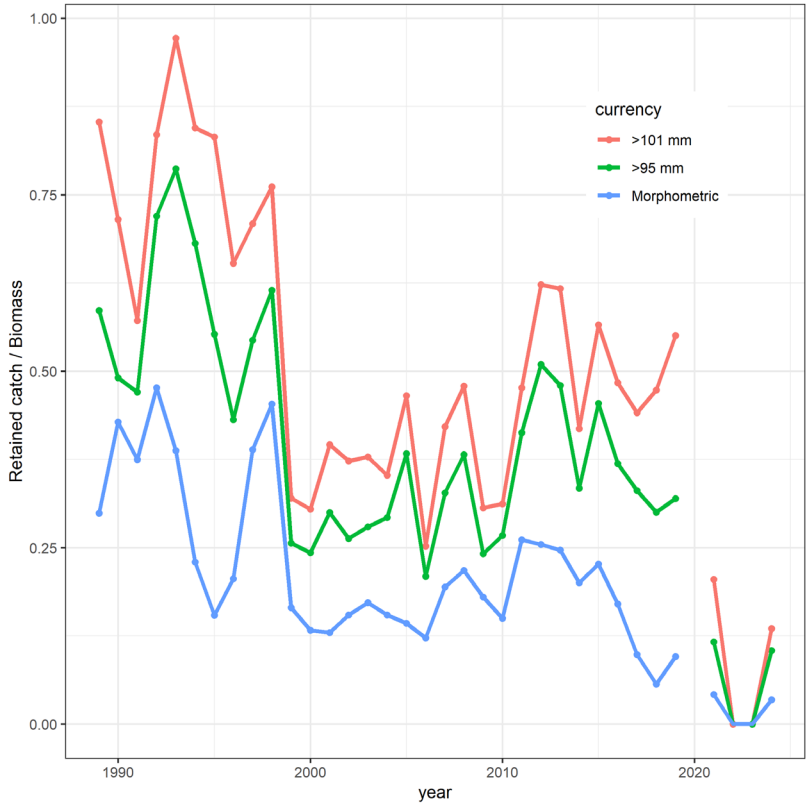




Recommendations

- Rationale
  - Even with a much more conservative HCR from the state, the stock is on a downward spiral.
  - An overfishing level that allows complete removal of large males is non-sensical.



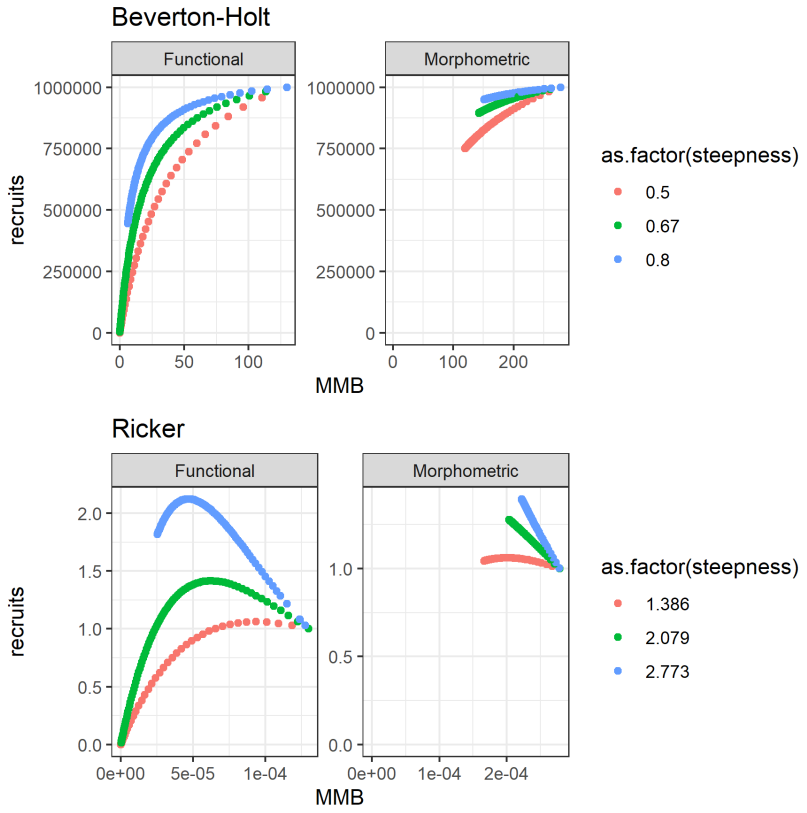


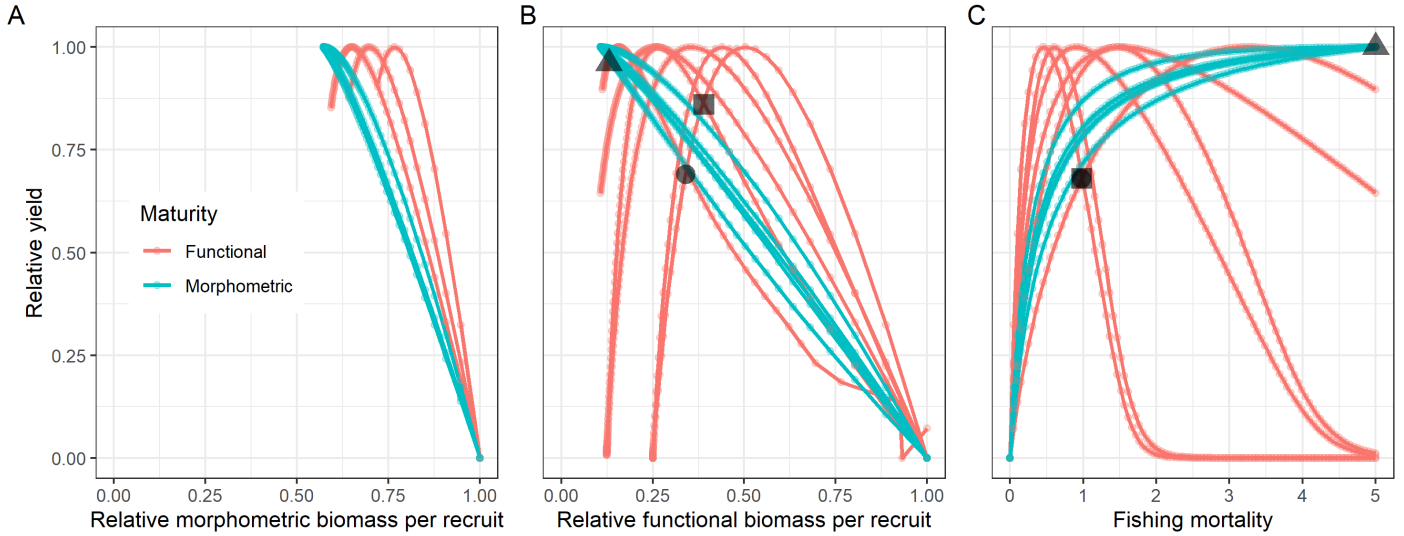
Overview

- Review of key changes to data
  - Catch data
  - Survey data
- Assessment scenarios
  - Diagnostics
  - Fits and OFLs
- Management recommendations
  - Tier 3 vs 4
  - Model-based vs. observed estimates of biomass

SSC recommendations

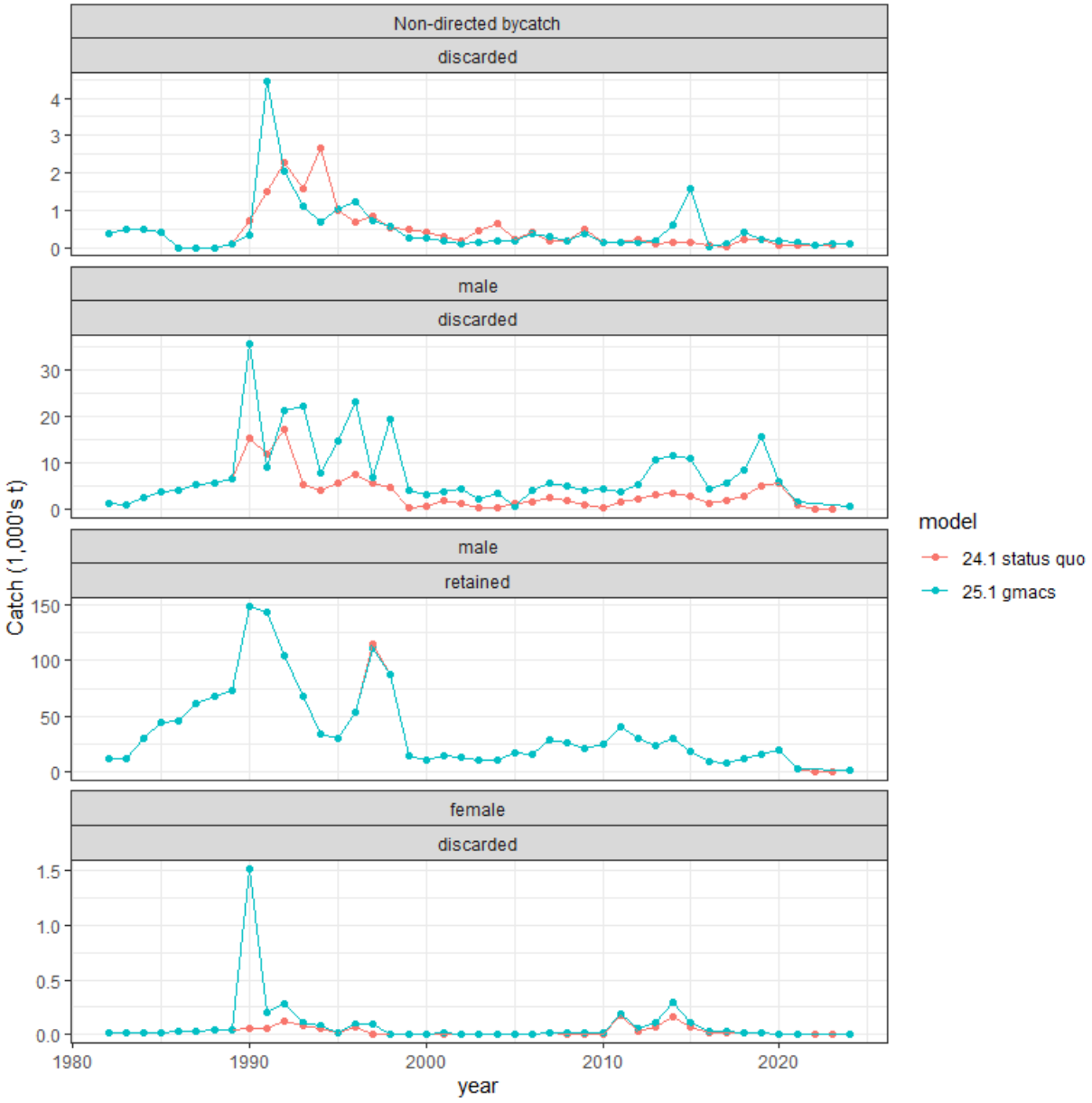
- **SSC comment: The maximin analysis should be completed assuming a Ricker stock-recruitment relationship, but including the same compensation ratios as the original Clark (1991) analysis. **
- **This was done and changed the SBPR% changed from 36% to 34% when using >95mm as currency.**





SSC recommendations

- **SSC comment: As the figures presented on the updated 1991+ catch data appear to indicate substantial differences in male discards, the SSC requests that the September document more clearly describe changes in the discard estimation and accounting process. **
- **The change in discards came from the way in which mortality was accounted for (i.e. before data input or within the model).**
- **Larger differences farther back (with a couple of exceptions).**



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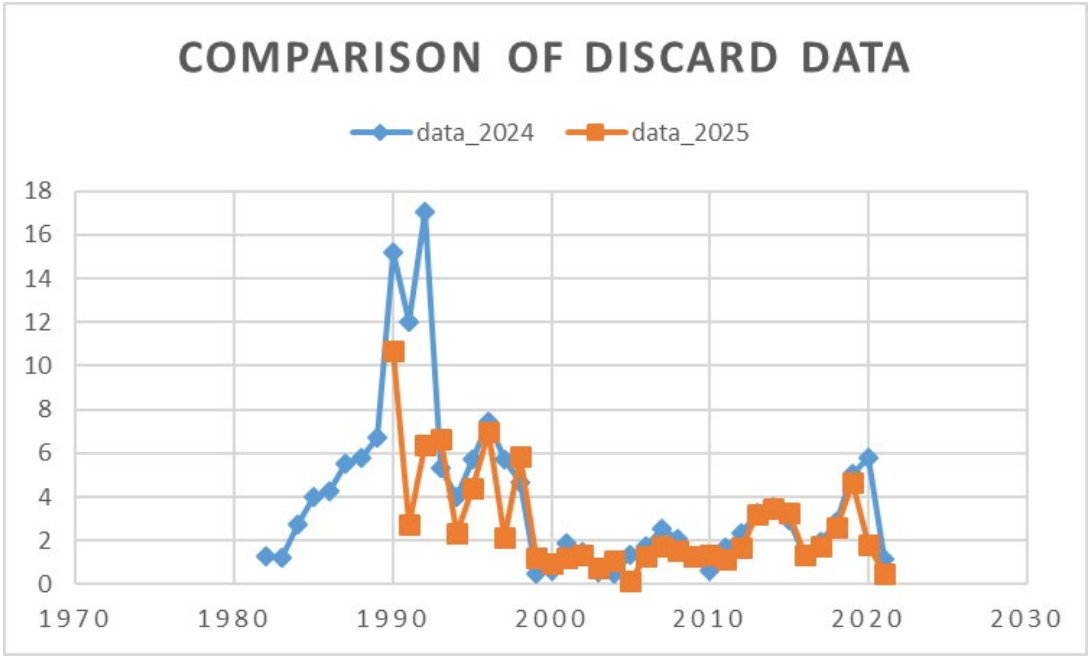
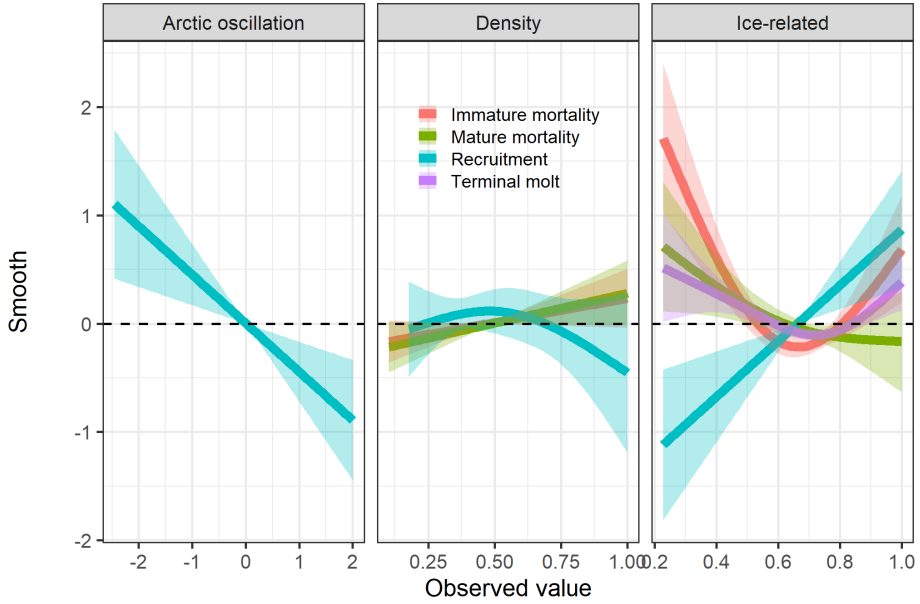


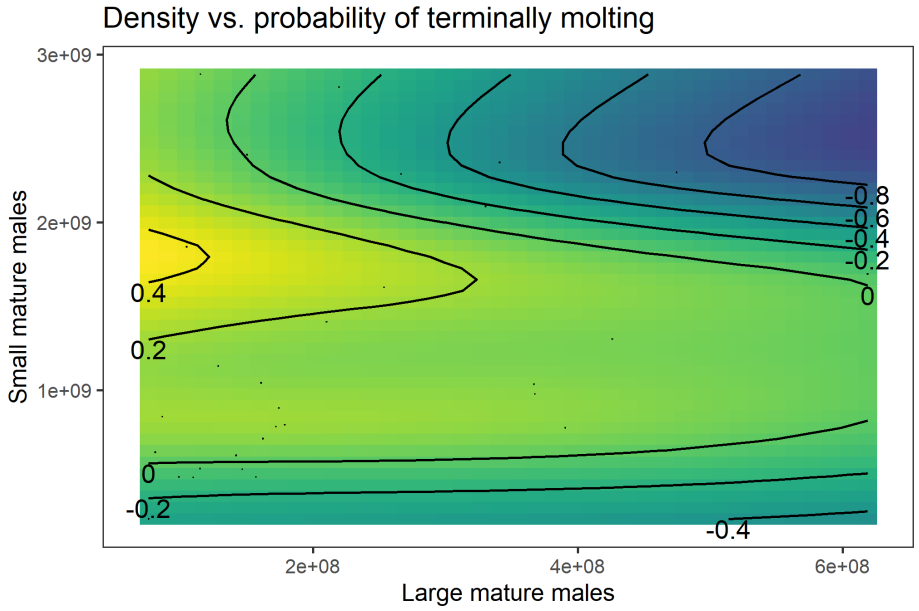
SSC recommendations

**SSC comment: Given the findings described in Mullowney and Baker (2021) from Canadian research indicating that the molt to maturity may occur at smaller sizes when lower densities of large males are present, it would be useful to determine if there is evidence for the same process occurring in EBS snow crab, and whether fishing mortality on the large males is consistently high enough to result in a strong effect. Further, it would be useful to evaluate whether clutch fullness may be related to size at maturity or the abundance of large-sized crab.*

*Given that natural mortality events seem to switch among years and sexes depending on the model or input data, it would be prudent to investigate whether it is possible to estimate a direct link between natural mortality and a bottom temperature covariate of appropriate spatial and temporal scale**

- **Done for males in May 2024—in review at Journal of Applied Ecology**

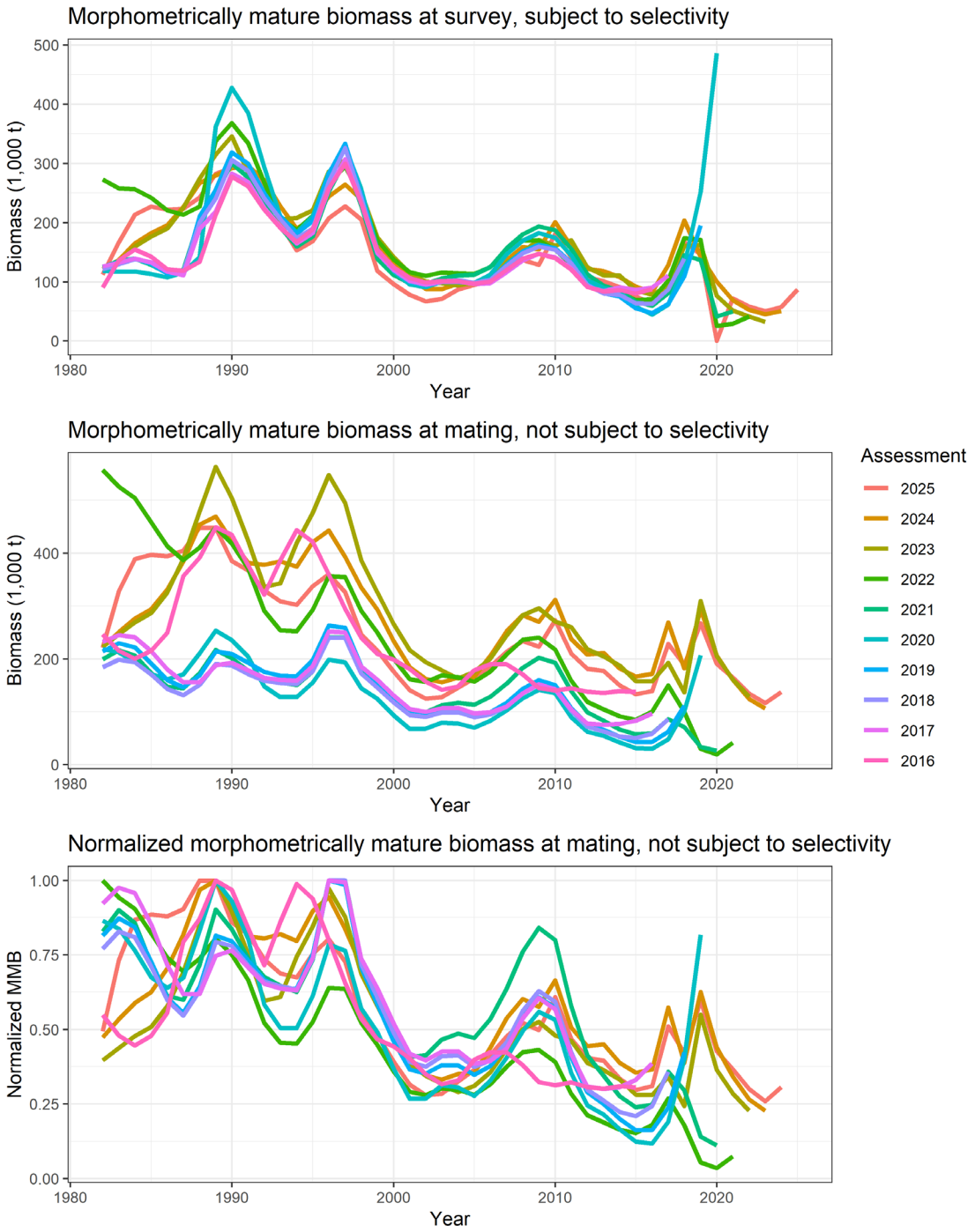




SSC recommendations

- **SSC comment: include historical bias plots **
- **See right.**

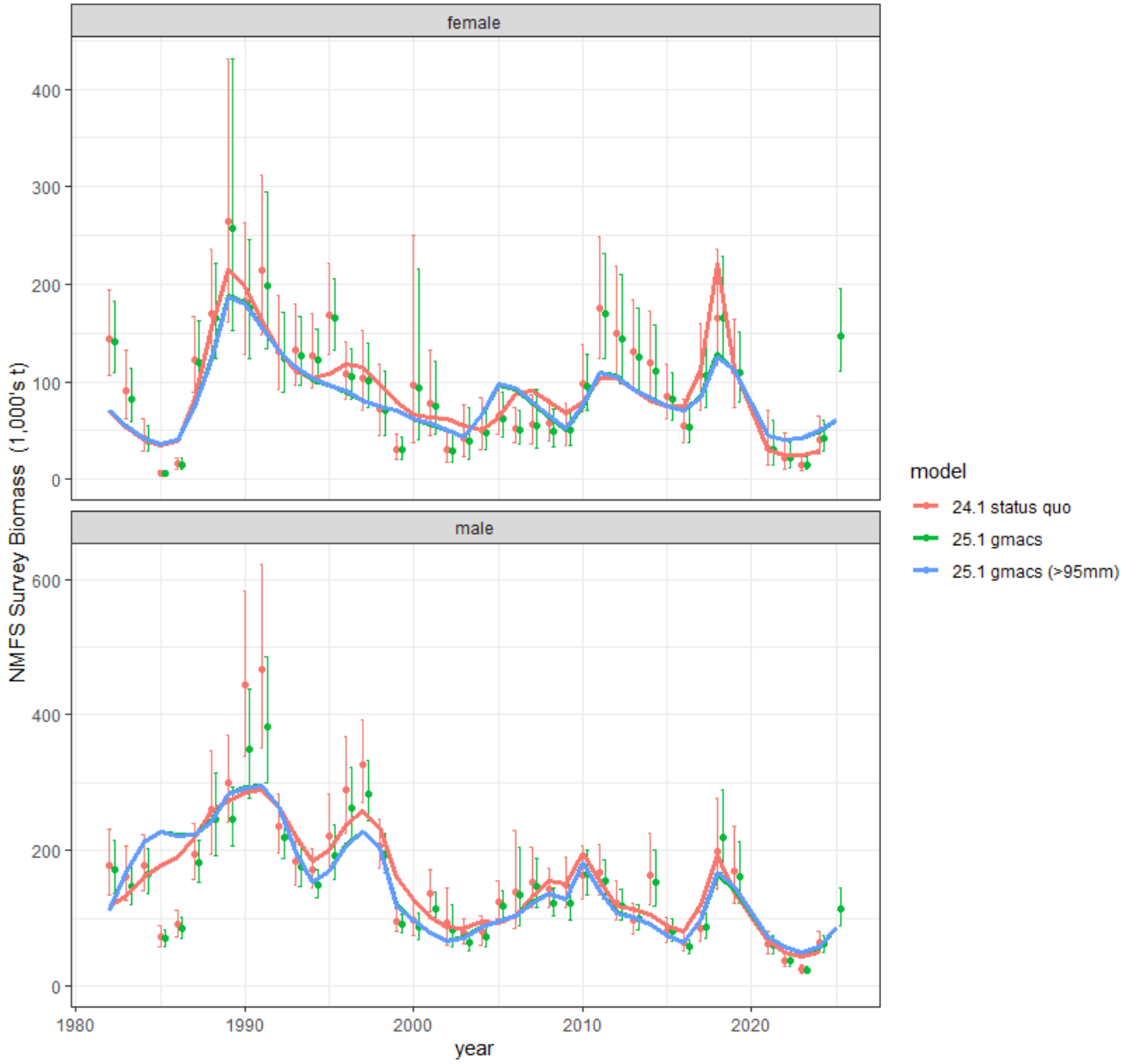
- **SSC comment: To explore development of an ABC control rule, the SSC requests that a yield per recruit analysis be developed for snow crab. **
- **No time**



Data changes

- Catch data
  - (discussed above)

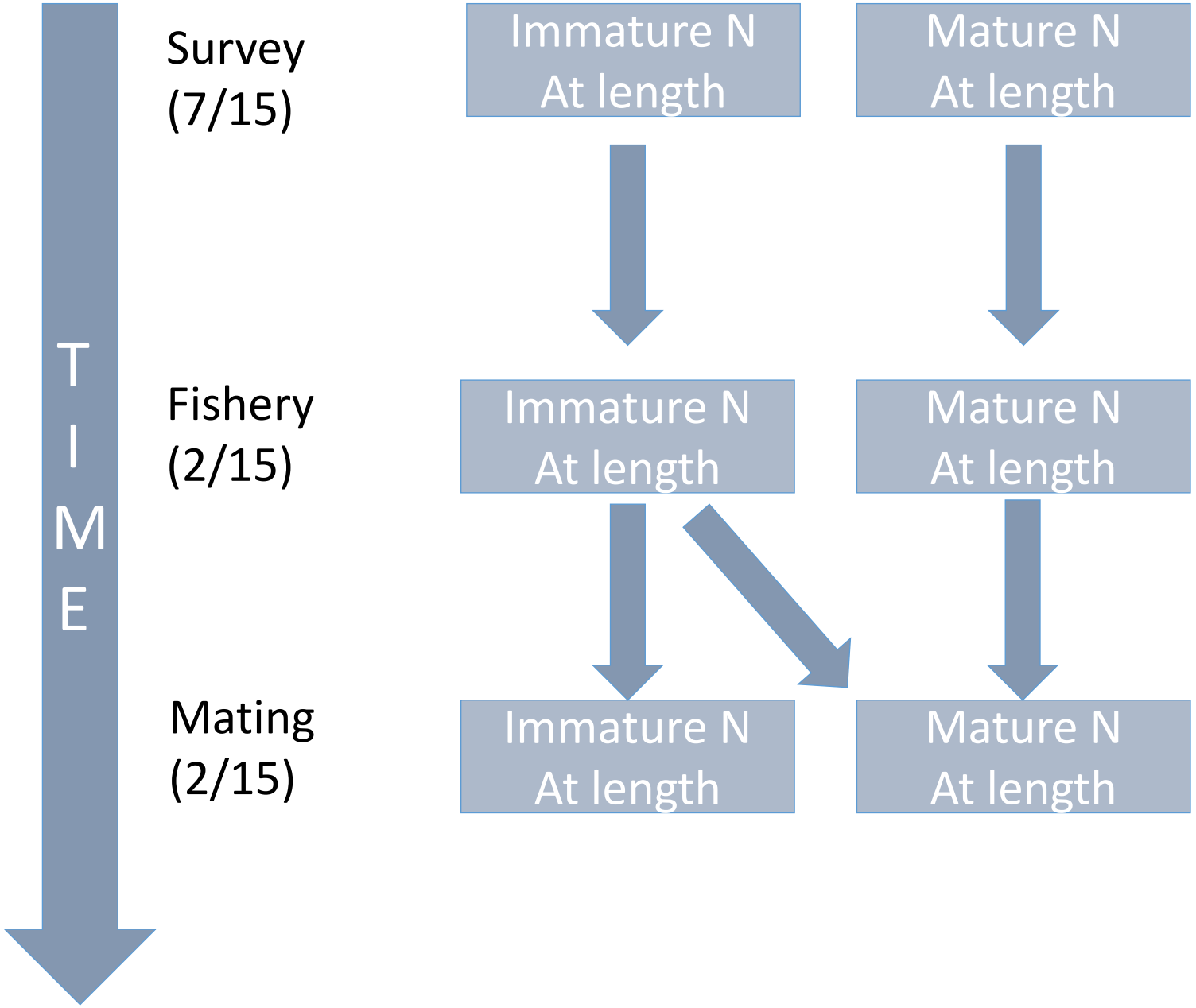
- Survey data
  - Both sexes updated
  - Large changes for males in some years
  - Incorporating the time-varying probability of terminal molt
  - Early data points were historically difficult to fit
  - Updates did not change the trajectory of estimates significantly



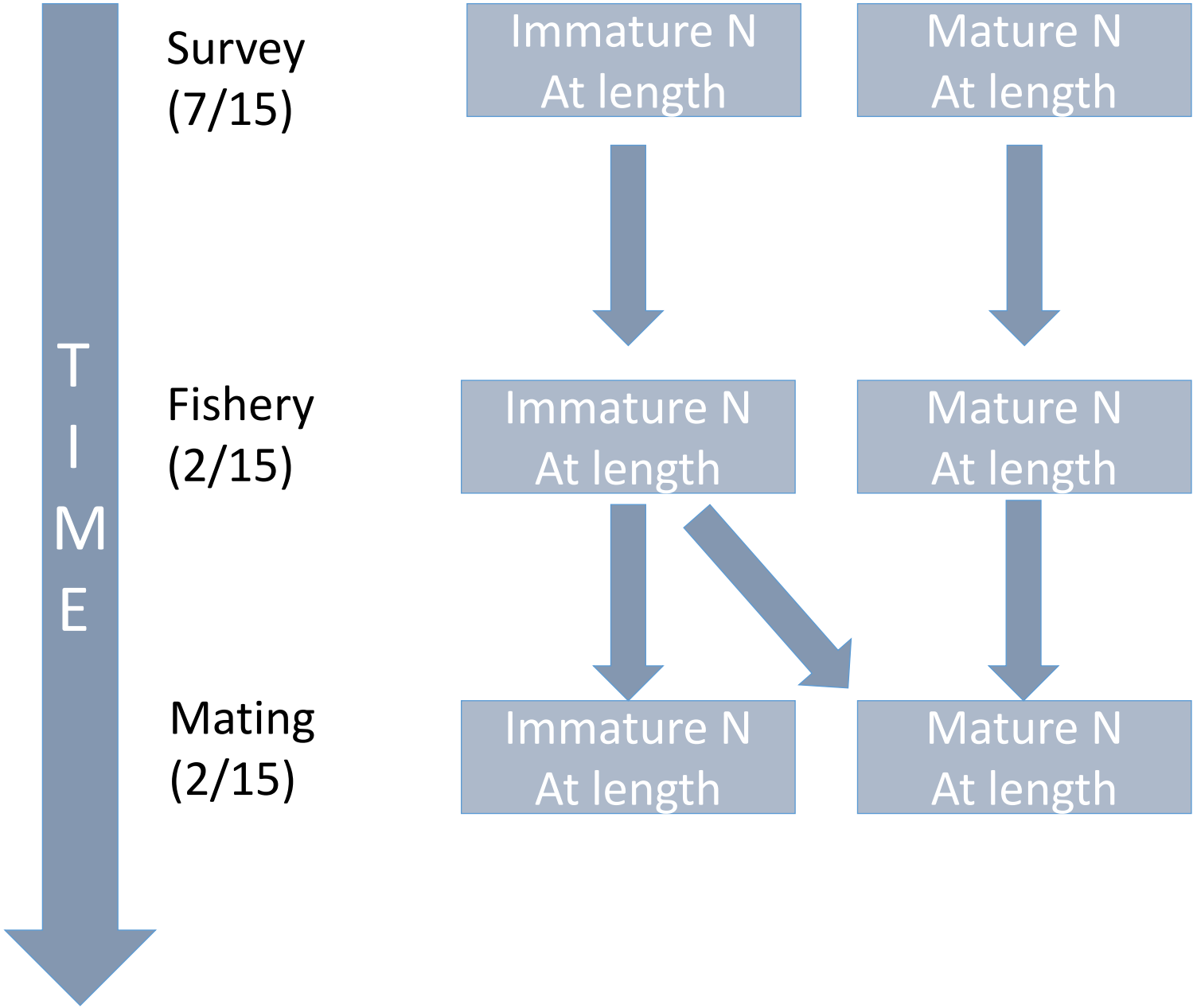
Assessment model

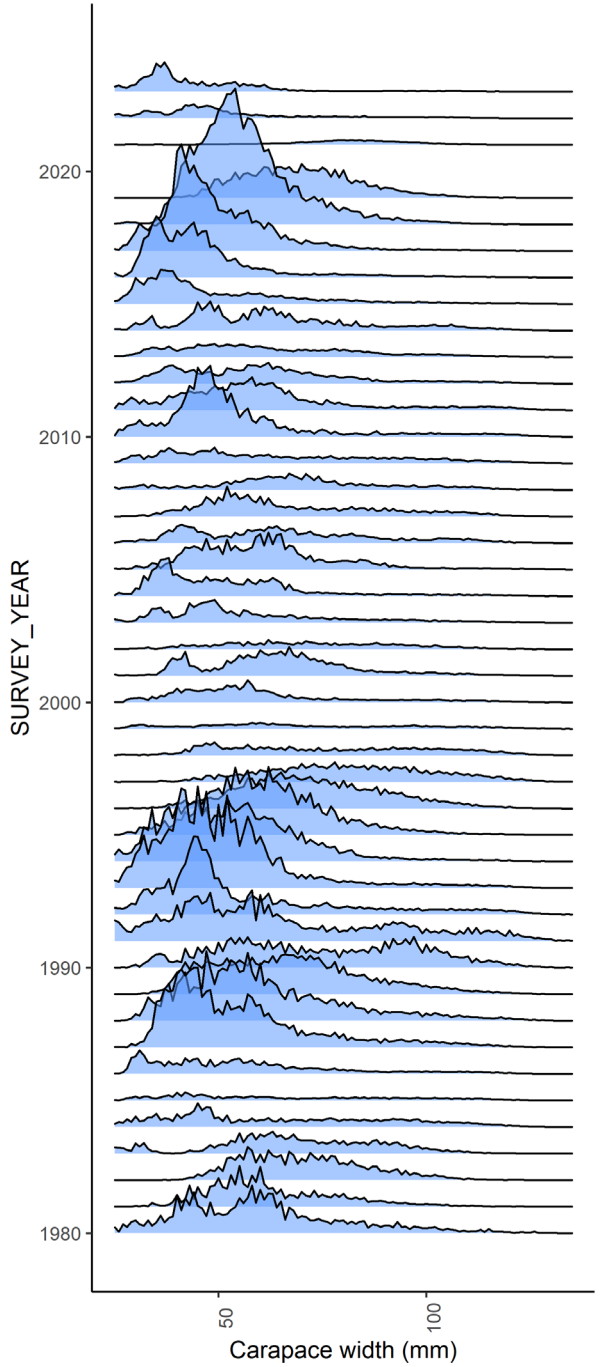
Key assumptions

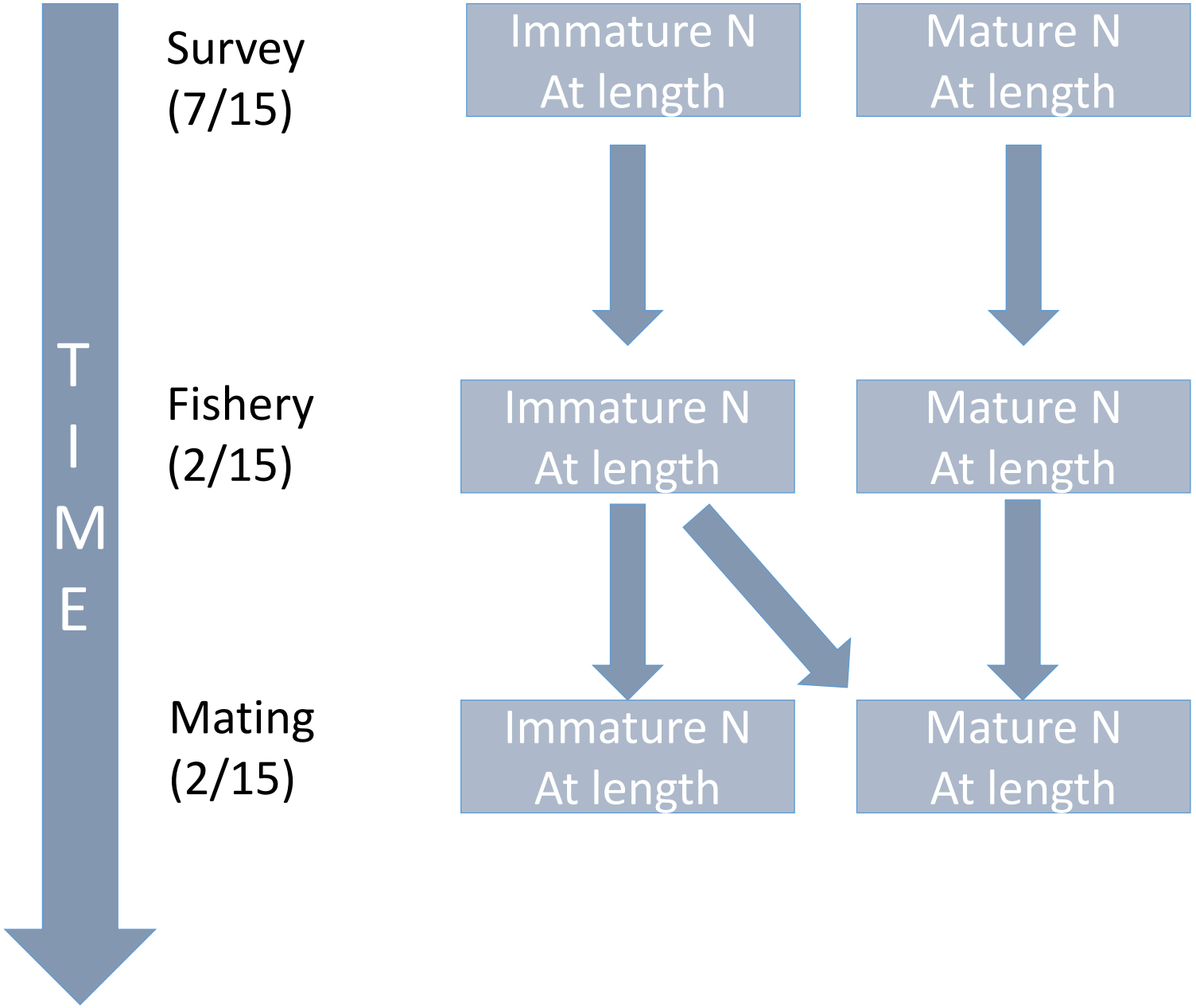
- the probability of *terminally molting at size varies over time* and size and is specified based on observations from the survey data
- survey selectivity is estimated by era (1982-88; 1989-present) and sex as a non-parametric curve subject to priors based on the BSFRF survey efficiency experiment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



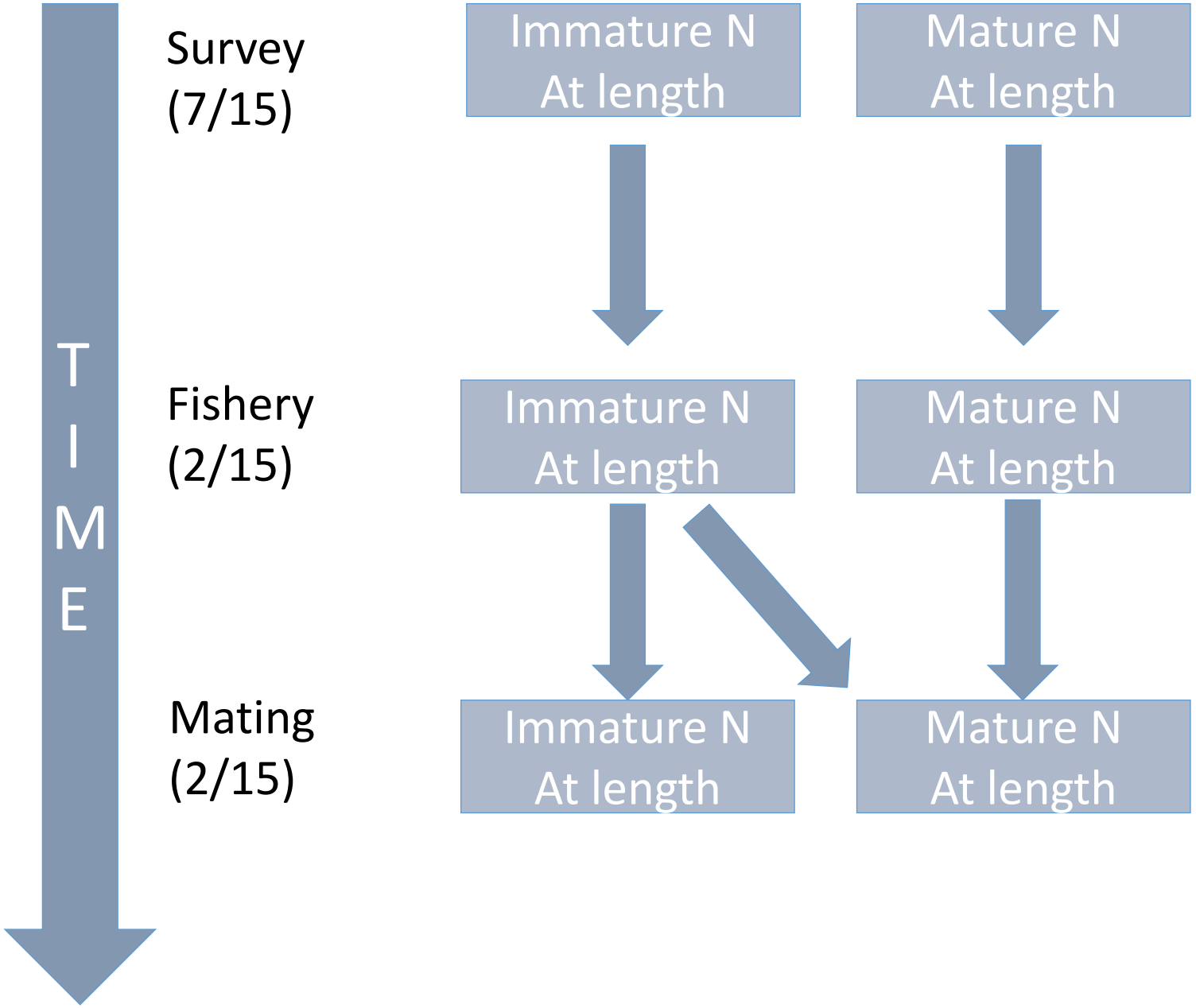
	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	....
1982									
1983									
1984									
1985									
1986									
1987									
....									


TIME
Survey
(7/15)
Immature N
At length
Mature N
At length
Fishery
(2/15)
Immature N
At length
Mature N
At length
Mating
(2/15)
Immature N
At length
Mature N
At length

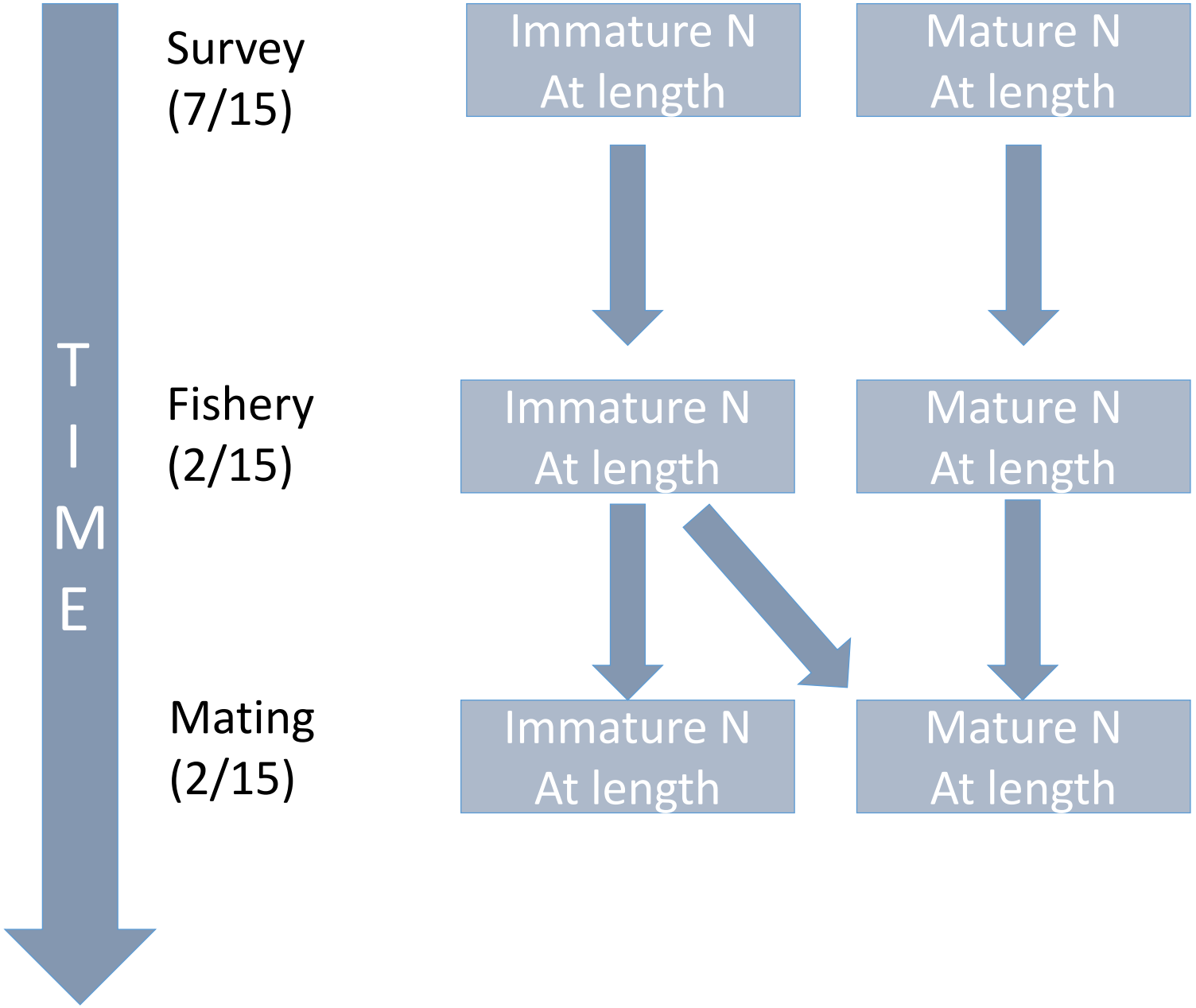

SURVEY_YEAR
2020
2010
2000
1990
1980
50
100
Carapace width (mm)



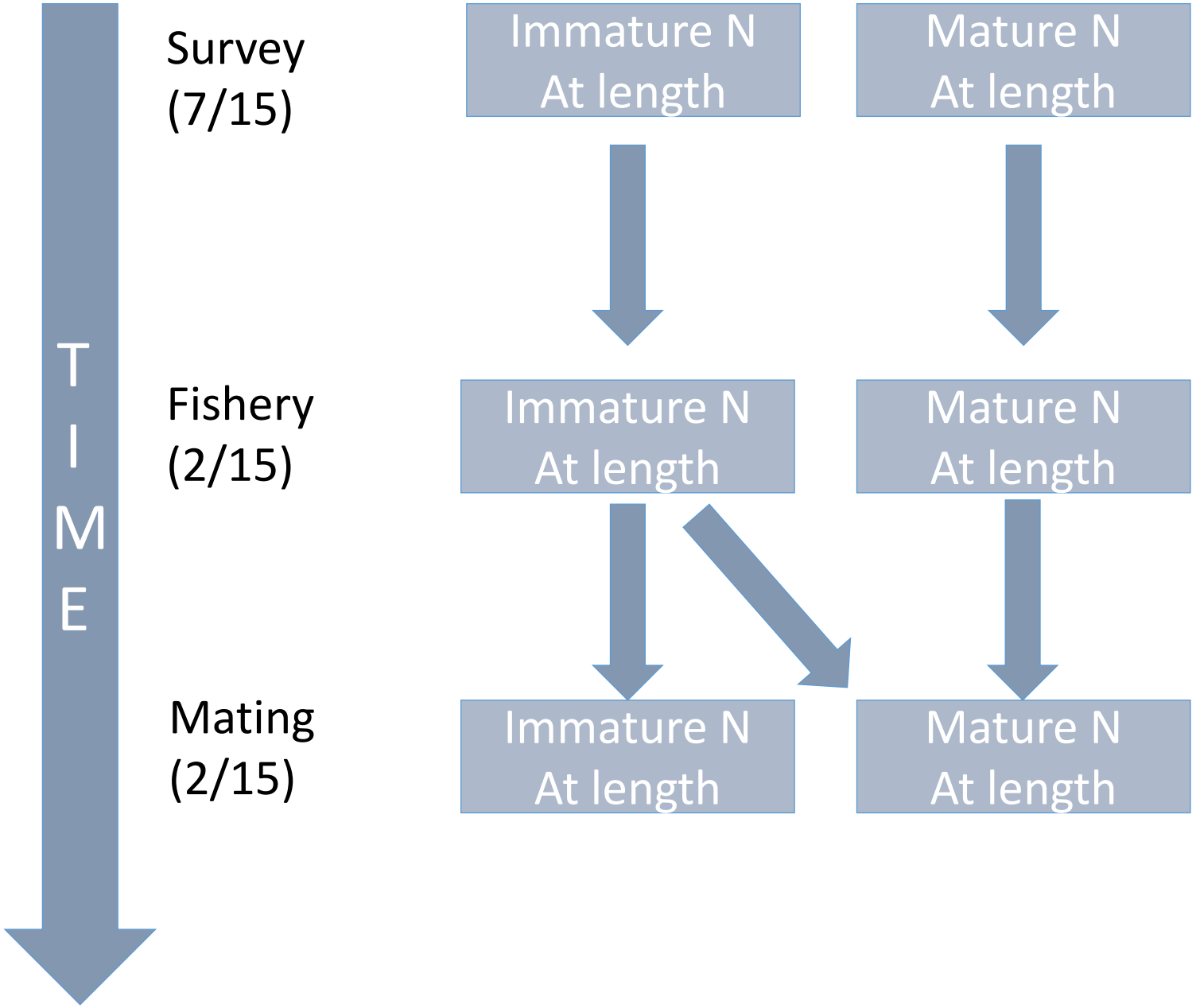
Survey data collected with an estimated selectivity



Natural mortality occurs (estimated by sex and maturity state + events)

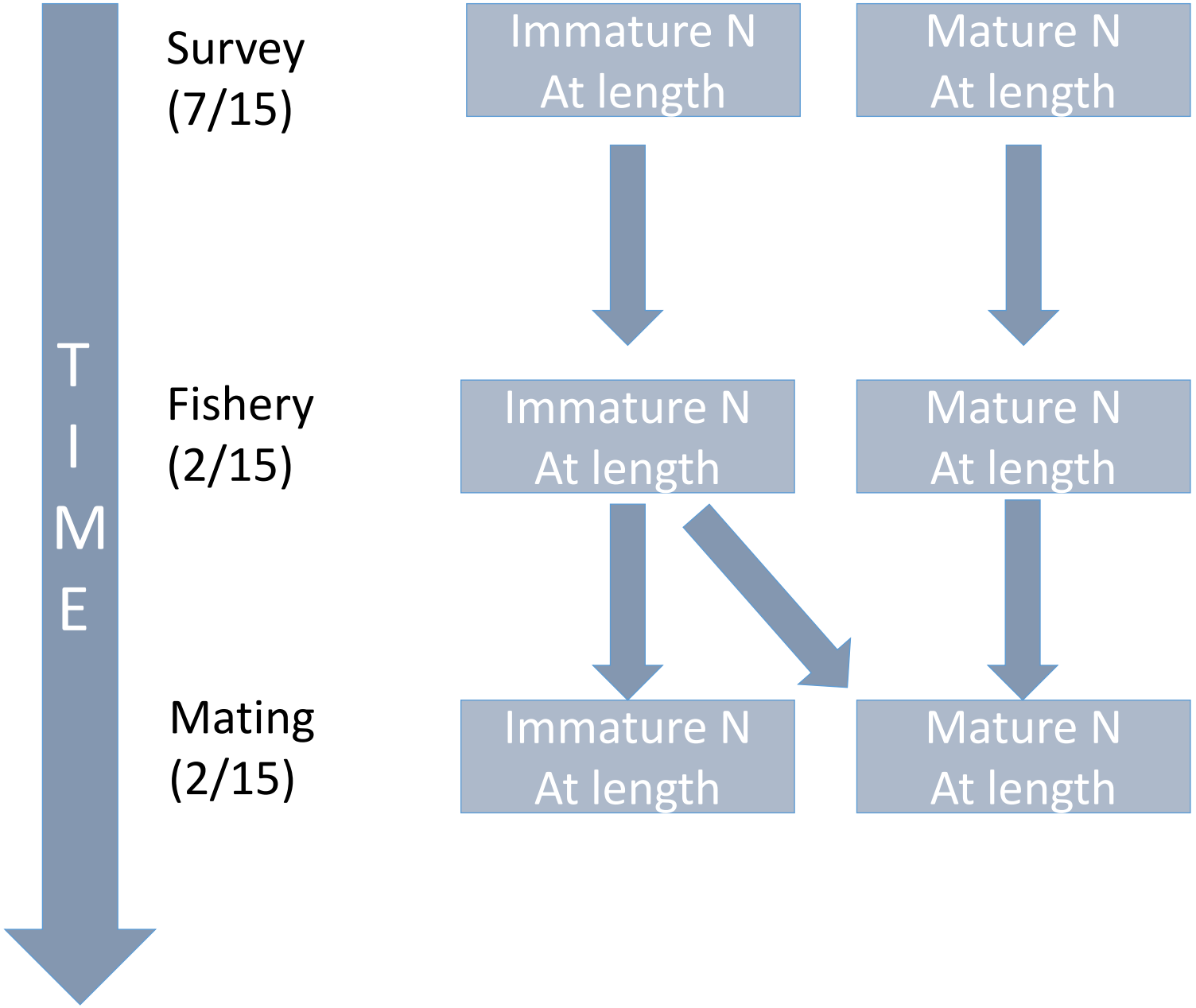


Directed and non-directed fishery occur with sex and fishery specific selectivity.

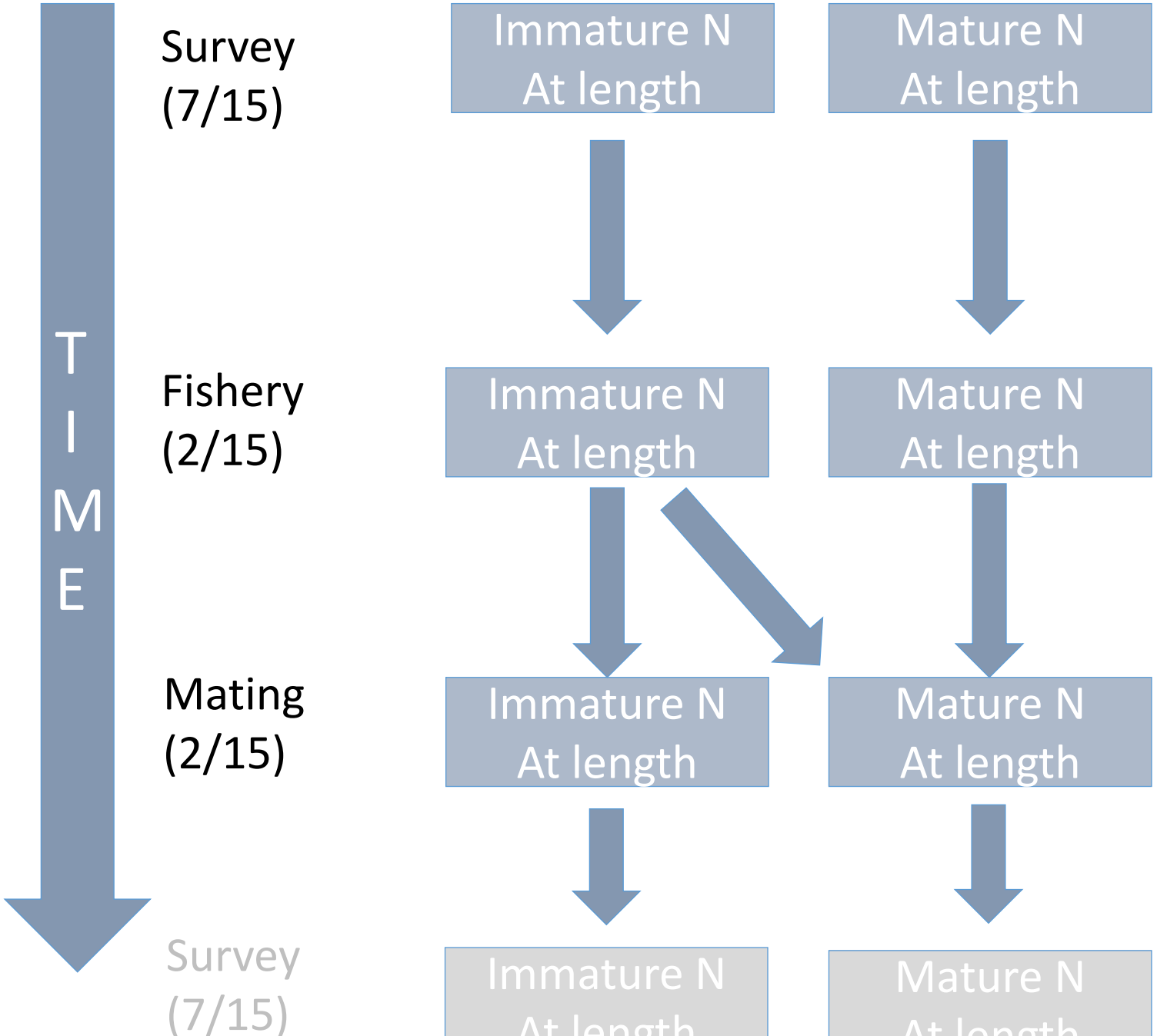


Growth occurs

After growth previously immature animals are allocated to immature or mature size bins based on a probability of having undergone terminal molt.



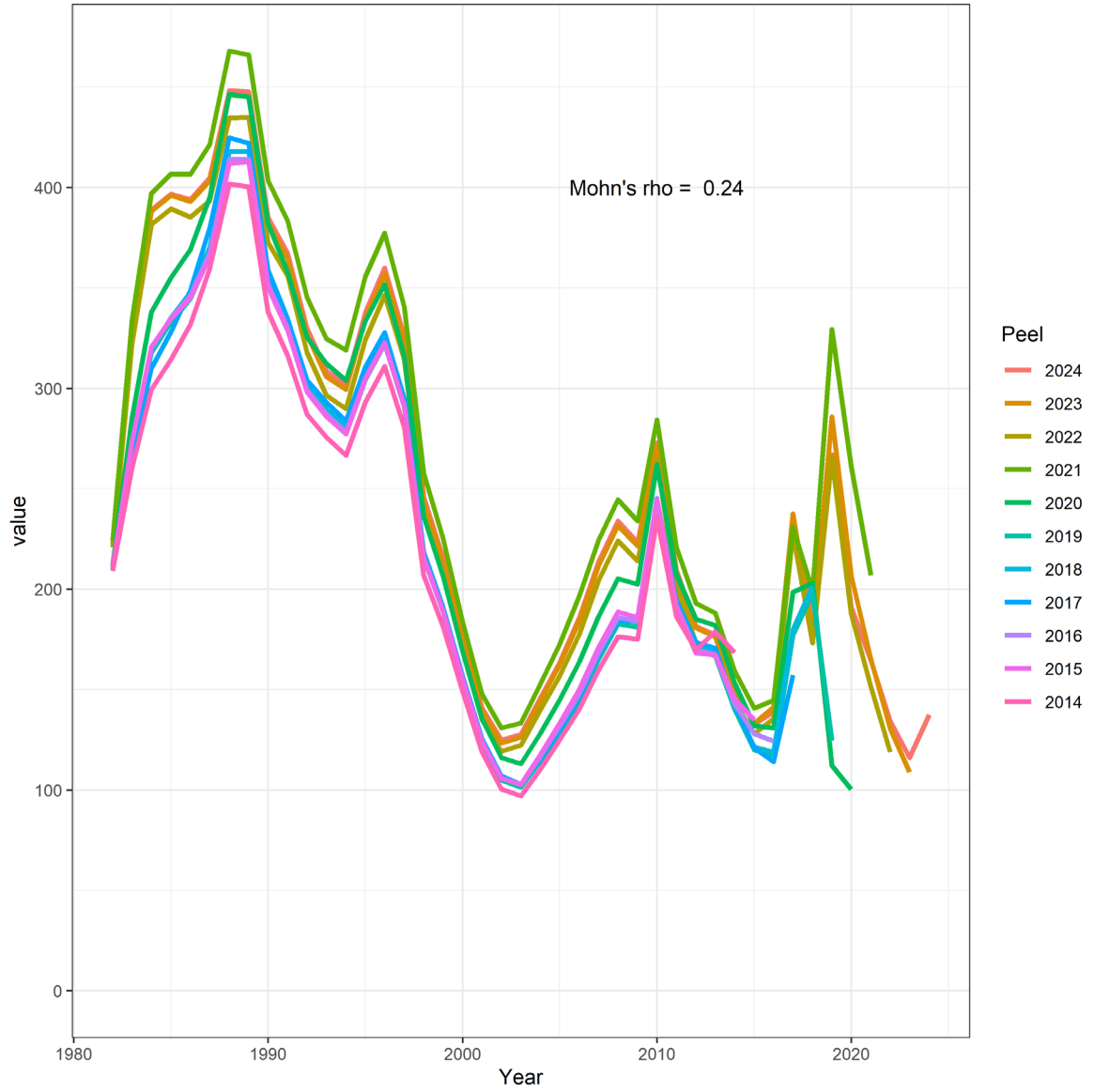
Recruitment occurs and is primarily allocated to the first three size bins.



Remaining natural mortality applied before the next survey.

Model diagnostics

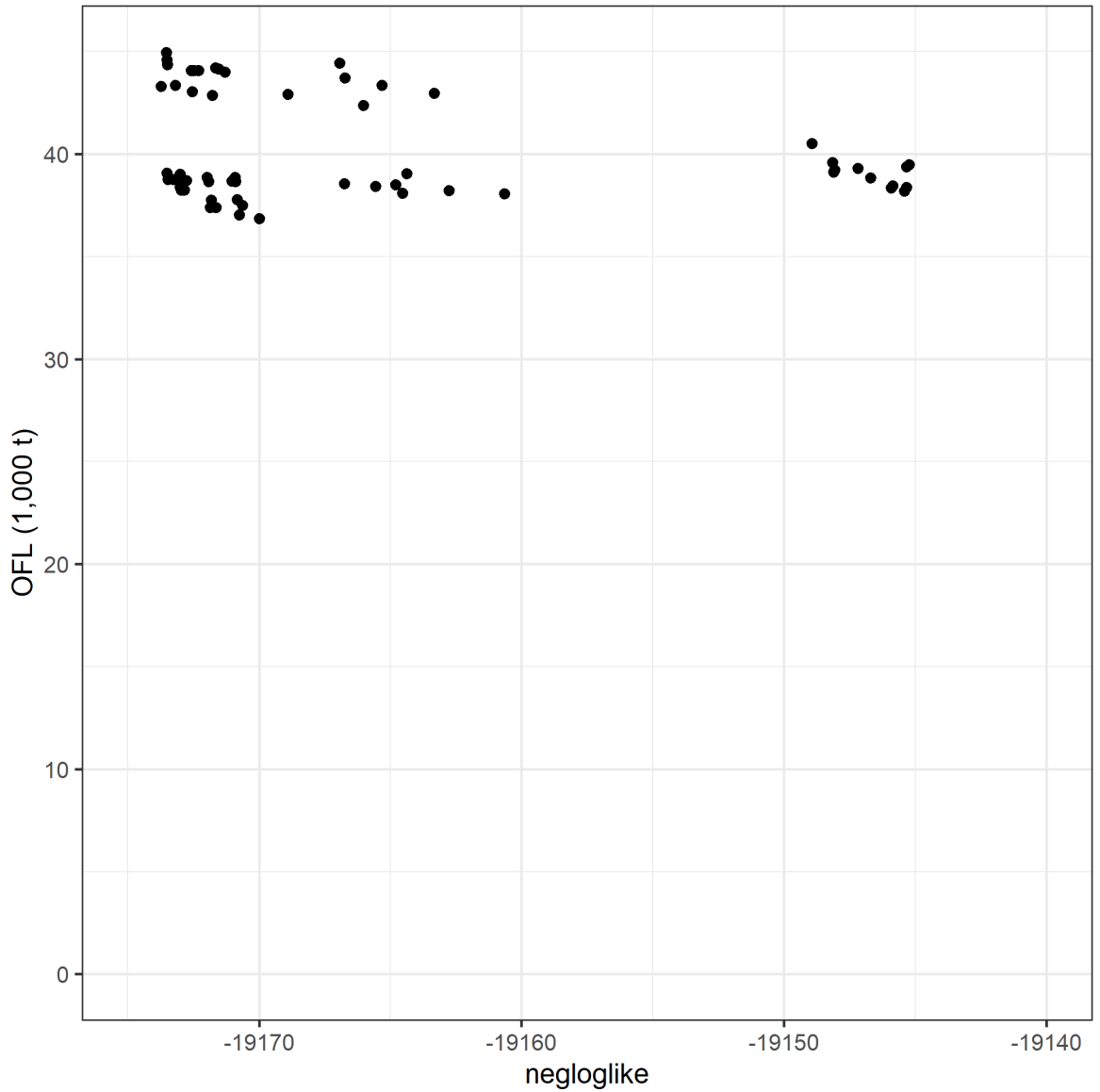
- Retrospective patterns not terribly concerning



Retrospective patterns in estimated mature male biomass for selected models.

Model diagnostics

- Retrospective patterns not terribly concerning
- Jittering patterns are concerning



Jittered runs for model 25.1. Each dot represents a ‘converged’ model run.

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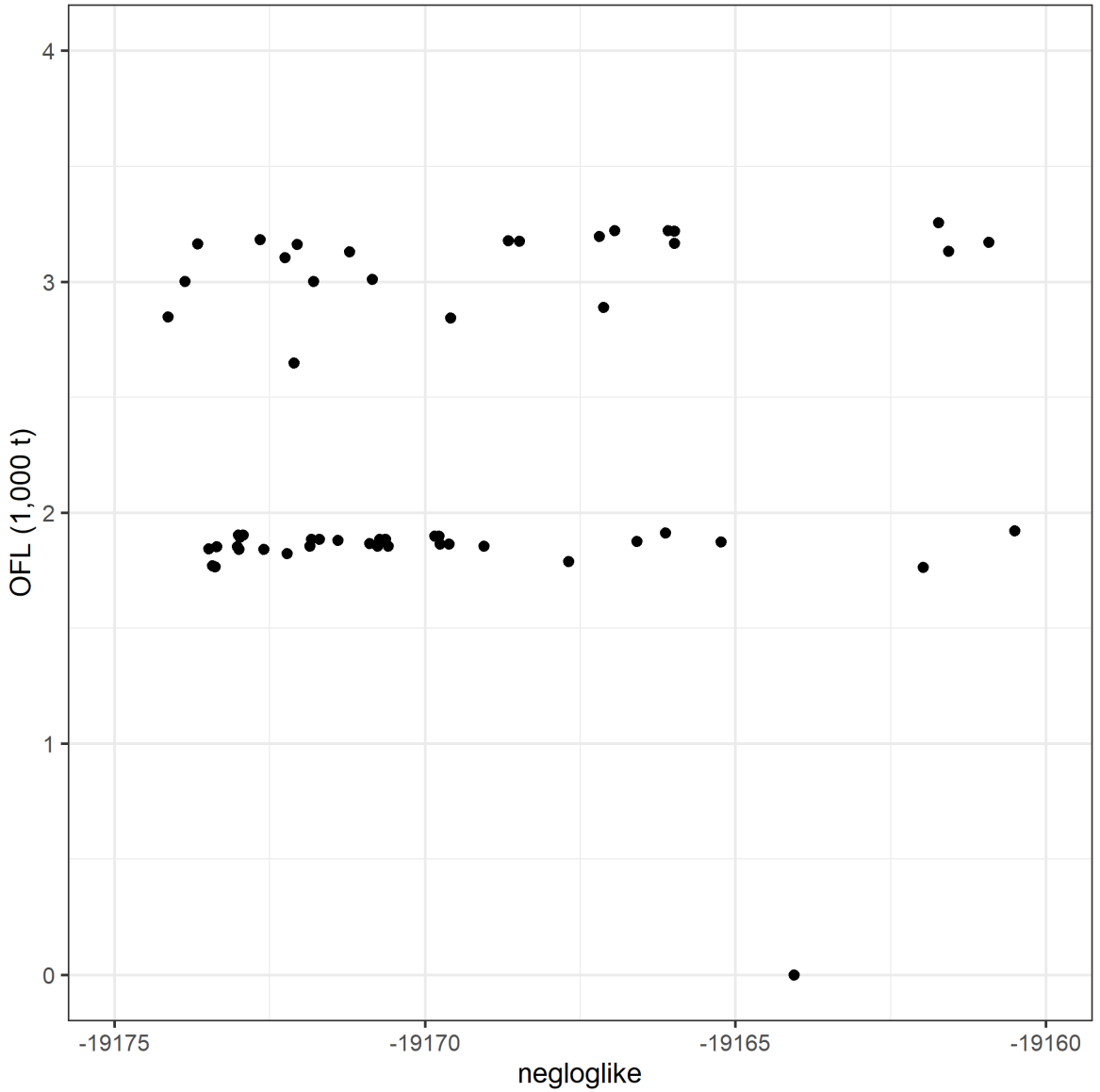

Jittered runs for model 25.1. Each dot represents a 'converged' model run.

Model diagnostics

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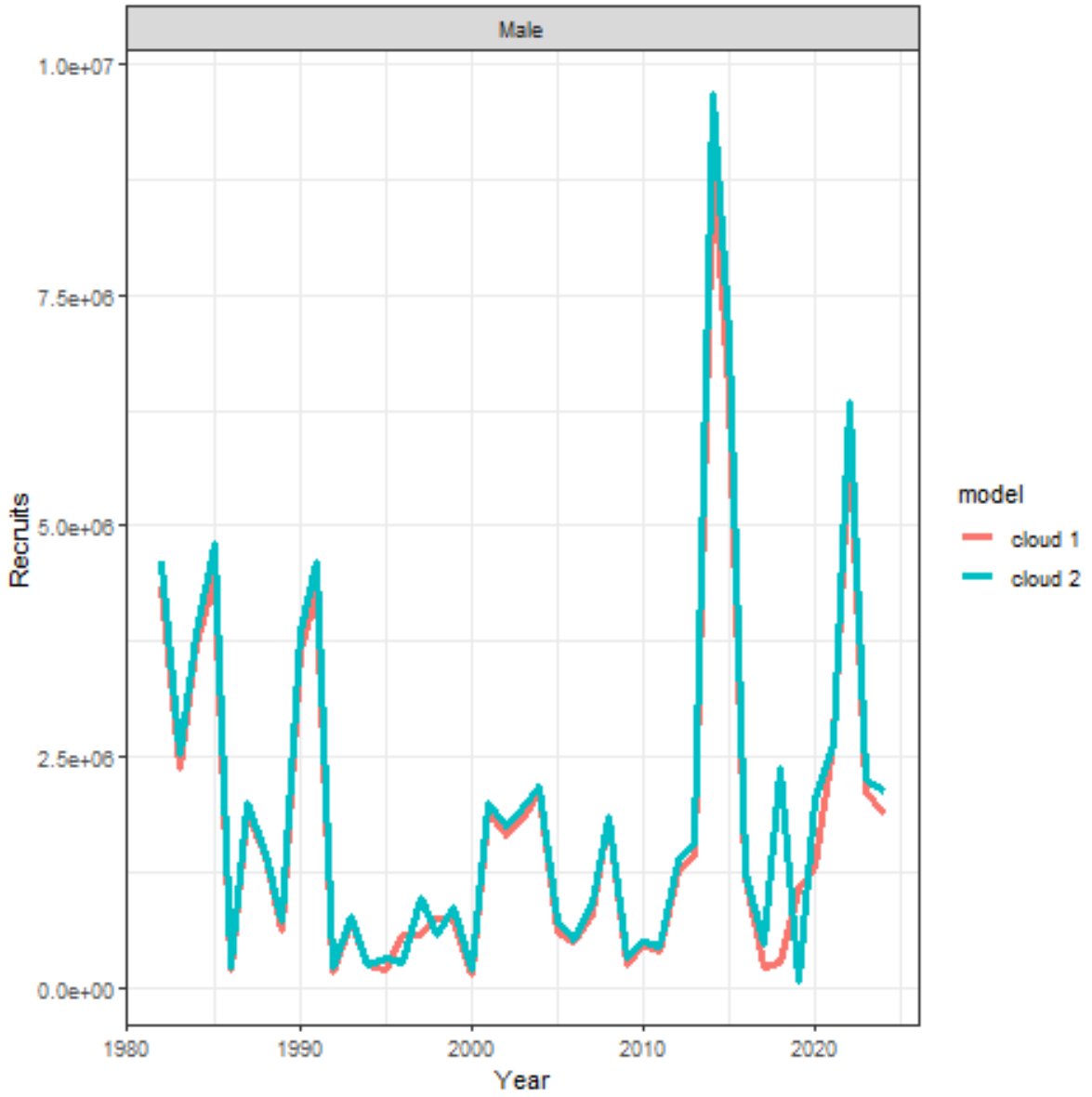
- Jittering patterns are concerning
- Differences in terminal year come from differences in estimated recruitment several years prior



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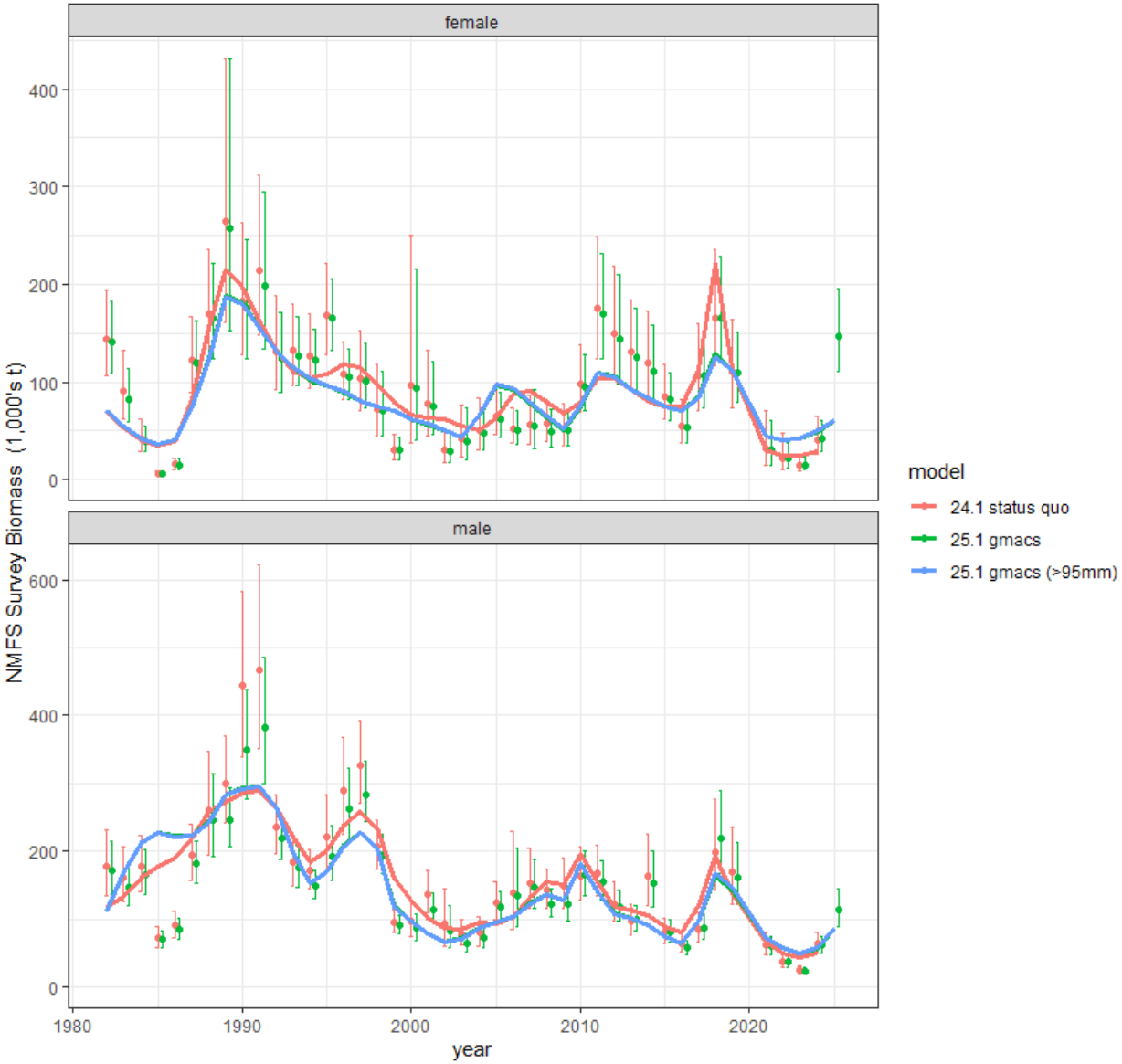
FMB index	Improved fits to growth resulted in large changes to FMB fits
MMB index	Fits changed little in spite of big changes in early years of survey biomass
Growth	
Catch biomass	
Catch size composition	
Survey size composition	
BSFRF priors	



Model fits to the observed mature biomass at survey.

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Growth	Improved fits to large females w/ lower CV; slight changes to males with new data
Catch biomass	
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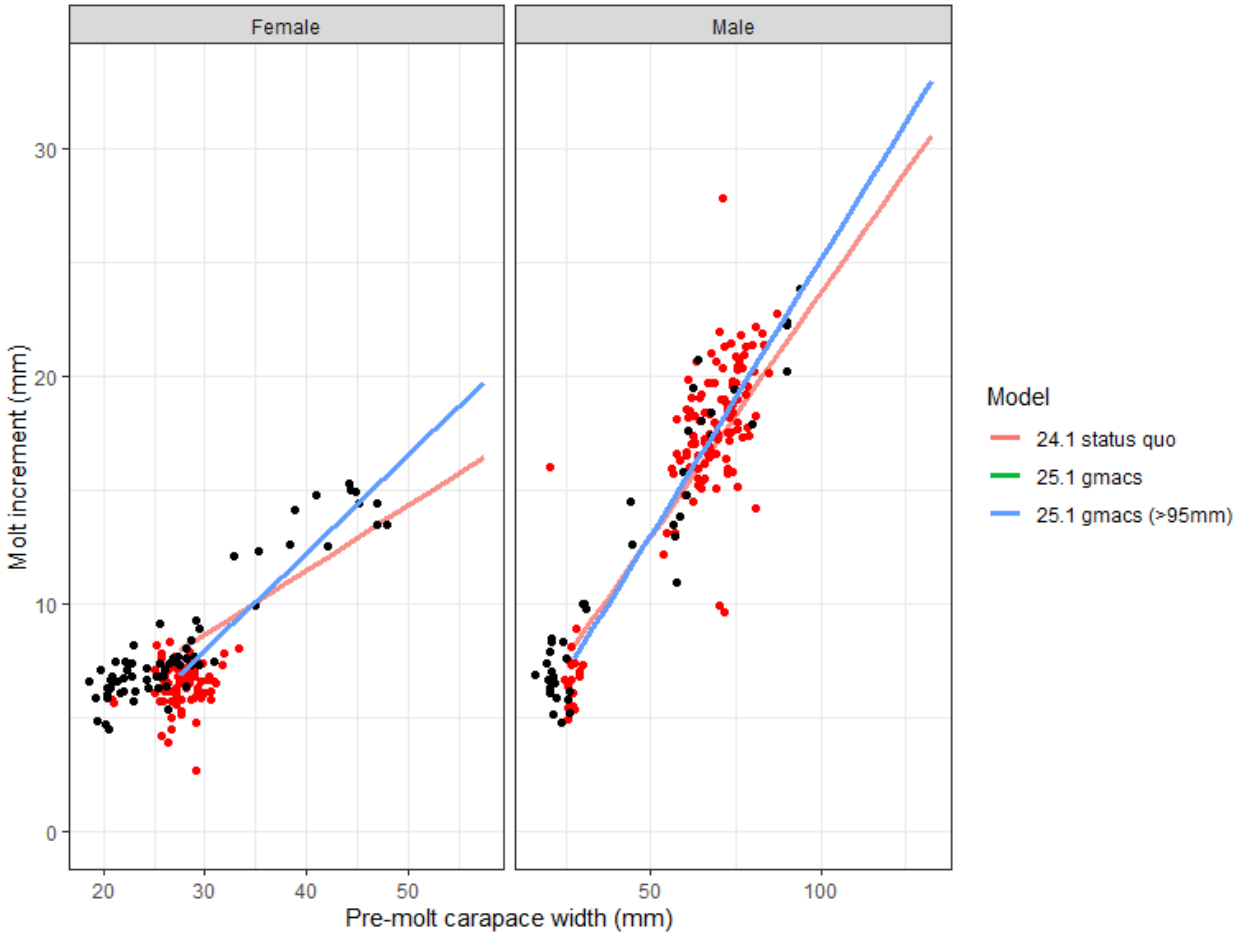
Survey size composition	
BSFRF priors	



Model fits (colored lines) to the growth data (dots).

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Catch size composition	
Survey size composition	
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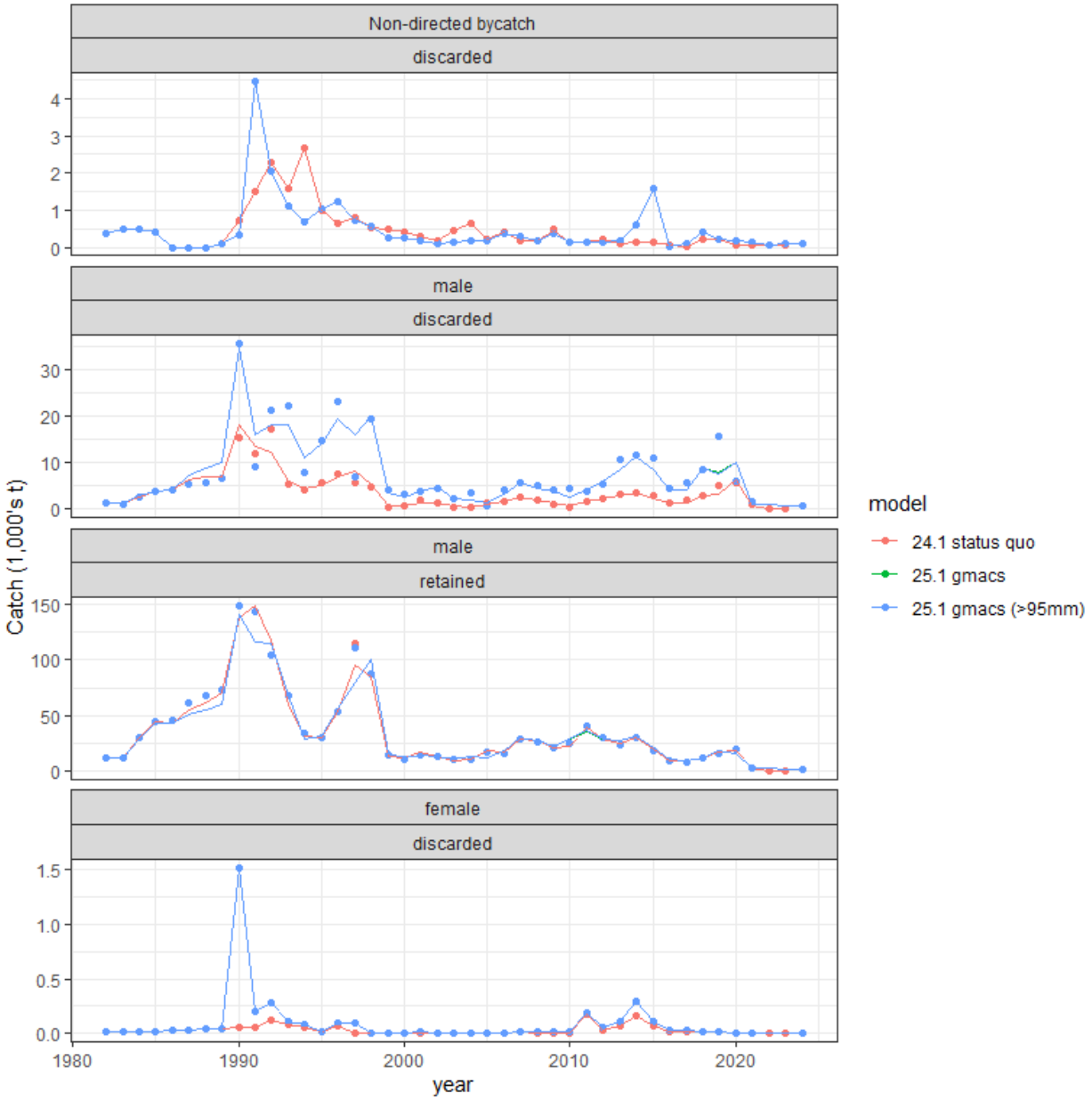

Model fits to catch data.

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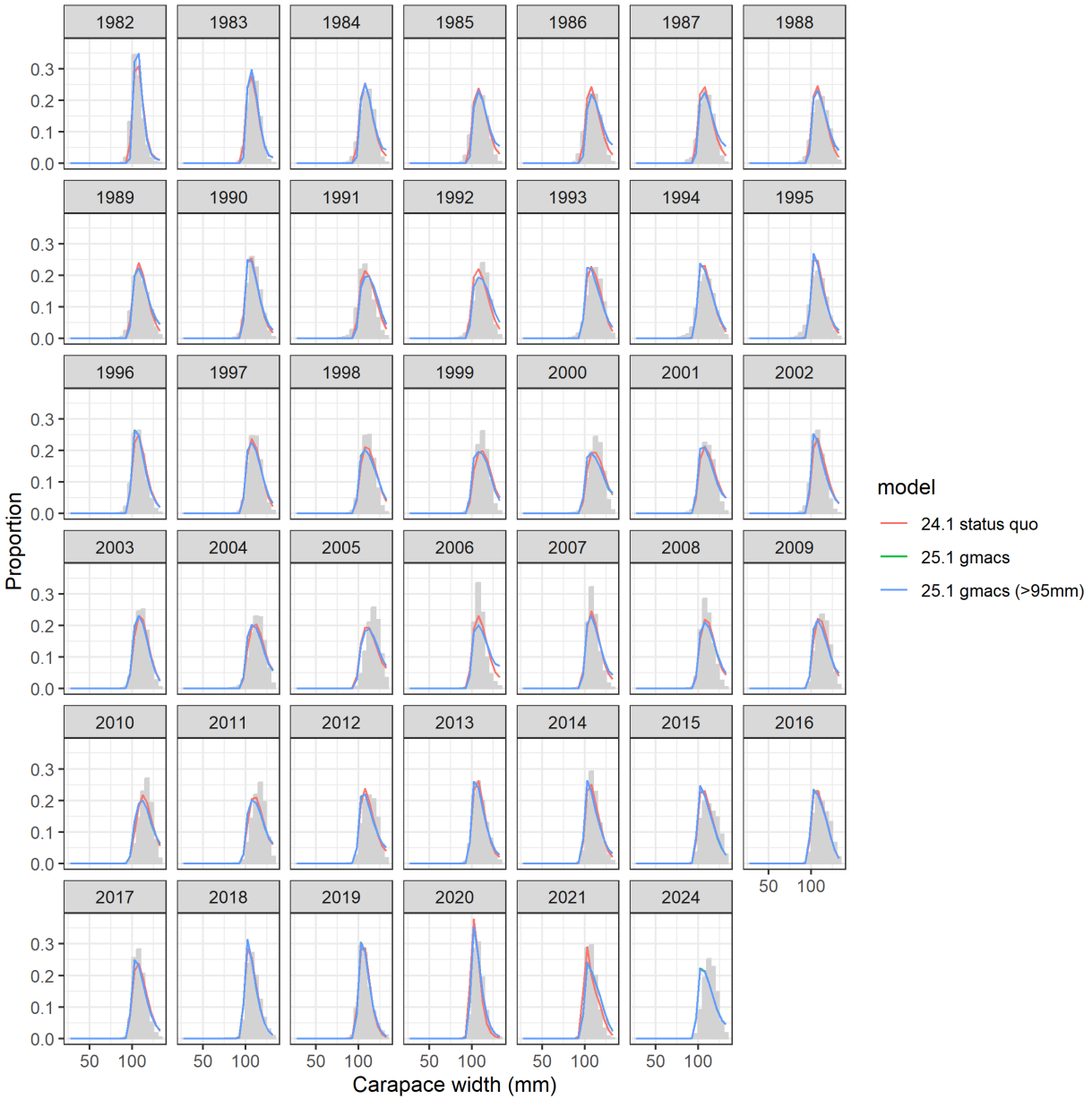

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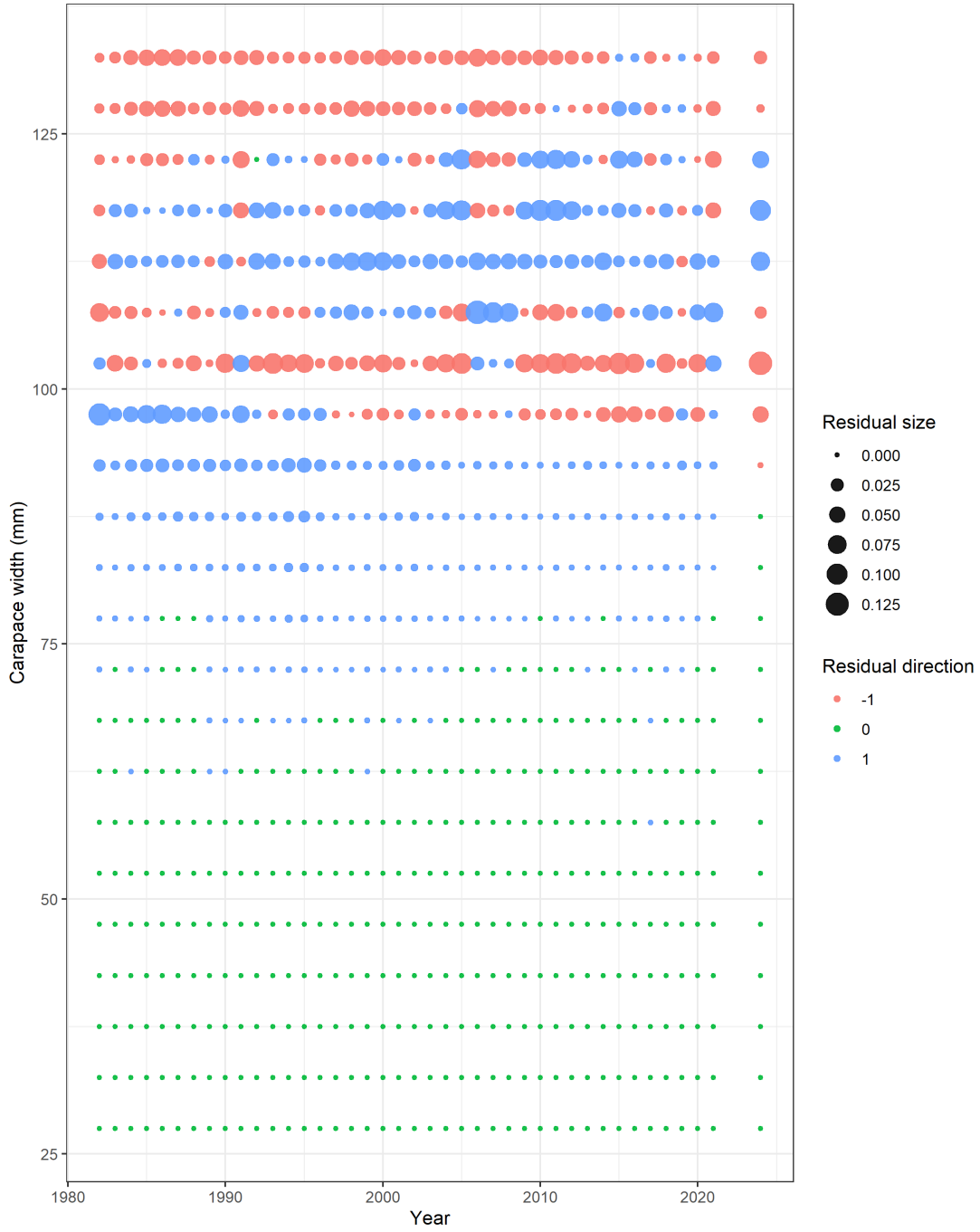

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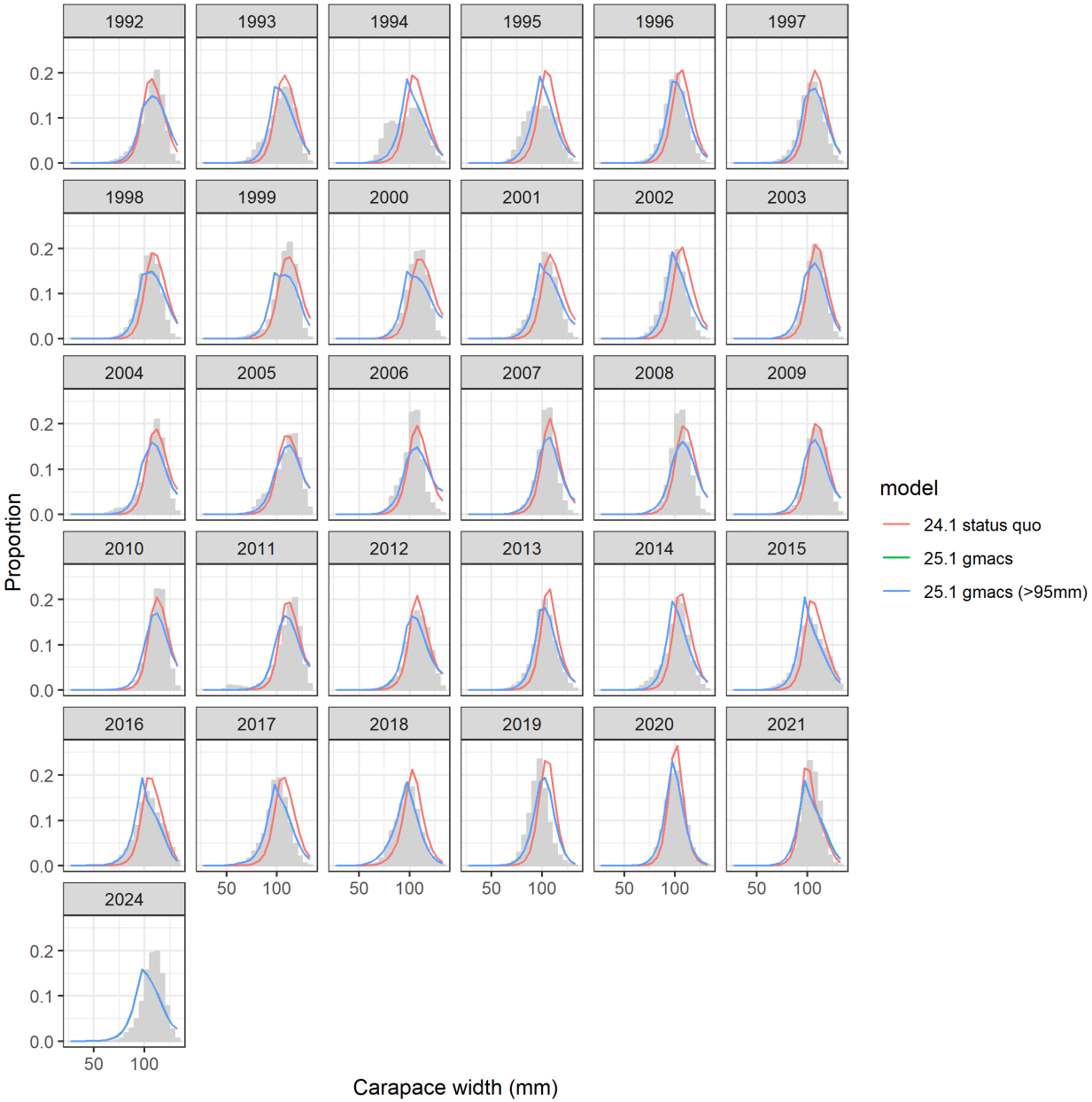

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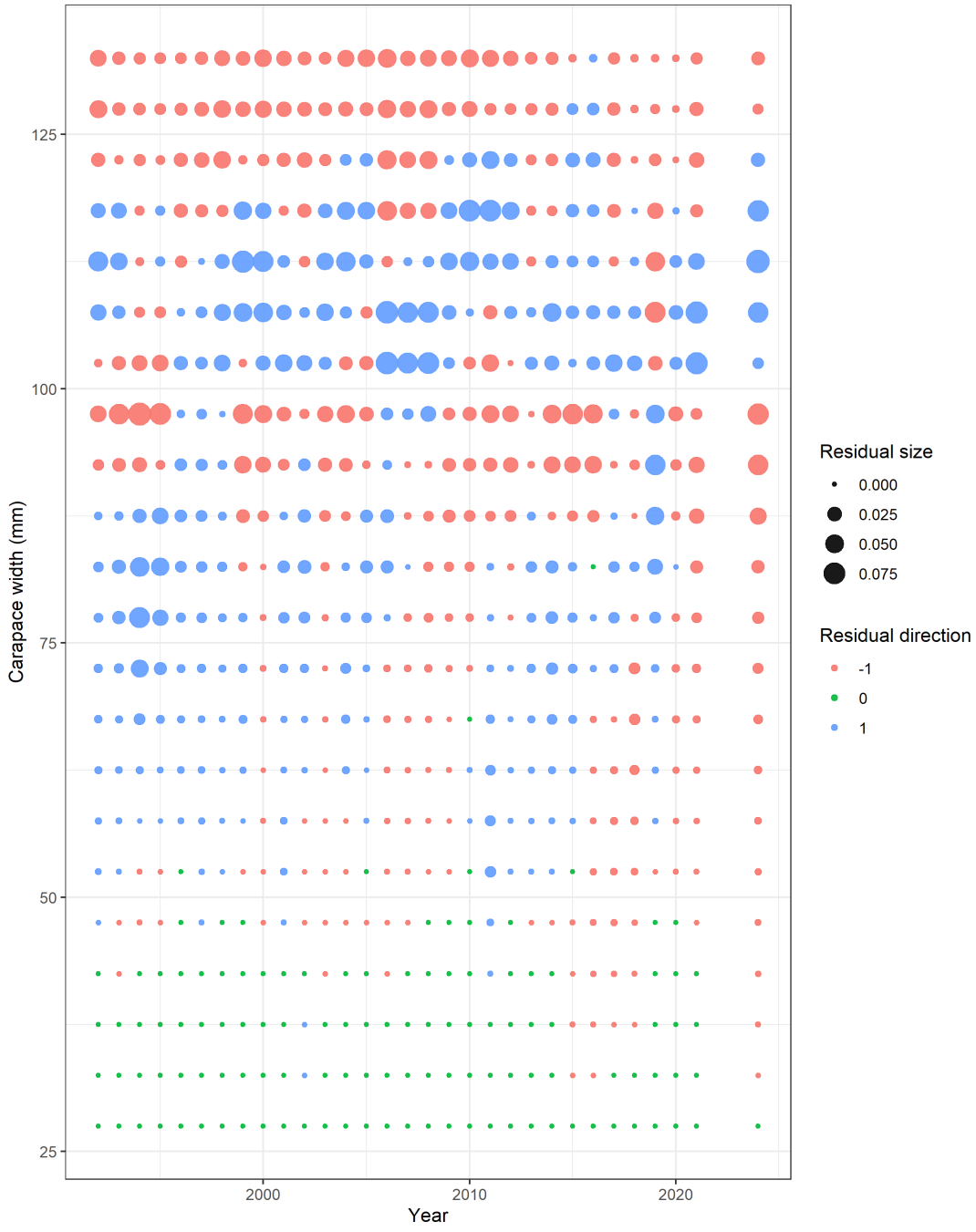

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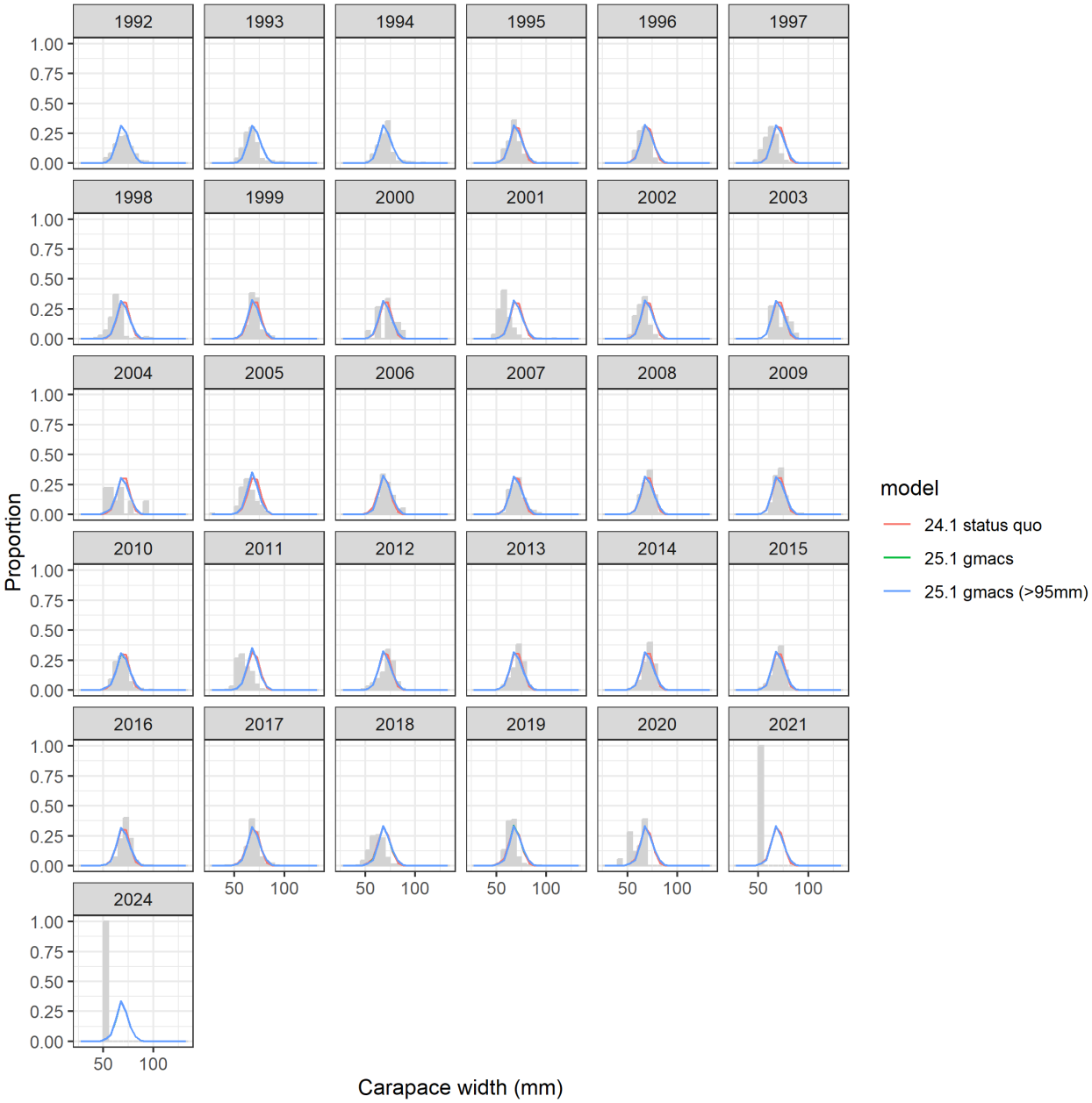

FEMALE (DIR)

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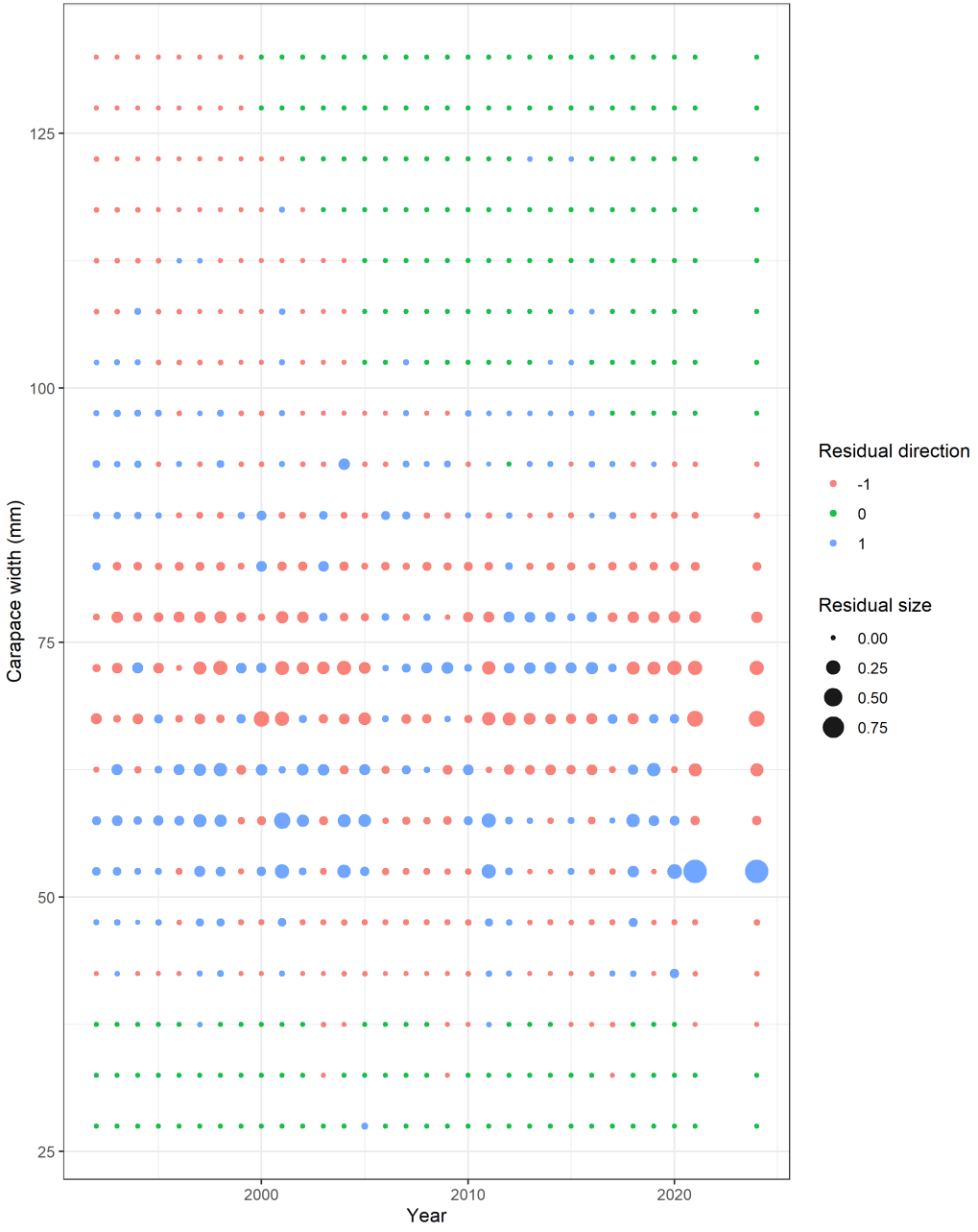
Survey size composition	
BSFRF priors	



FEMALE (DIR)

Data source	comments
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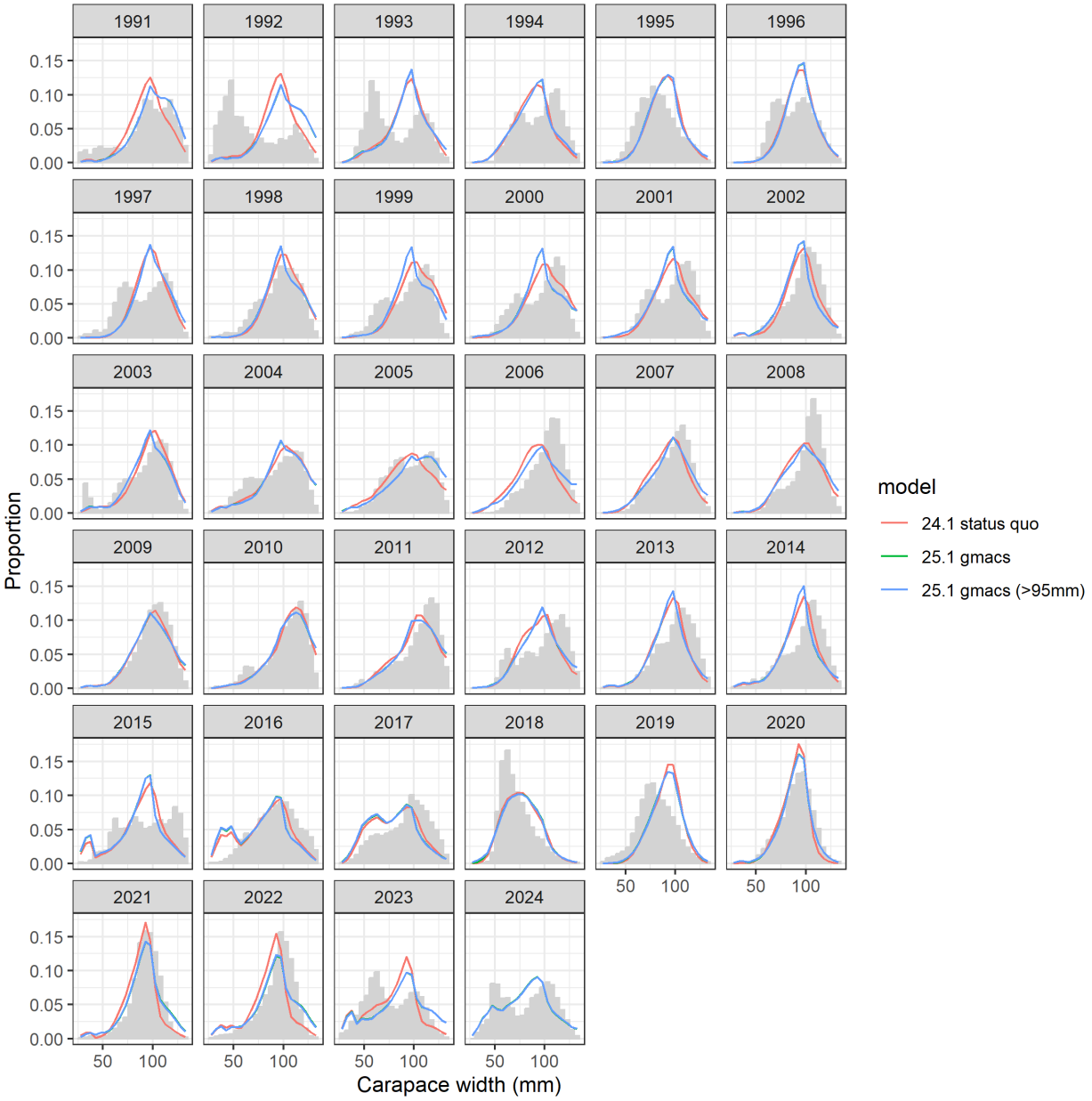
Survey size composition	
BSFRF priors	



NONDIRECTED (M)

Data source	comments
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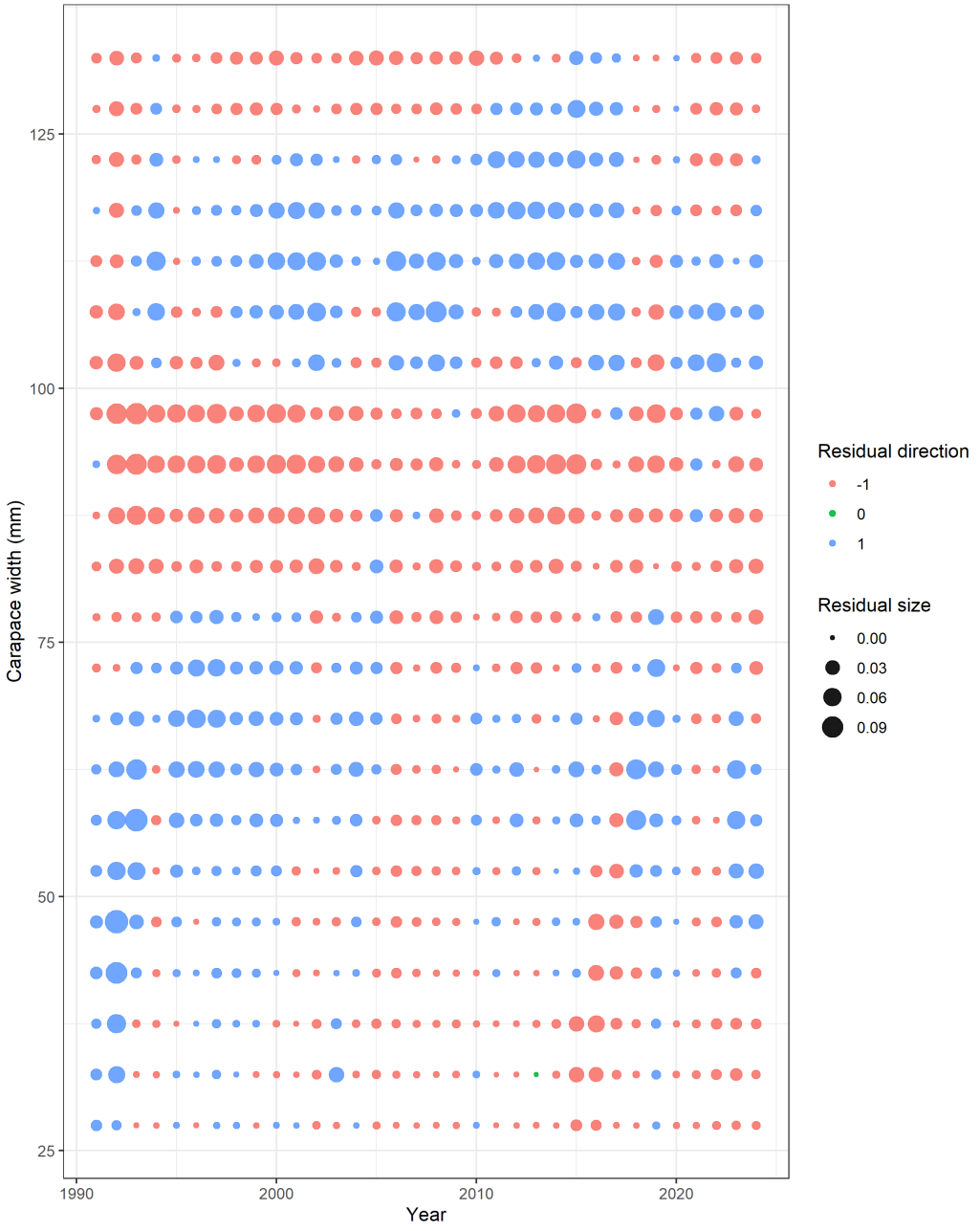

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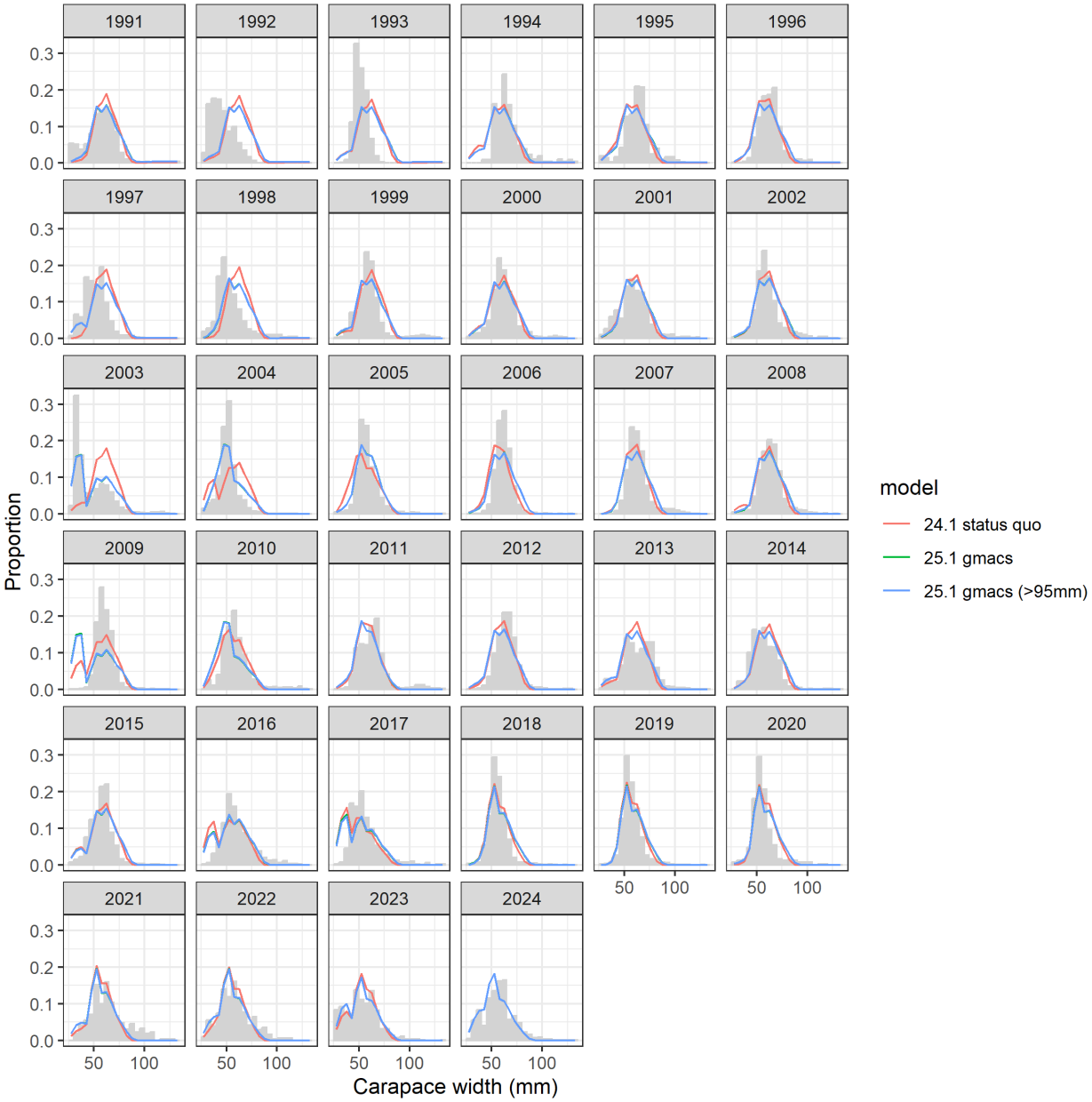

NONDIRECTED (F)

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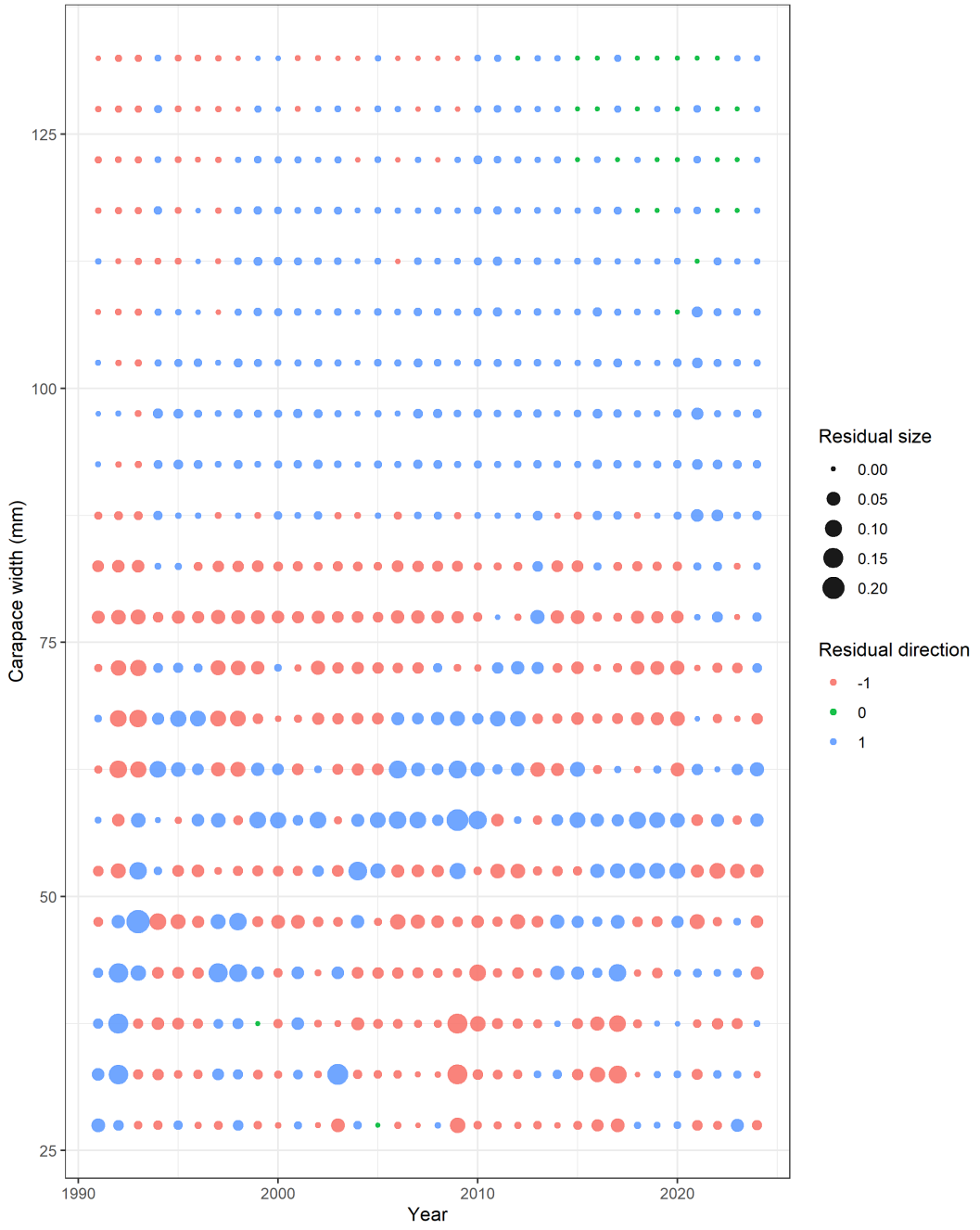

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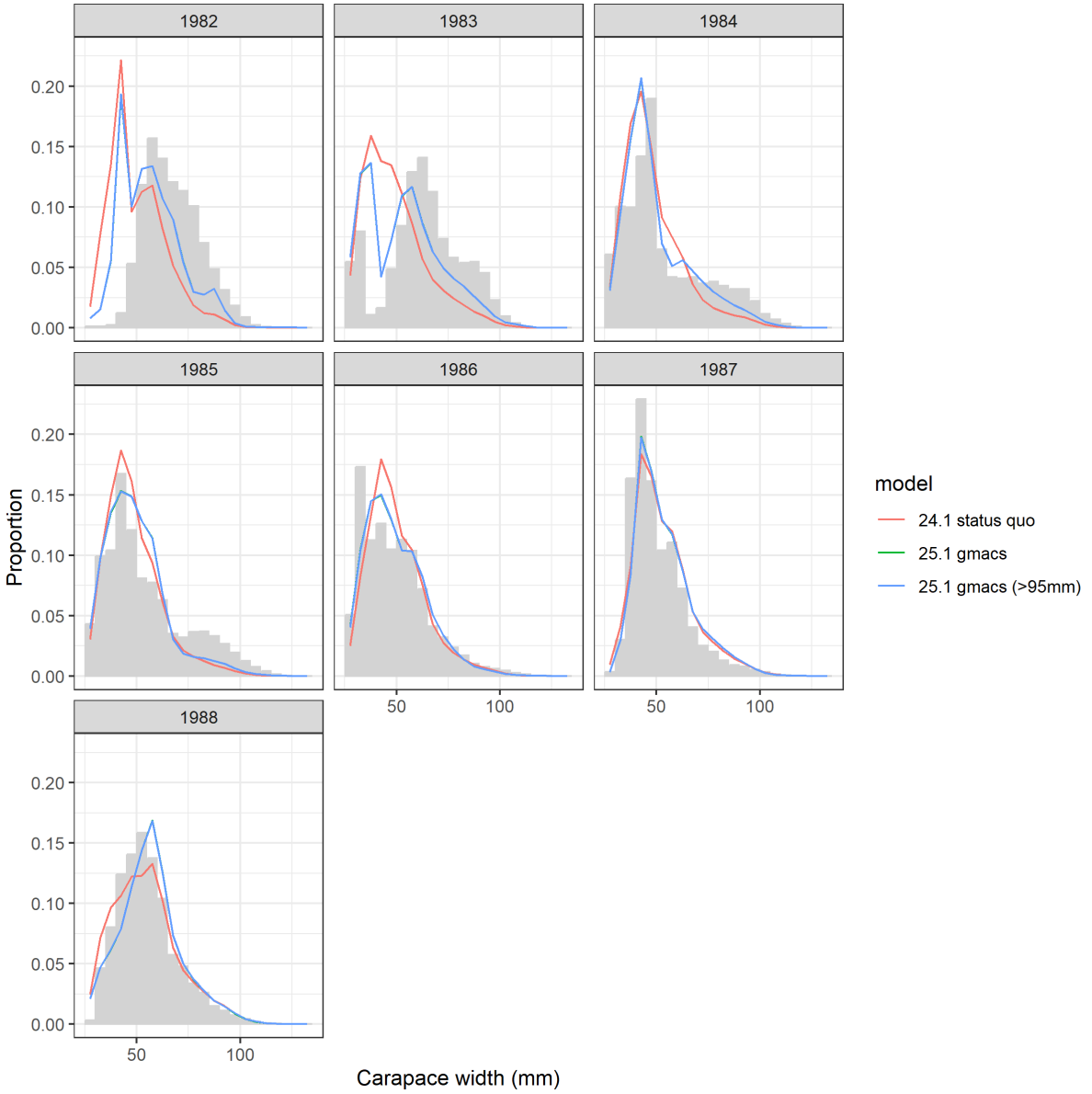

IMMATURE MALE

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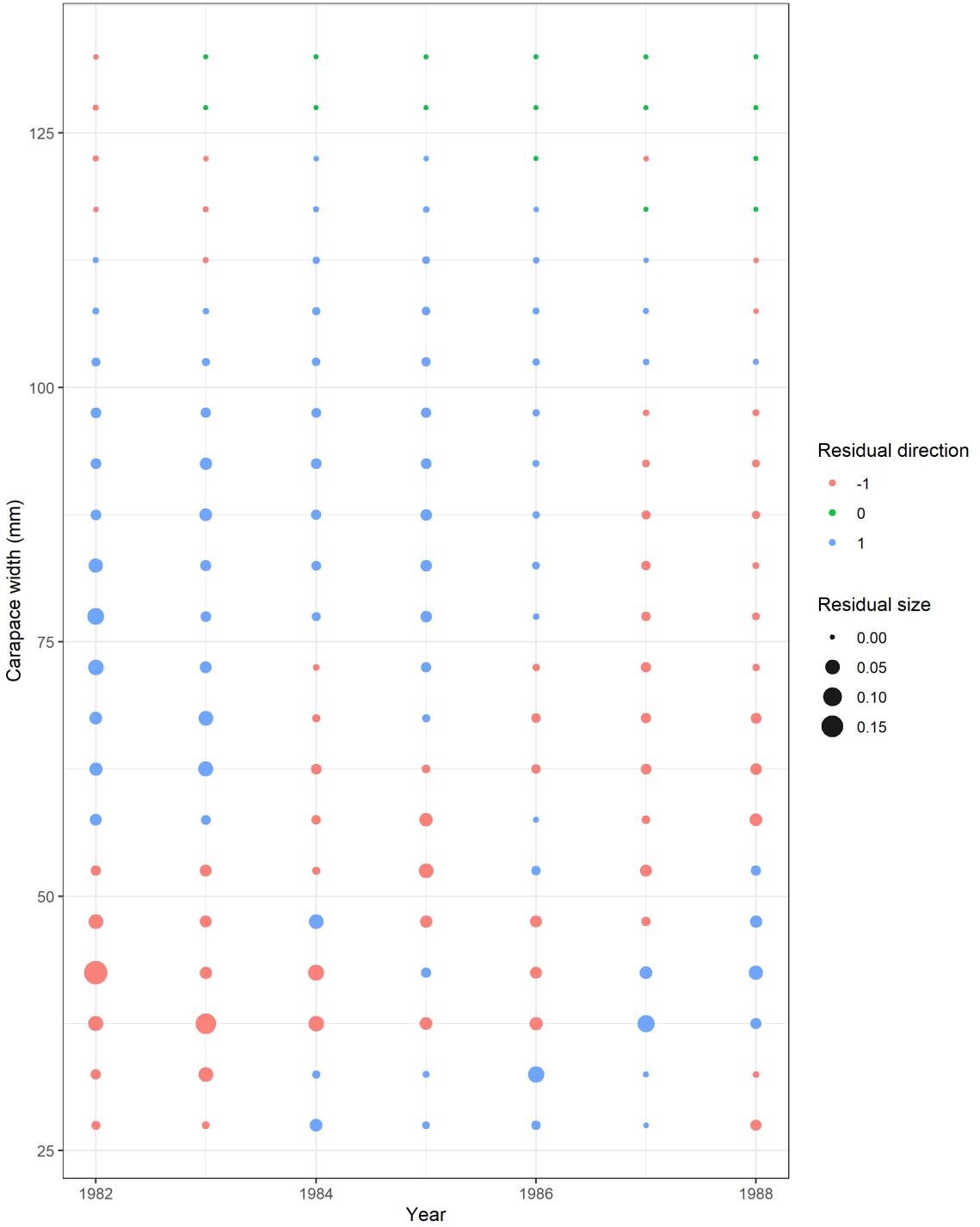

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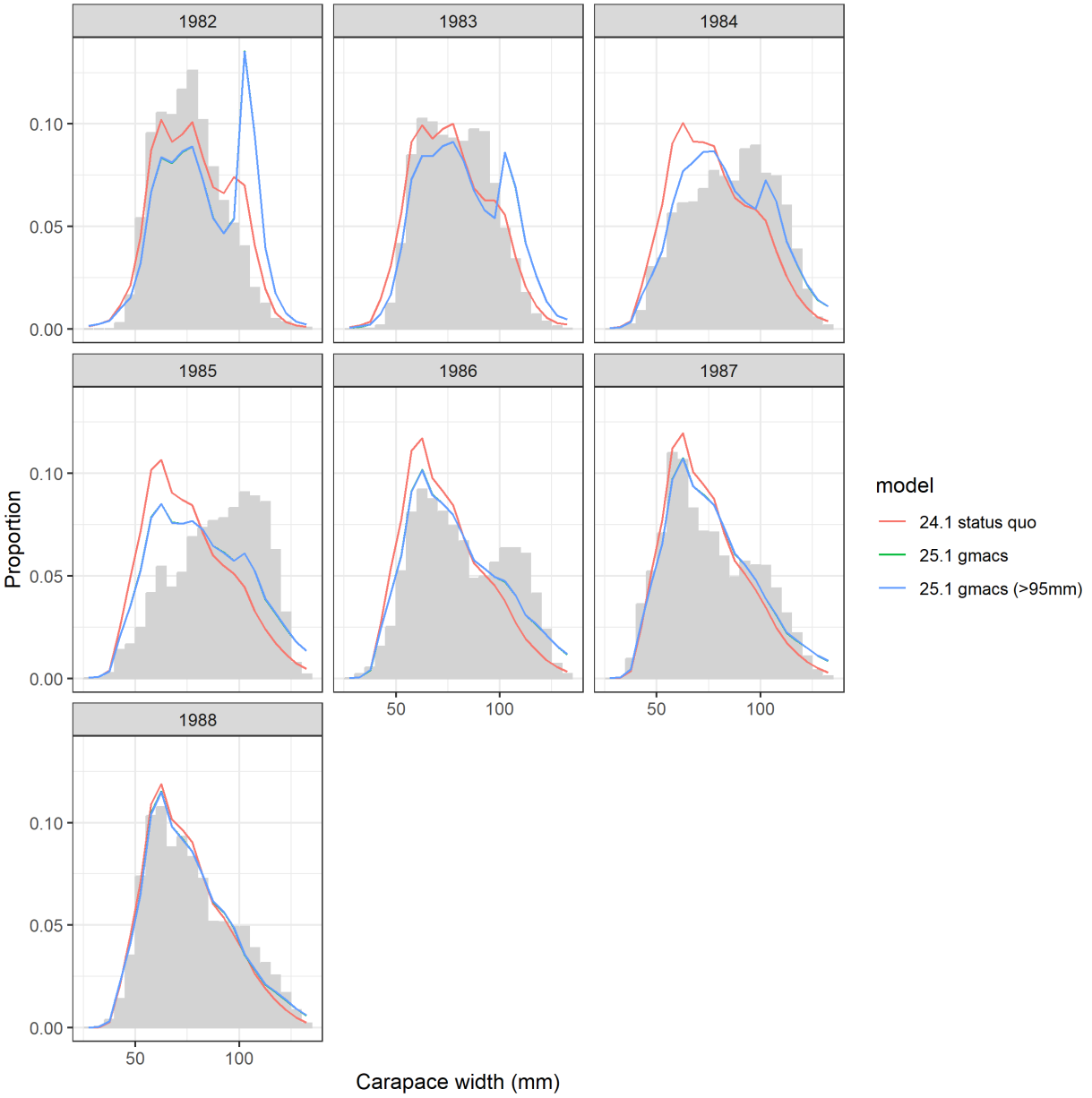

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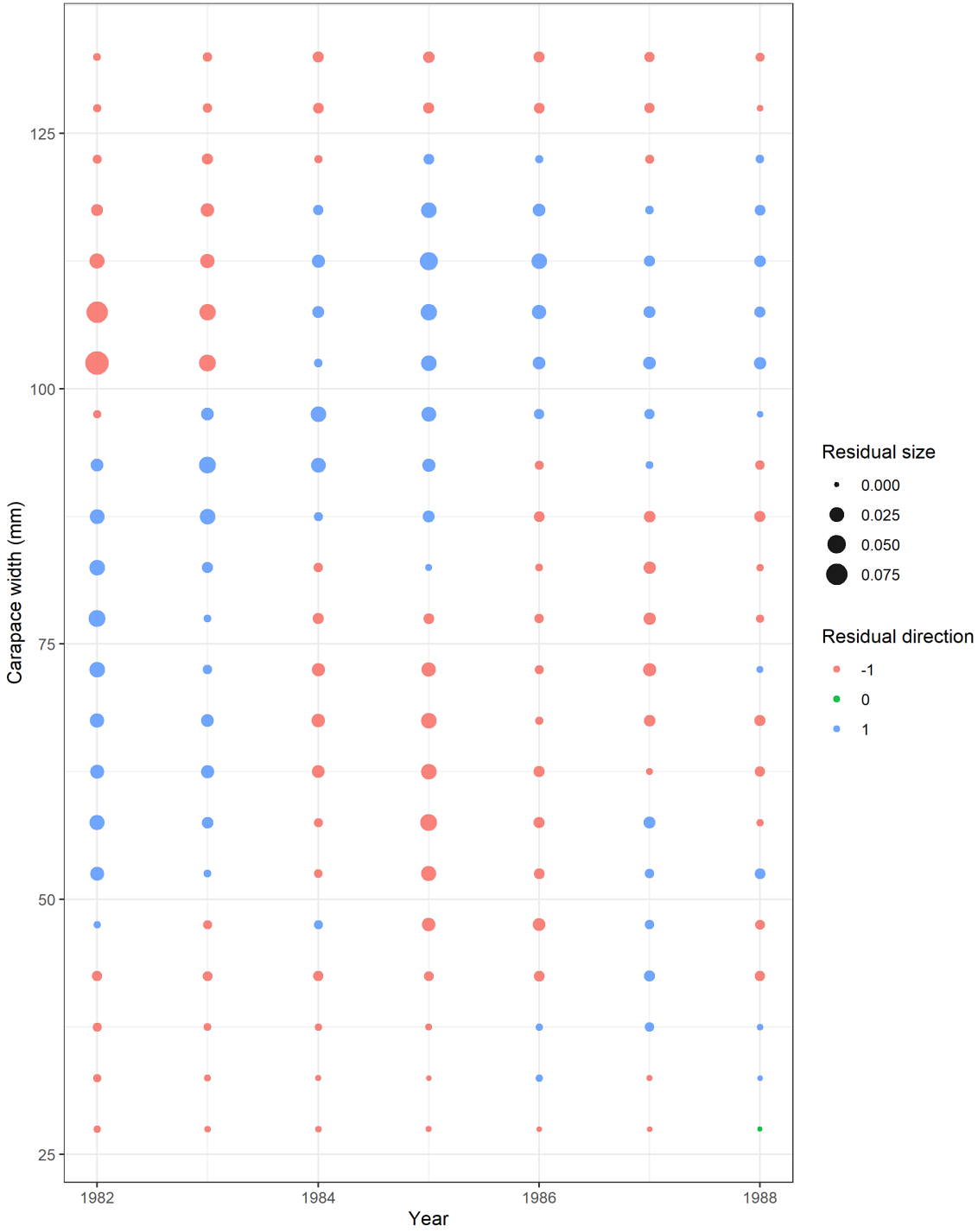

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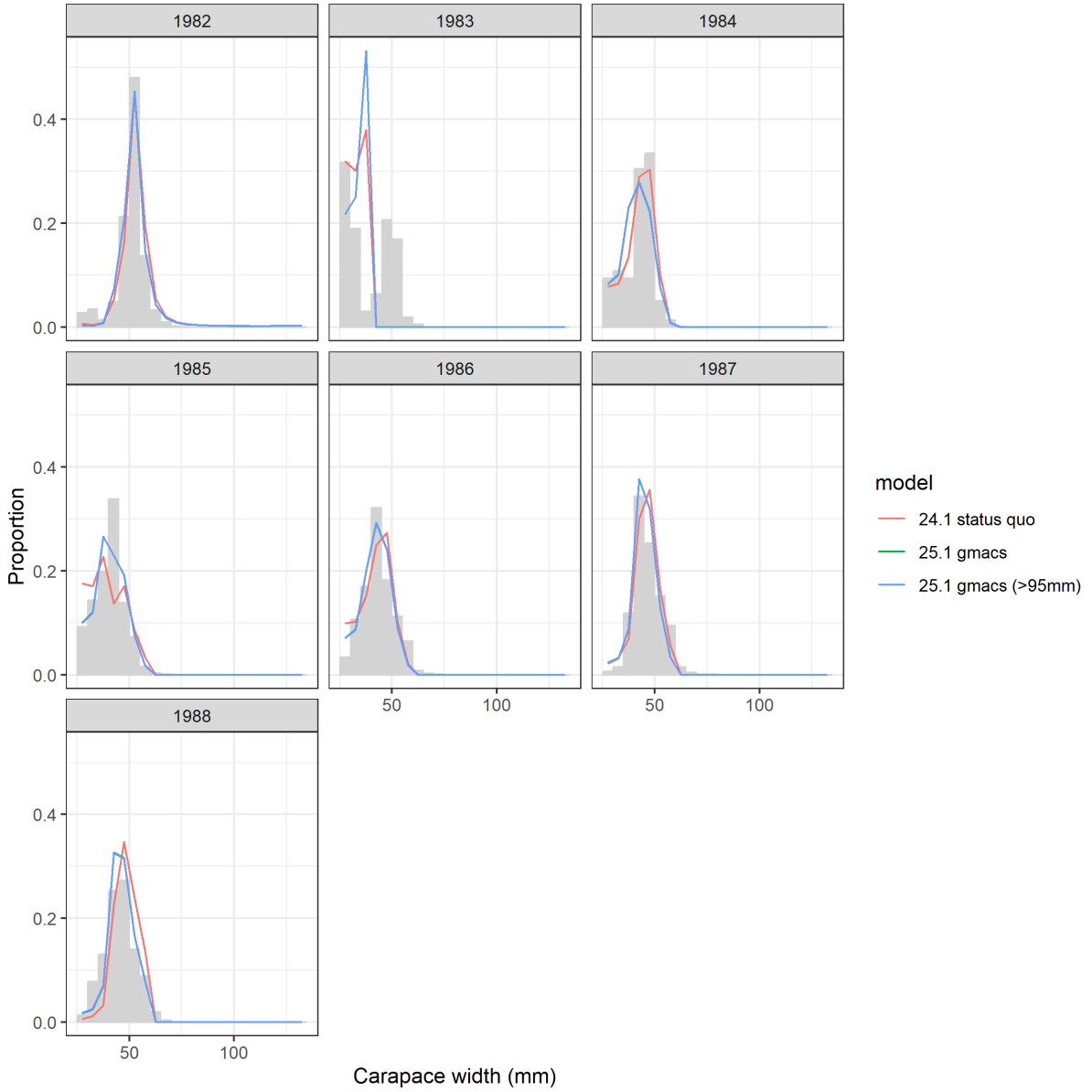

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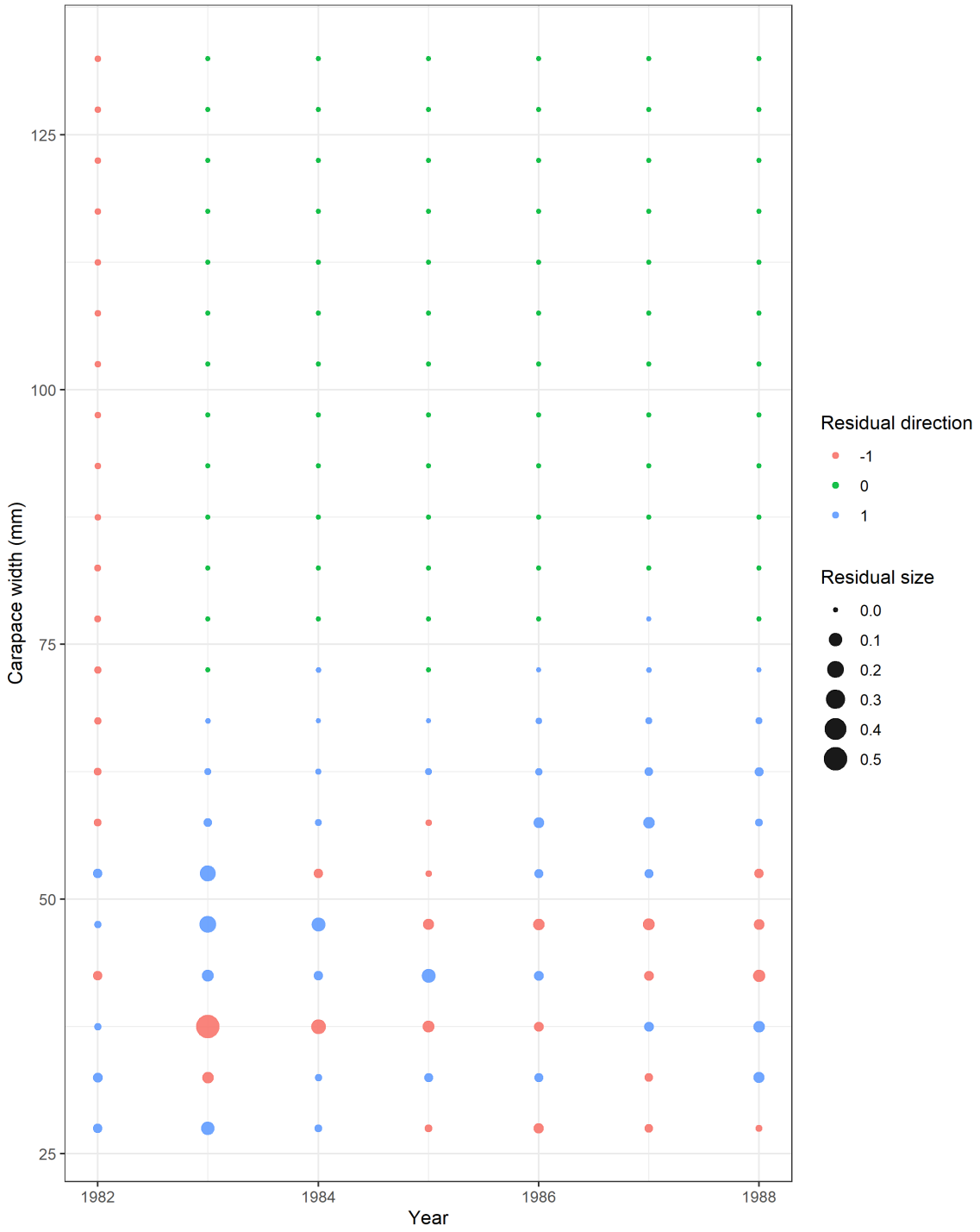

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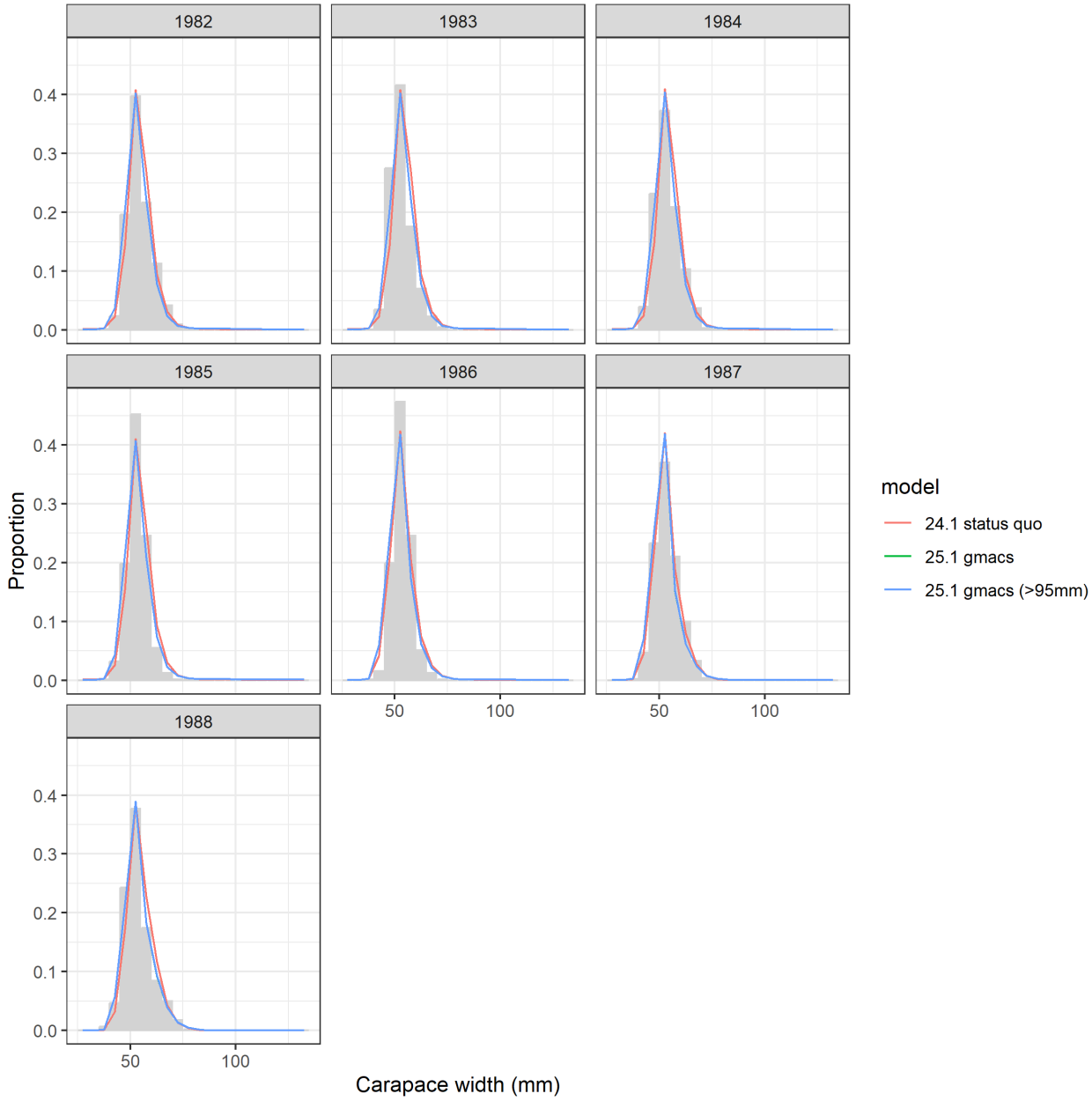

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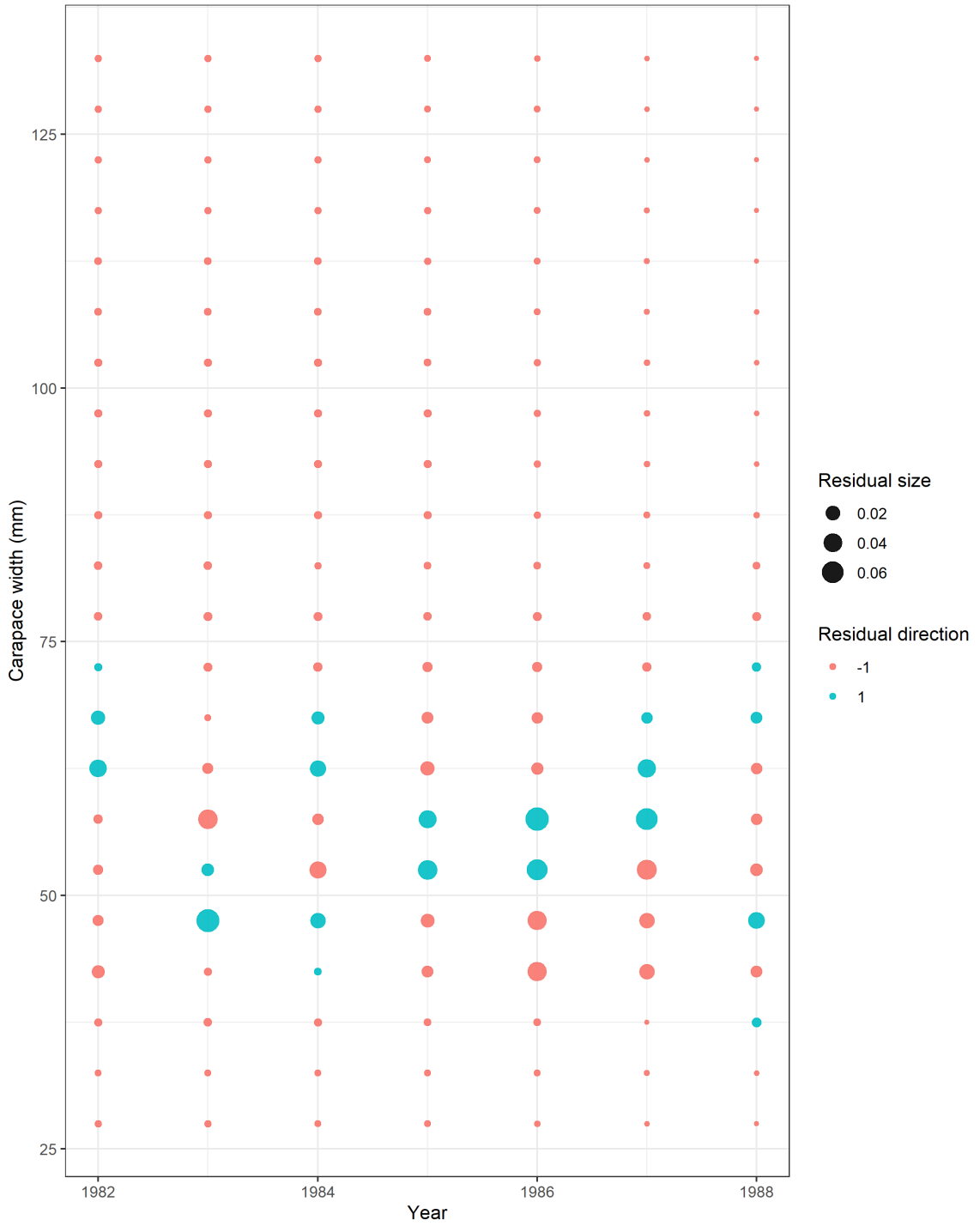

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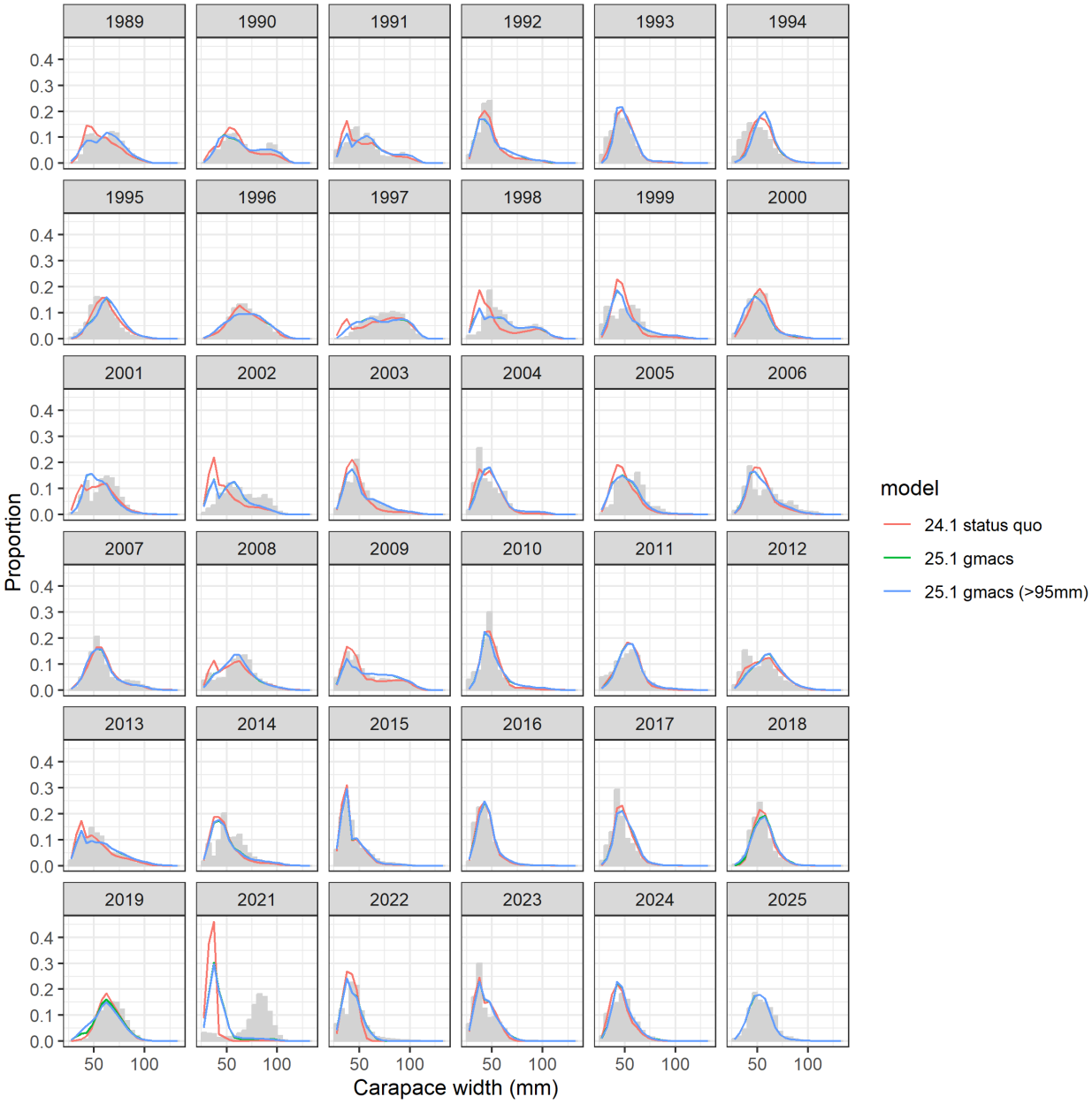

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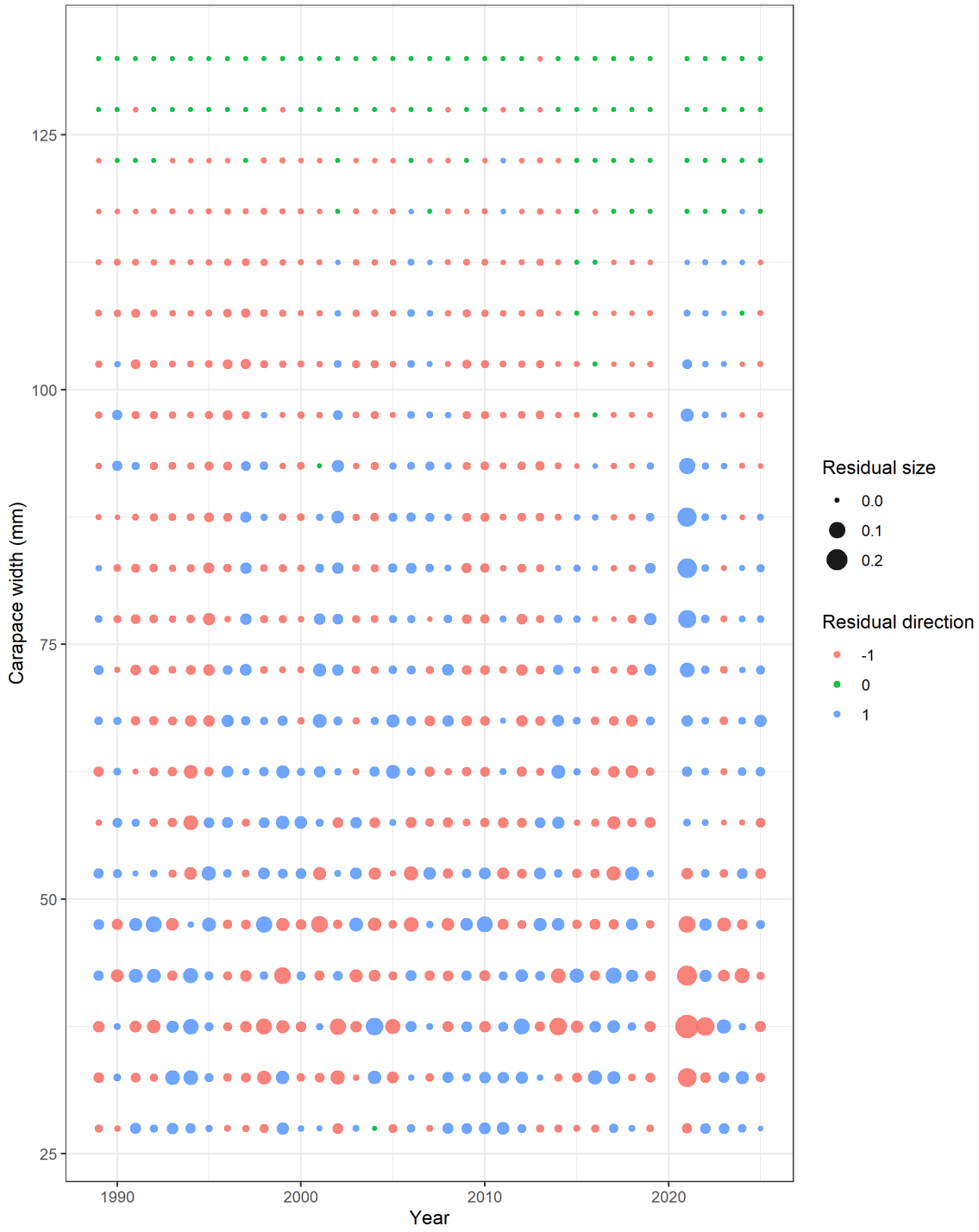

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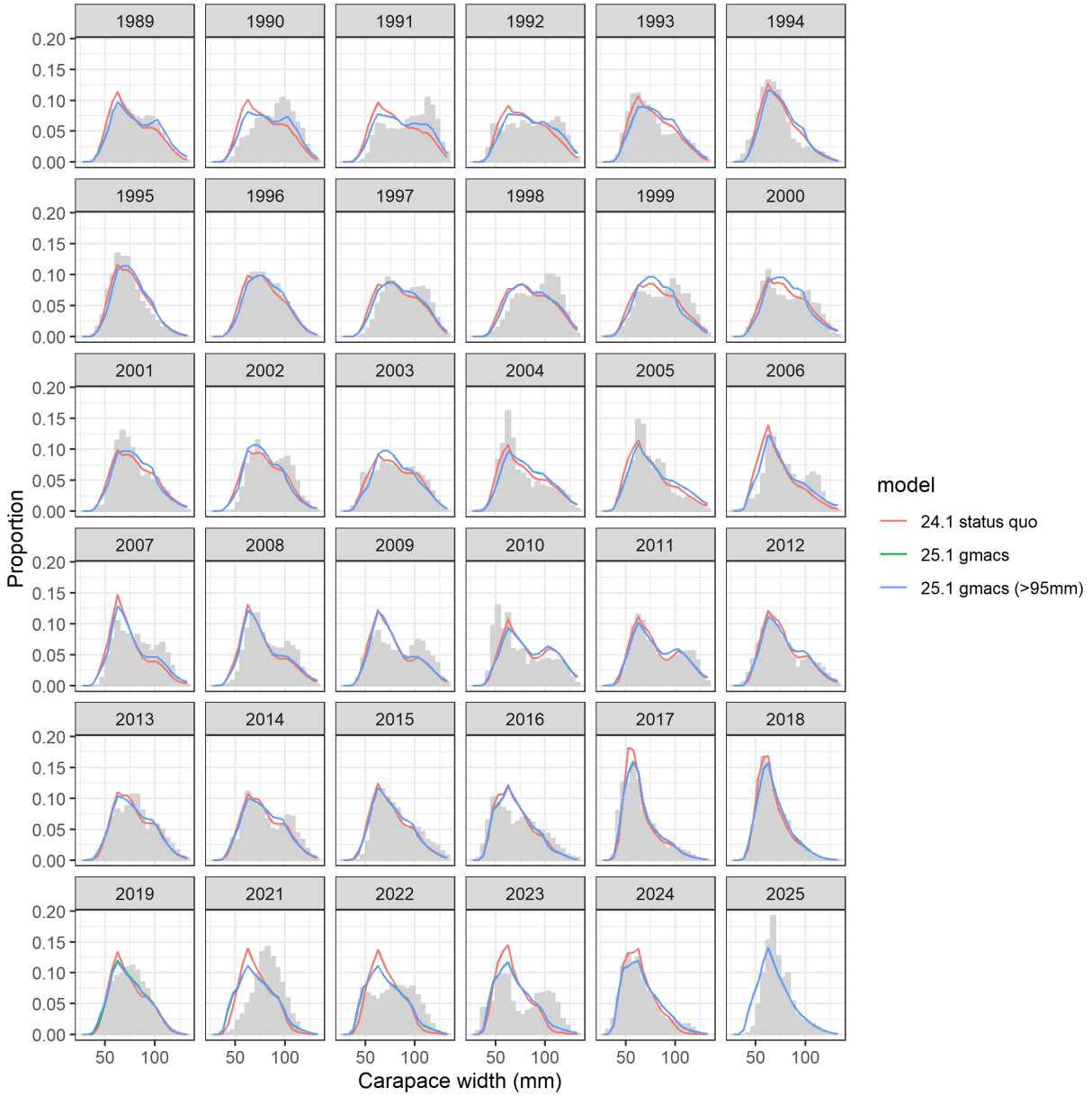

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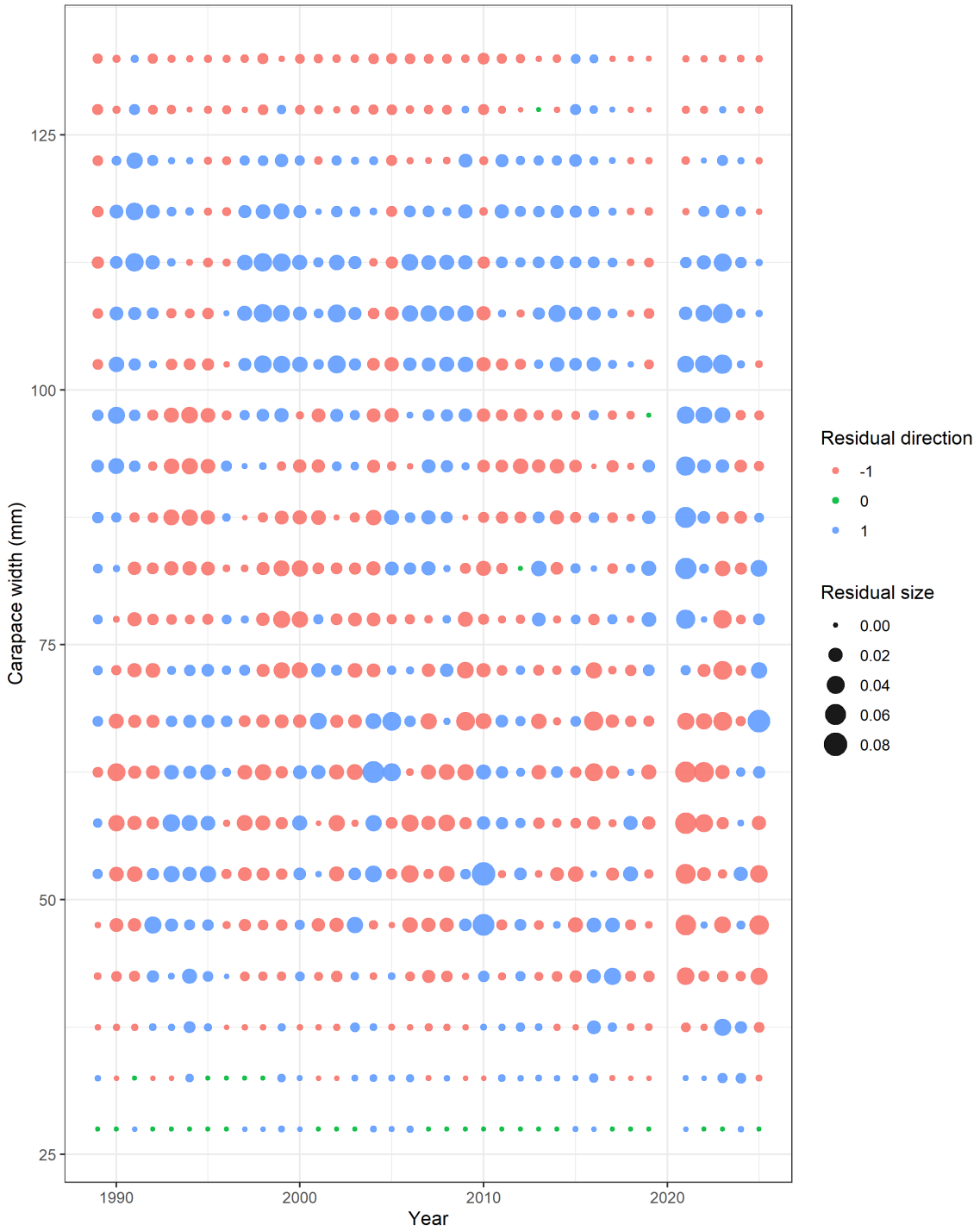

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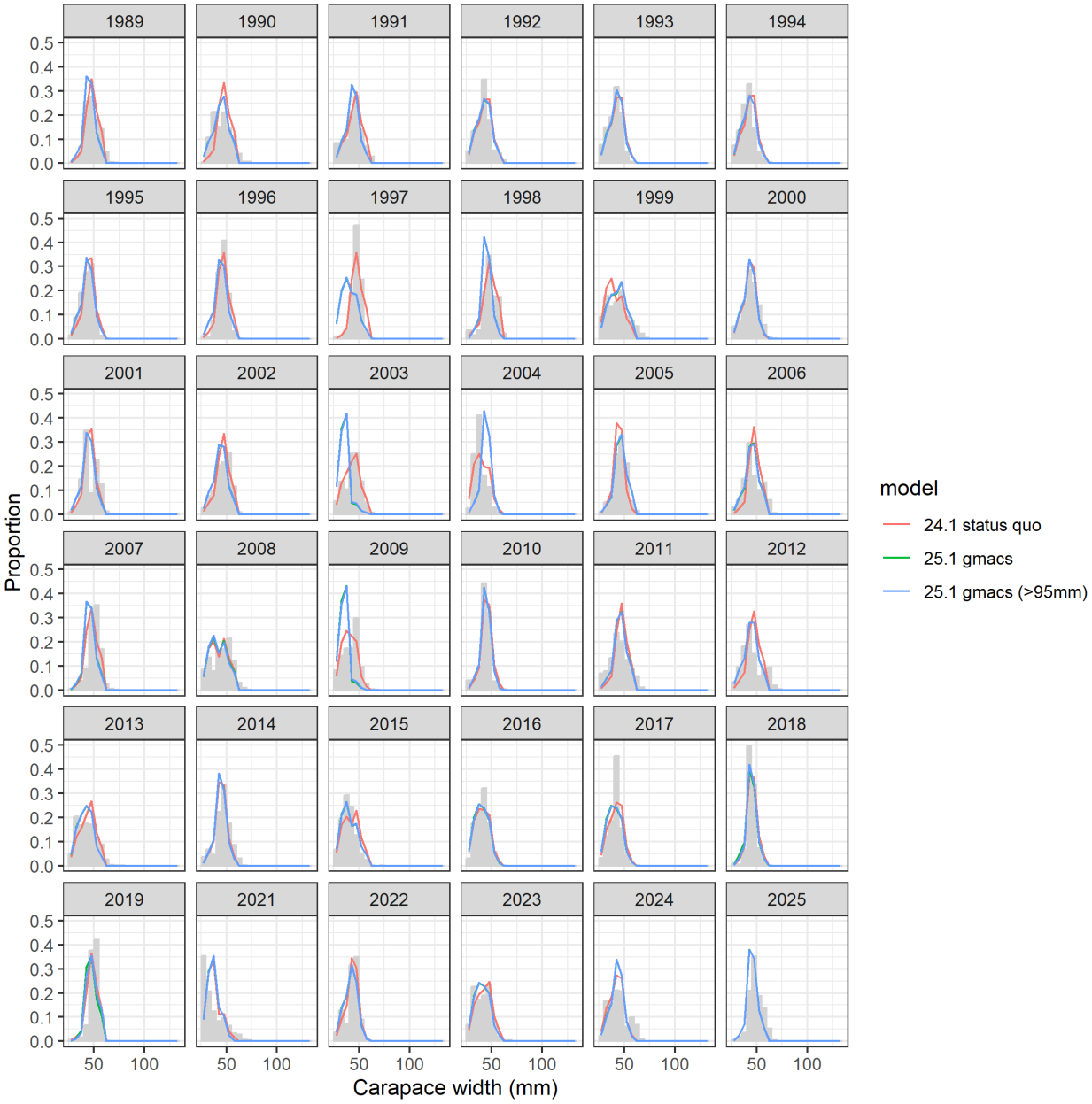

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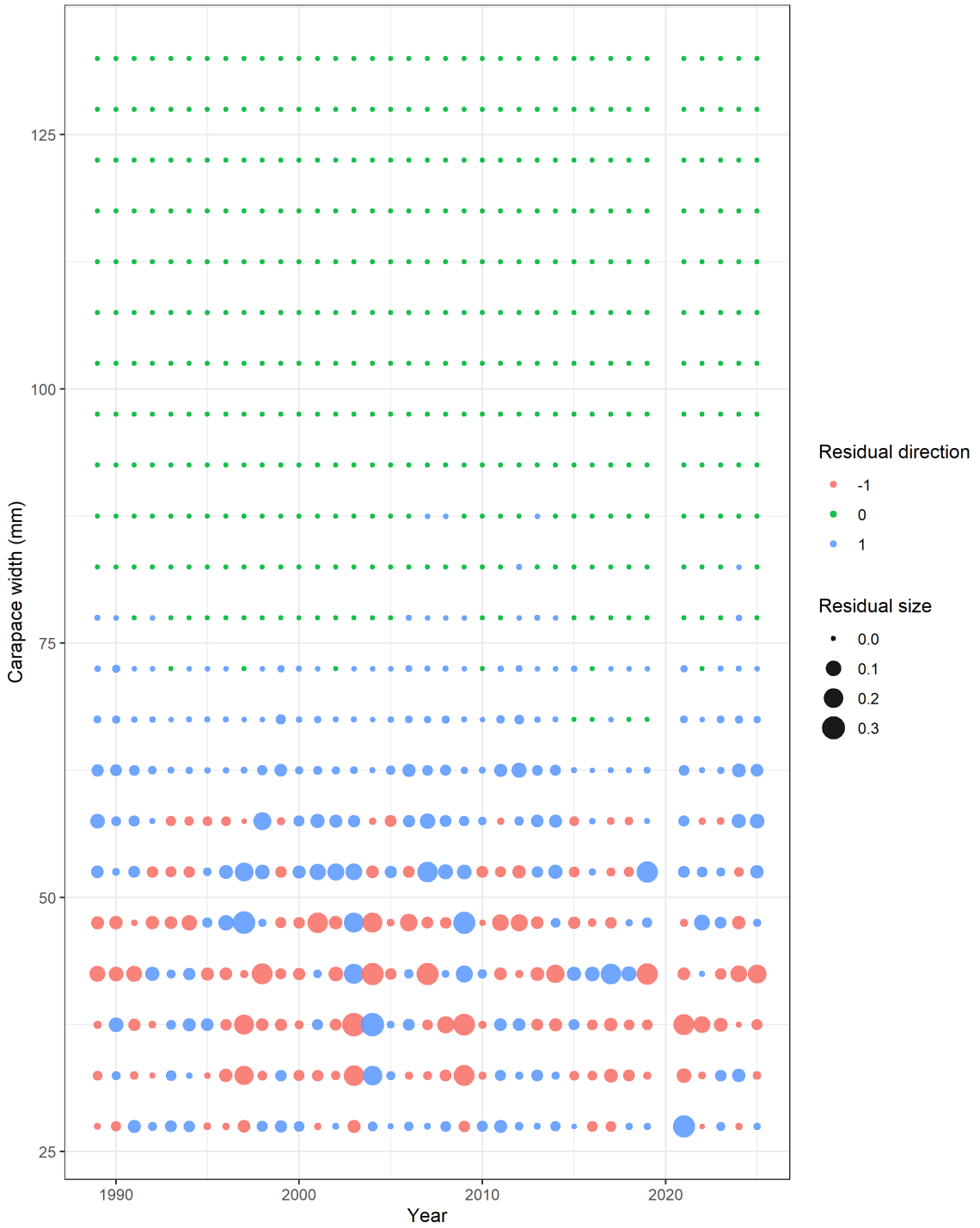

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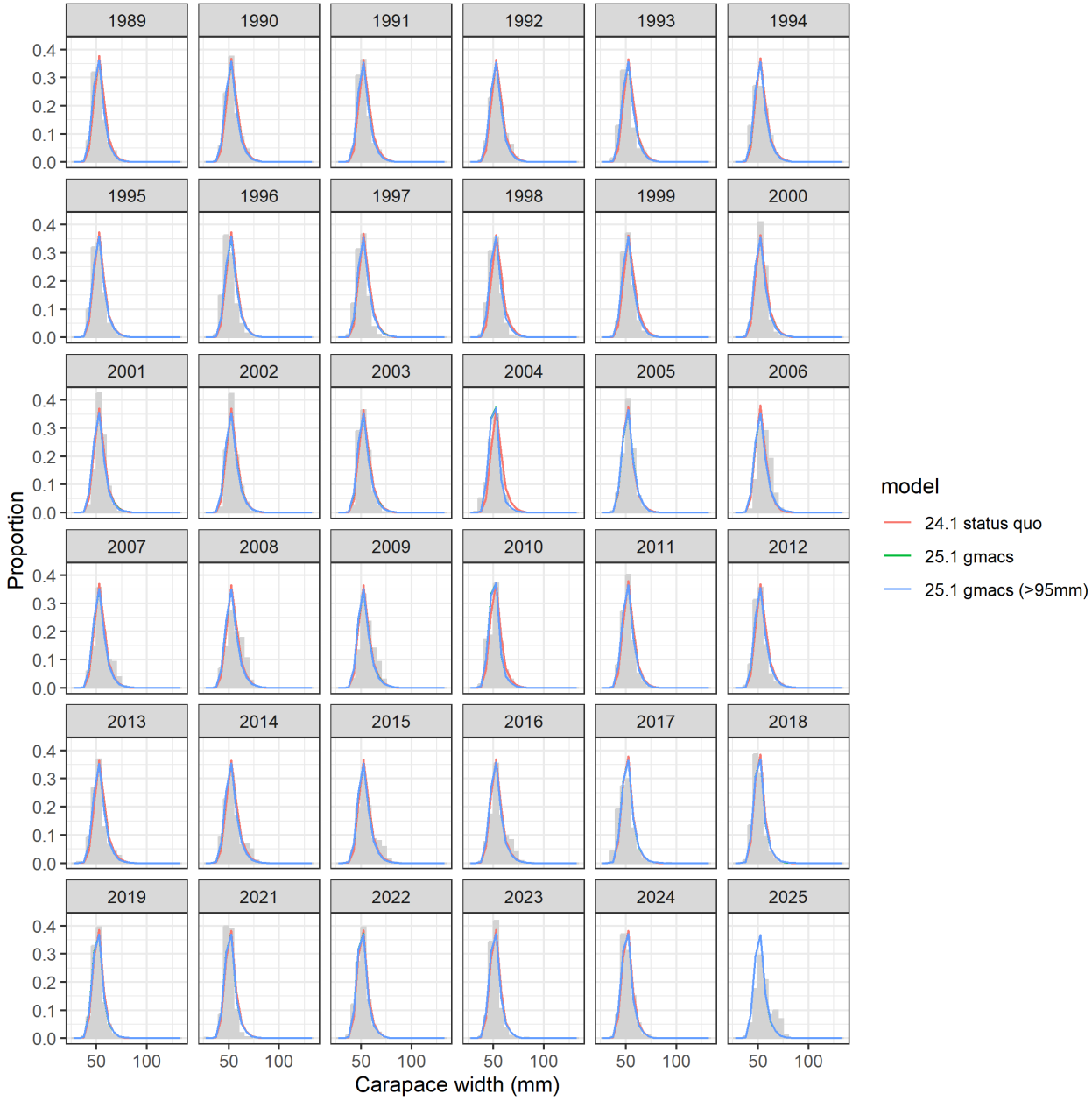

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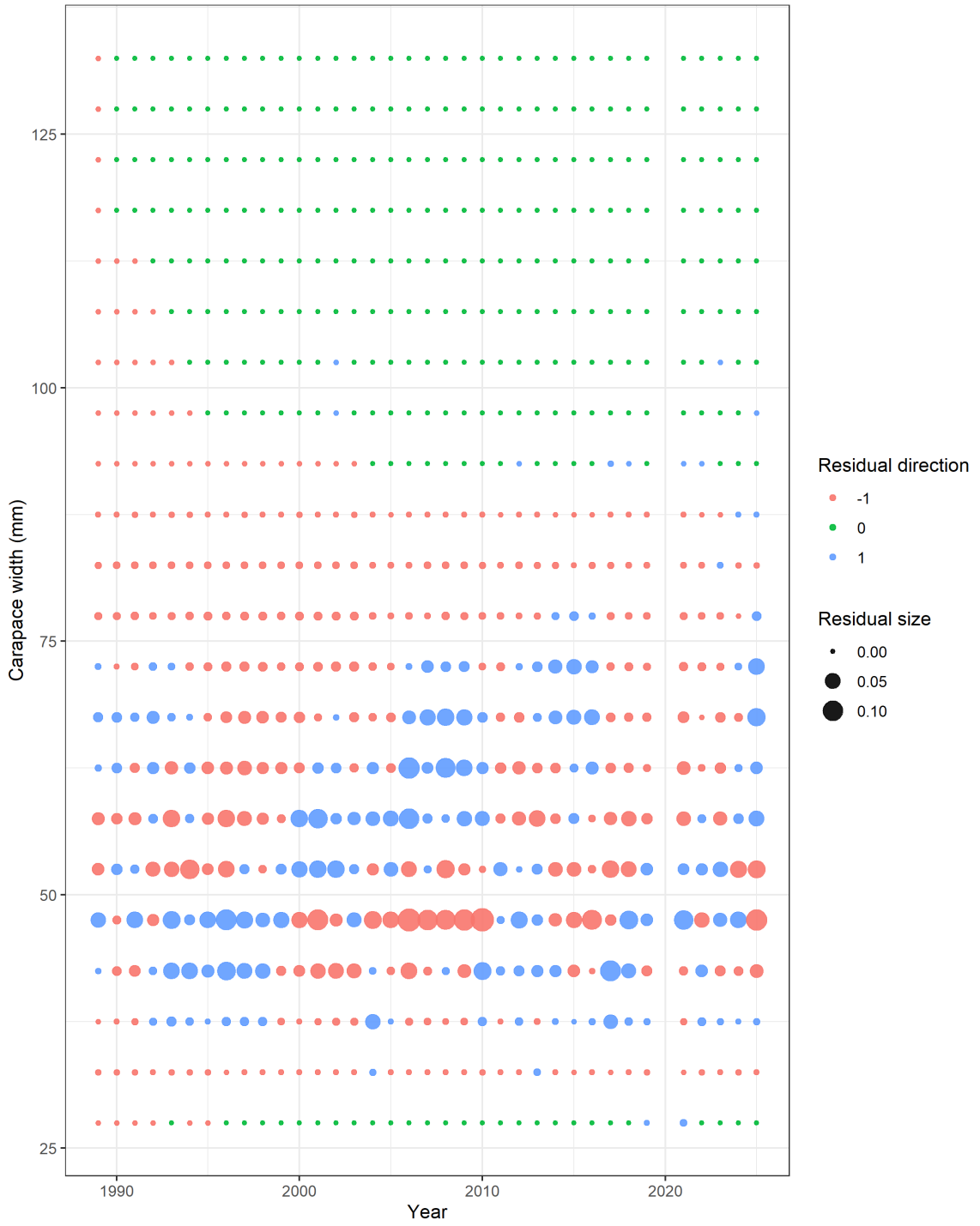

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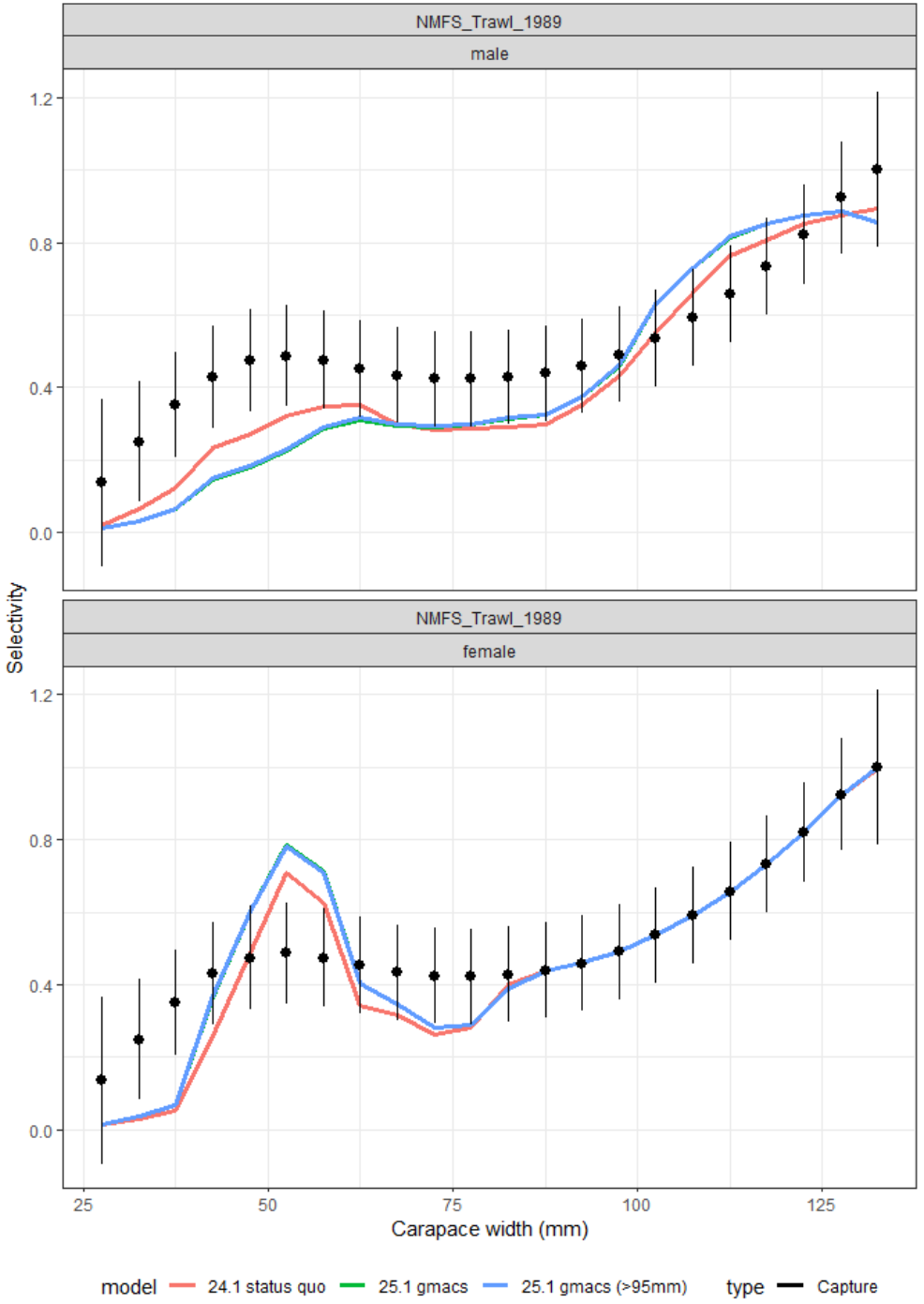
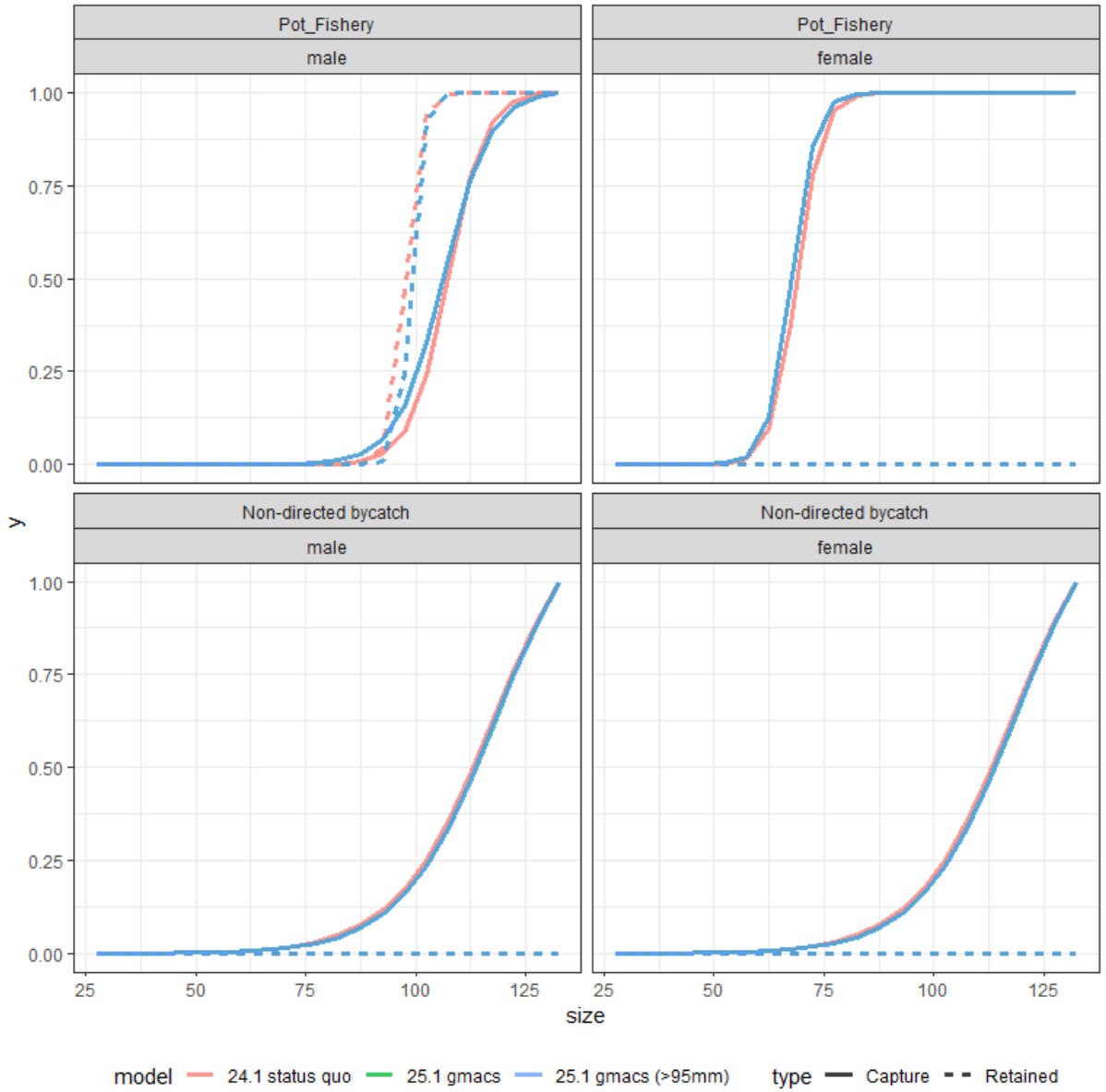


Population process	comments
Selectivity	Slight difference between estimated directed fishery selectivity with update
Fishing mortality	
Recruitment	
Natural mortality	
Maturity	



Population process	comments
Selectivity	Slight difference between estimated directed fishery selectivity with update
Fishing mortality	Changes in estimated F reflect changes in input data
Recruitment	
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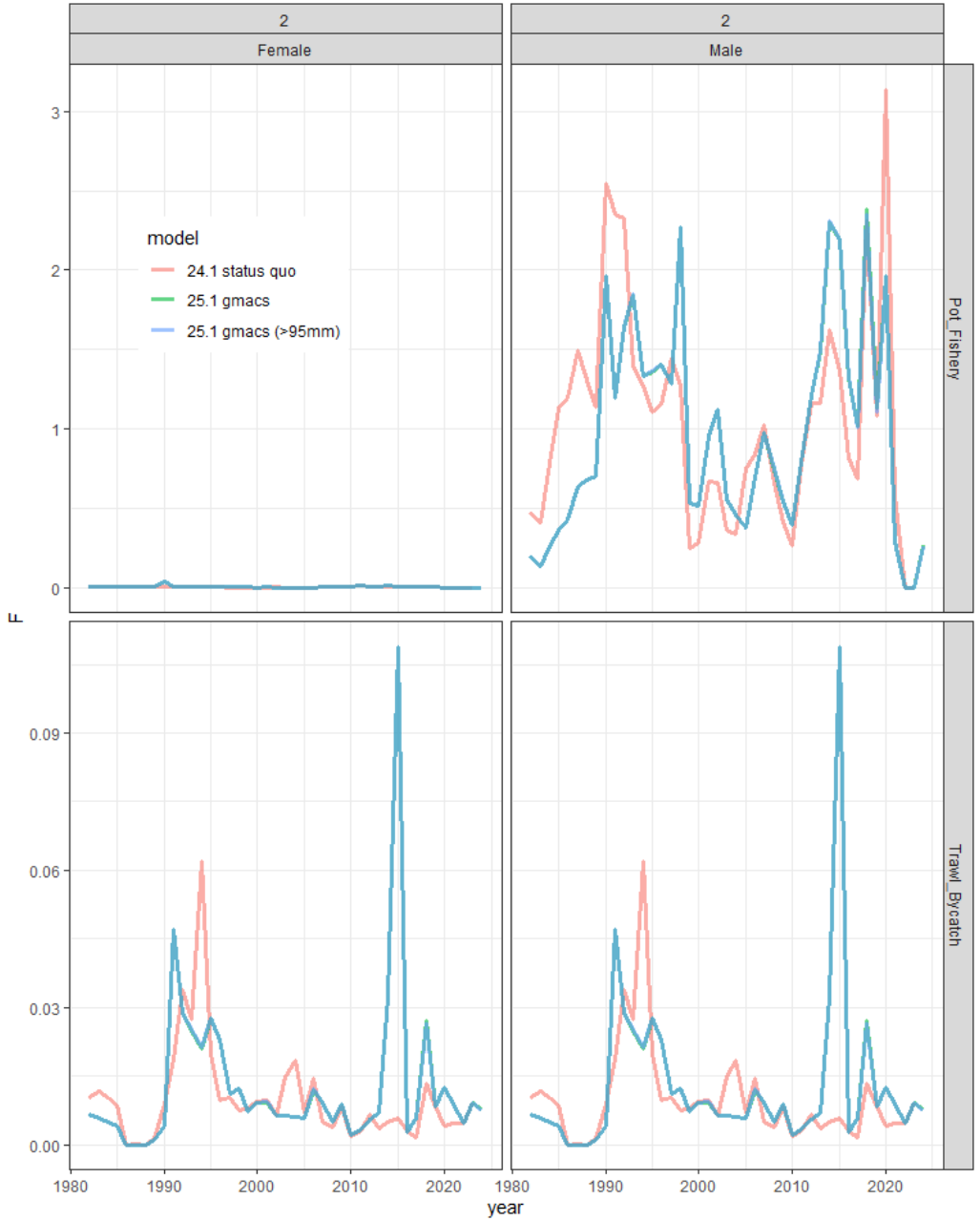

Population process	comments
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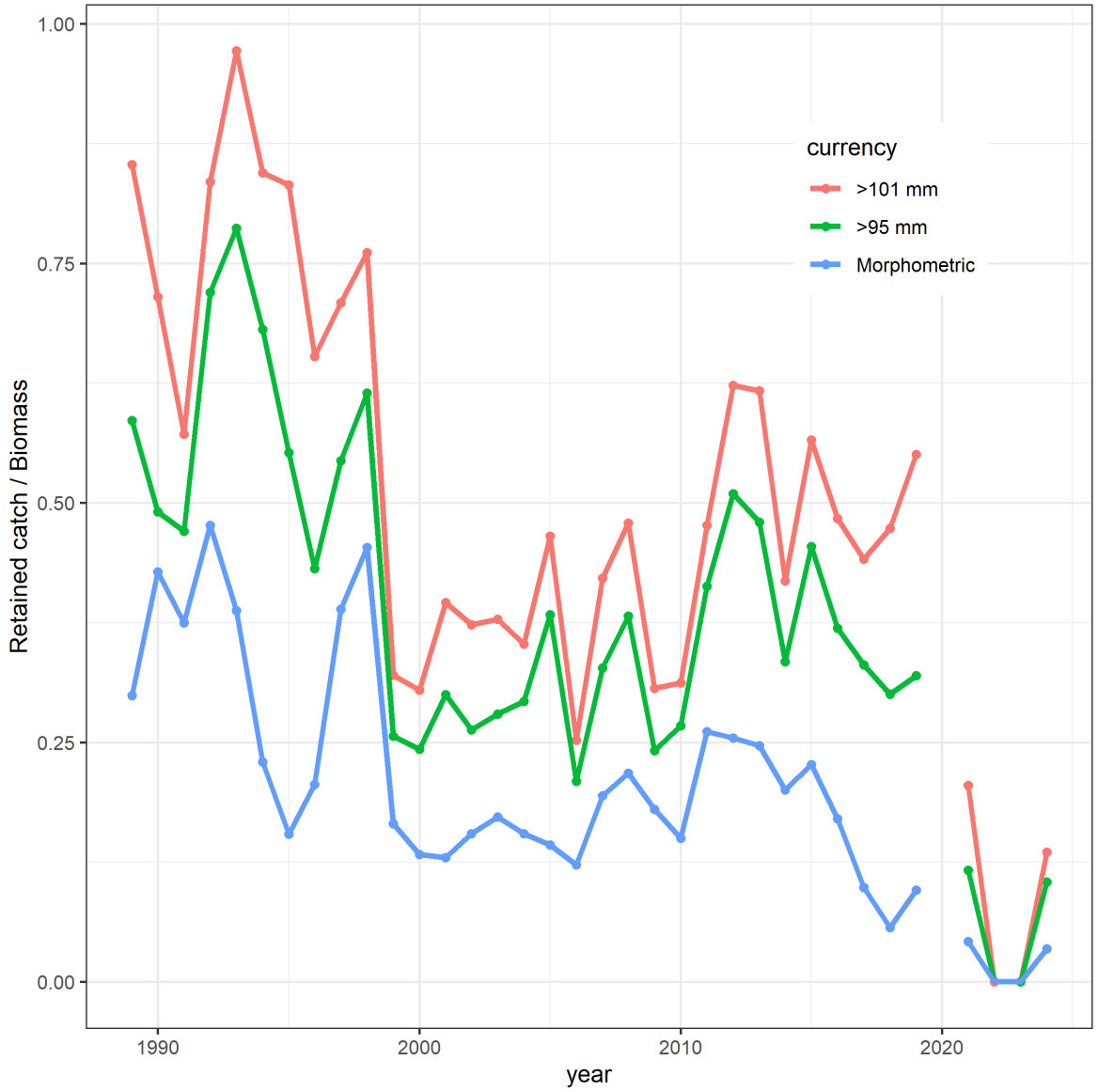

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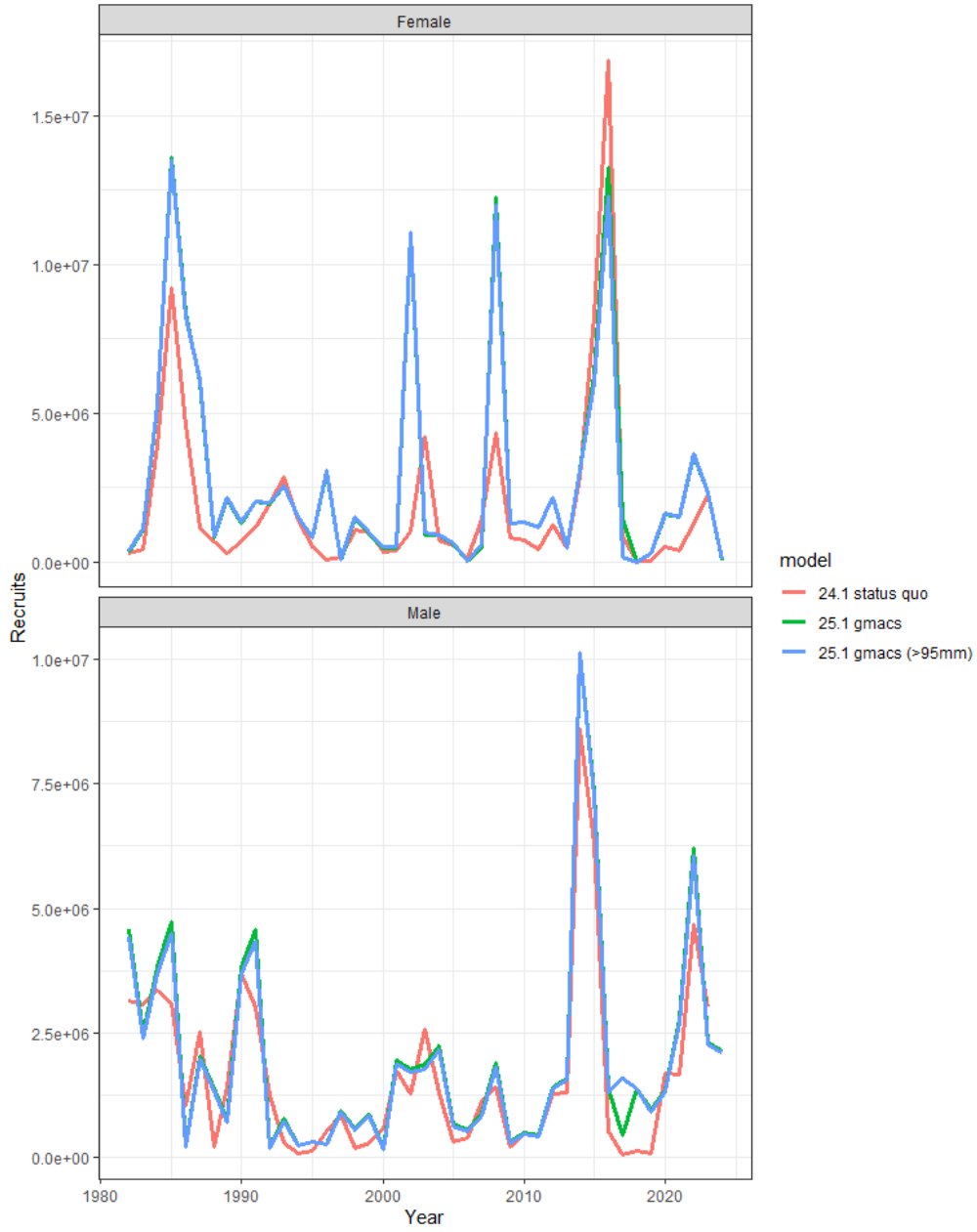

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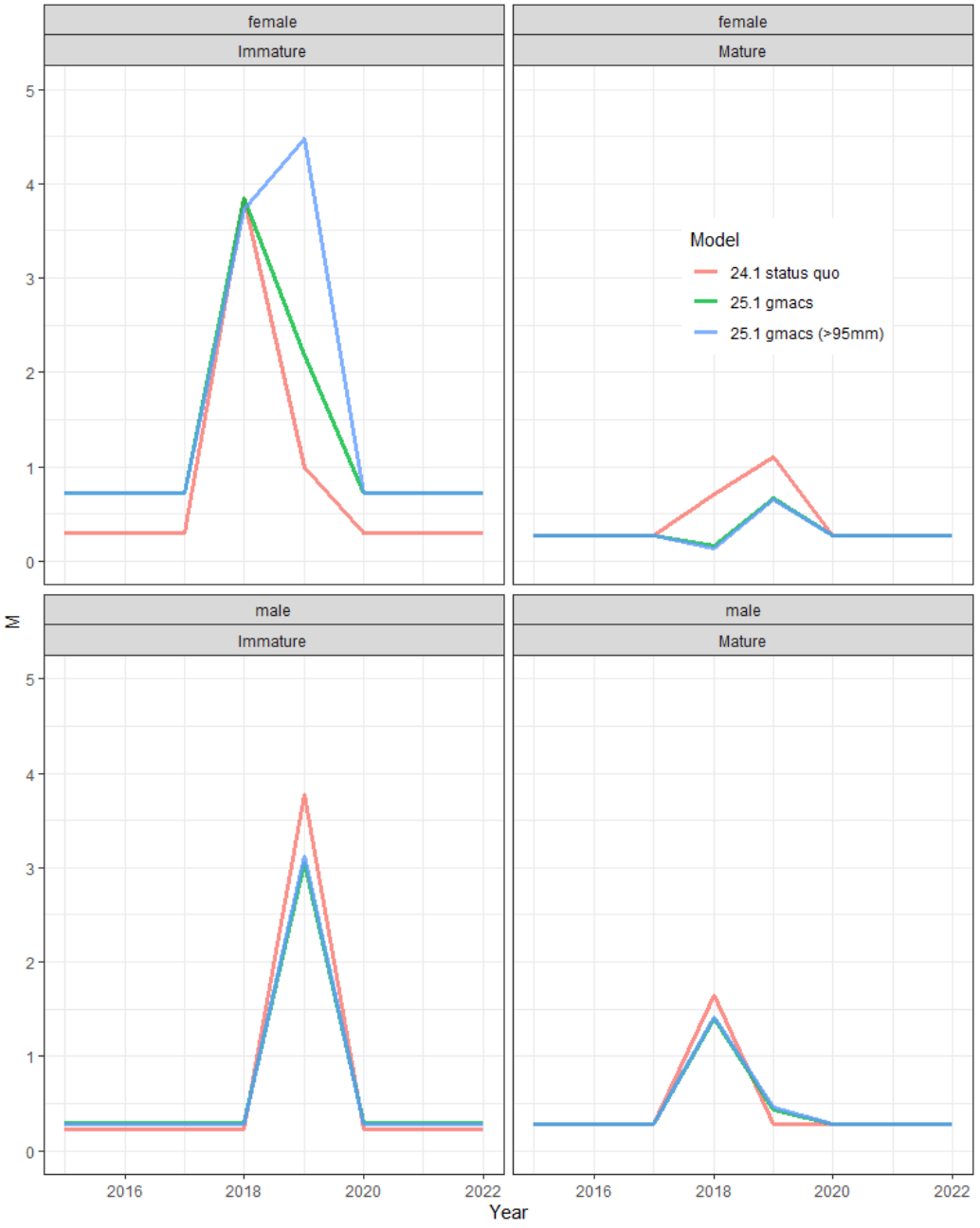

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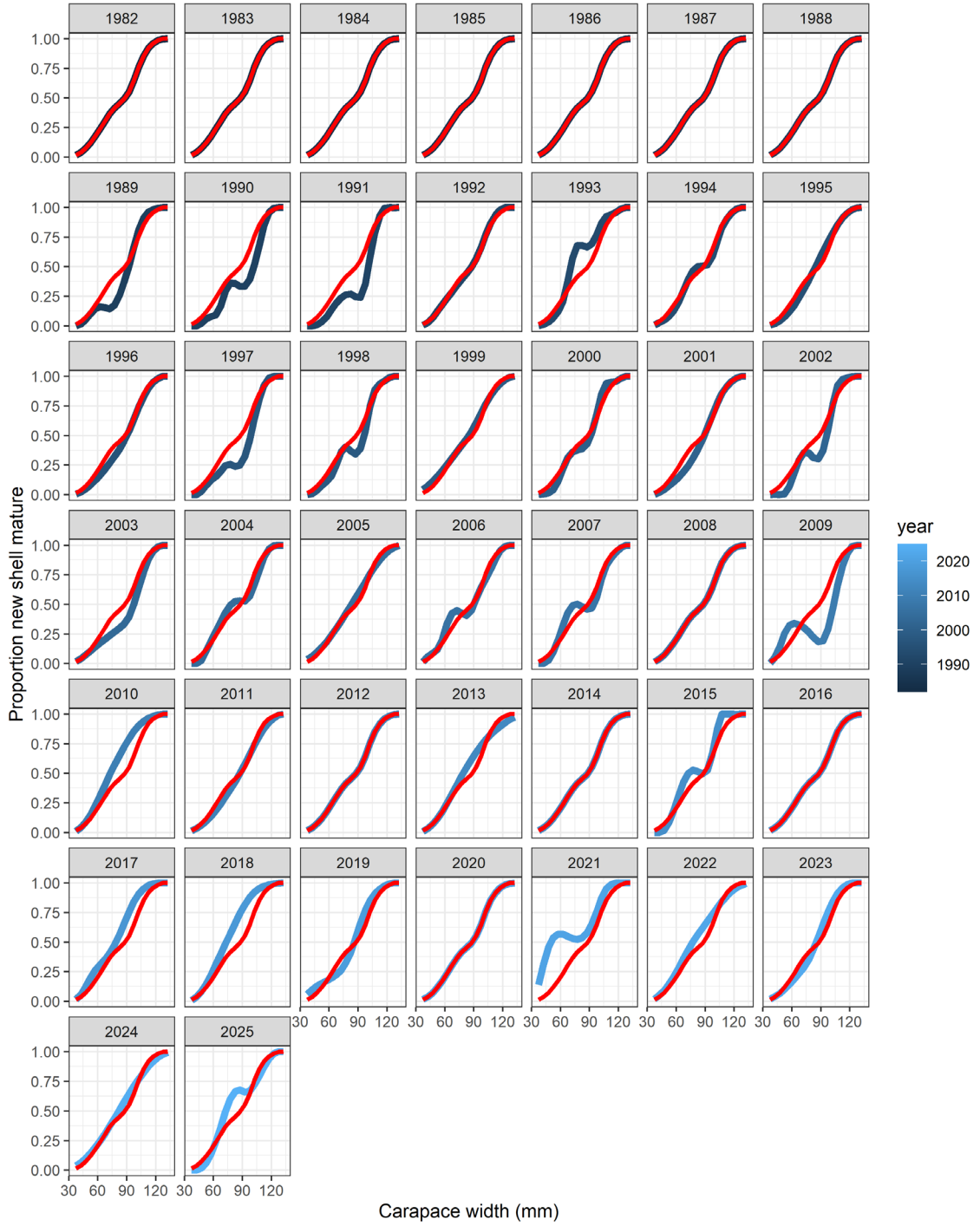
Maturity	Increased observed probability of terminally molting in 2025 for males



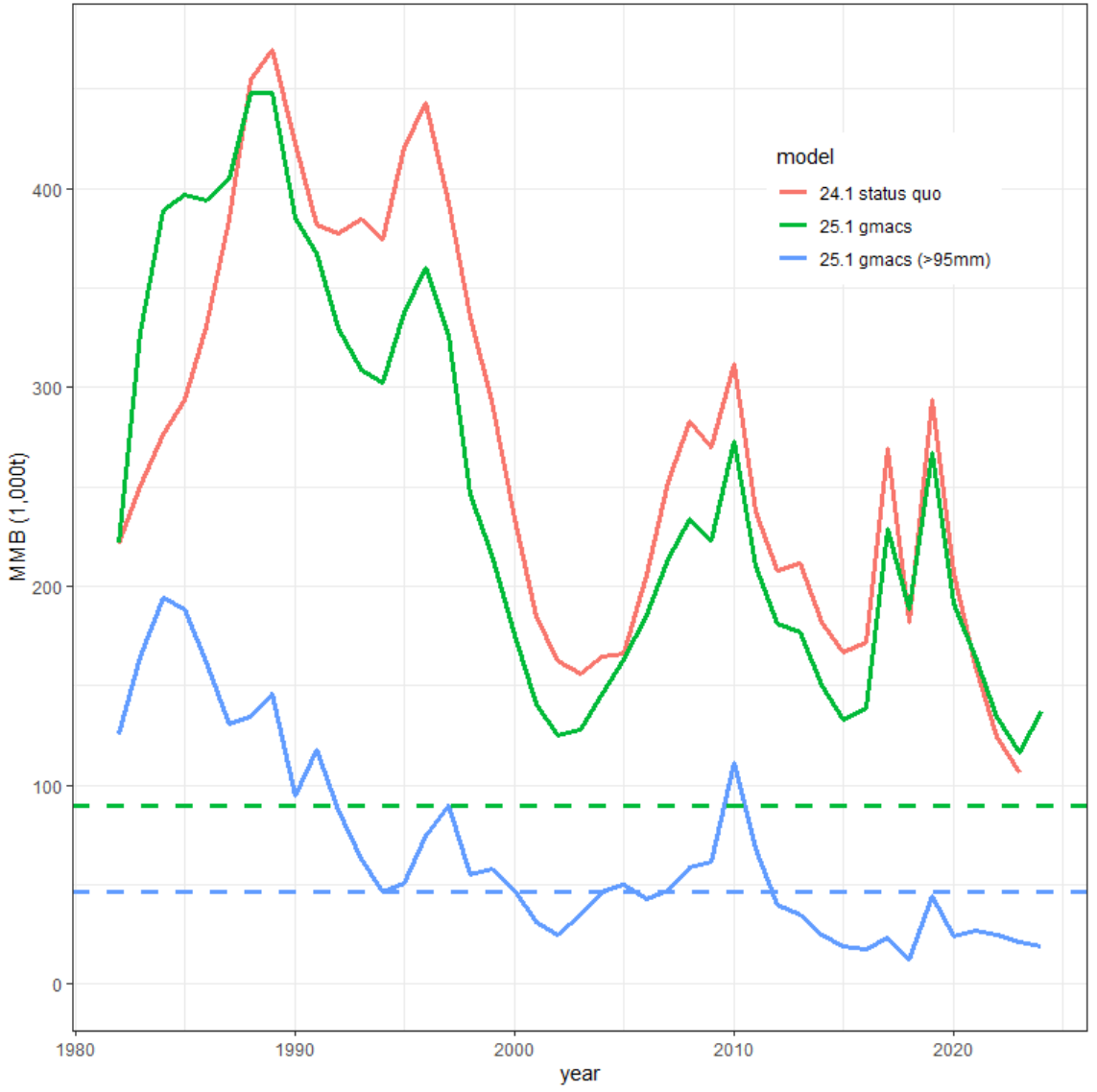
Harvest control rules

GMACS + tier 3

25.1: Morphometric mature biomass; B35%

25.1: >95mm mature biomass; B35%

	BMSY	status	OFL (tot)	Fmsy	Fofl
24.1 Status quo	191.81	0.56	19.60	49.63	25.07
25.1 gmacs	180.06	0.88	44.29	39.52	34.37
25.1 gmacs (>95mm)	93.52	0.32	3.26	0.73	0.18



* Dashed lines are MSST, not B35%

GMACS + tier 3

25.1: Morphometric mature biomass; B35%

25.1: >95mm mature biomass; B35%

	BMSY	status	OFL (tot)	Fmsy	Fofl
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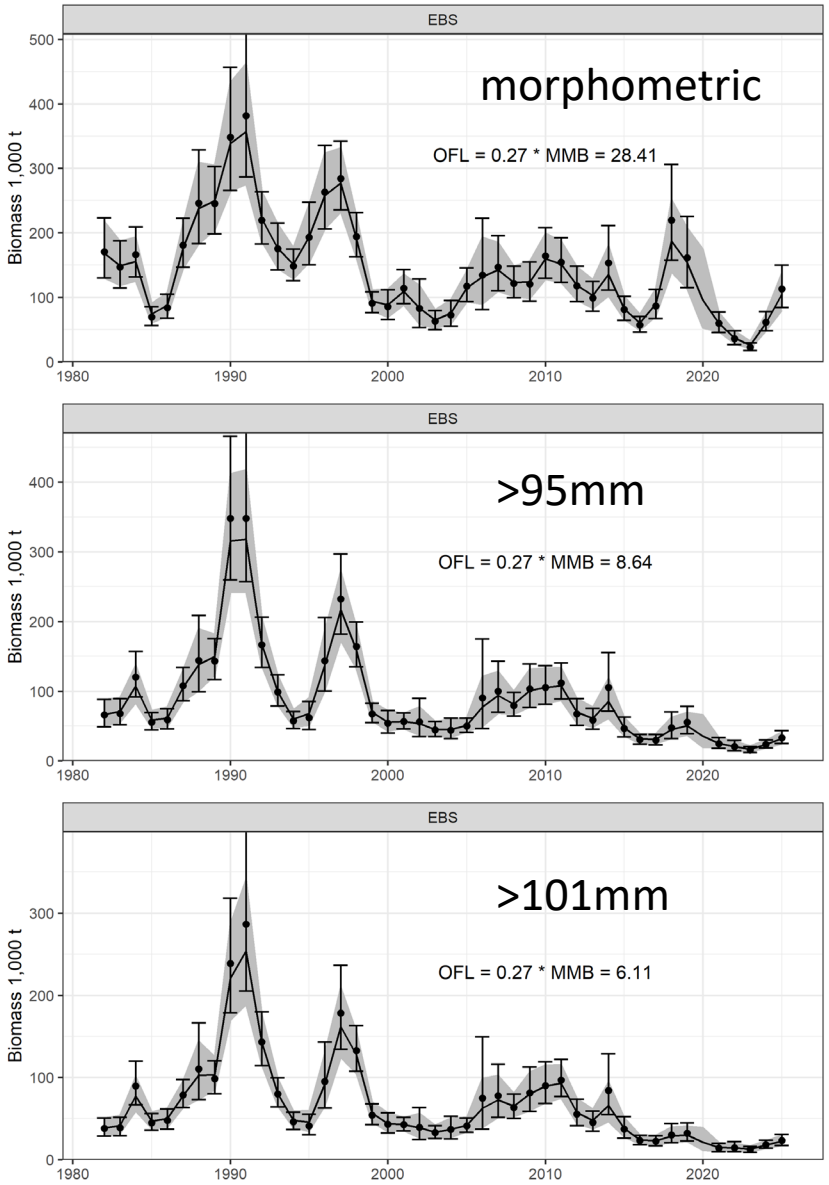
Survey biomass + tier 4



Risk table

TOPIC	COMMENT	SCORE
Assessment	Biology good Reference points bad Jittering bad	Increased concern (2)
Population dynamics	Large males downward trajectory Recent population collapse Potential for density dependence in terminal molt	Increased concern (2)
Environmental/ecosystem	ESP indicators mostly neutral	Normal (1)
Fishery performance	Fishery closure opened CPUE increased	Normal (1)

Recommendations

2024 OFL

- Author: Tier 4, 95mm = 0.66 (20%)
- CPT: Tier 3, 95mm = 0.05 (20%)
- SSC: Tier 3, morph = 19.6 (60%)

Author/CPT Rationale

- No big crab == no fishery
  - “Optimal yield”
- Preferred abundance trend strongly negative under conservative management
- Potential biological risks
  - Density dependent maturity
  - Large males important in reproduction
  - Genetic component

2025 OFL

- Author: Tier 3, 95mm = 3.26 (20%)
- CPT:
- SSC:

Author/CPT Rationale

- No change

Final thoughts

- Stock is in bad shape in spite of conservative harvest from the state, but with potential reasons for optimism
- Assessment model represents the best available information on biology
- Models are the best tools we have to:
  - try to understand the drivers of the stocks (e.g. why did the stock collapse?),
  - ask hypotheticals (e.g. what if we change selectivity?),
  - incorporate multiple data sources (e.g. BSFRF data)
- Management options were not designed with snow crab biology in mind
- Uncertainties around biology represent potentially large risks
- Harmonizing state and federal rules would be useful for communicating with stakeholders
- Agreeing on a good way to quantify tradeoffs, justify decisions under variable levels of uncertainty and risk, and communicate both of these points would be useful