Eastern Bering Sea snow crab

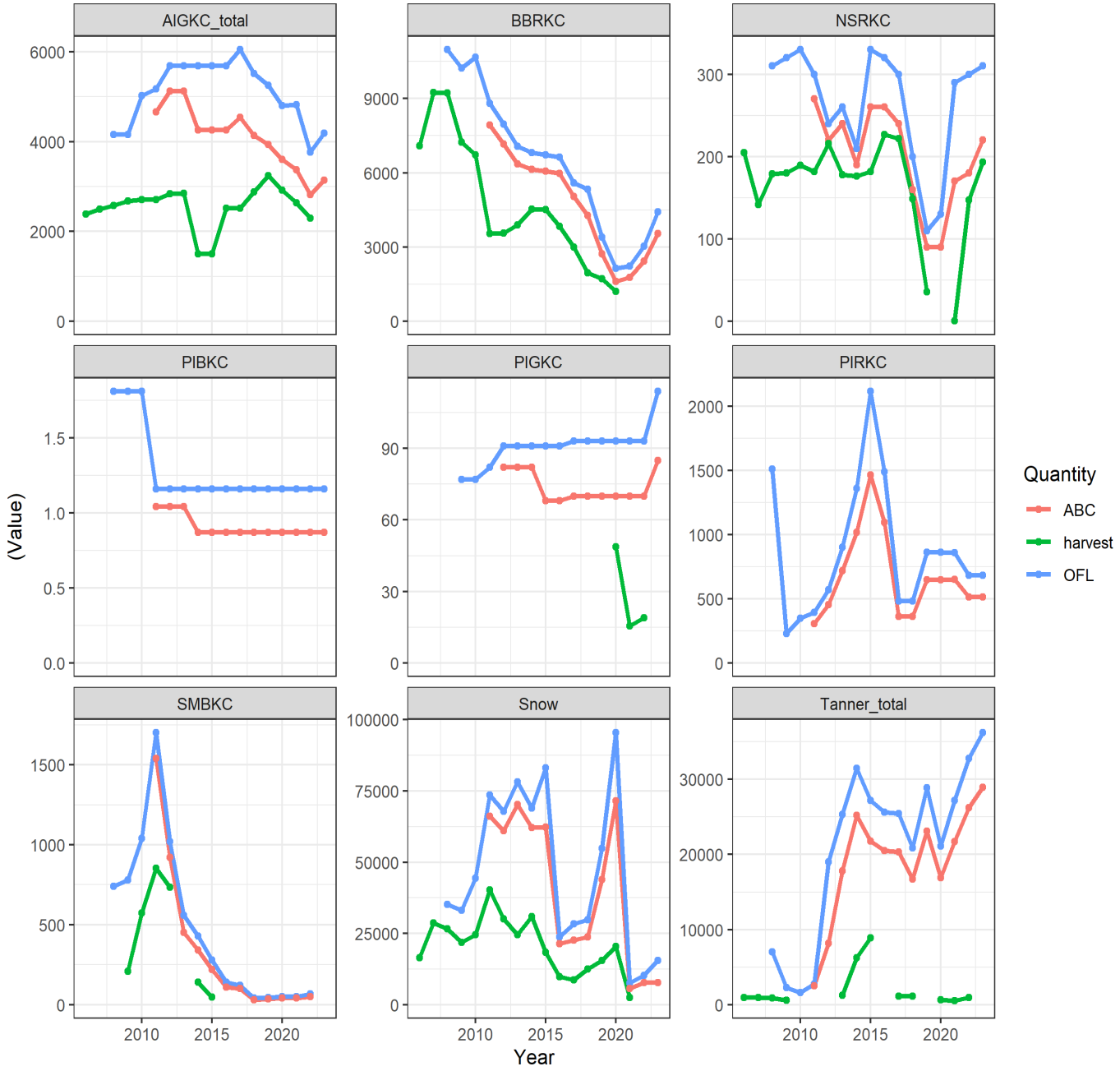
Cody Szuwalski & Grant Adams

May 14, 2025

EBS crab context

- No federal OFL/ABC has ever constrained removals

- In spite of conservative management (compared to OFL), the stocks are still at historical lows



EBS crab context

- No federal OFL/ABC has ever constrained removals

- In spite of conservative management (compared to OFL), the stocks are still at historical lows

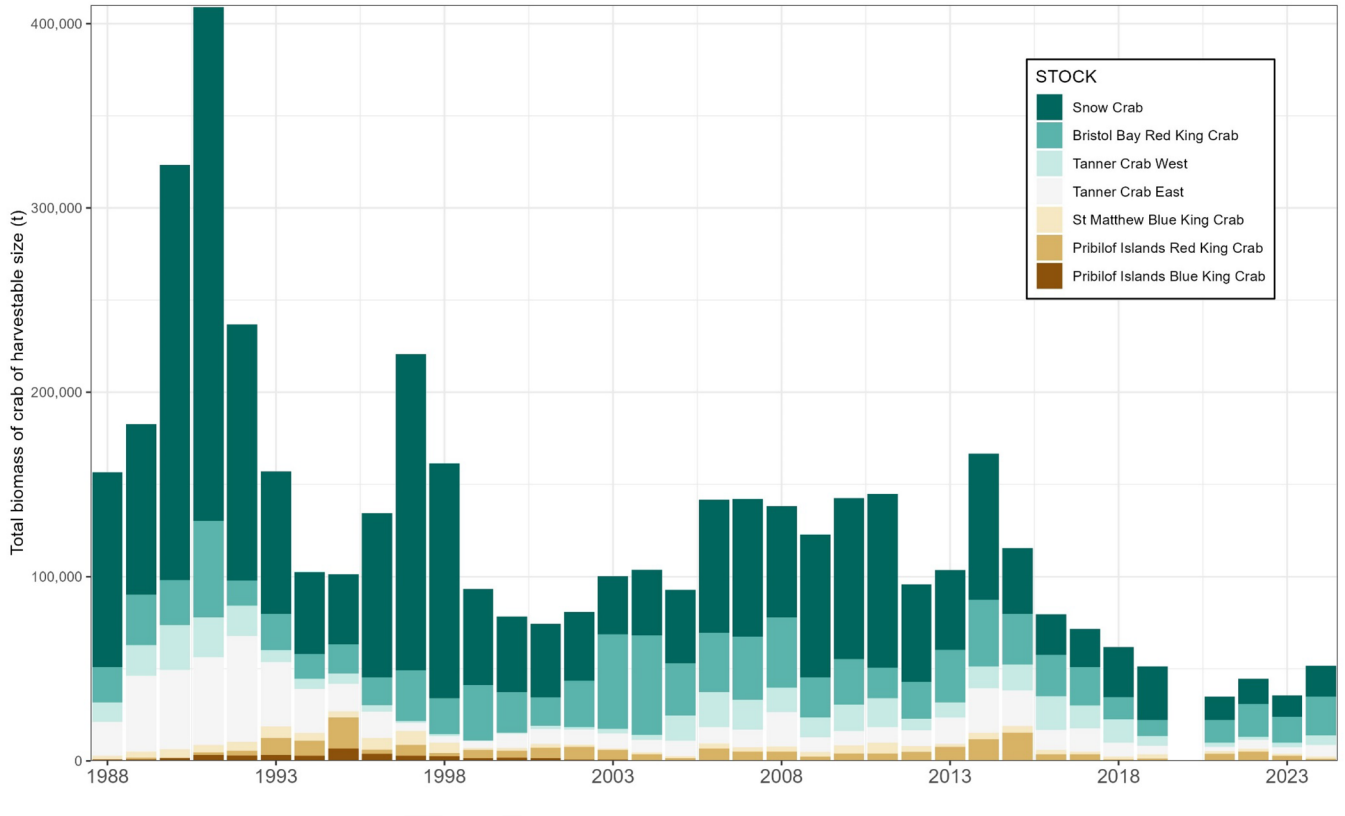


Figure 5. -- Biomass (t) of crab of harvestable size for four commercial species caught on National Marine Fisheries Service eastern Bering Sea bottom trawl surveys from 1988 through 2024, by stock. Harvestable size is defined by the legal size for *Paralithodes* species and the industry-preferred size for *Chionoecetes* species.

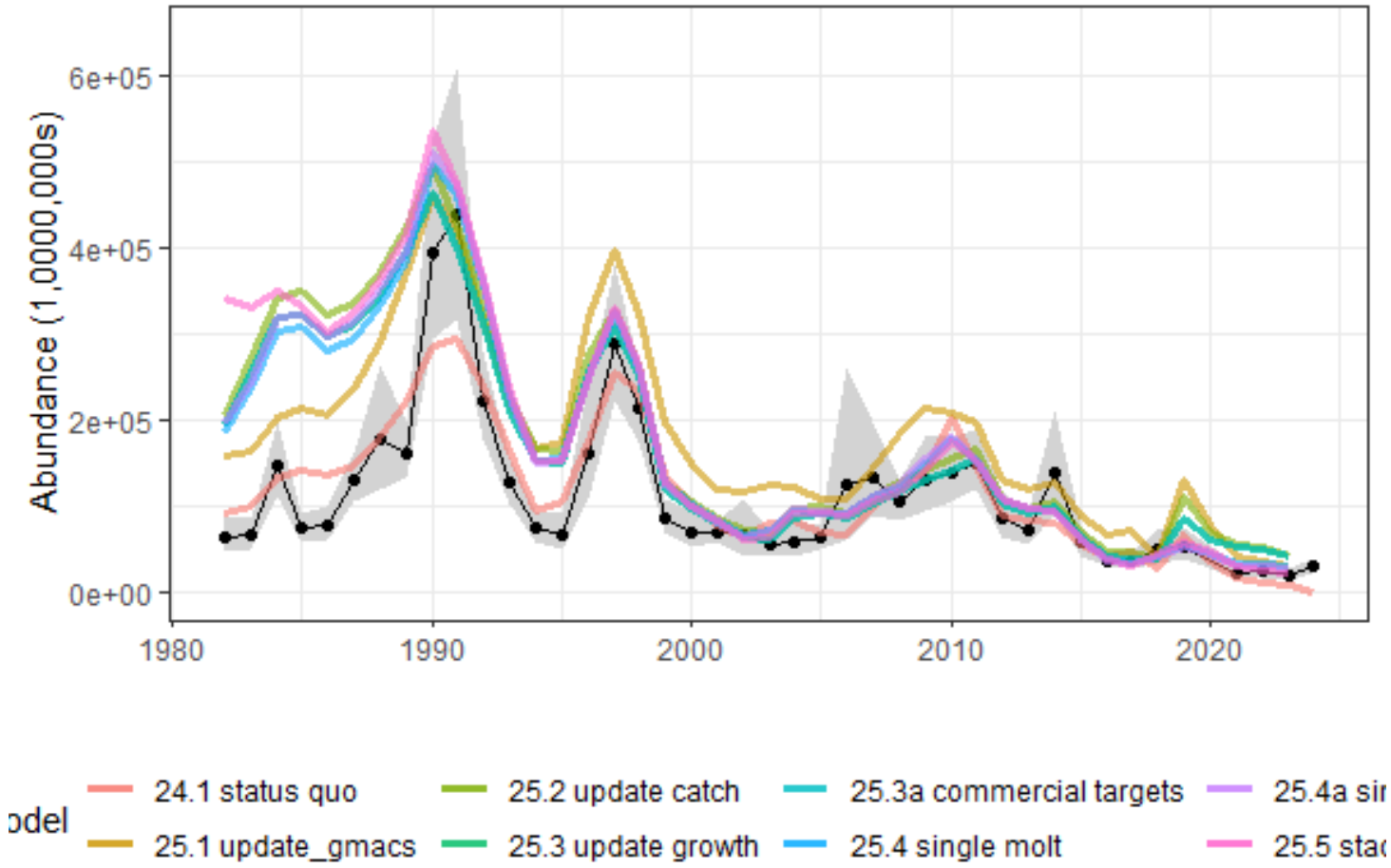
Snow crab context

- Commercial males at all-time lows

  (no assessment needed)

- Taking all commercial males maybe not a good idea

  (no room of PhDs needed)



Currency of management + HCR

If the answer is “MMB”

- Reference points allow removal of all large males
- OFL will not be constraining
- We don’t need an assessment

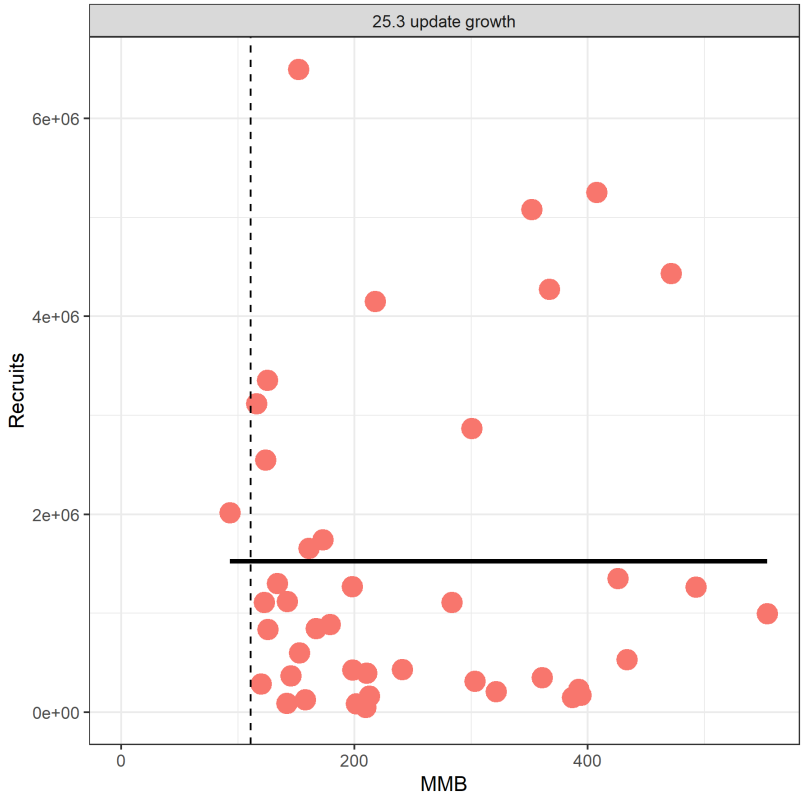
If the answer is “Large males”

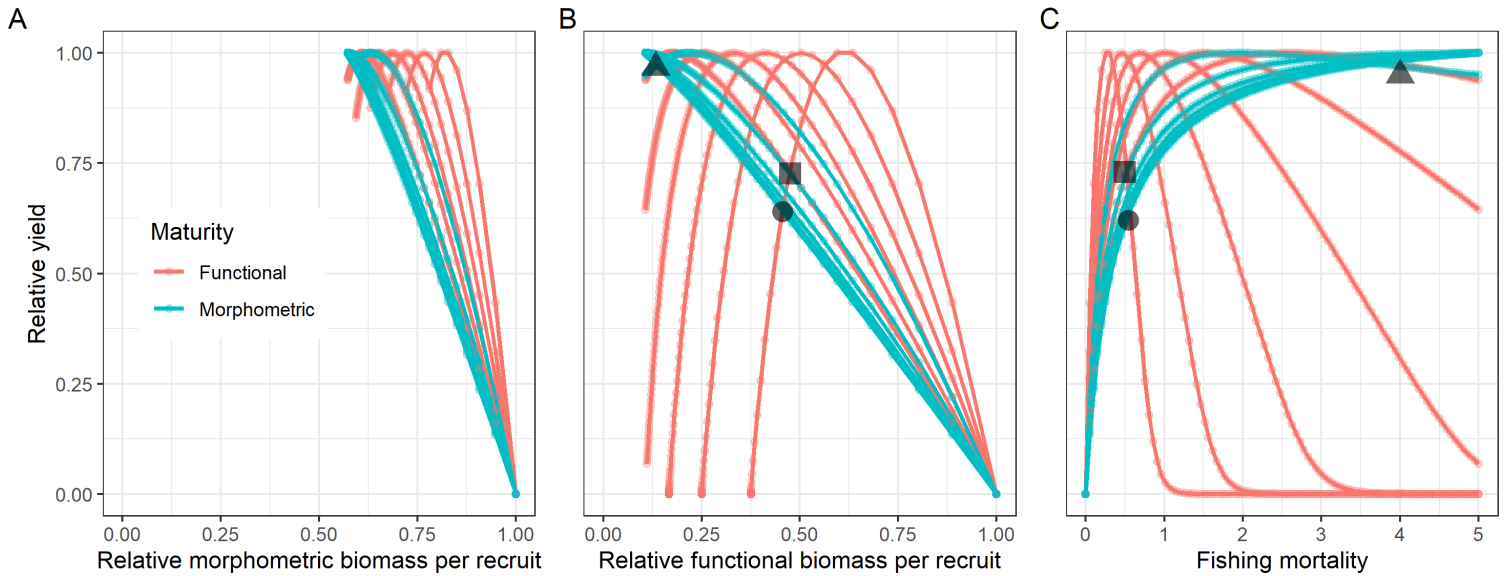
- Big can of worms
- Potential choke species at the federal level and ensuing tradeoffs
- Potential conflicts with the state rule

(the next [and harder] question is ‘how much of each do you want to keep in the water?)

SSC comments

(9/2024) The highest priority would be to continue to refine the Maximin analysis as requested by the SSC in June 2024, specifically using values of steepness of 0.50, 0.67, and 0.80, and considering both the Beverton-Holt and Ricker stock recruitment relationships. The yield analysis also indicated that fishing mortality rates much lower than F35% achieved a high percentage of MSY, indicating potential flexibility in specifying reference points. The SSC suggested that some type of collaborative work during the spring, perhaps including SSC members and/or others might facilitate additional progress on this topic. The SSC is interested in developing a wider range of options for reference points for snow crab for consideration in the next assessment cycle.

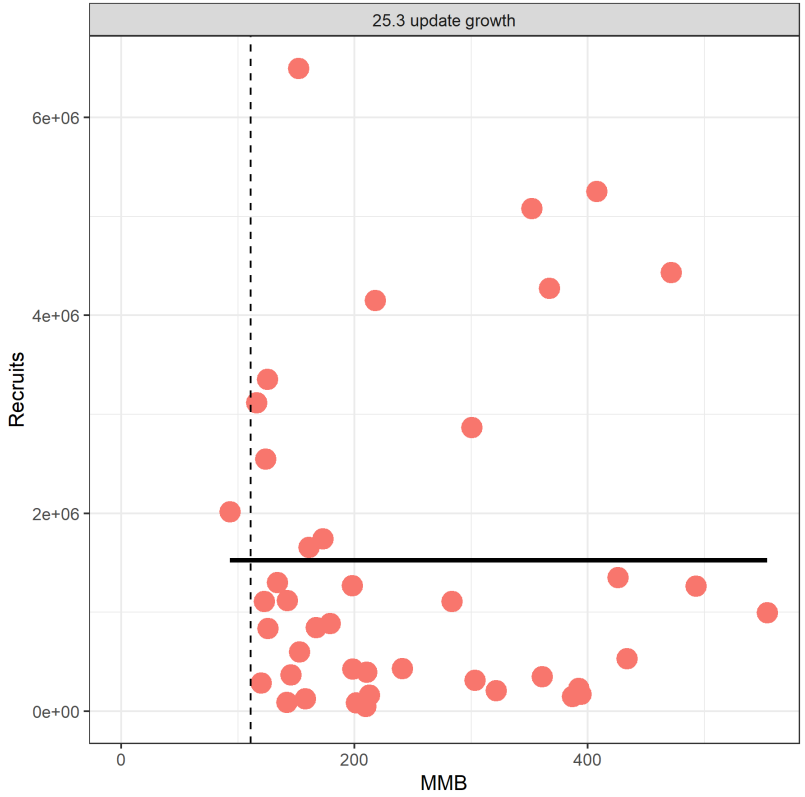


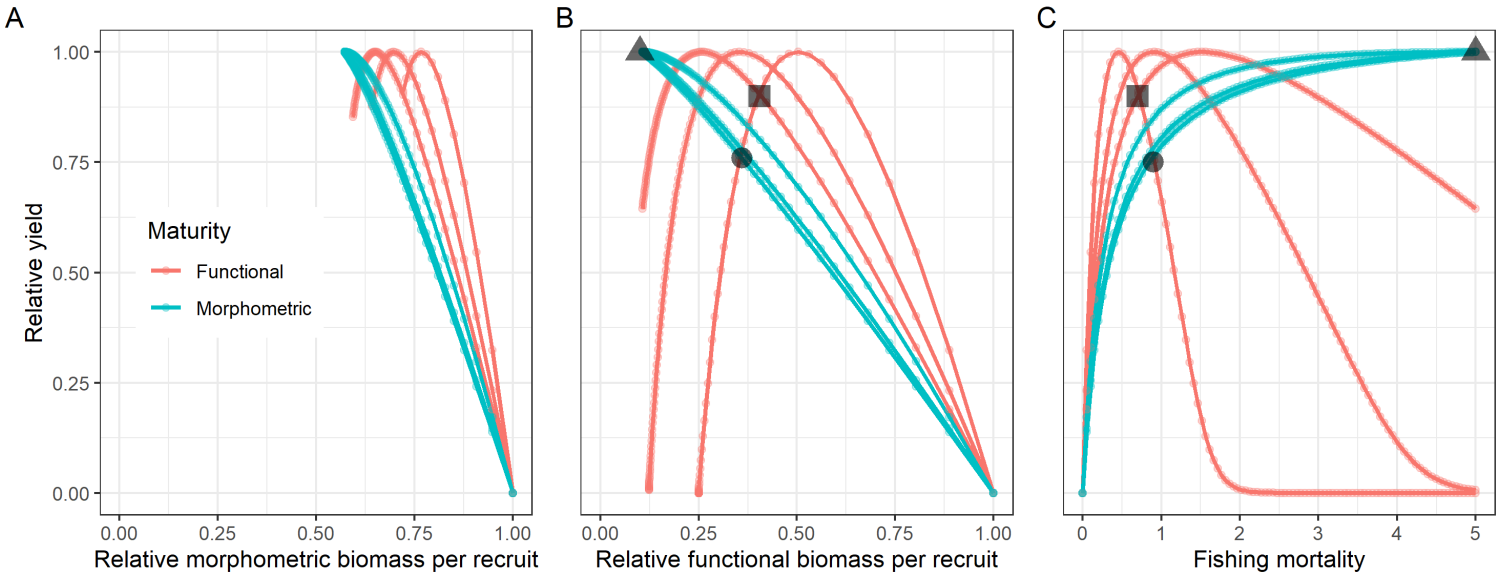


B45% based on steepness from 2024

SSC comments

(9/2024) The highest priority would be to continue to refine the Maximin analysis as requested by the SSC in June 2024, specifically using values of steepness of 0.50, 0.67, and 0.80, and considering both the Beverton-Holt and Ricker stock recruitment relationships. The yield analysis also indicated that fishing mortality rates much lower than F35% achieved a high percentage of MSY, indicating potential flexibility in specifying reference points. The SSC suggested that some type of collaborative work during the spring, perhaps including SSC members and/or others might facilitate additional progress on this topic. The SSC is interested in developing a wider range of options for reference points for snow crab for consideration in the next assessment cycle.





B36% based on SSC steepness values

Both SBPR% were presented in 2024; both resulted in federal closures.

24.1a: Morphometric mature biomass; B35%

24.1b: >95mm mature biomass; B35%

24.1c: >95mm mature biomass; B45%

Model	MMB	B35	F35	FOFL	OFL	M	avg_rec	Status
23.1	128.11	164.05	61.78	24.21	23.40	0.29	154.55	0.78
24.1	115.46	181.01	59.72	26.12	20.15	0.29	167.37	0.64
24.1a	106.52	191.81	49.63	25.07	19.60	0.28	164.98	0.56
24.1b	13.40	94.82	0.81	0.00	0.05	0.28	164.98	0.14
24.1c	13.40	121.91	0.53	0.00	0.05	0.28	164.98	0.11

FEDERAL CLOSURE

SSC comments

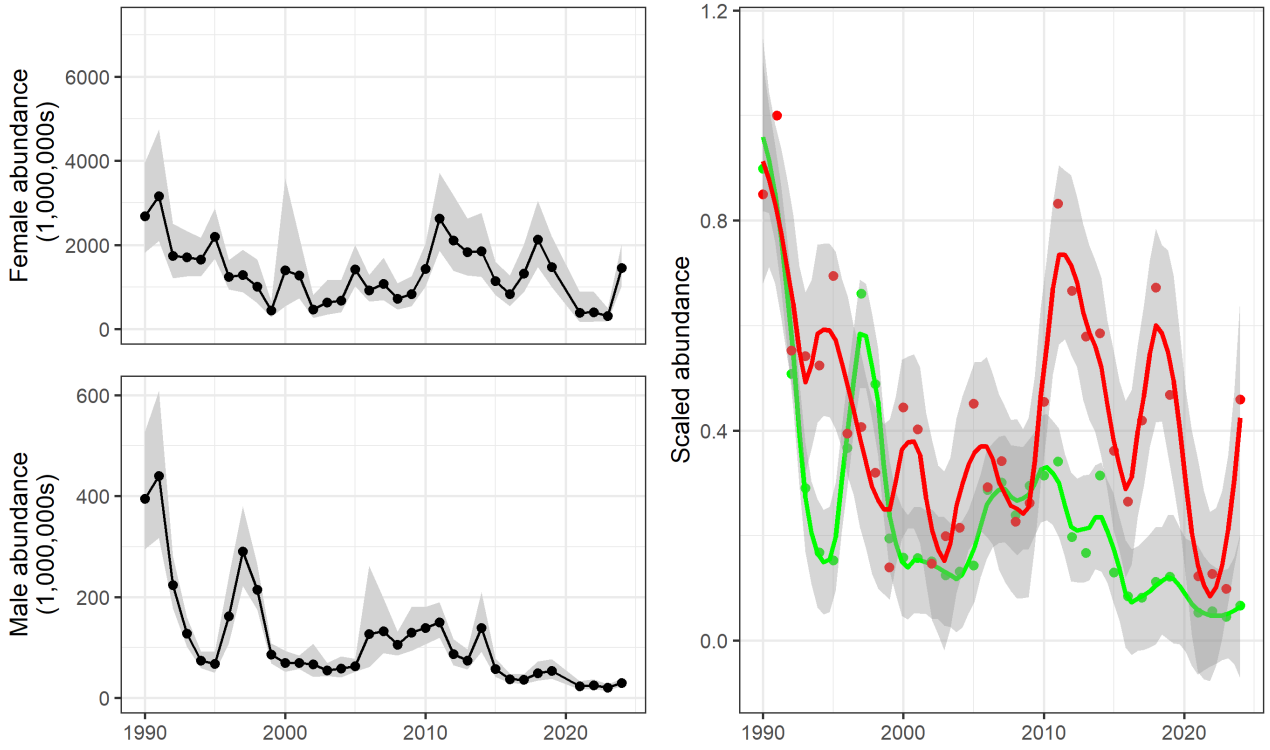
(9/2024) The SSC again requests an analysis of the probability of maturing/terminal molt which addresses the observation error in these data and the lack of a monotonically increasing curve. A hierarchical analysis that treats years as random effects might be a starting point. The SSC would also like to better understand the sampling design for the molt data and is concerned about the weighting of the spatial samples in the analysis; weighting should be based on abundance if the sampling rate differs by area (which it would, unless abundance were uniform and/or the targets were in direct proportion to abundance).

Kodiak lab will be talking about this.

SSC comments

(9/2024) Investigate whether there is information outside the assessment model (e.g., larval or post-settlement data) or in the model, supporting estimated skewed sex-ratios at recruitment and the mismatch between recent large recruitments for males and females occurring in different years. Explore whether the estimated large differences in male and female recruitment years could be related to the lack of fit to molt-increment data.

I suggest excluding females from the model to focus on large males.



SSC comments

(9/2024) Geostatistical (e.g. VAST) modeling of trawl survey data including both the NBS and EBS should be prioritized. This could help understand some of the inconsistent recruitment/growth trends observed in recent years as well as prepare for potential changes in stock distribution or productivity under future warming of the Bering Sea. Geostatistical modeling should evaluate alternative error distributions and other model configurations as appropriate.

Kodiak lab talked about this.

SSC comments

(9/2024) For the Tier 4 fallback model requested by the SSC, the SSC recommends standardizing the approach to the Tier 4 fallback across BBRKC, Tanner and snow crab assessments so that the same methods are used for each including all mature male biomass, a BMSY proxy based on the time-series of REMA-smoothed survey estimates and an FMSY proxy based on the best estimate of natural mortality (from the Tier 3 model). As the SSC intends the Tier 4 calculation only as a fallback if the Tier 3 analysis fails to converge, no other Tier 4 calculations need to be included in future assessments.

I still think this is a bad idea, but I'll do it.

Currency of management + HCR

If the answer is “MMB”

- Reference points allow removal of all large males
- OFL will not be constraining
- We don’t need an assessment

If the answer is “Large males”

- Big can of worms
- Potential choke species at the federal level and ensuing tradeoffs
- Potential conflicts with the state rule

(the next [and harder] question is ‘how much of each do you want to keep in the water?)

Assessment variants considered:

24.1: accepted model from last year
25.1: Same data from 24.1, but updated GMACS model
25.2: 25.1 + updated catch data from 1990-present provided by ADFG
25.3: 25.2 + updated growth data from Kodiak lab

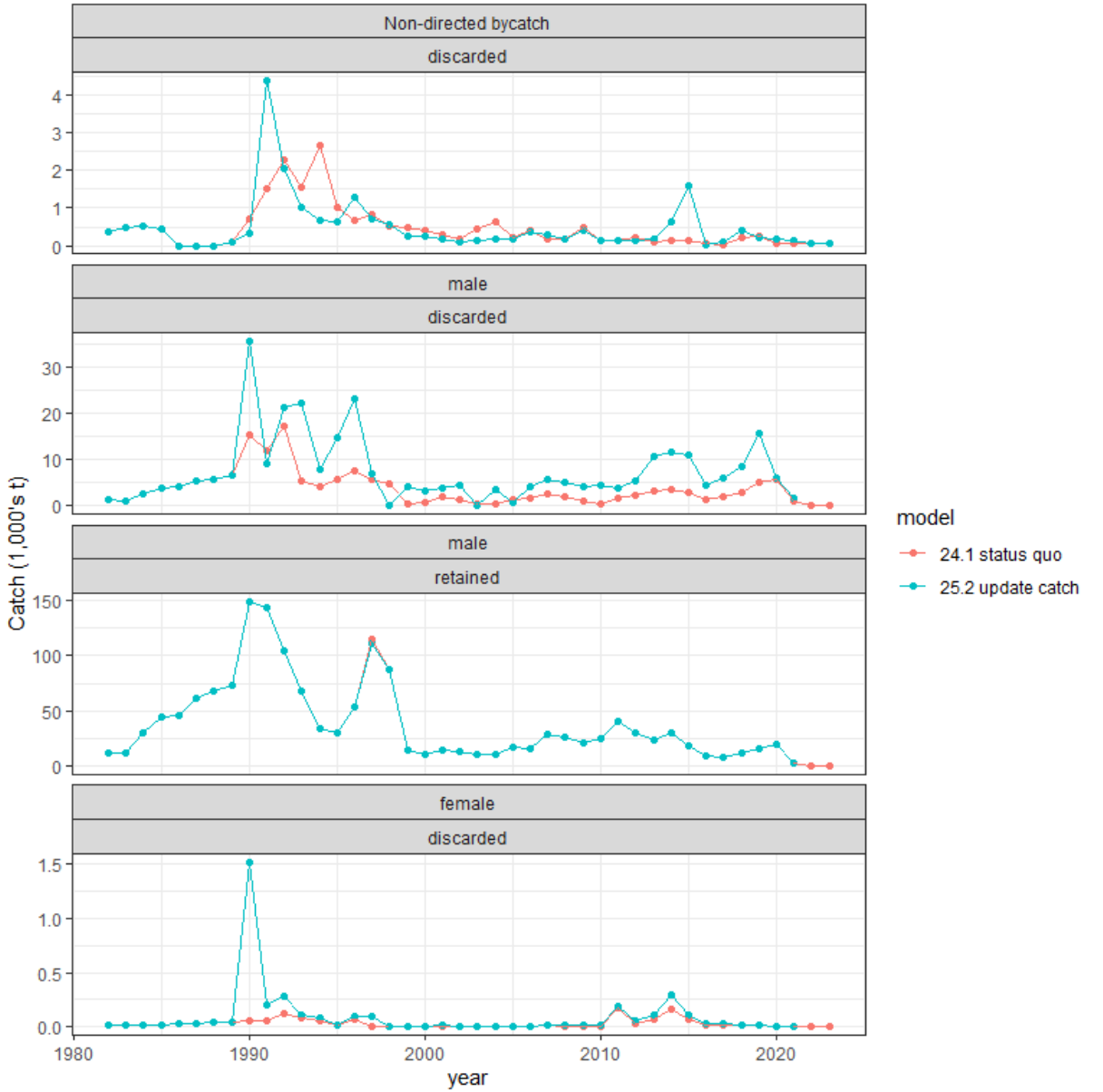
25.3a: 25.3 + reference points calculated on commercial biomass instead of morphometrically mature
25.4: 25.3 + a single specified molting probability
25.4a: 25.3 + a single specified molting probability based on alternate analyses by Kodiak
25.5: 25.4 + a stacked logistic curve for survey selectivity

Assessment variants considered:

24.1: accepted model from last year
25.1: Same data from 24.1, but updated GMACS model
25.2: 25.1 + updated catch data from 1990-present provided by ADFG
25.3: 25.2 + updated growth data from Kodiak lab

25.3a: 25.3 + reference points calculated on commercial biomass instead of morphometrically mature
25.4: 25.3 + a single specified molting probability
25.4a: 25.3 + a single specified molting probability based on alternate analyses by Kodiak
25.5: 25.4 + a stacked logistic curve for survey selectivity

1. Date correcting pre-rationalized fisheries to the regulatory crab year (Jul – Jun)
2. Excluding pots that had compromised biotwine (i.e. rot cotton)
3. Consistent handling of missing data fields like legal status / maturity
4. Expanding total catch / bycatch in a fishery using directed effort opposed to total fishery effort

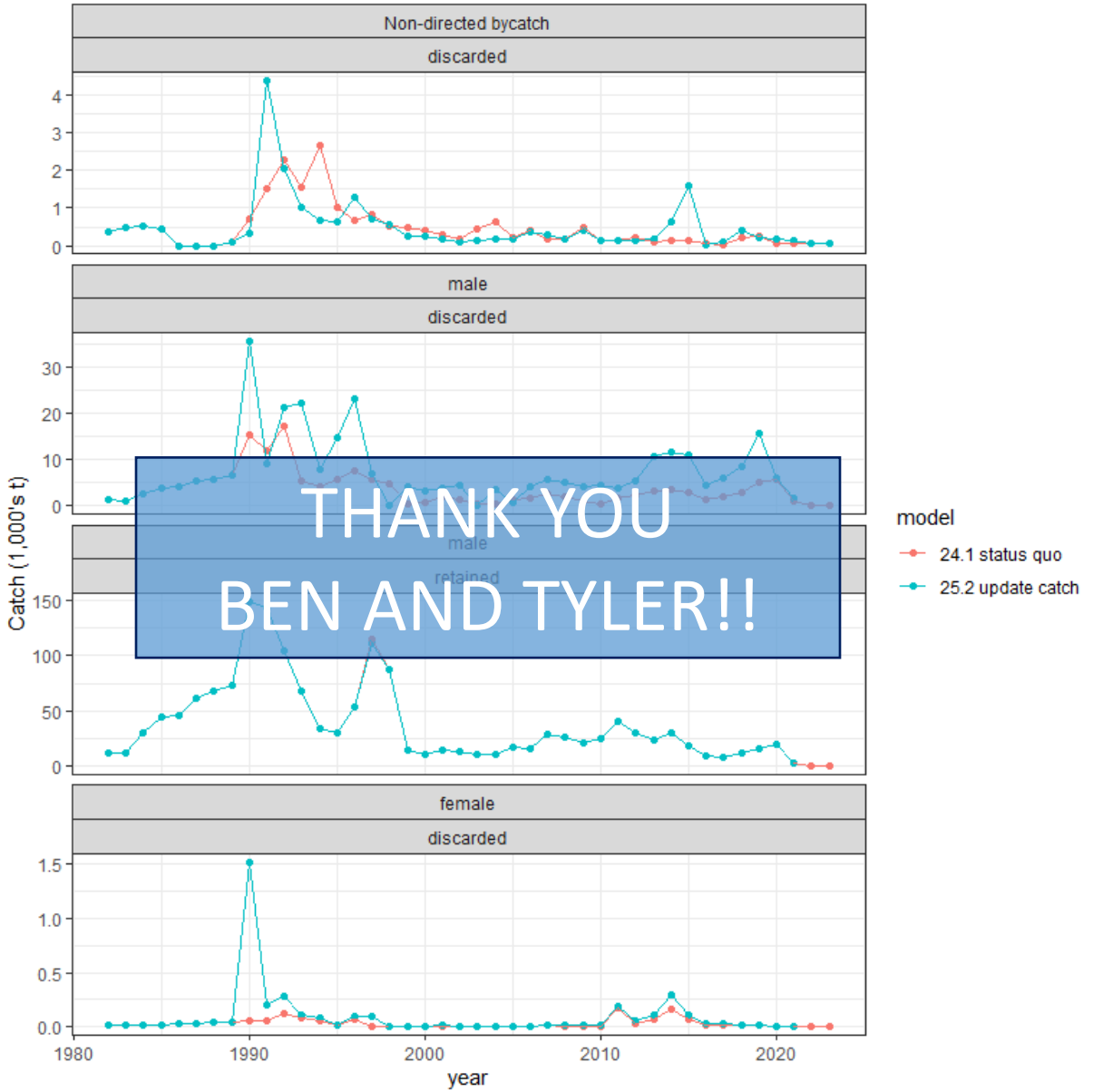


Assessment variants considered:

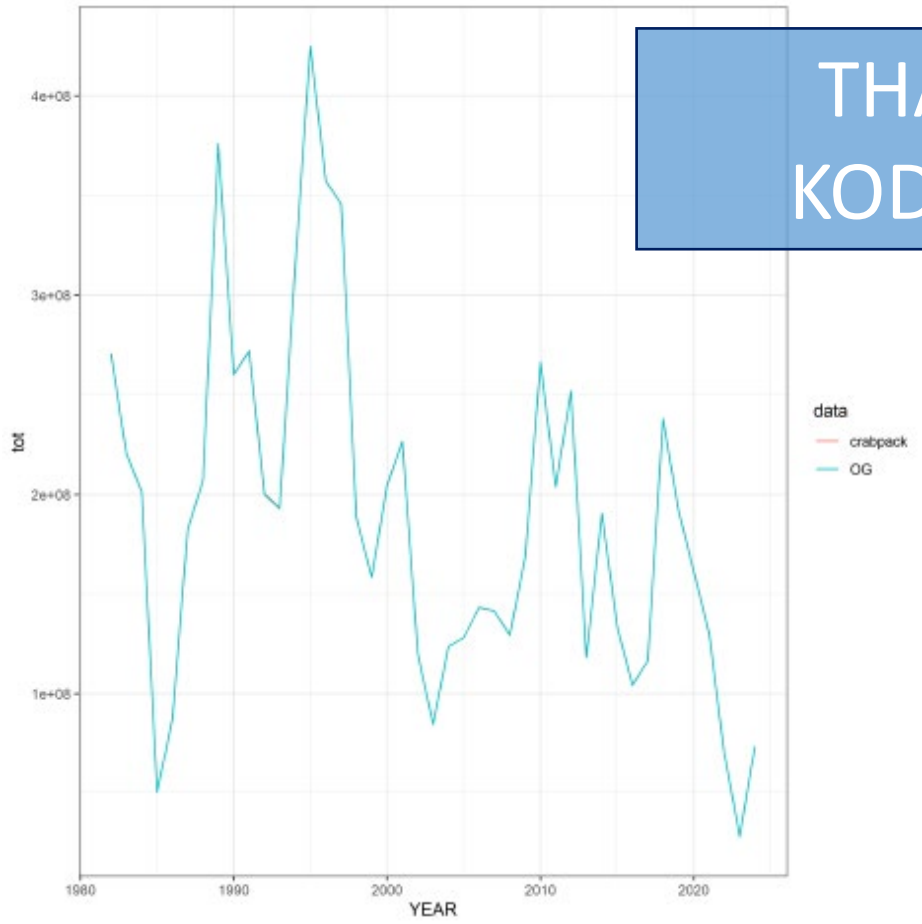
24.1: accepted model from last year
25.1: Same data from 24.1, but updated GMACS model
25.2: 25.1 + updated catch data from 1990-present provided by ADFG
25.3: 25.2 + updated growth data from Kodiak lab

25.3a: 25.3 + reference points calculated on commercial biomass instead of morphometrically mature
25.4: 25.3 + a single specified molting probability
25.4a: 25.3 + a single specified molting probability based on alternate analyses by Kodiak
25.5: 25.4 + a stacked logistic curve for survey selectivity

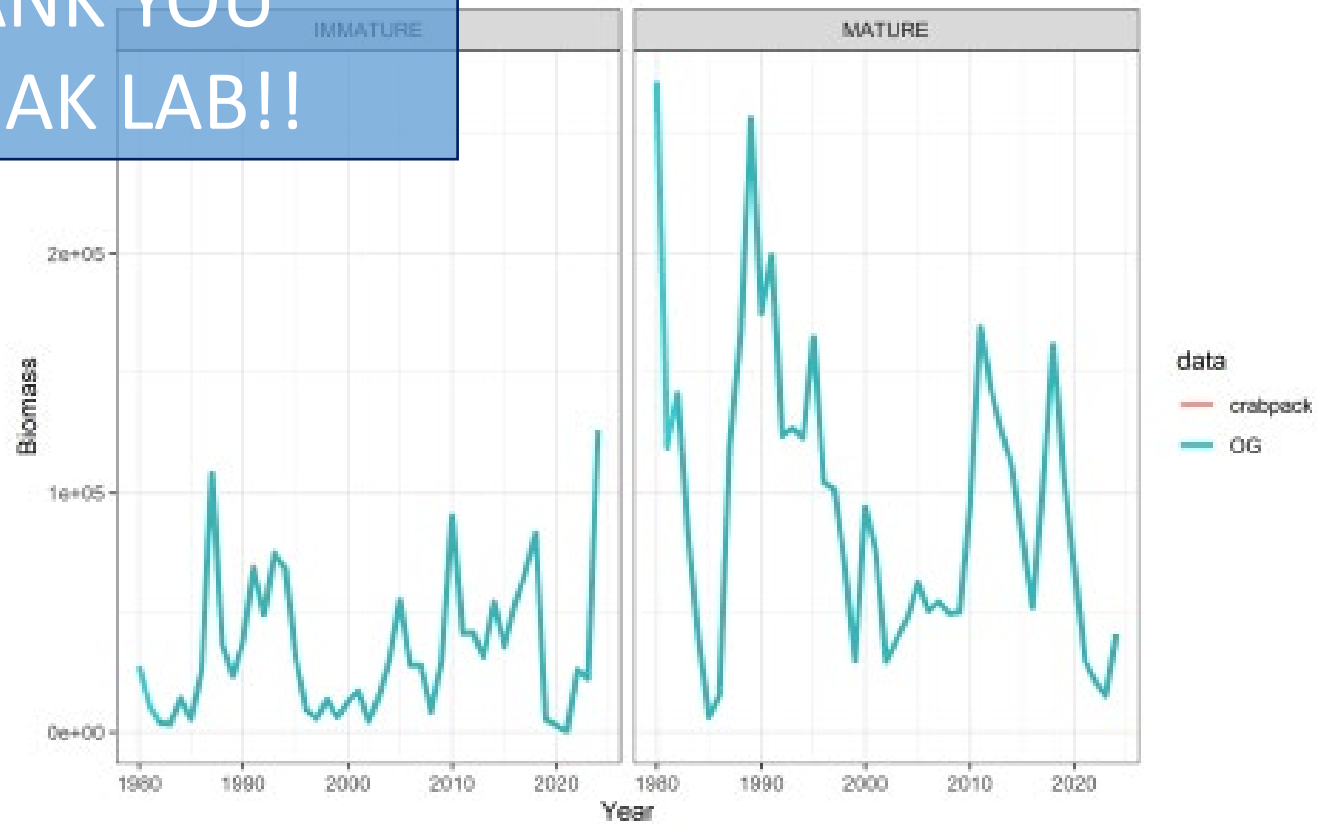
1. Date correcting pre-rationalized fisheries to the regulatory crab year (Jul – Jun)
2. Excluding pots that had compromised biotwine (i.e. rot cotton)
3. Consistent handling of missing data fields like legal status / maturity
4. Expanding total catch / bycatch in a fishery using directed effort opposed to total fishery effort



Crabpack will be used for data pulls in September.



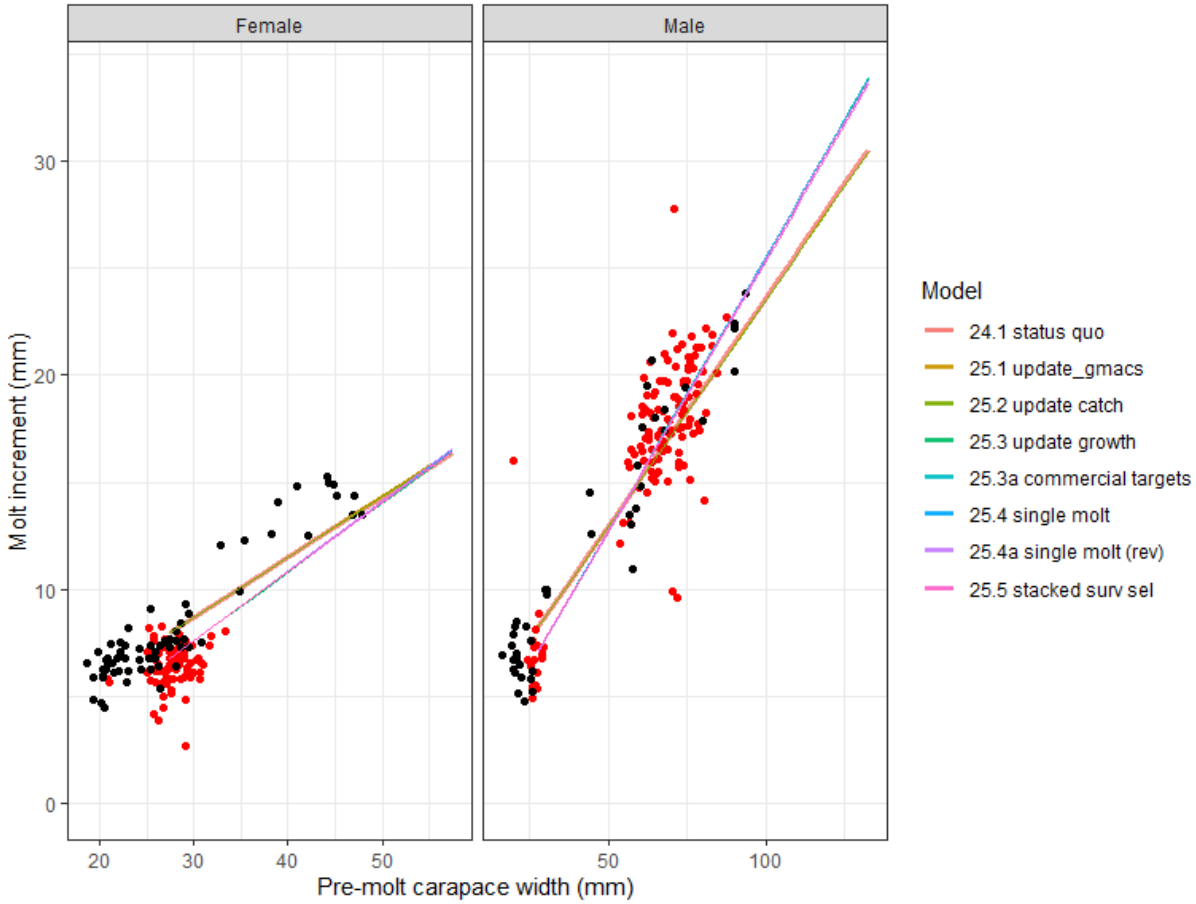
THANK YOU
KODIAK LAB!!



Assessment variants considered:

24.1: accepted model from last year
25.1: Same data from 24.1, but updated GMACS model
25.2: 25.1 + updated catch data from 1990-present provided by ADFG
25.3: 25.2 + updated growth data from Kodiak lab

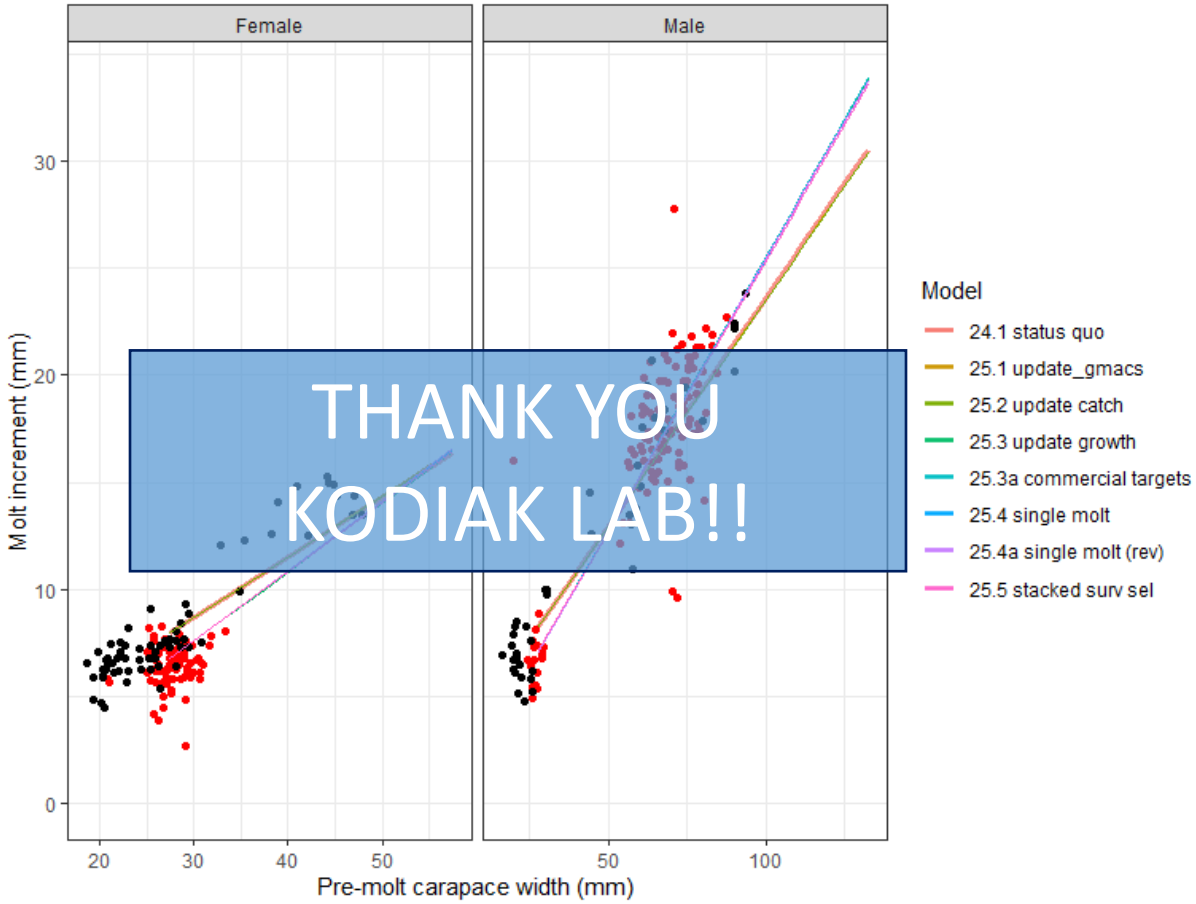
25.3a: 25.3 + reference points calculated on commercial biomass instead of morphometrically mature
25.4: 25.3 + a single specified molting probability
25.4a: 25.3 + a single specified molting probability based on alternate analyses by Kodiak
25.5: 25.4 + a stacked logistic curve for survey selectivity



Assessment variants considered:

24.1: accepted model from last year
25.1: Same data from 24.1, but updated GMACS model
25.2: 25.1 + updated catch data from 1990-present provided by ADFG
25.3: 25.2 + updated growth data from Kodiak lab

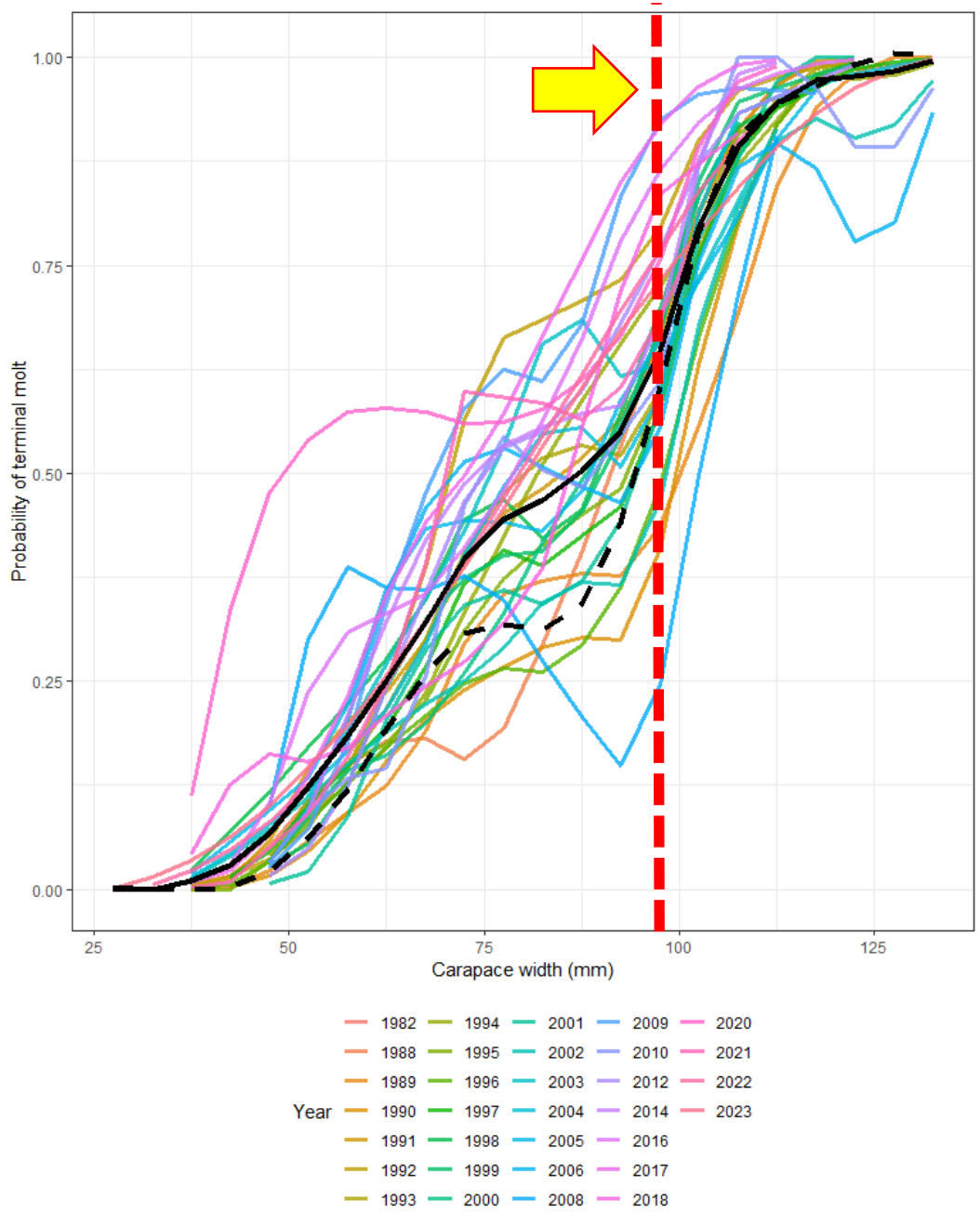
25.3a: 25.3 + reference points calculated on commercial biomass instead of morphometrically mature
25.4: 25.3 + a single specified molting probability
25.4a: 25.3 + a single specified molting probability based on alternate analyses by Kodiak
25.5: 25.4 + a stacked logistic curve for survey selectivity



Assessment variants considered:

24.1: accepted model from last year
25.1: Same data from 24.1, but updated GMACS model
25.2: 25.1 + updated catch data from 1990-present provided by ADFG
25.3: 25.2 + updated growth data from Kodiak lab

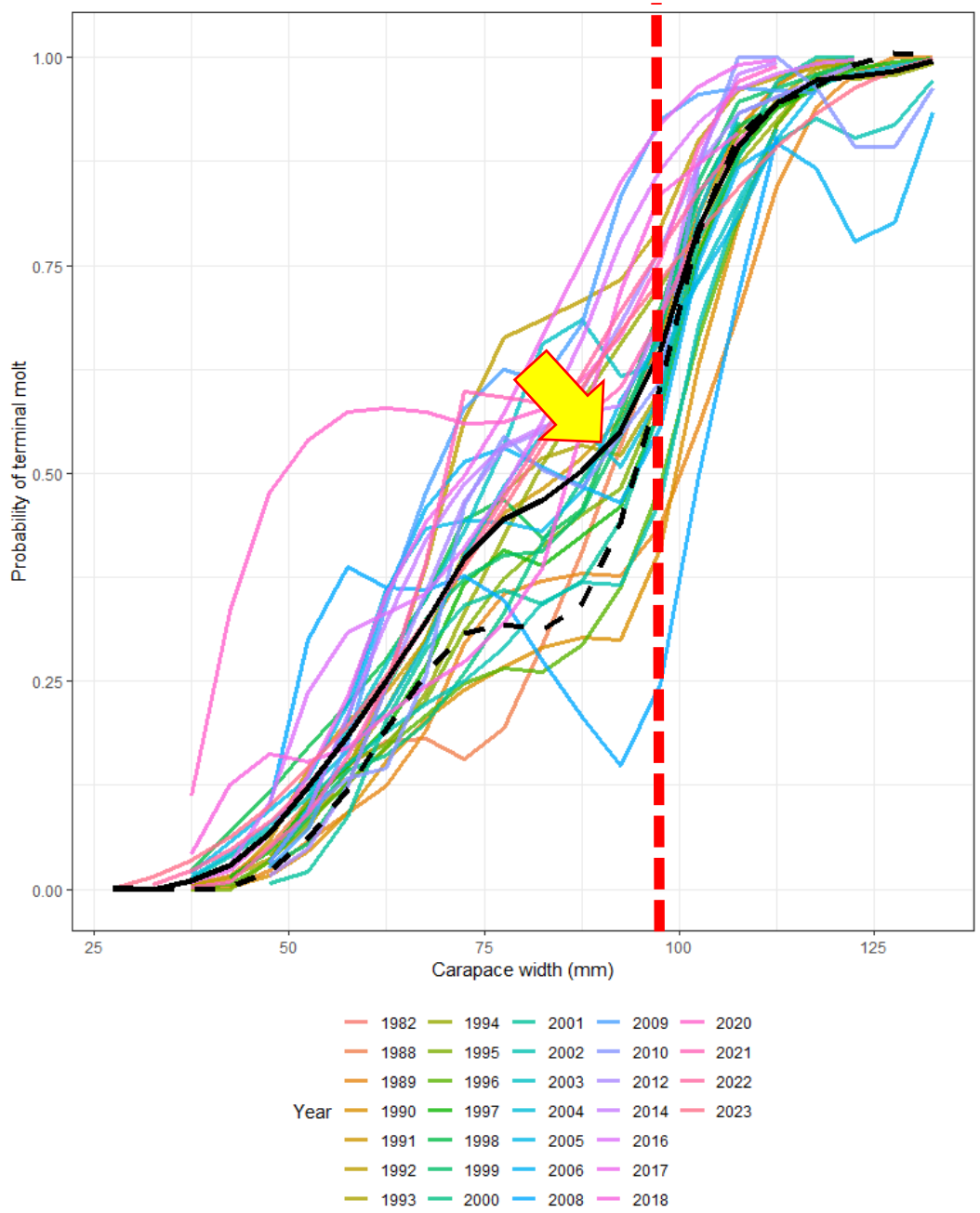
25.3a: 25.3 + reference points calculated on commercial biomass instead of morphometrically mature
25.4: 25.3 + a single specified molting probability
25.4a: 25.3 + a single specified molting probability based on alternate analyses by Kodiak
25.5: 25.4 + a stacked logistic curve for survey selectivity



Assessment variants considered:

24.1: accepted model from last year
25.1: Same data from 24.1, but updated GMACS model
25.2: 25.1 + updated catch data from 1990-present provided by ADFG
25.3: 25.2 + updated growth data from Kodiak lab

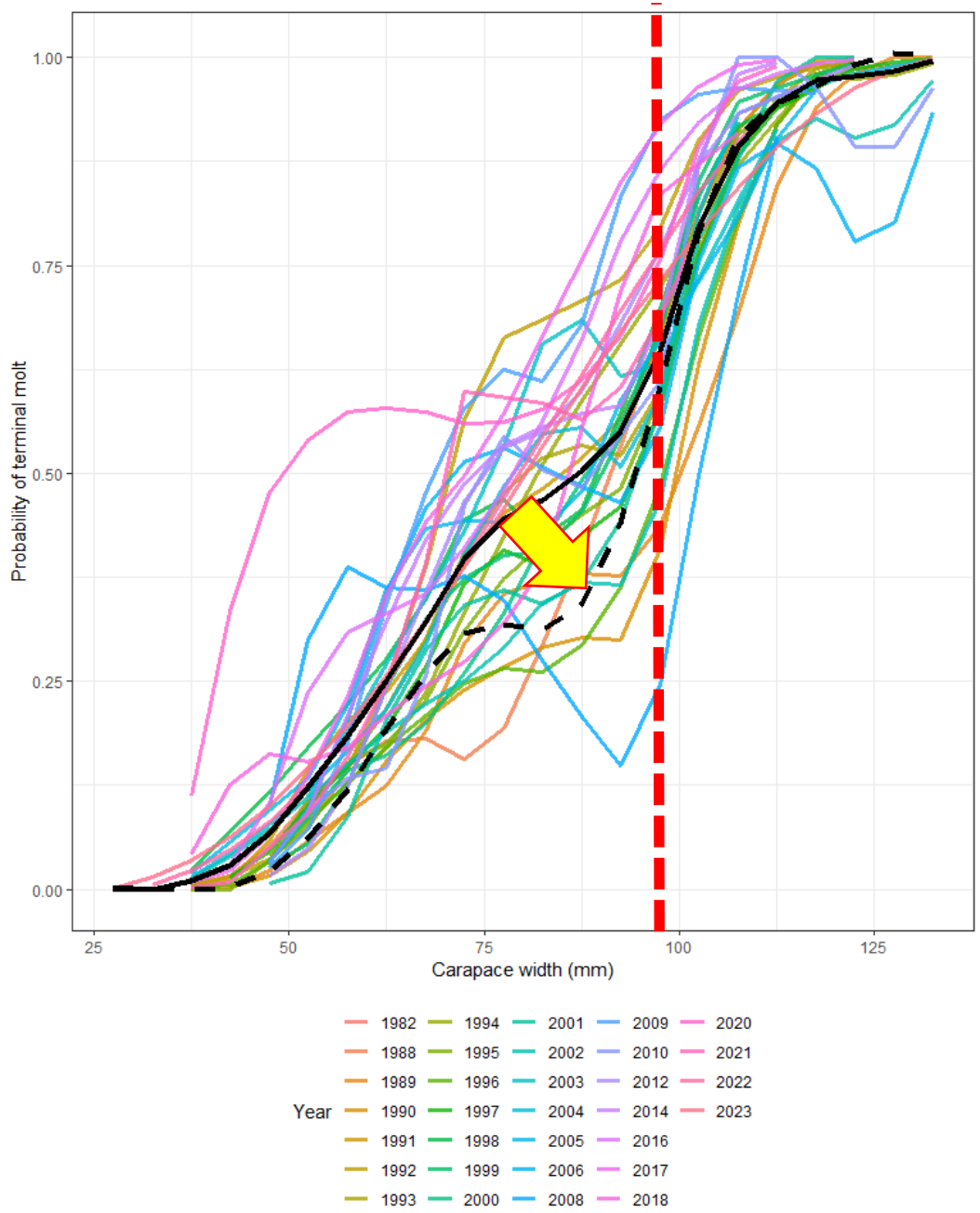
25.3a: 25.3 + reference points calculated on commercial biomass instead of morphometrically mature
25.4: 25.3 + a single specified molting probability
25.4a: 25.3 + a single specified molting probability based on alternate analyses by Kodiak
25.5: 25.4 + a stacked logistic curve for survey selectivity



Assessment variants considered:

24.1: accepted model from last year
25.1: Same data from 24.1, but updated GMACS model
25.2: 25.1 + updated catch data from 1990-present provided by ADFG
25.3: 25.2 + updated growth data from Kodiak lab

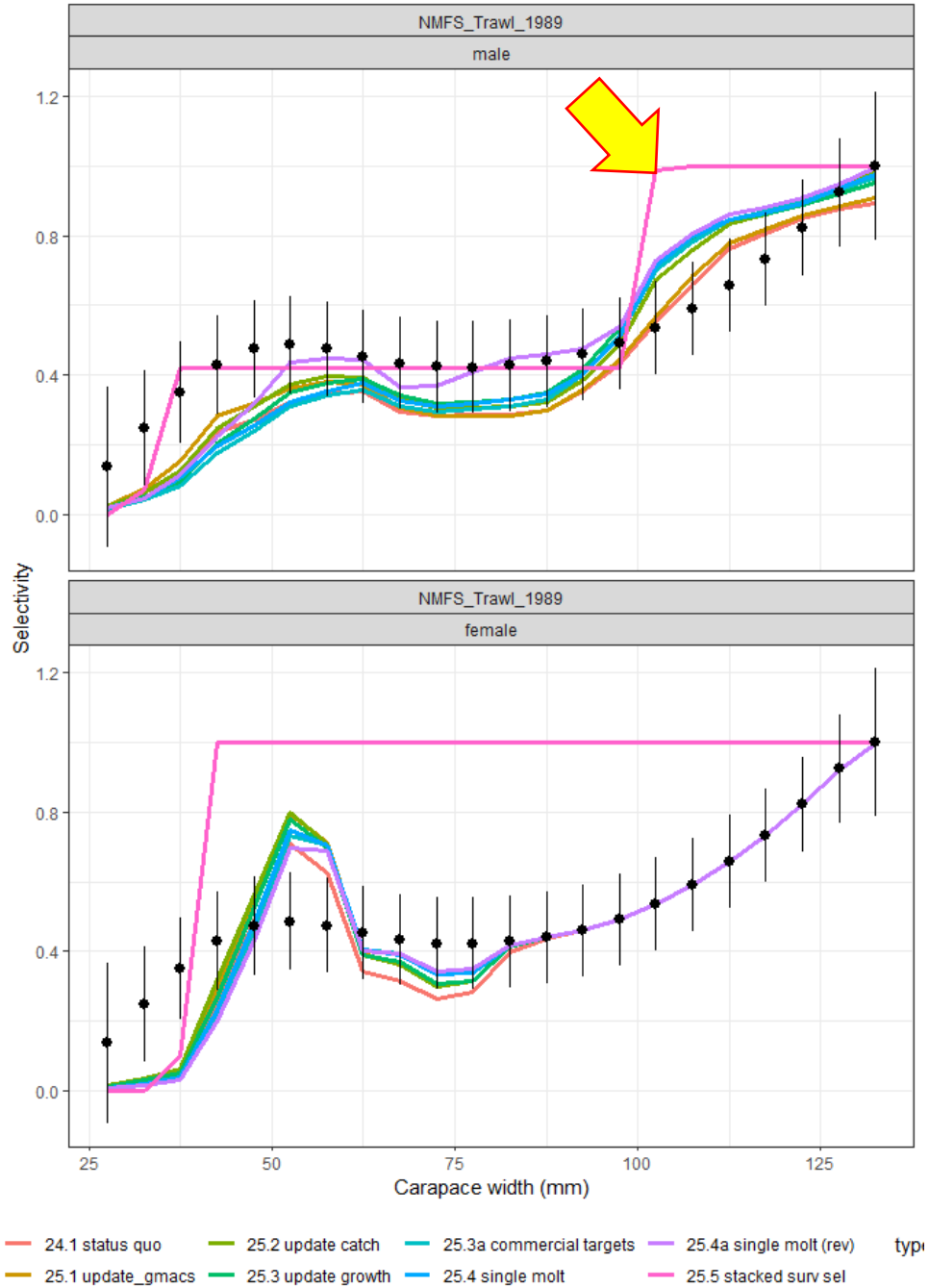
25.3a: 25.3 + reference points calculated on commercial biomass instead of morphometrically mature
25.4: 25.3 + a single specified molting probability
25.4a: 25.3 + a single specified molting probability based on alternate analyses by Kodiak
25.5: 25.4 + a stacked logistic curve for survey selectivity



Assessment variants considered:

24.1: accepted model from last year
25.1: Same data from 24.1, but updated GMACS model
25.2: 25.1 + updated catch data from 1990-present provided by ADFG
25.3: 25.2 + updated growth data from Kodiak lab

25.3a: 25.3 + reference points calculated on commercial biomass instead of morphometrically mature
25.4: 25.3 + a single specified molting probability
25.4a: 25.3 + a single specified molting probability based on alternate analyses by Kodiak
25.5: 25.4 + a stacked logistic curve for survey selectivity

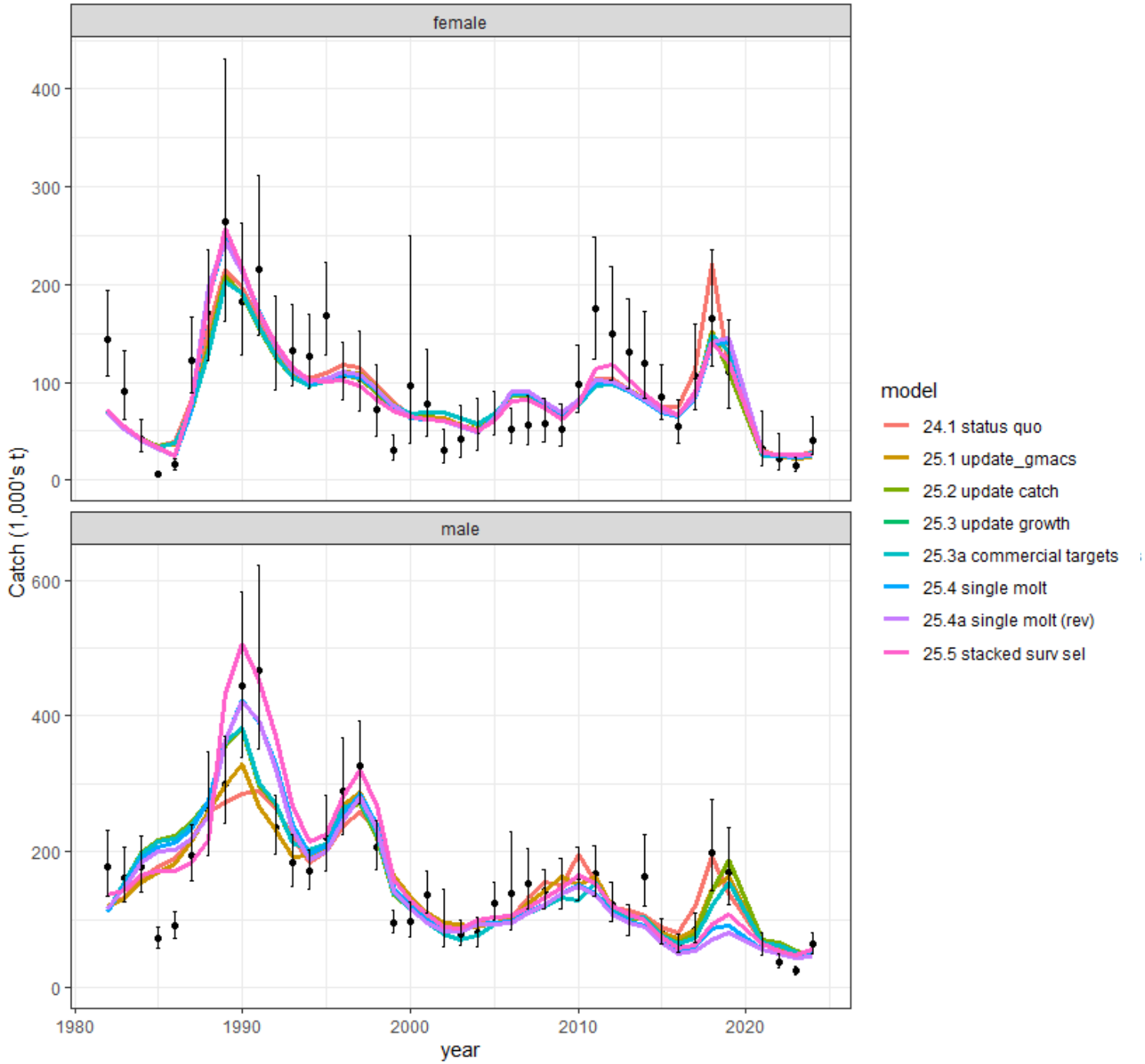


Note on posted SAFE

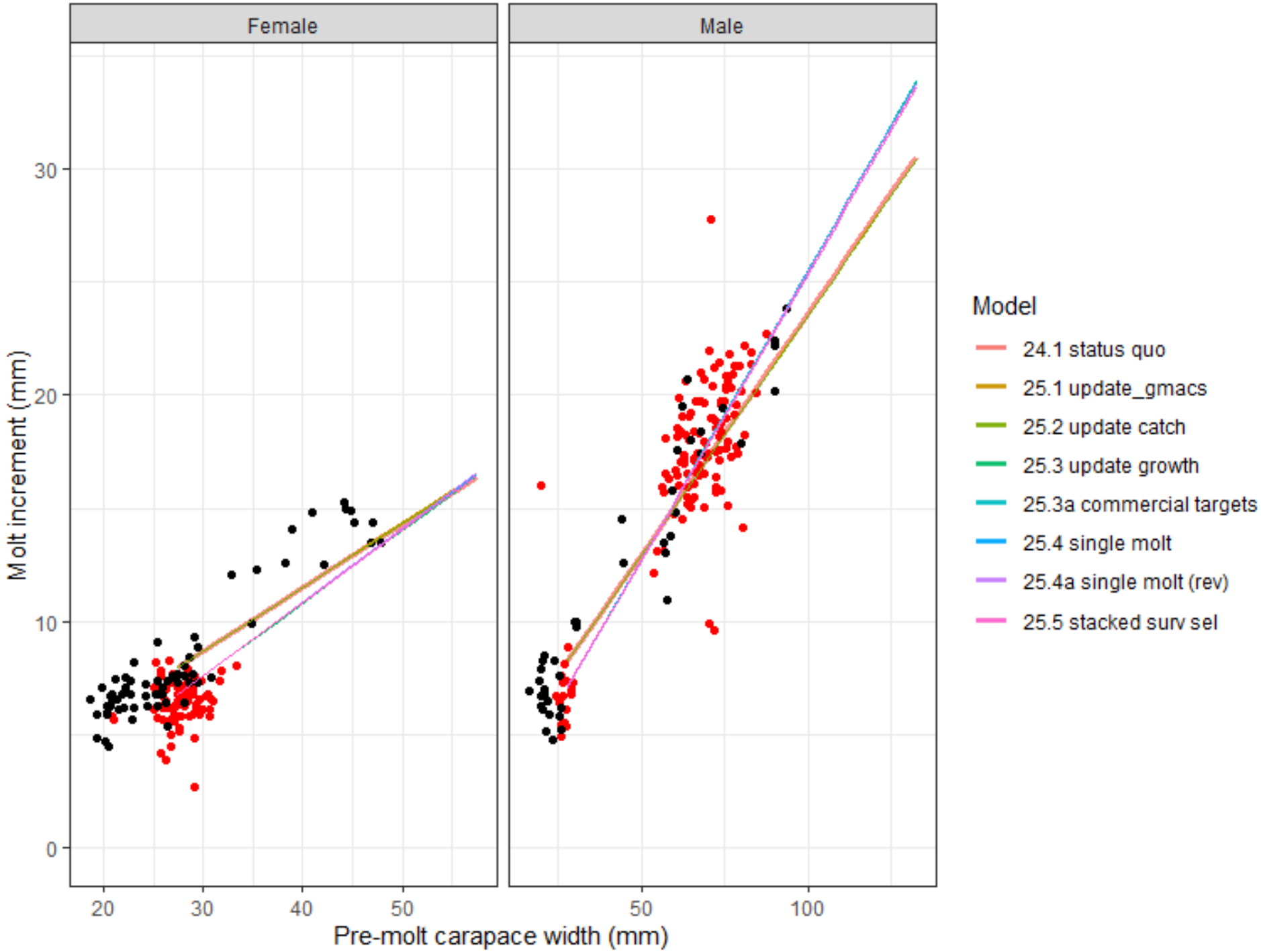
- 25.3 and 25.3a should have been identical
- The ones in the document were not
- I fiddled with 25.3 to try to get it to converge (unsuccessfully), but did not do the same fiddles to 25.3a

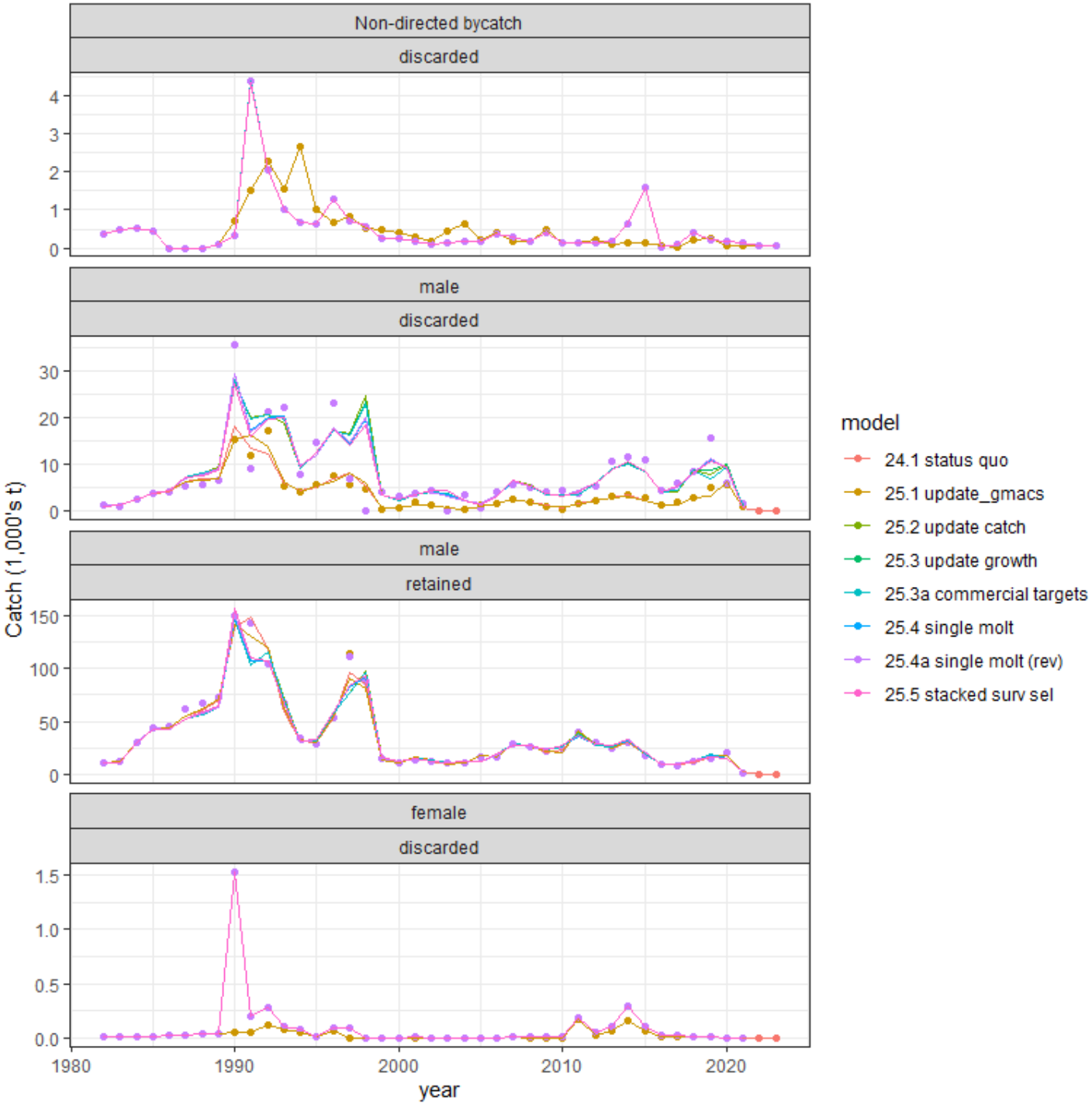
Assessment variants considered:

24.1: accepted model from last year
25.1: Same data from 24.1, but updated GMACS model
25.2: 25.1 + updated catch data from 1990-present provided by ADFG
25.3: 25.2 + updated growth data from Kodiak lab
25.3a: 25.3 + reference points calculated on commercial biomass instead of morphometrically mature
25.4: 25.3 + a single specified molting probability
25.4a: 25.3 + a single specified molting probability based on alternate analyses by Kodiak
25.5: 25.4 + a stacked logistic curve for survey selectivity

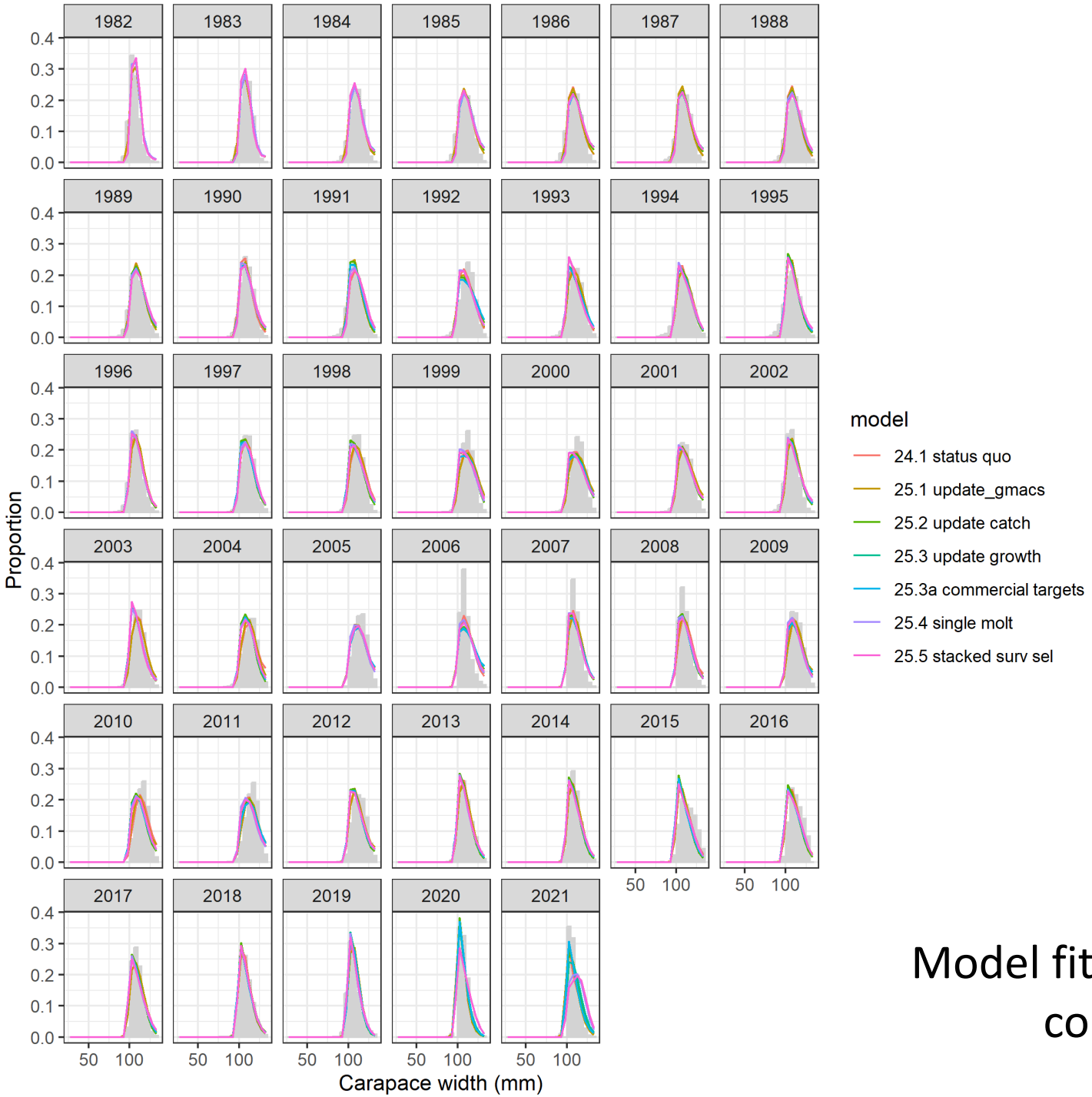


- Changes in timing of mortality during 2018-19 heatwave
- Stacked logistic fits the early period better for males, but misses the 2018 run up
- Single molting probability models also miss the 2018 run up

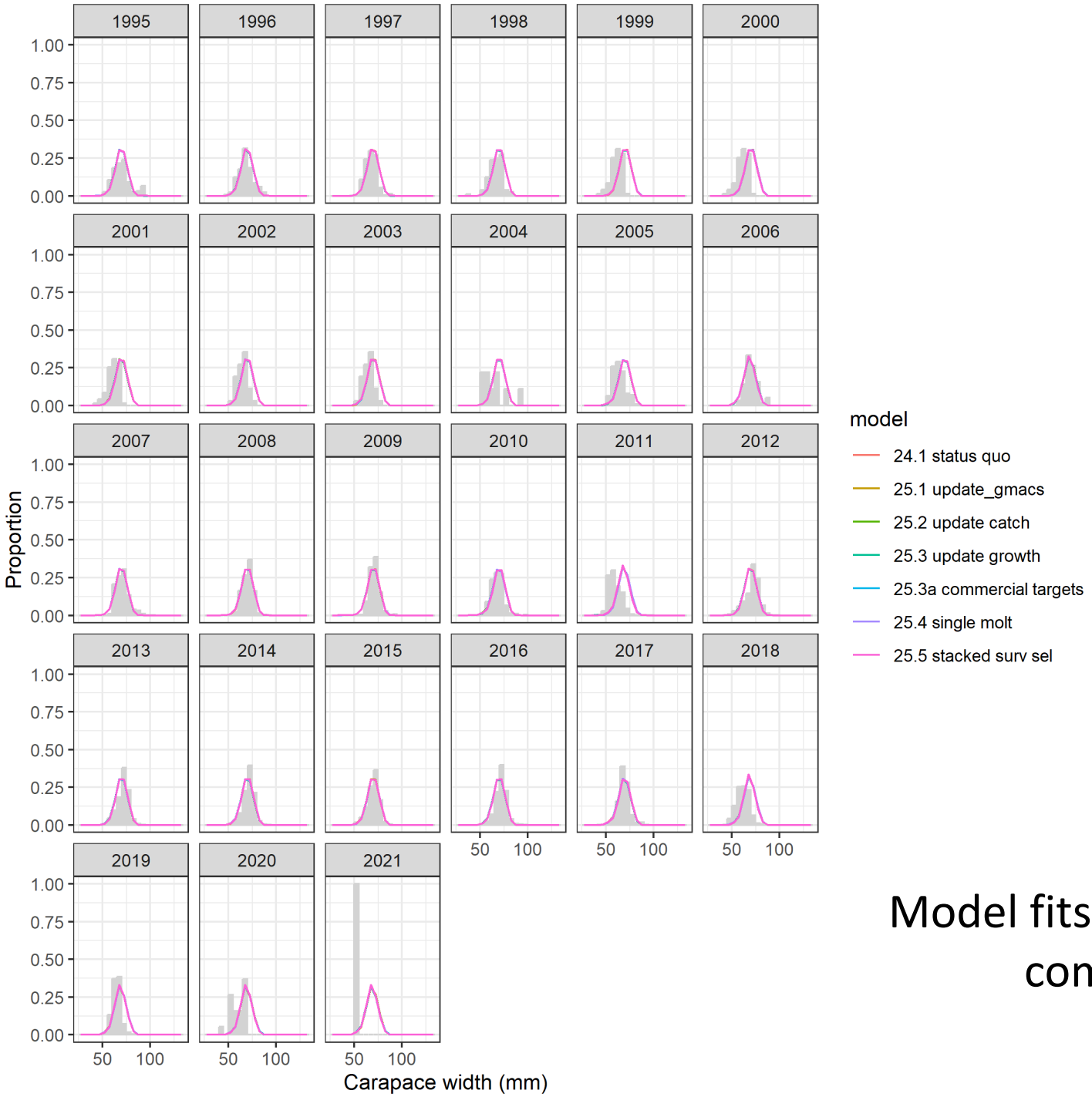

Female
Male
Molt increment (mm)
0
10
20
30
20
30
40
50
50
100
Pre-molt carapace width (mm)
Model
24.1 status quo
25.1 update_gmacs
25.2 update catch
25.3 update growth
25.3a commercial targets
25.4 single molt
25.4a single molt (rev)
25.5 stacked surv sel



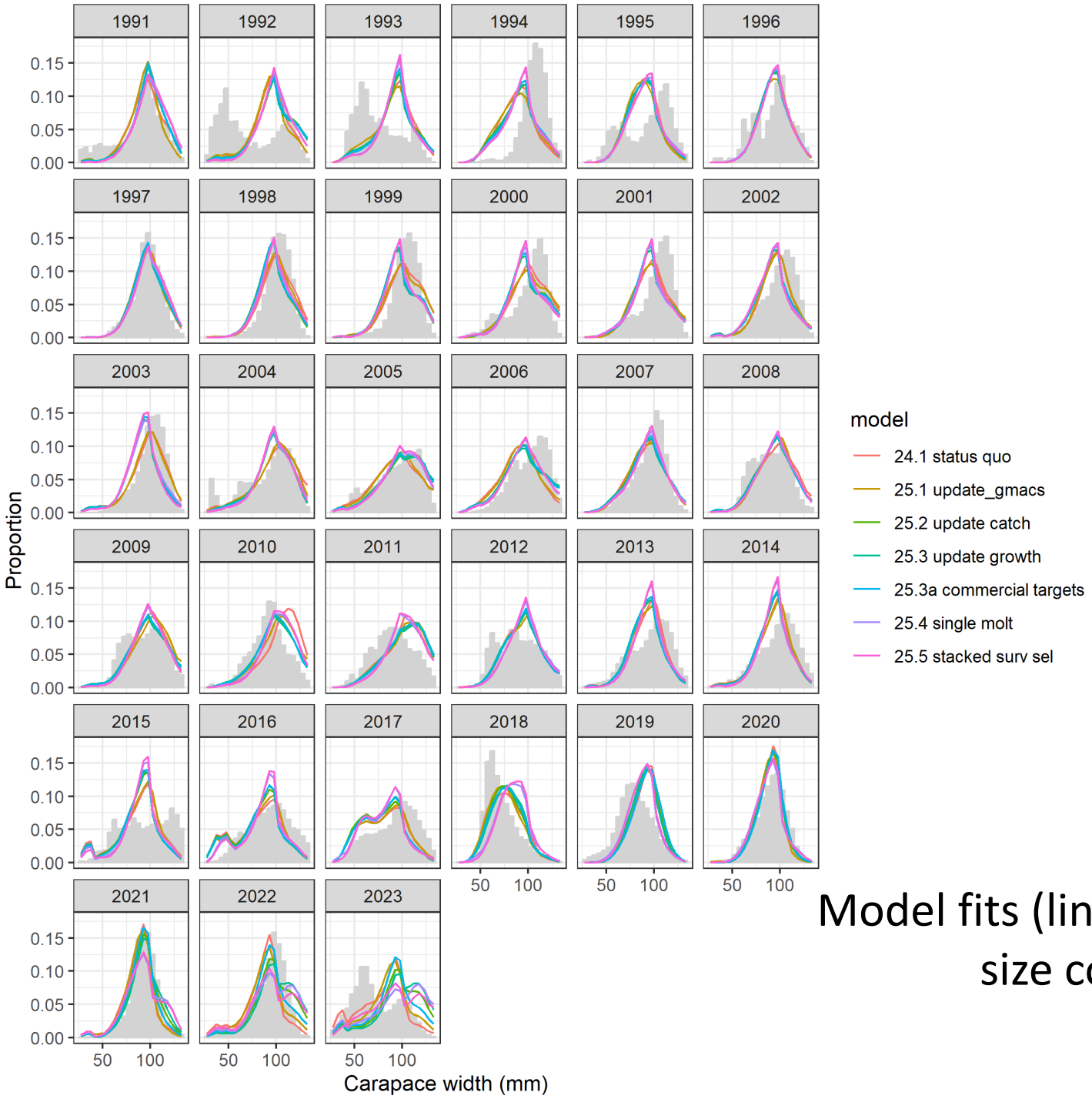
- Predictions for updated discard data did not fit as well



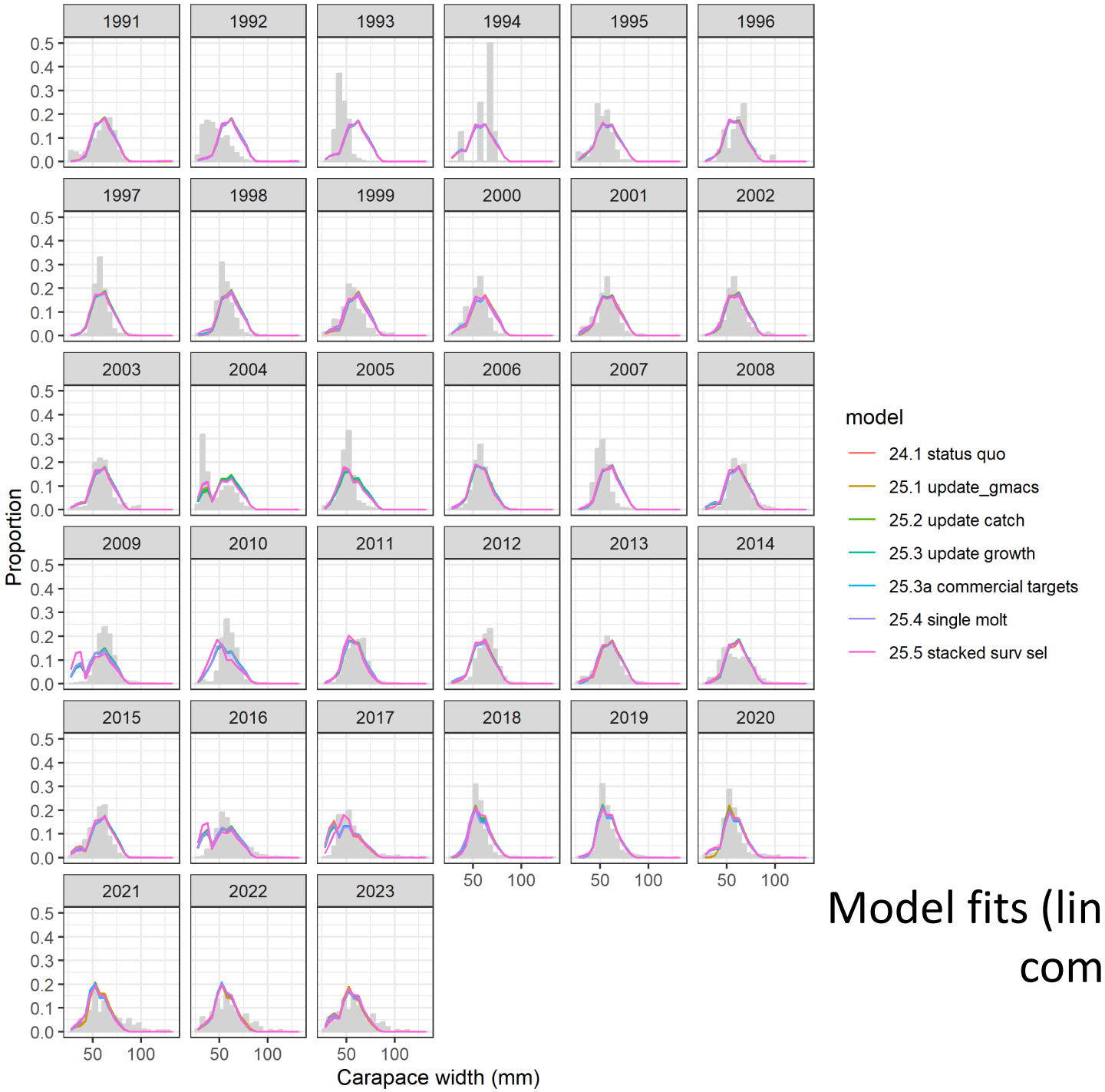
Model fits (lines) to the retained catch size composition data (grey bars).



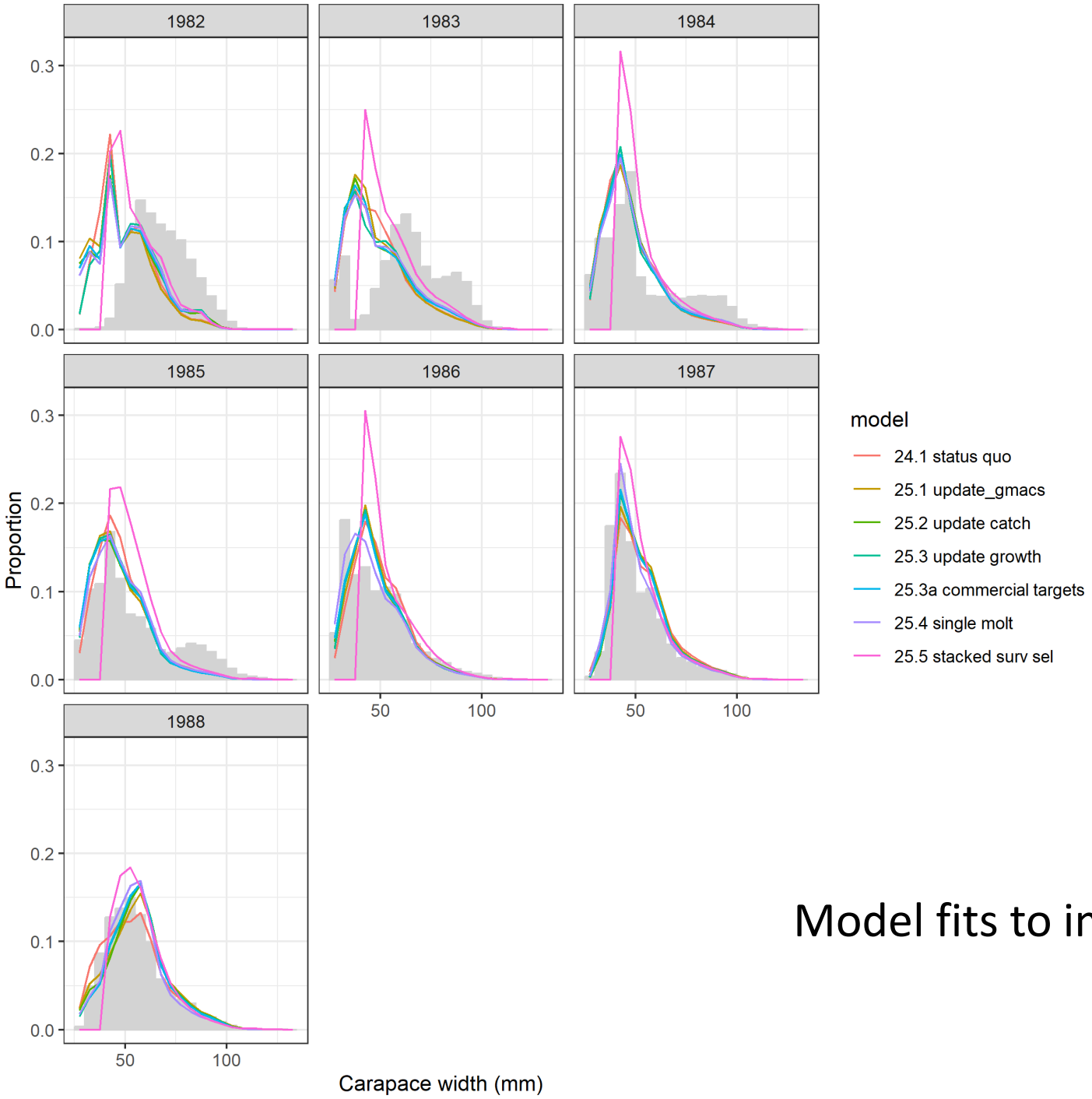
Model fits (lines) to the female discard size composition data (grey bars).



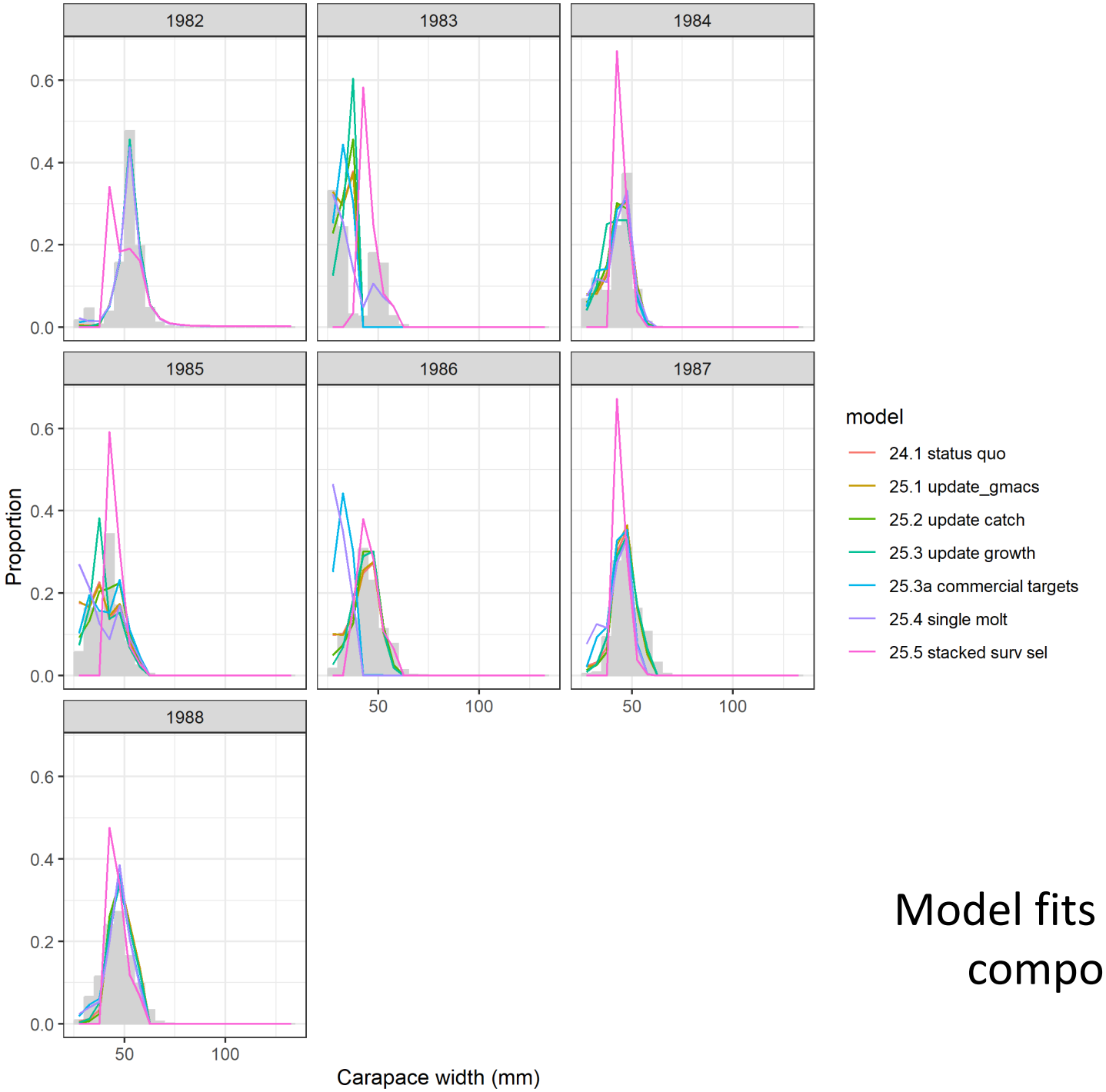
Model fits (lines) to the male non-directed fishery size composition data (grey bars).



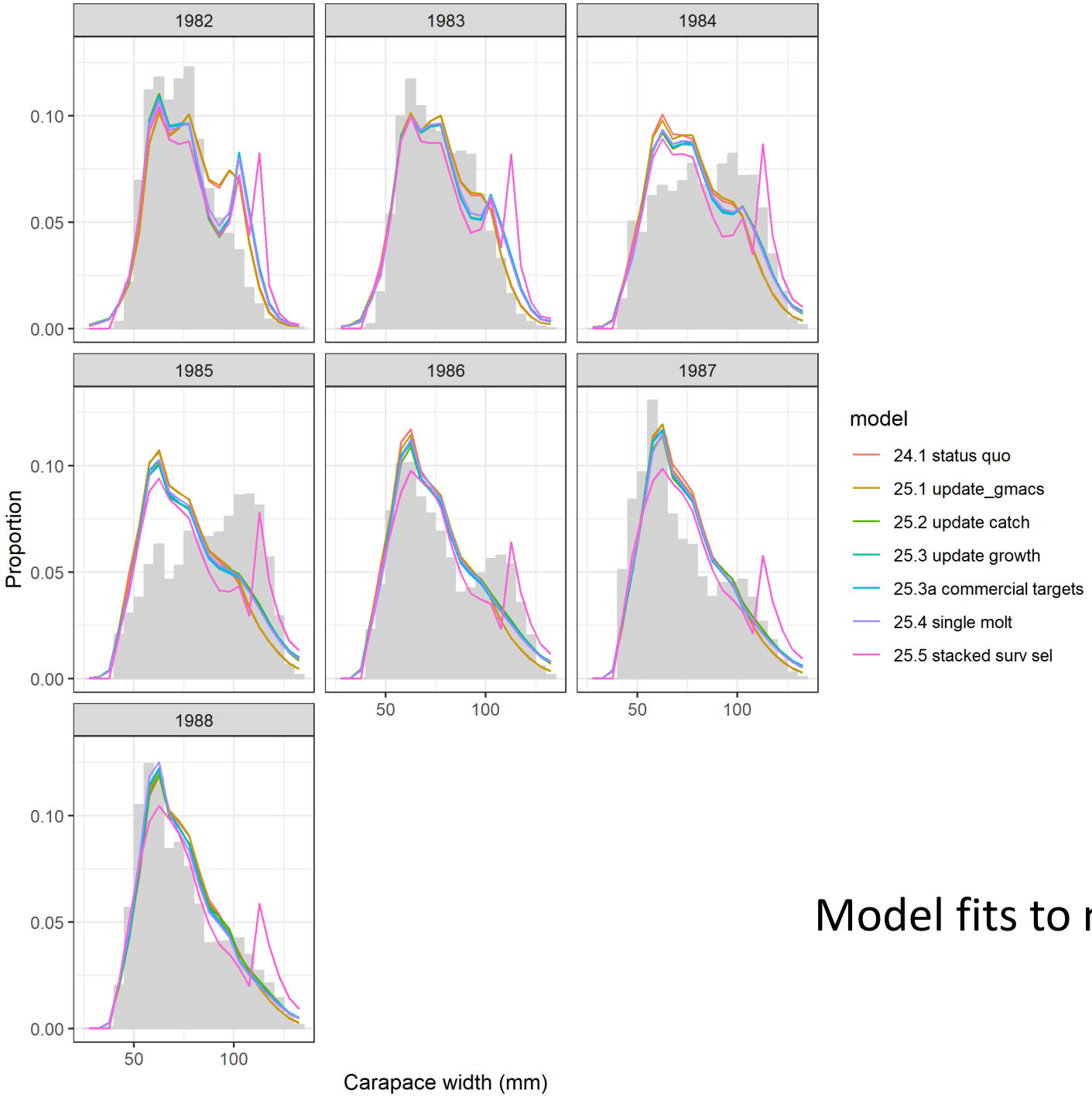
Model fits (lines) to the female non-directed size composition data (grey bars).



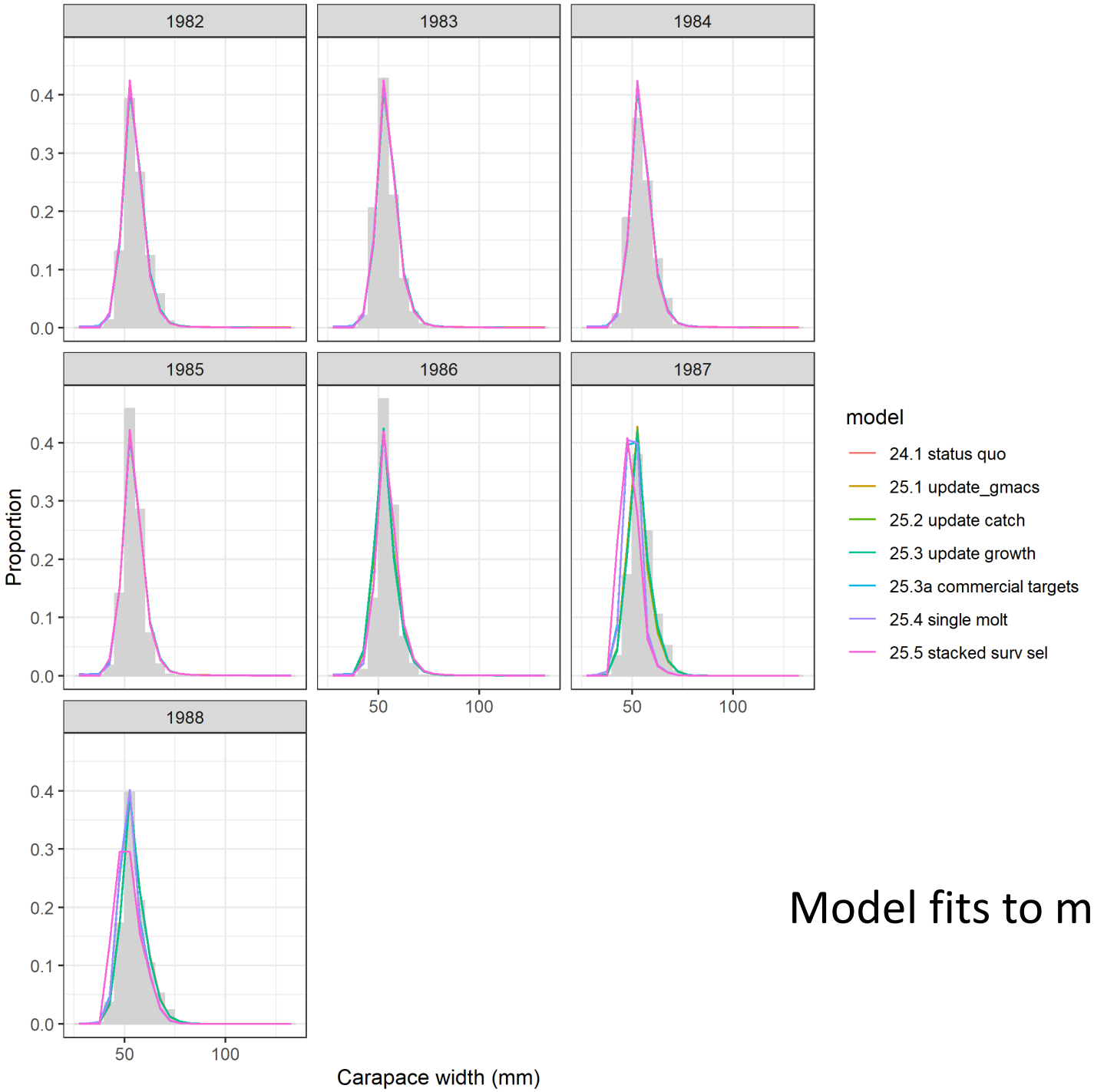
Model fits to immature male survey size composition data from 1982-1988.



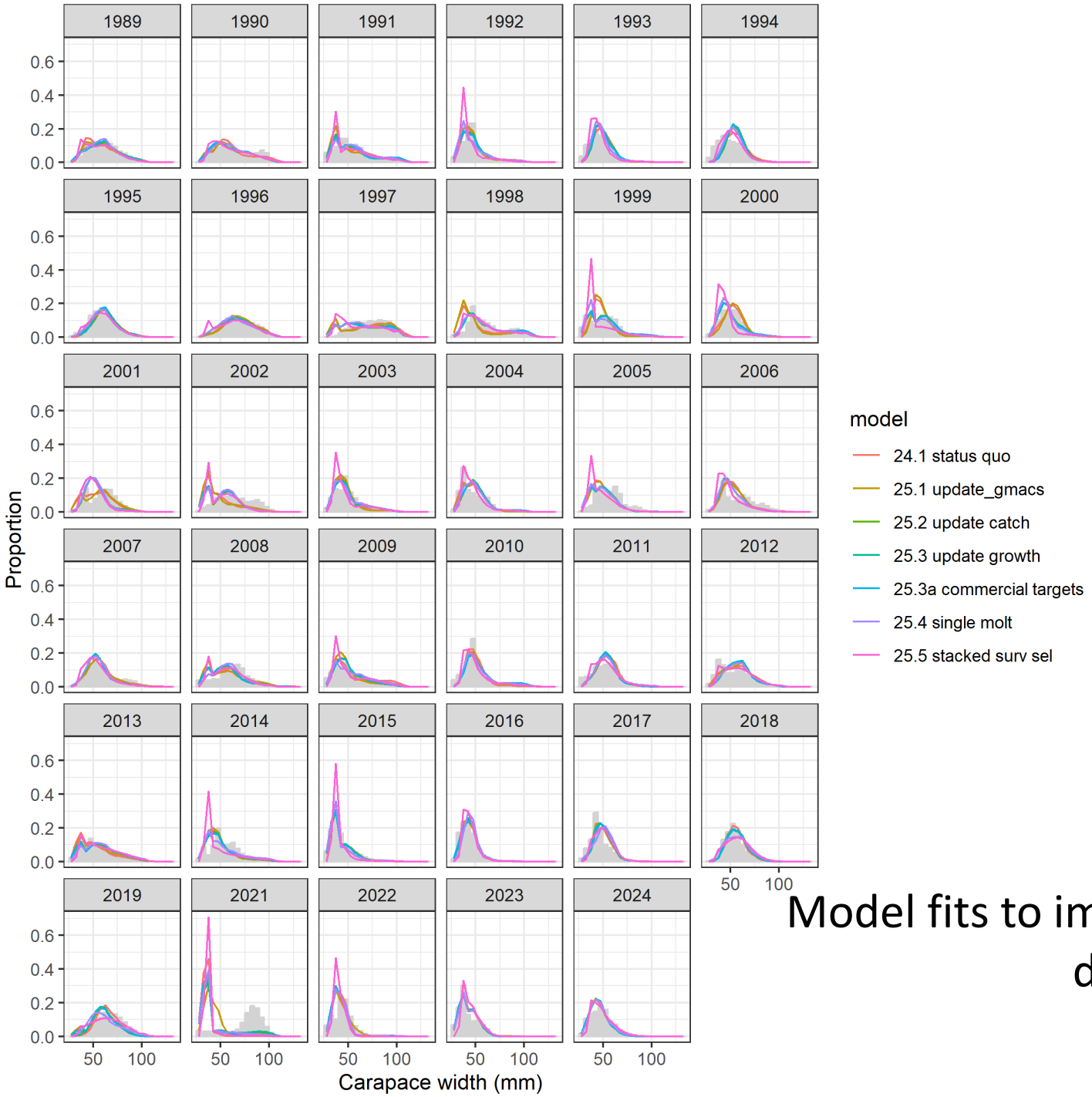
Model fits to immature female survey size composition data from 1982-1988.



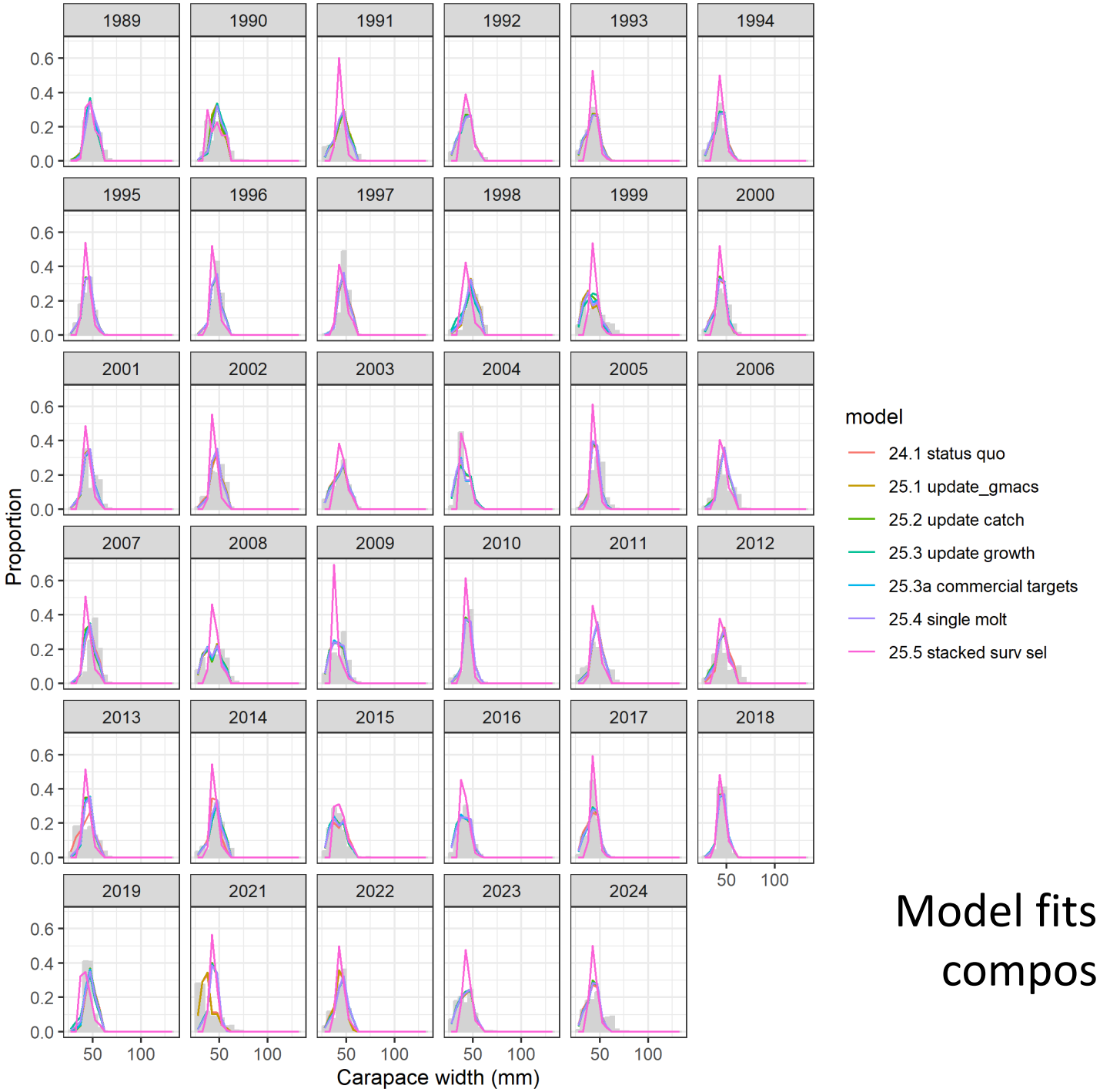
Model fits to mature male survey size composition data from 1982-1988.



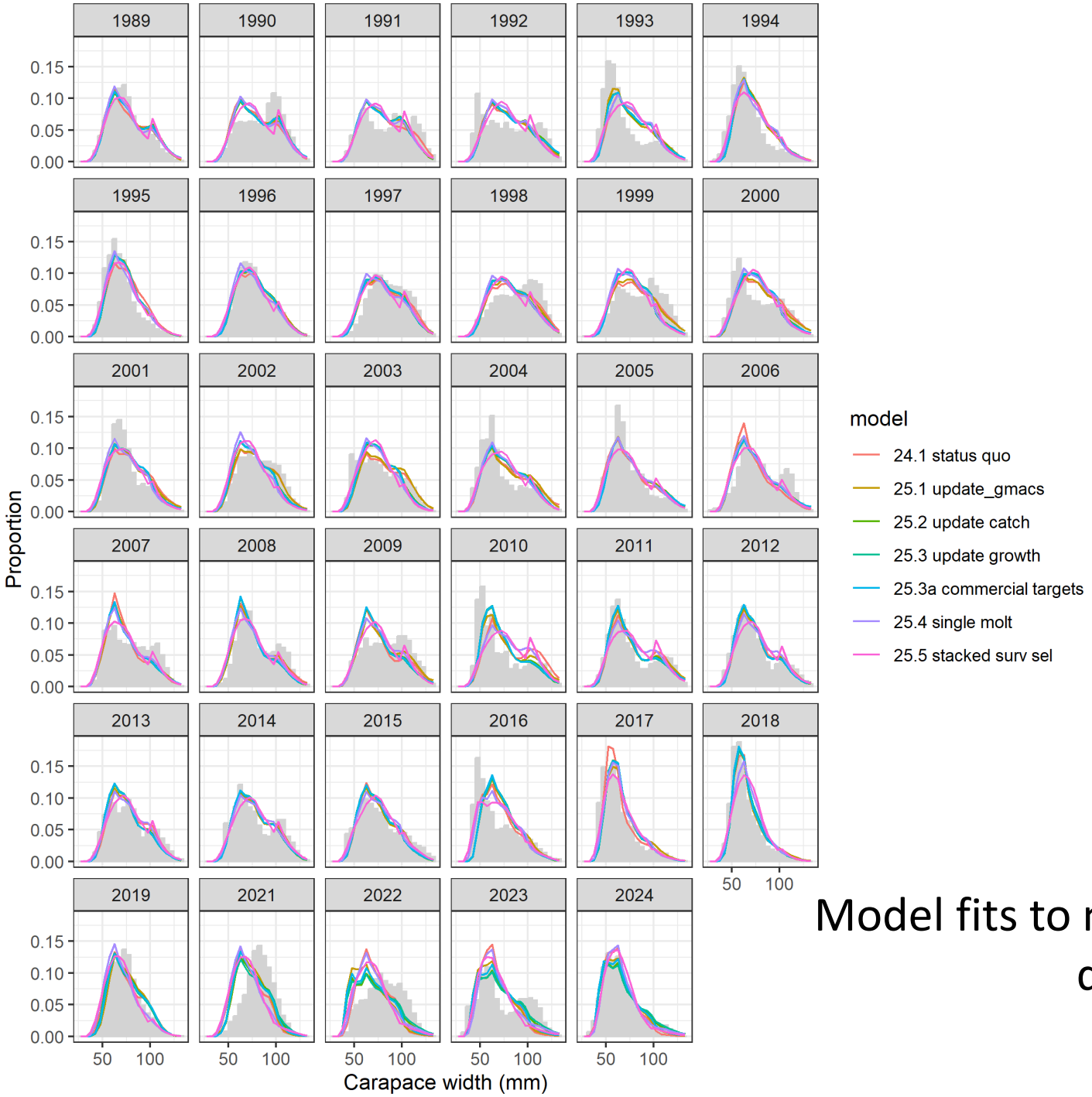
Model fits to mature female survey size composition data from 1982-1988.



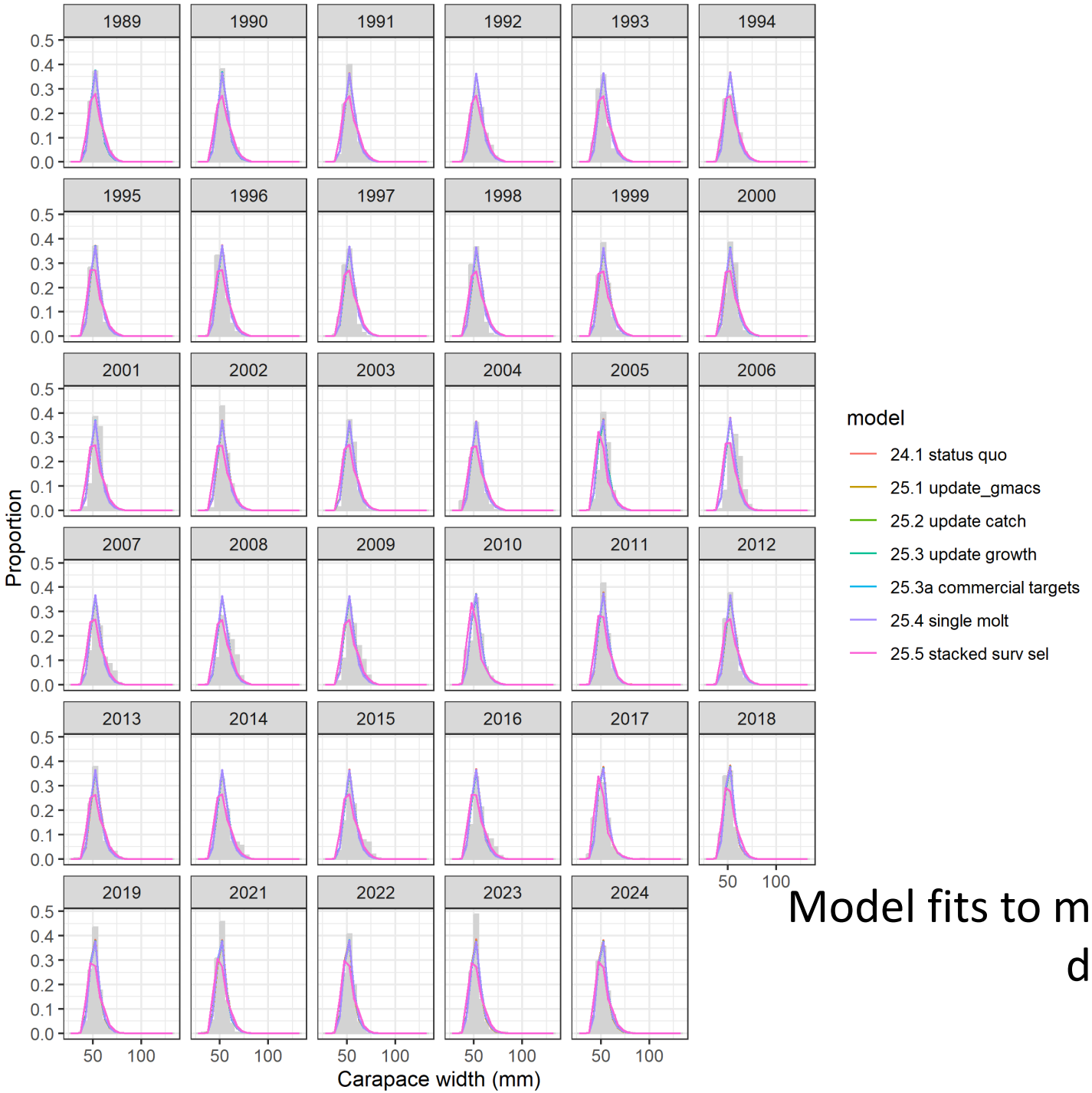
Model fits to immature male survey size composition data from 1989-present.



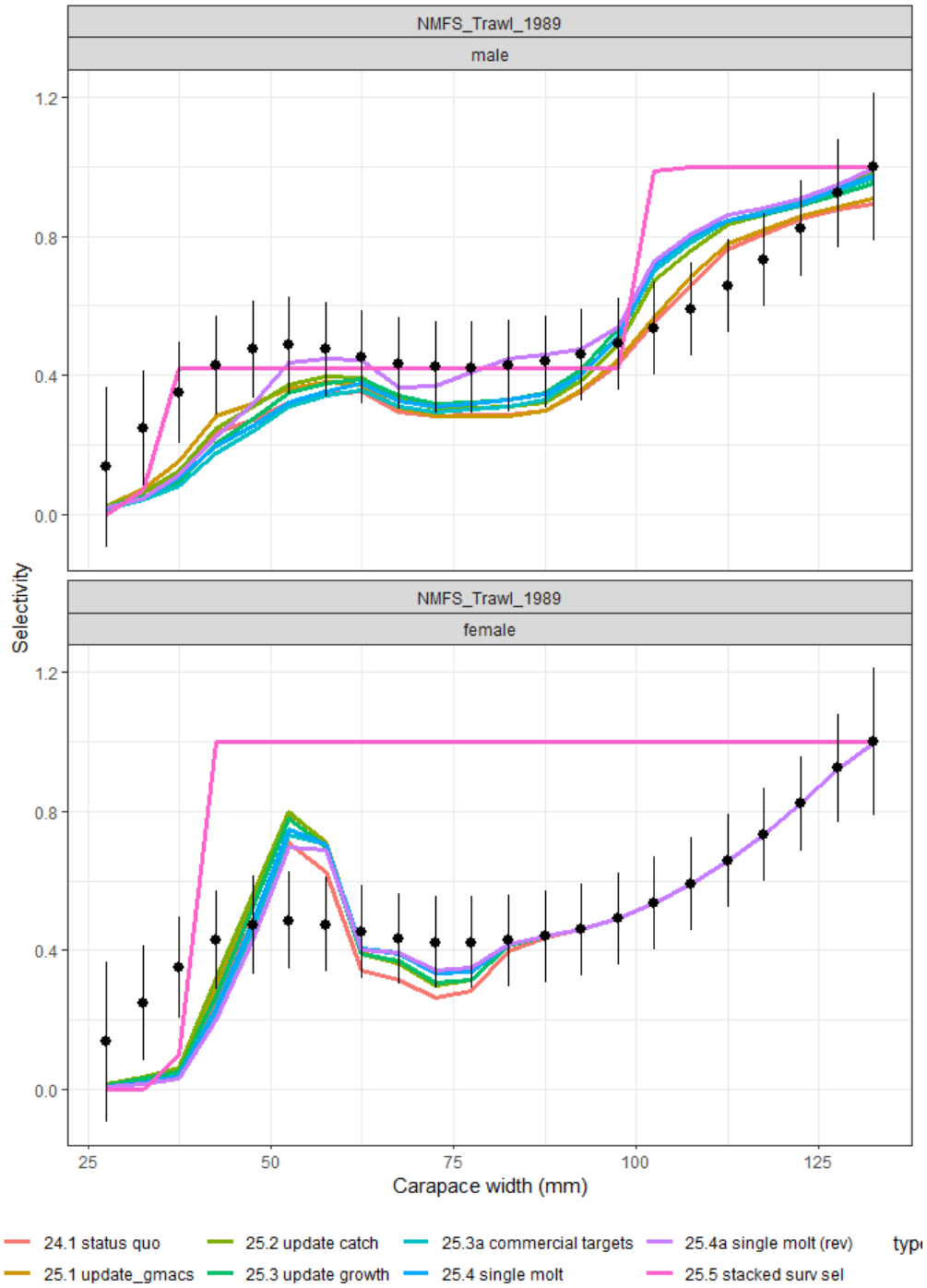
Model fits to immature female survey size composition data from 1989-present.



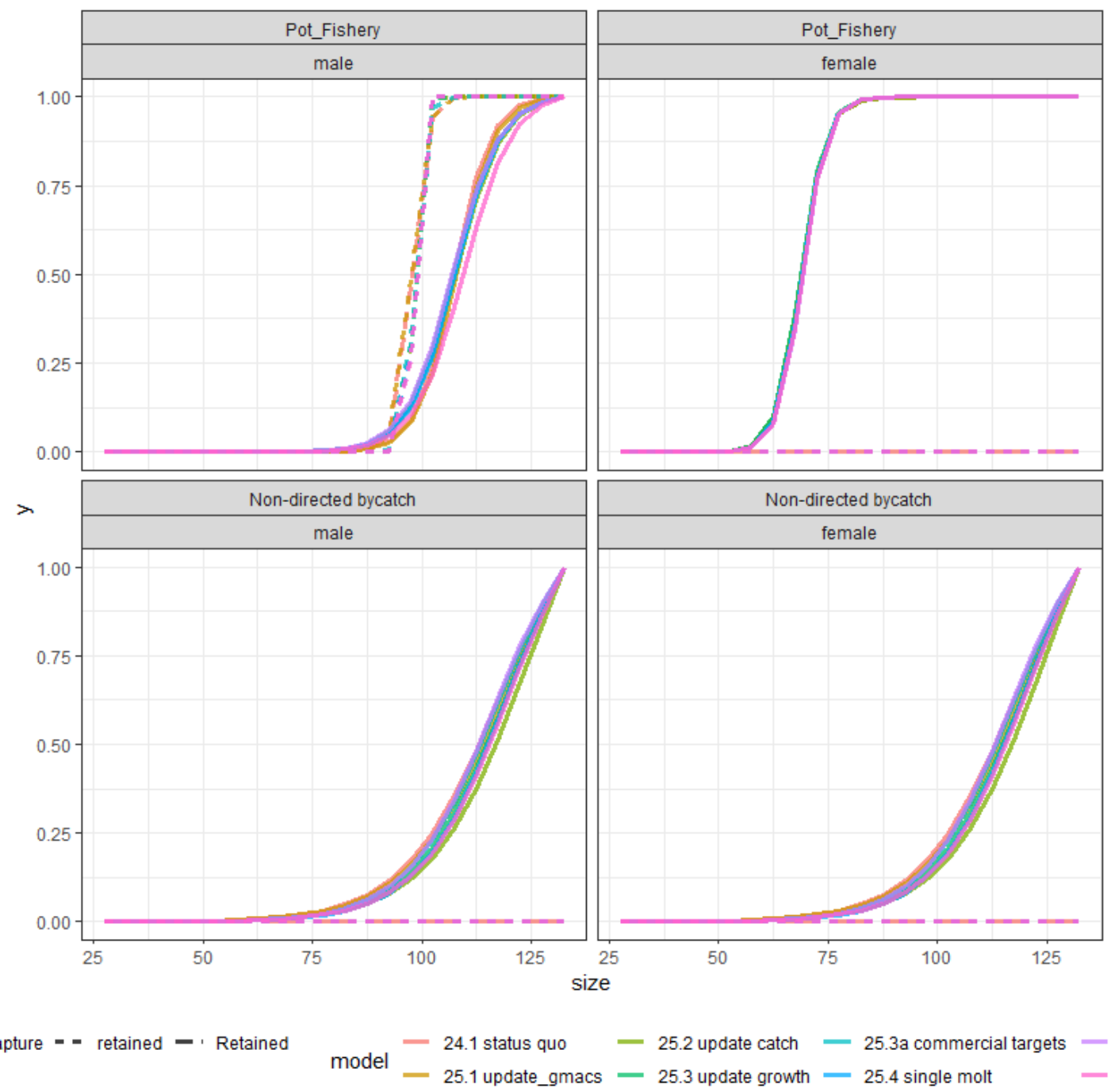
Model fits to mature male survey size composition data from 1989-present.



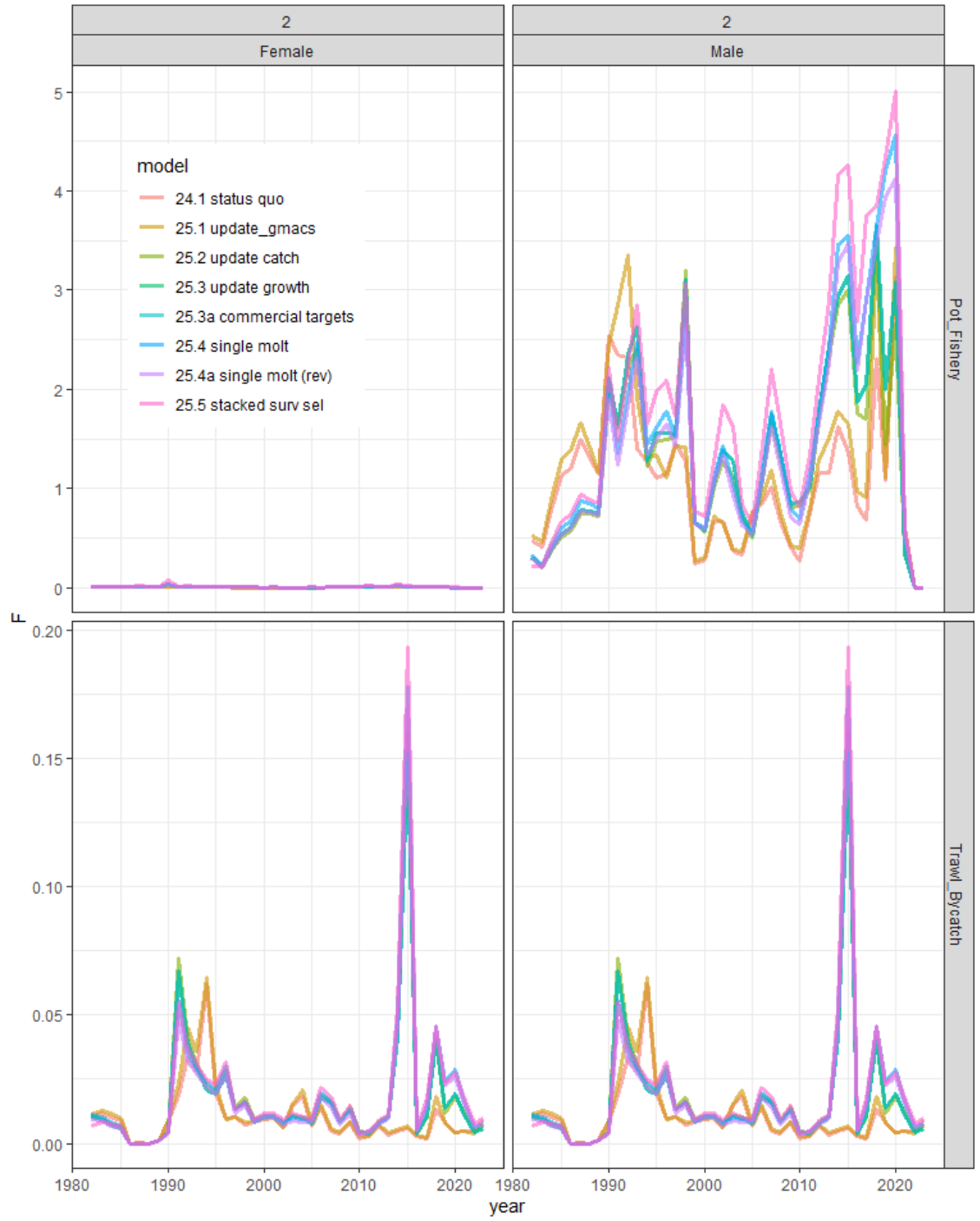
Model fits to mature female survey size composition data from 1989-present.



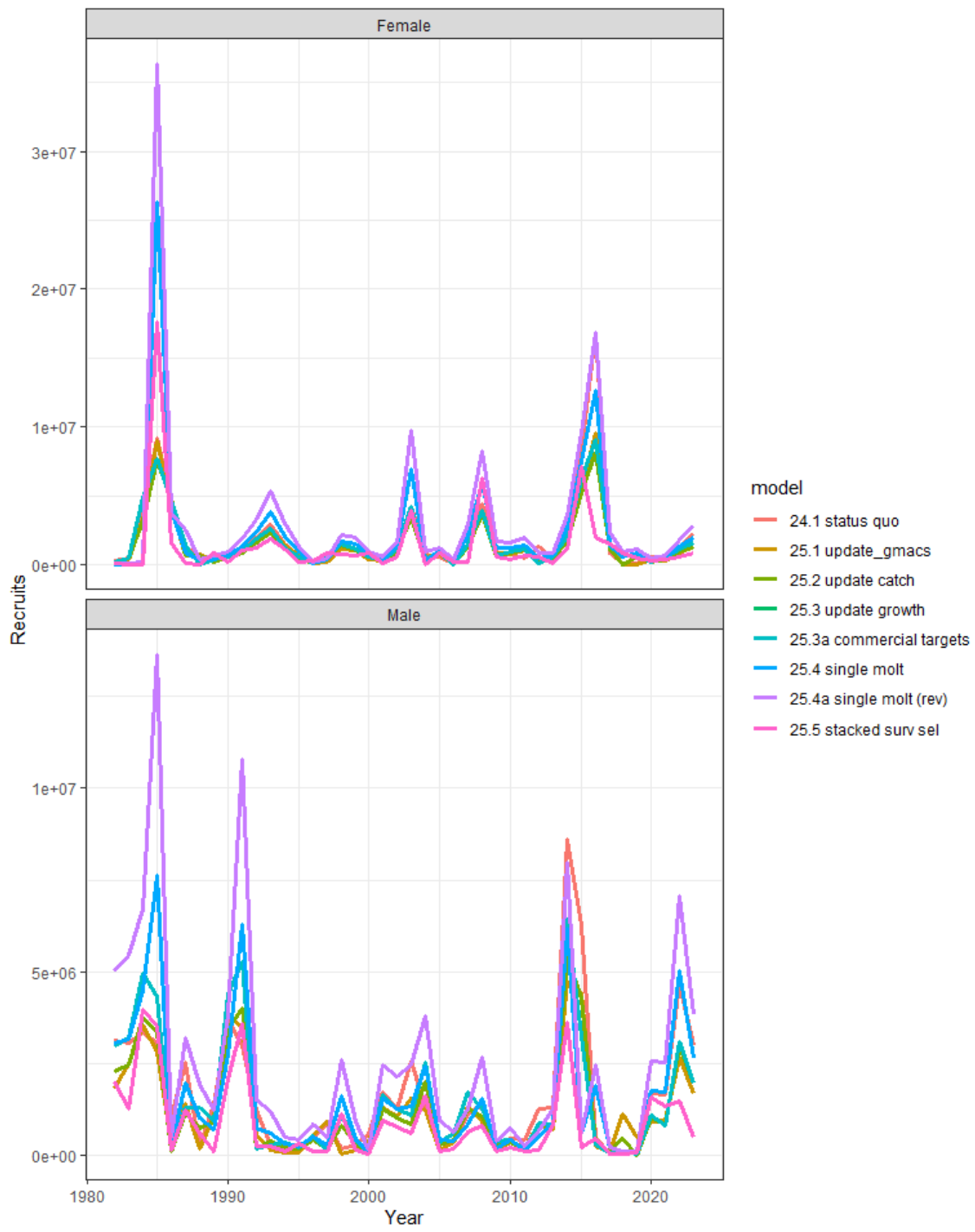
Estimated survey selectivity (lines) with normal priors derived from BSFRF selectivity experiment data. Points are the mean of the prior at a given size; intervals are 95th quantiles based on input CVs. Model 25.5 not estimated with priors.



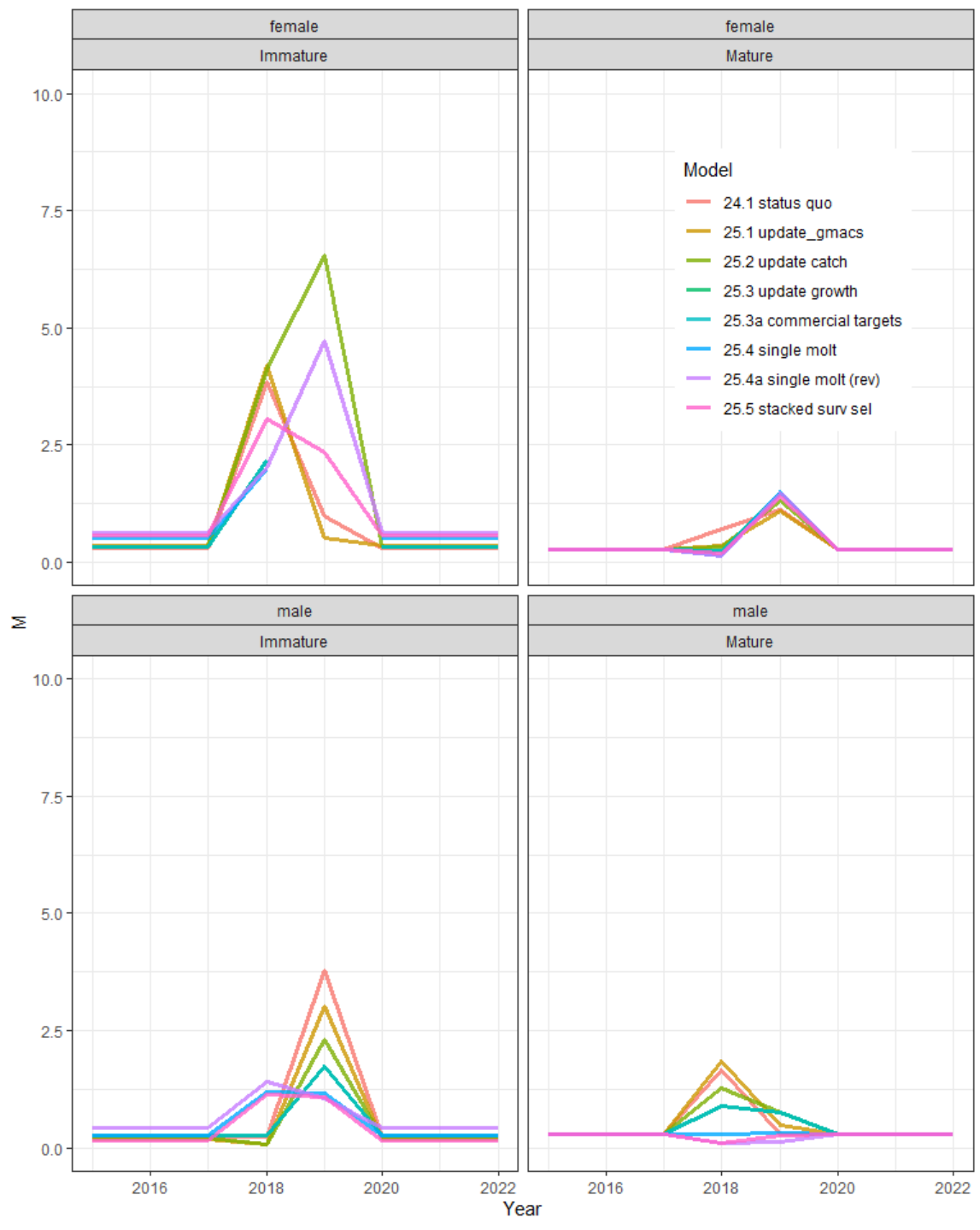
Estimated selectivities by fishing fleet and sex for capture and retained catches.



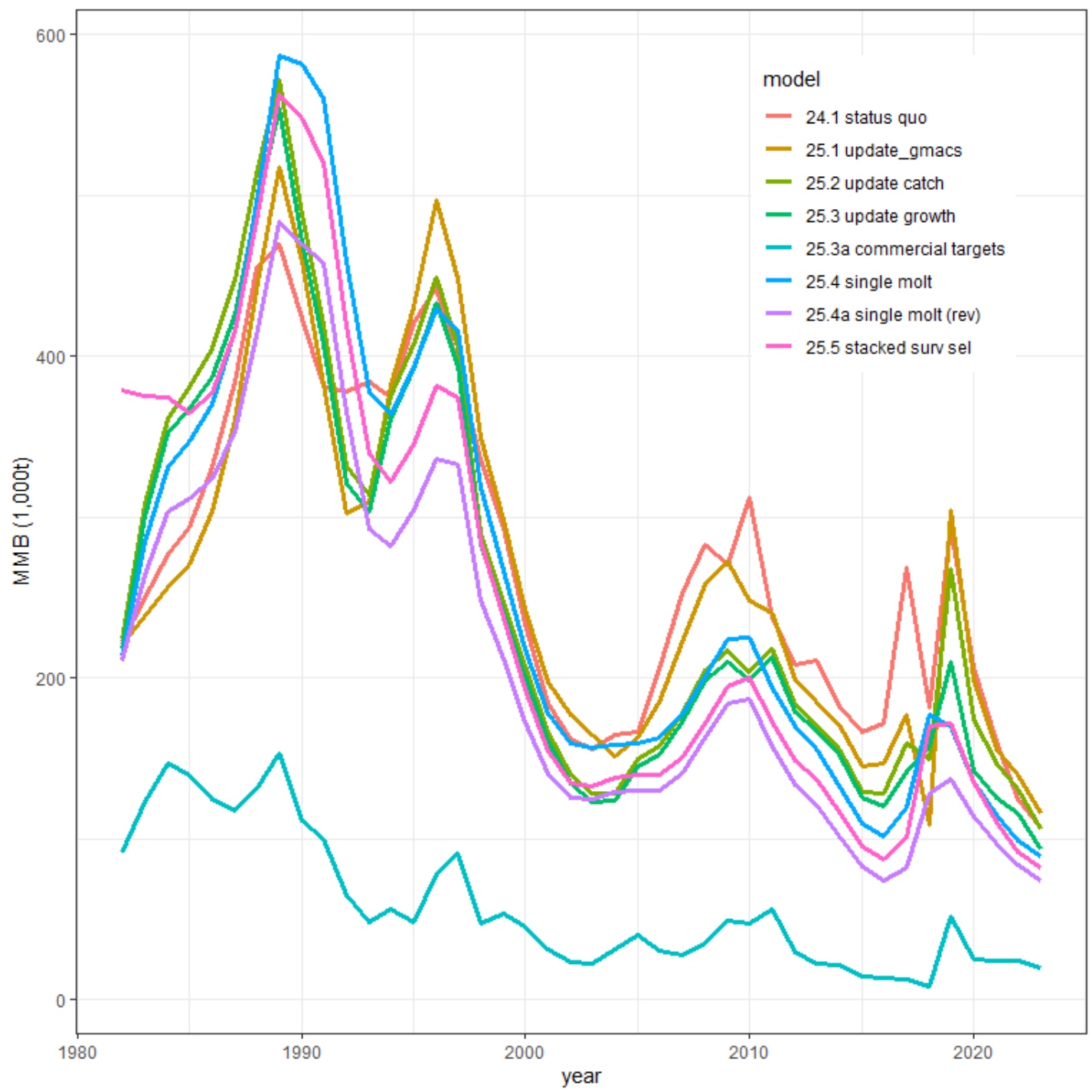
Estimated fishing mortalities for the directed and non-directed fisheries.



Estimated recruitment by sex (bottom) and portions recruiting to length bin (top) by model.



Estimated natural mortality by sex and maturity state. Natural mortality in all years previous to 2018 and after 2019 are equal to the estimated M in 2017.



Model predicted mature male biomass at mating time in 1,000 tonnes.

	BMSY	Bcurr/BMSY	OFL(tot)	Fmsy	Fofl
24.1 Status quo	191.81	0.56	19.60	49.63	25.07
25.1 update_gmacs	173.74	0.54	21.97	38.37	18.90
25.2 update catch	158.37	0.49	20.76	49.46	21.38
25.3 update growth	143.24	0.45	20.20	54.12	20.97
25.4 single molt	157.14	0.52	19.00	62.78	29.07
25.5 stacked surv sel	141.96	0.59	14.14	37.32	20.21
25.3a commercial targets	79.43	0.20	0.23	0.80	0.00
25.4a single molt (rev)	131.02	0.49	14.44	18.58	8.08

25.3 update growth: retained portion of the OFL 15.8 kt (of 20.20 kt)

Currency of management + HCR

If the answer is “MMB”

- Reference points allow removal of all large males
- OFL will not be constraining
- We don’t need an assessment

If the answer is “Large males”

- Big can of worms
- Potential choke species at the federal level and ensuing tradeoffs
- Potential conflicts with the state rule

(the next [and harder] question is ‘how much of each do you want to keep in the water?)

Focus on most immediate problems first

- Why model females when the large males are at historical lows and we don't know why, but we're still using reference points that recommend taking them all?

Work from what has happened, not what should have happened

- We have good data and do not observe a stock recruit relationship, perhaps we should stop trying to force a square peg
- This is where we can think about what an appropriate fraction is to leave in the water based on actions taken in the past and their outcomes

Work towards providing non-conflicting management advice

- I don't know what this looks like, but it is counterproductive to have two different harvest control rules for the same stock that produce dissonant catch advice

Identify and quantify tradeoffs more effectively

- E.g. controlling non-directed bycatch vs. fishery losses

Currency of management + HCR

If the answer is “MMB”

- Reference points allow removal of all large males
- OFL will not be constraining
- We don’t need an assessment

If the answer is “Large males”

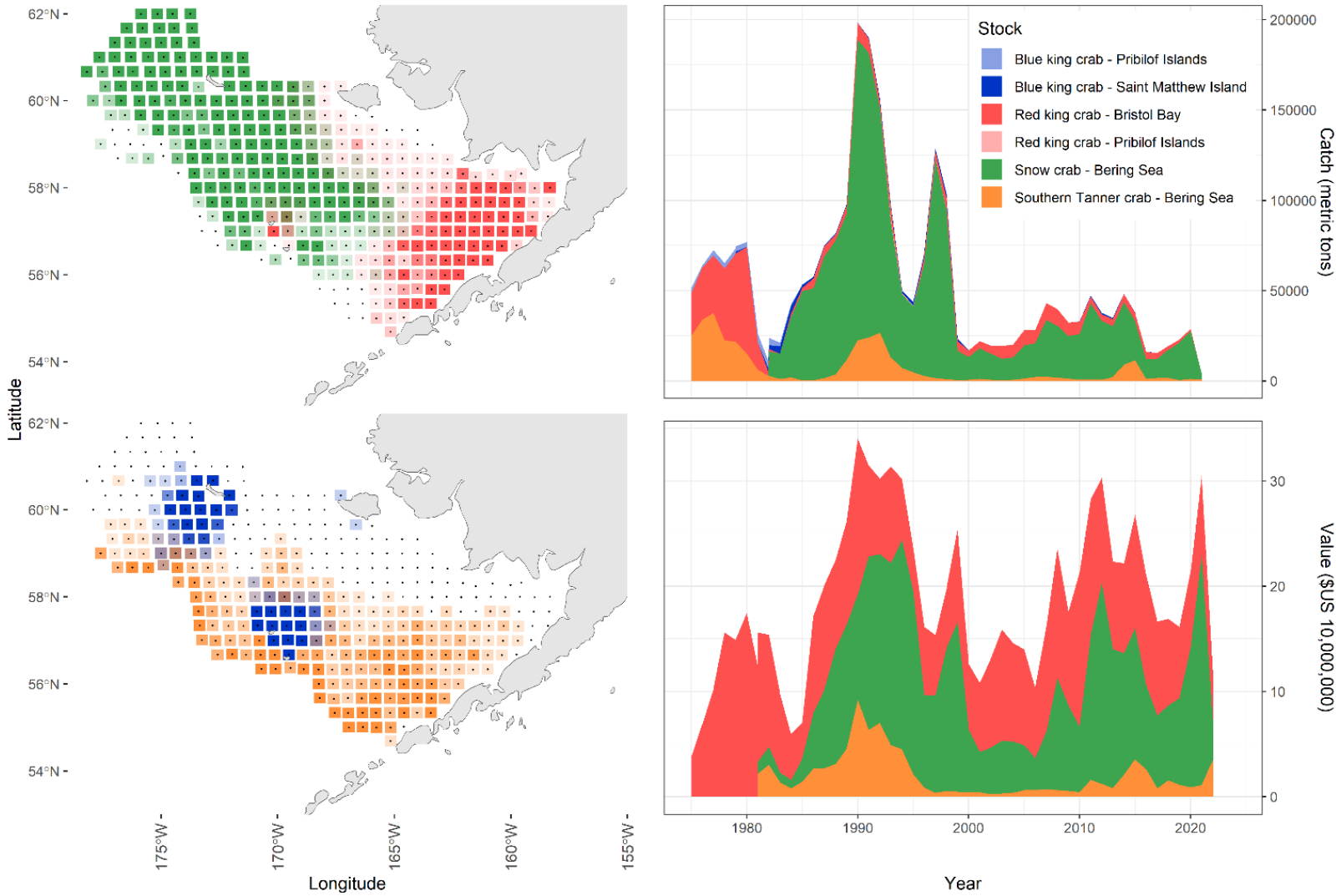
- Big can of worms
- Potential choke species at the federal level and ensuing tradeoffs
- Potential conflicts with the state rule

(the next [and harder] question is ‘how much of each do you want to keep in the water?)

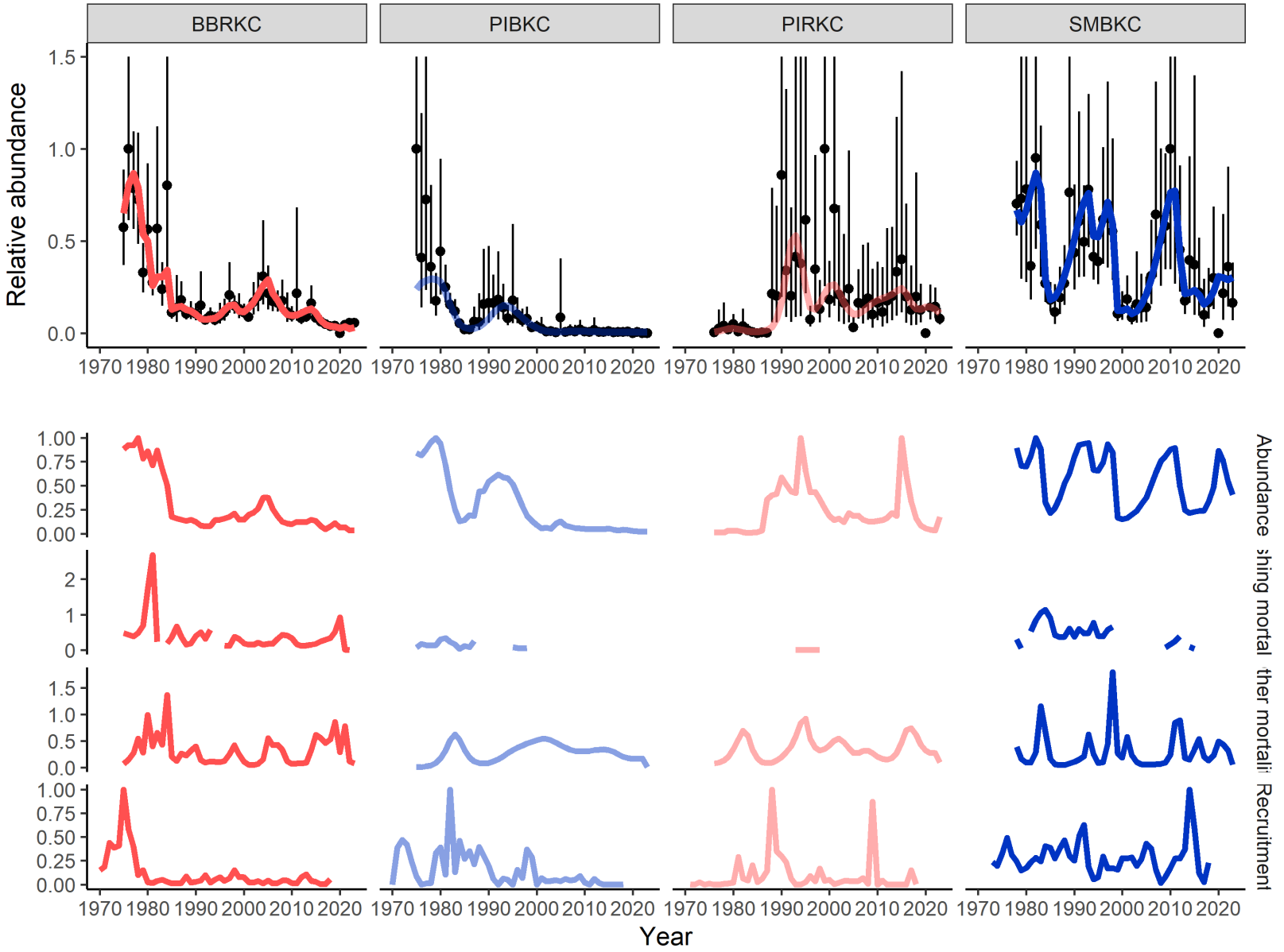
Mortality events drive Bering Sea crab populations

- How frequent are large declines in Bering Sea crab populations?
- What drives these declines and are there common linkages?
- How can we consider mortality events in management?

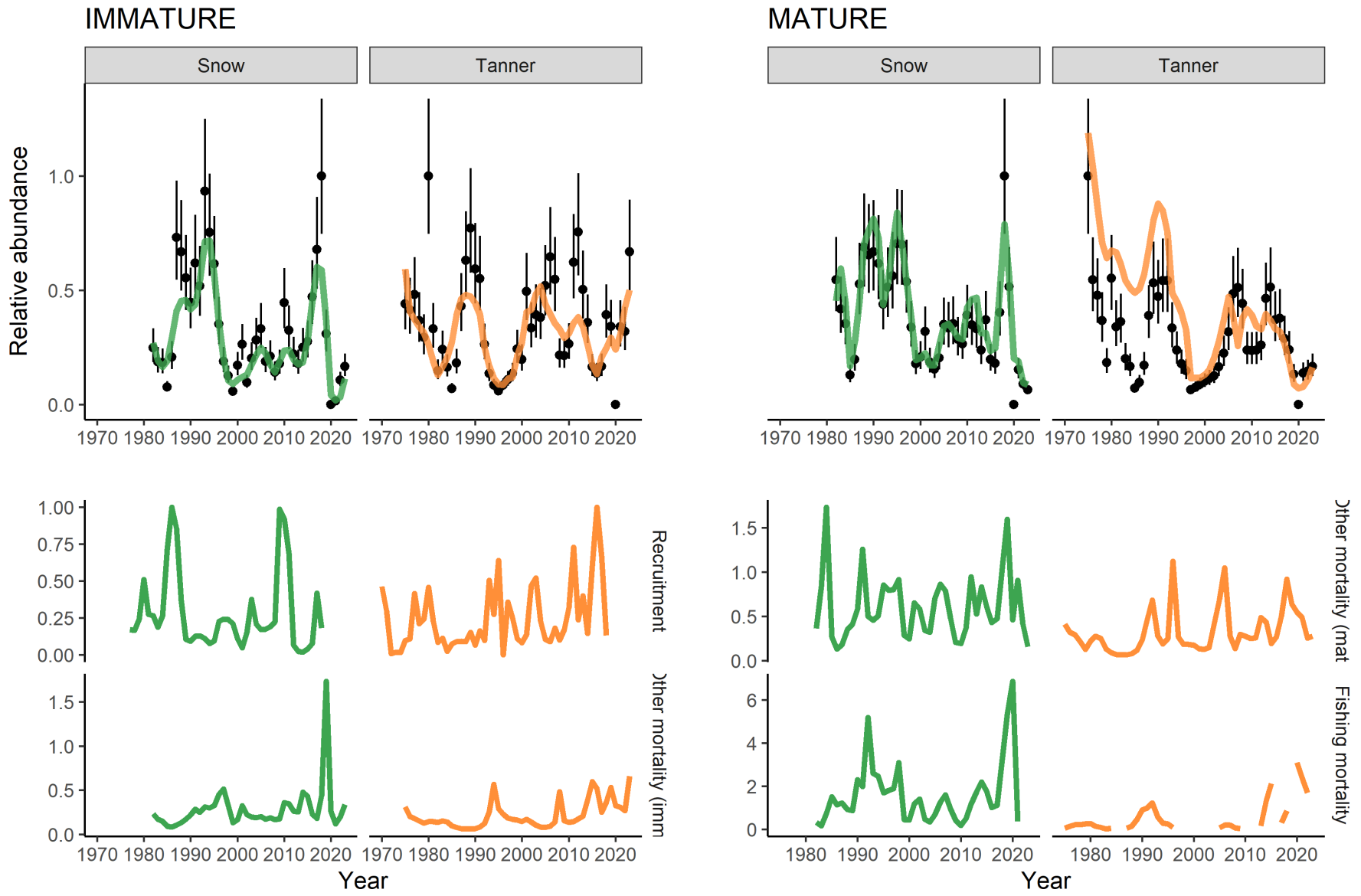
Mortality events drive Bering Sea crab populations



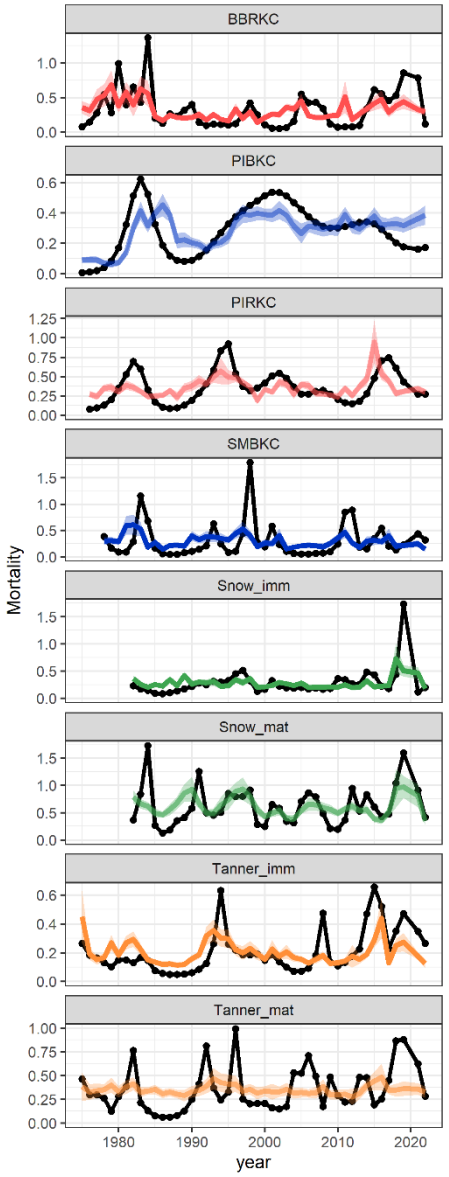
Mortality events drive Bering Sea crab populations

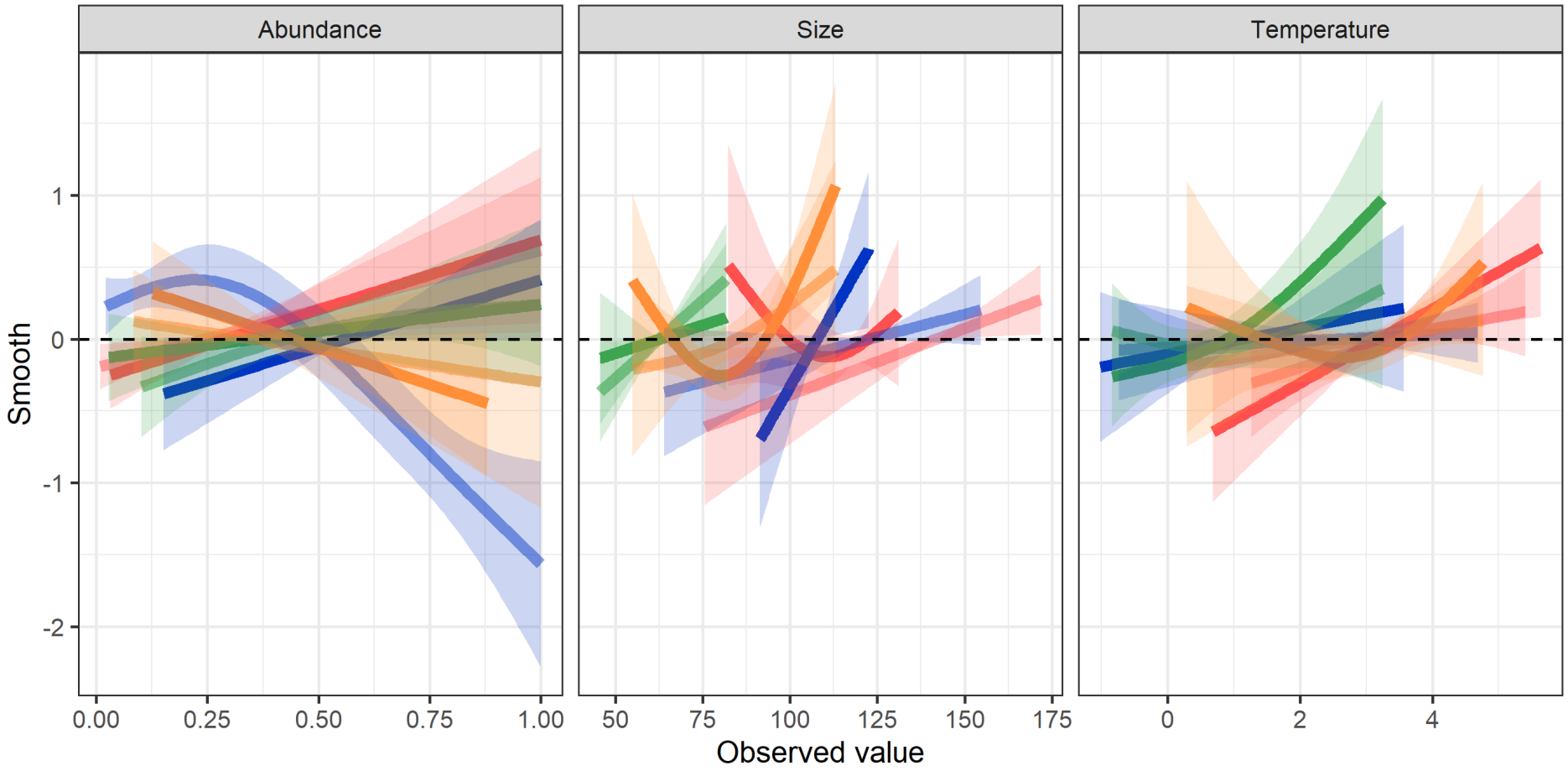


Mortality events drive Bering Sea crab populations

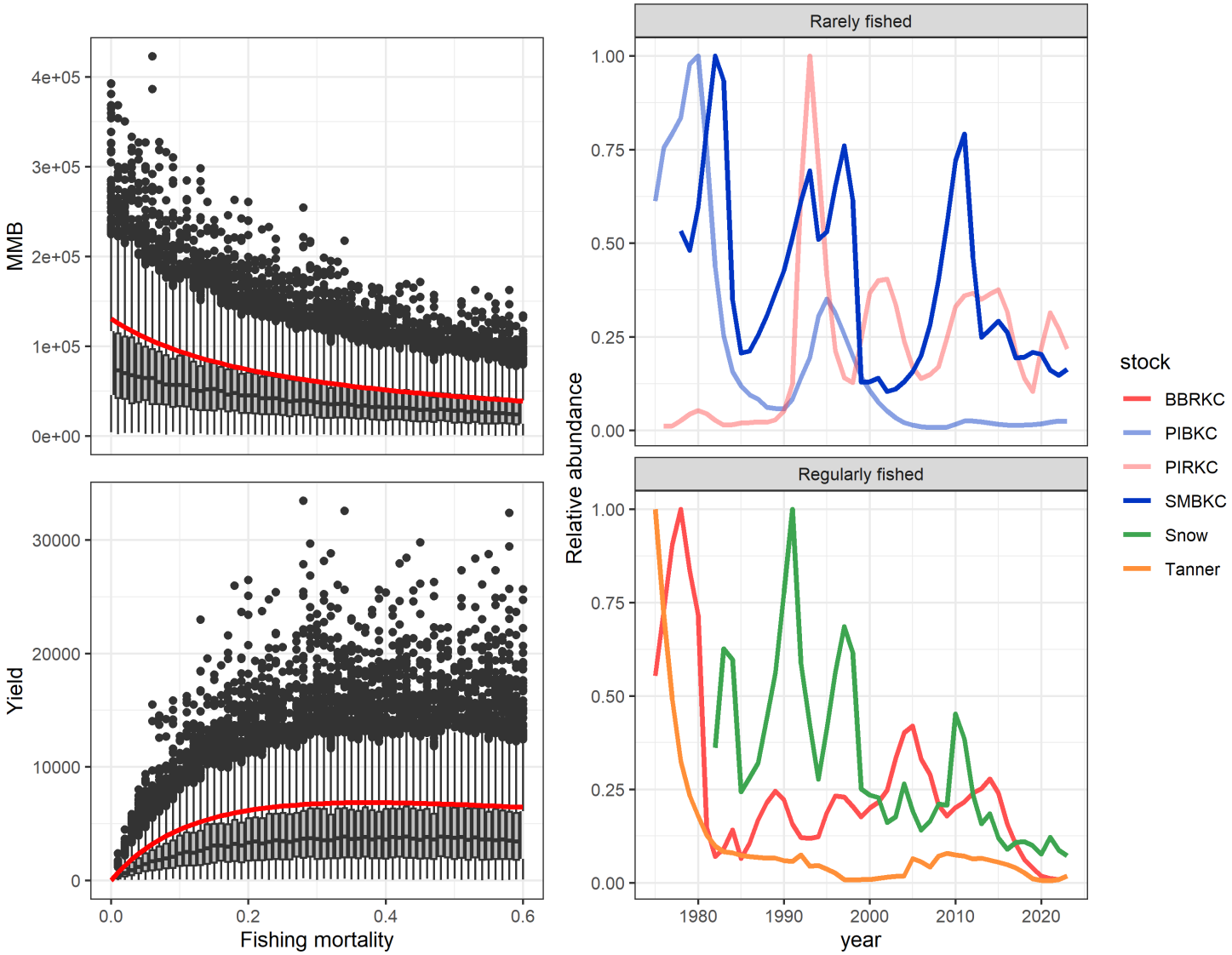


Mortality events drive Bering Sea crab populations





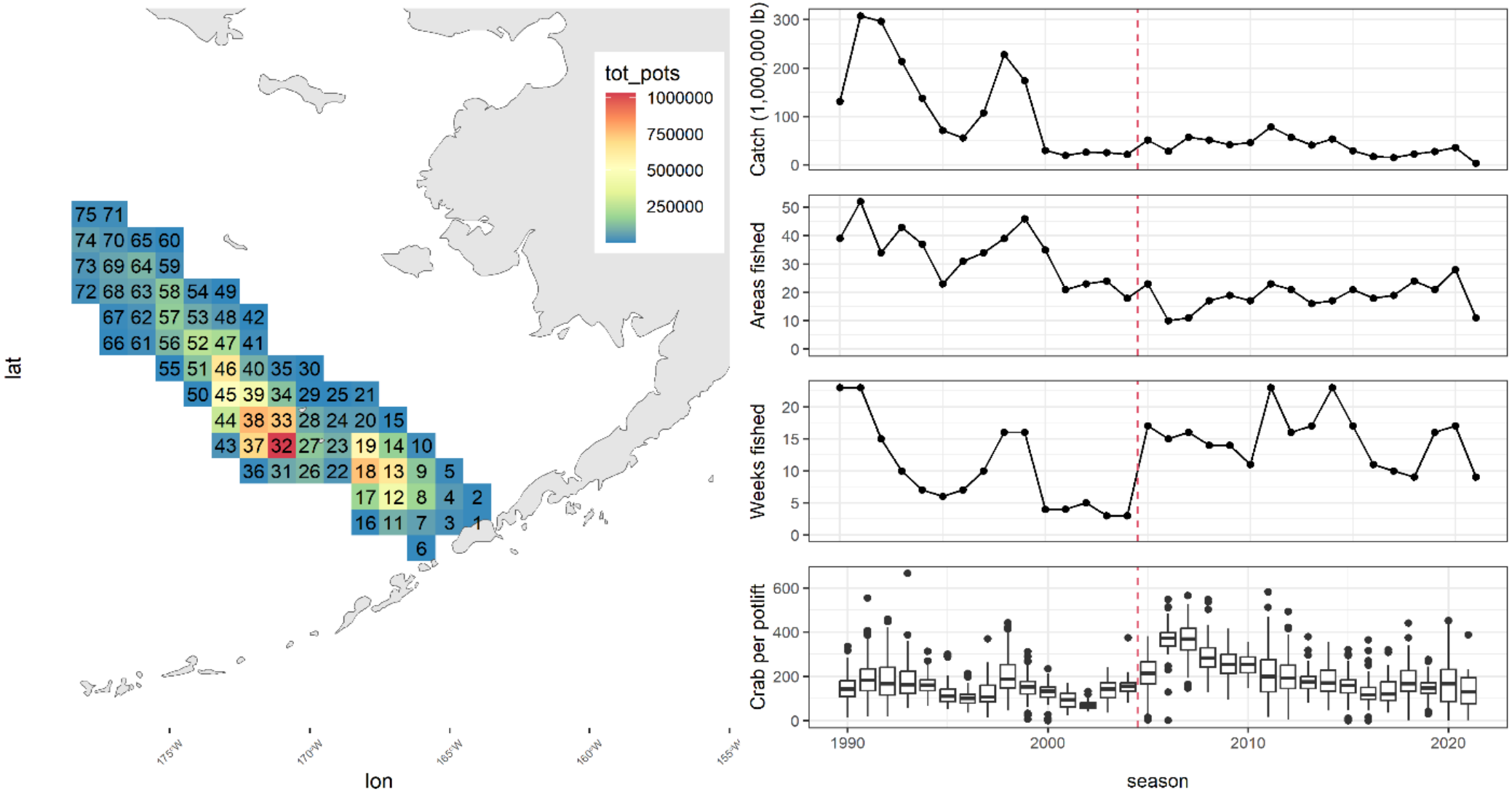
Mortality events drive Bering Sea crab populations



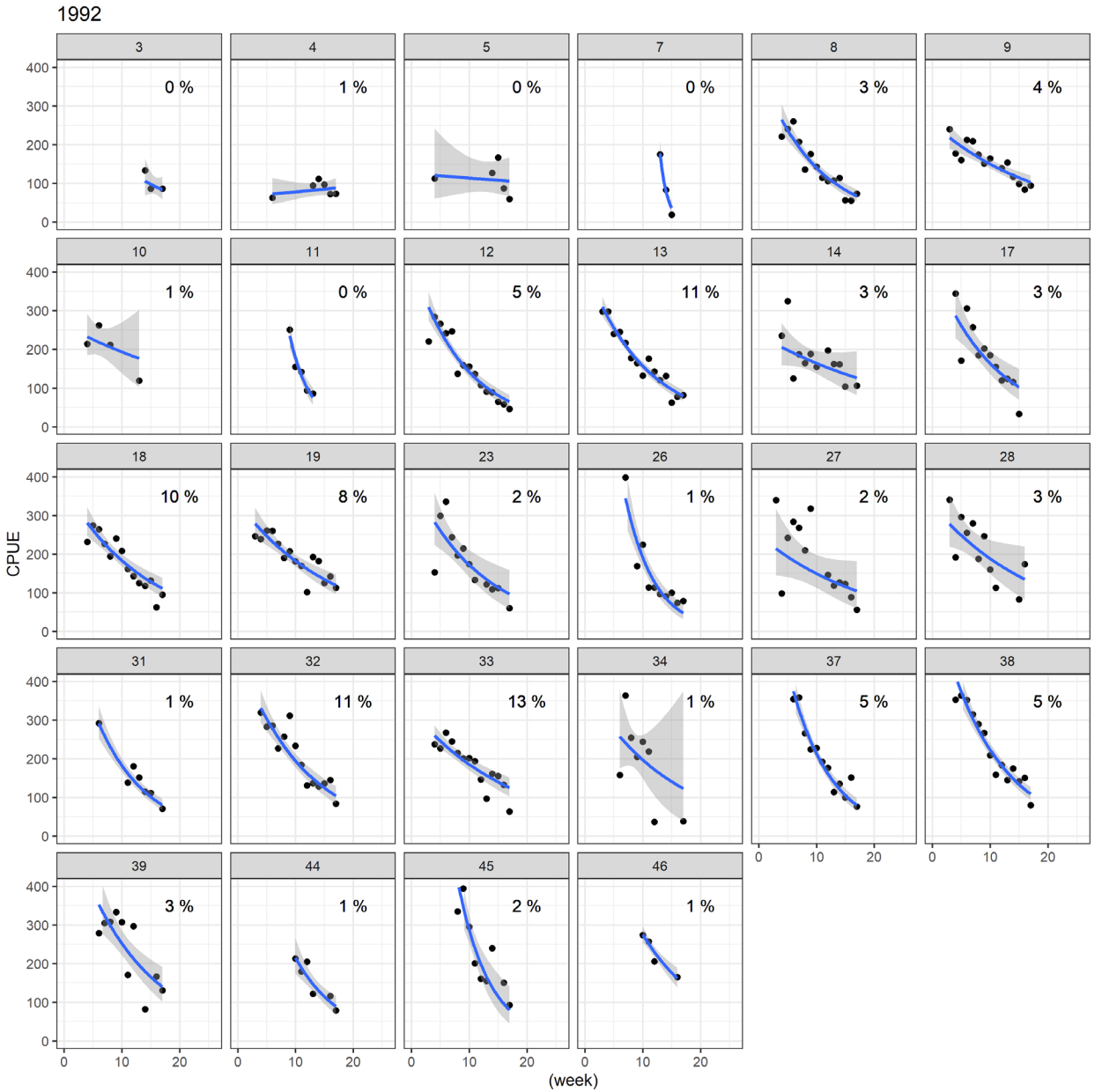
Incorporating mortality events into reference points would allow more fishing at lower biomasses compared to not incorporating it.

How would size- and density-dependence in mortality change the shape of an optimal control rule?

Is spatial depletion in the fishery a problem?

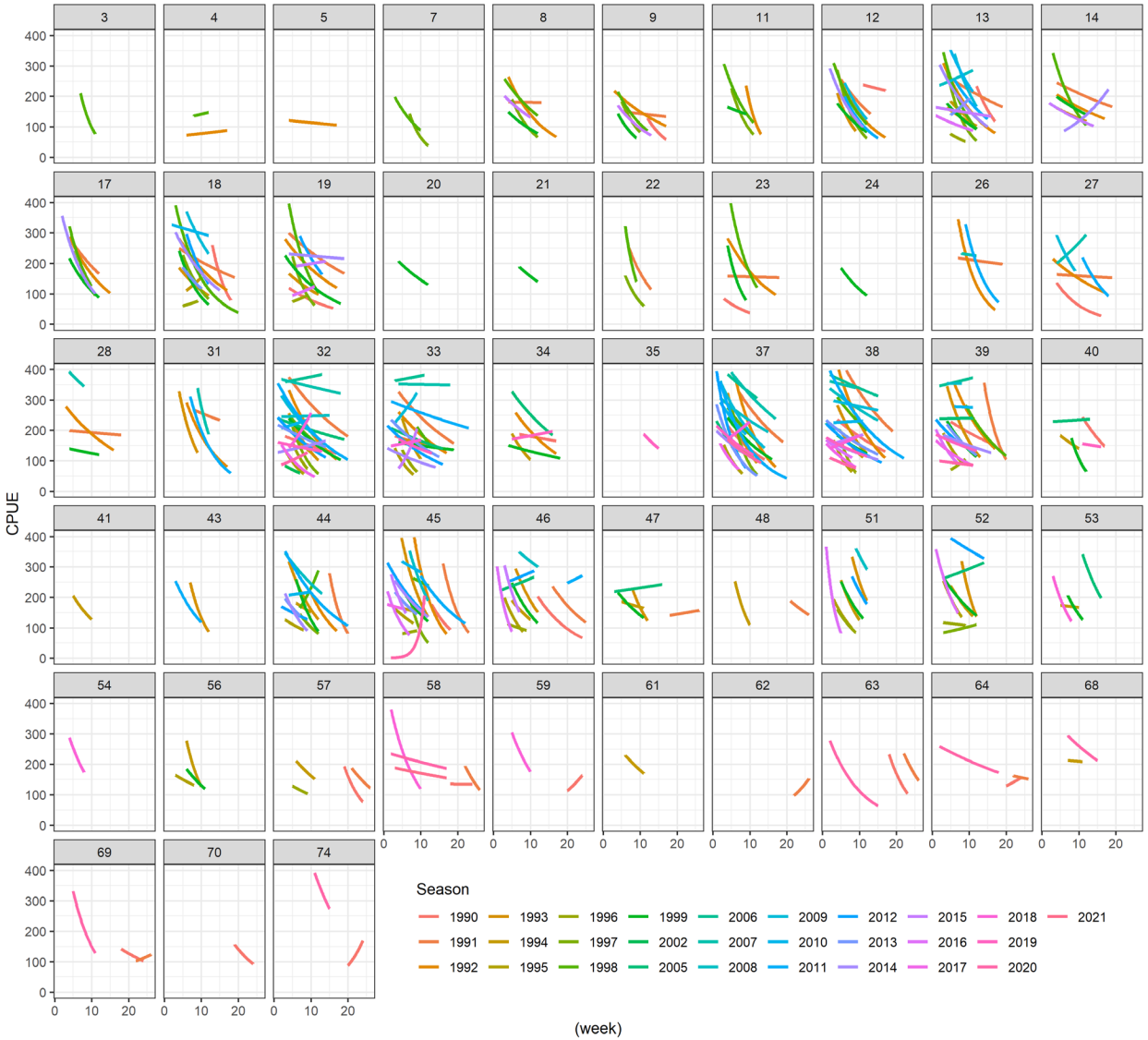


Is spatial depletion in the fishery a problem?



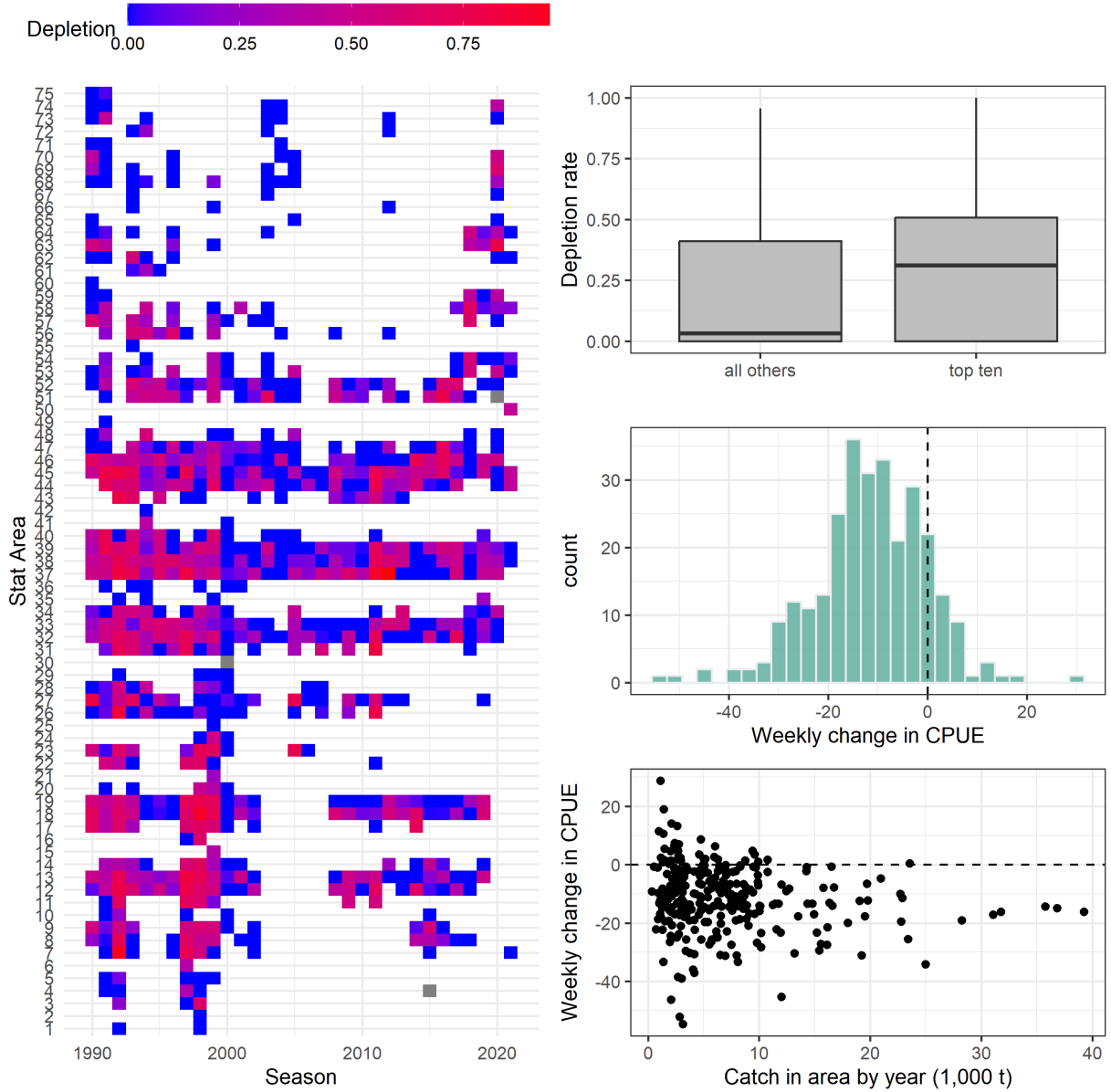
- Fit glm() with log link to CPUE by statistical area
- Depletion = $1 - \frac{CPUE_{begin}}{CPUE_{end}}$

Is spatial depletion in the fishery a problem?



- Fit glm() with log link to CPUE by statistical area
- Depletion = $1 - \frac{CPUE_{begin}}{CPUE_{end}}$
- Large declines within area from beginning to end of season represent a large impact of the fishery in an area

Is spatial depletion in the fishery a problem?



- Fit glm() with log link to CPUE by statistical area
- Depletion = $1 - \frac{CPUE_{begin}}{CPUE_{end}}$

- Large declines within area from beginning to end of season represent a large impact of the fishery in an area
- Depletion quite high in some areas and years

Currency of management + HCR

If the answer is “MMB”

- Reference points allow removal of all large males
- OFL will not be constraining
- We don’t need an assessment

If the answer is “Large males”

- Big can of worms
- Potential choke species at the federal level and ensuing tradeoffs
- Potential conflicts with the state rule

(the next [and harder] question is ‘how much of each do you want to keep in the water?)