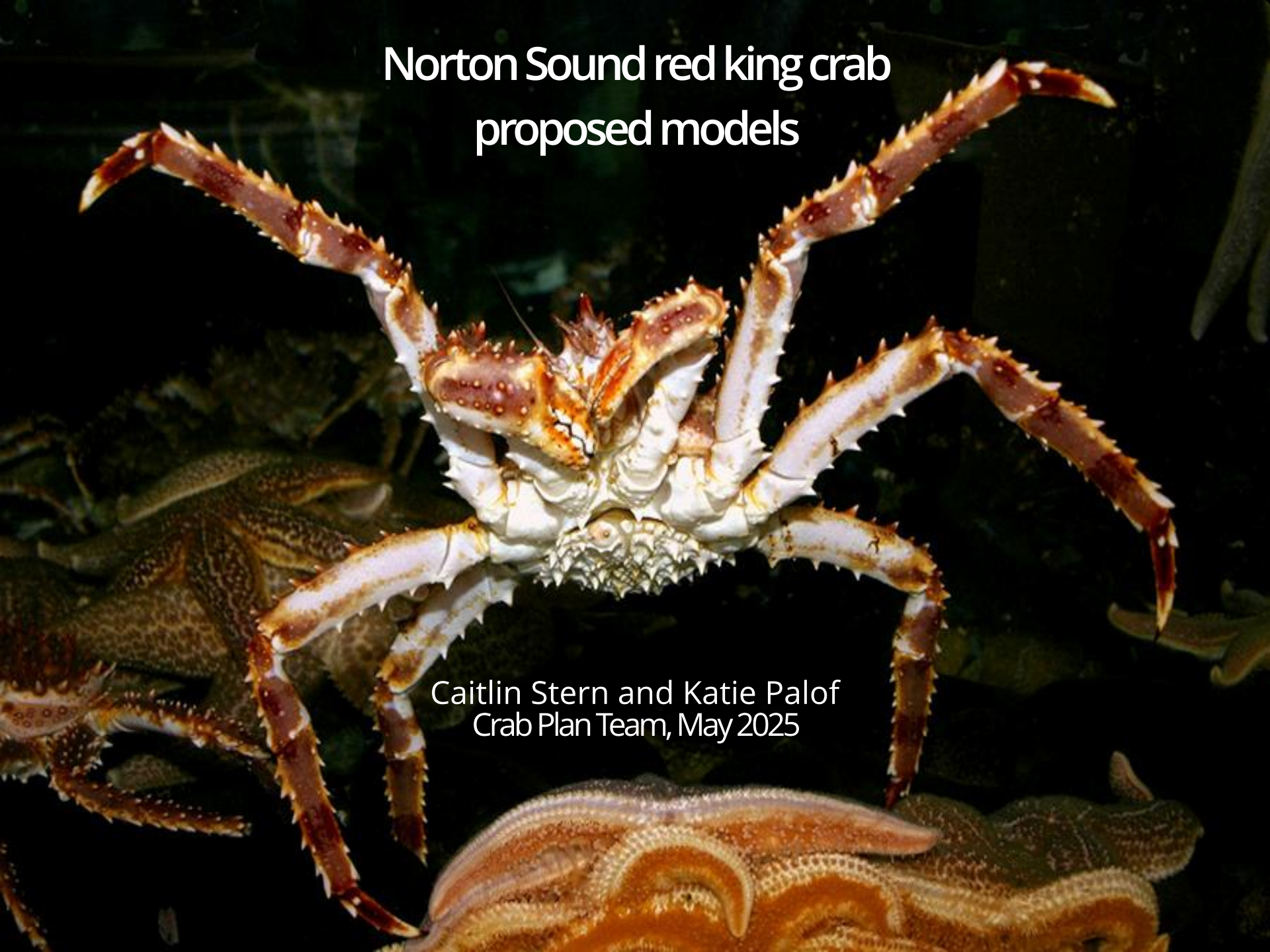
Norton Sound red king crab proposed models



Caitlin Stern and Katie Palof
Crab Plan Team, May 2025

Stock assessment background

Model 24.0, in GMACS, accepted for 2025 harvest specs

- males $\geq$ 64 mm only, 8 size classes
- catch: winter com. retained, sub. retained, sub. total, summer com. retained
- relative abundance: 3 trawl surveys, stand. summer com. fishery CPUE in 3 time blocks
- size comps: winter com. retained, summer com. retained, summer com. discards, summer com. total, 3 trawl surveys, winter pot survey (all include shell condition)
- size-dependent M = 0.18 for males with CL $\leq$ 123 mm, est. for CL $>$ 123 mm (2 largest size bins; est. = 0.58 in model 24.0)
- survey selectivity: only estimated for NOAA NS trawl survey, other trawl survey selectivities mirrored to that value. Est. trawl survey selectivity = 1 for all size classes. Winter pot survey selectivity mirrored to the winter com. pot fishery
- survey catchability = 1 for ADF&G trawl survey, est. for other trawl surveys and fishery CPUE indices. Base model est. q = 0.74 for NOAA NS survey, q = 0.70 for NOAA NBS survey, and q < 0.002 for all 3 time blocks of the CPUE index

Stock assessment background

SSC and CPT comments

Complete transition to GMACS:

- fix OFL calculation
- *include winter subsistence total catch*

Address long-standing issues:

- use of shell condition, given potential for error
- over-estimation of larger males
- use of size-dependent *M* to fix over-estimation
- use prior from BBRKC for size-independent natural mortality
- inconsistencies in area used to calculate abundance among trawl surveys

Outline

Modeling topics:

- **Bridging analysis:** use model with lowest or 2nd lowest objective function value as new base model?
- **Shell condition:** should future models include shell condition?
- **Natural mortality:** move to using BBRKC prior for *M*? Use size-independent *M*?
- **Model-based indices:** prediction area to use, focus of future work (combined index?)

Bridging analysis

SSC comment: *calculate OFL within GMACS*

24.0 - model used for 2025 harvest specs, GMACS 2.20.14

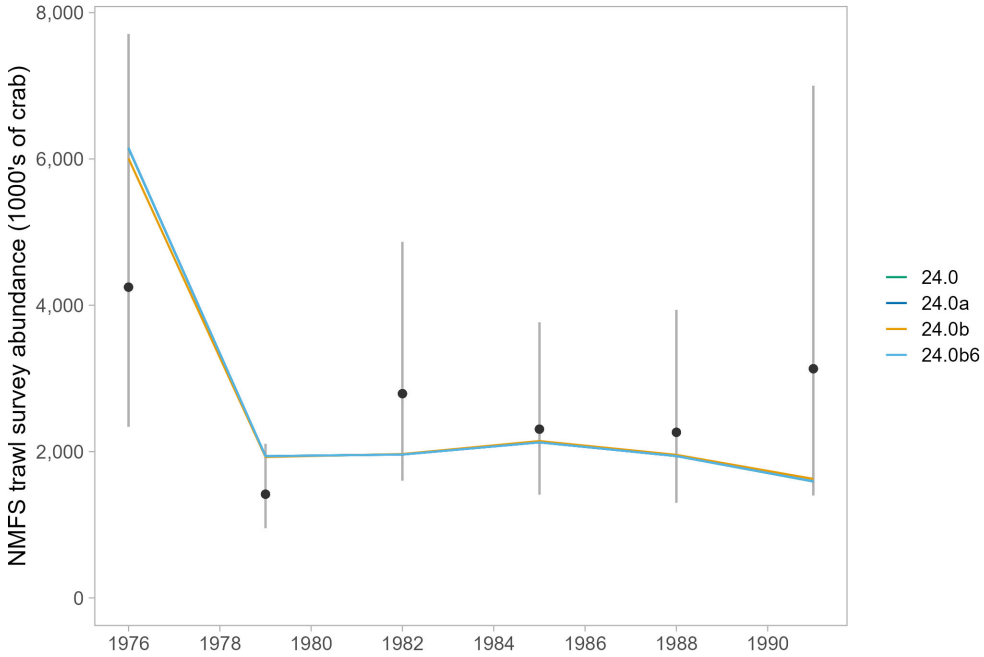
24.0a - 24.0 with input data errors corrected, GMACS 2.20.14

24.0b - 24.0a in GMACS 2.20.20, with correct OFL estimation

24.0b6 - 24.0b with 2nd lowest objective function value

	24.0	24.0a	24.0b	24.0b6
Objective function value	4188	4183	4181	4183
Total estimated parameters	226	226	226	226

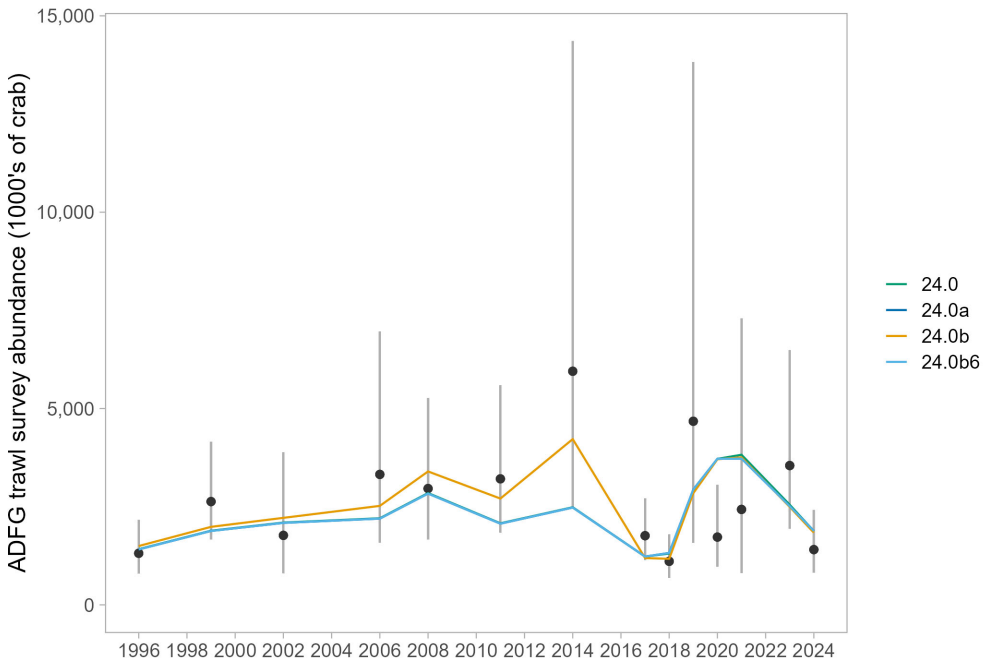
Bridging: fits



24.0b has:

- better fits to all 3 trawl survey indices and size comps
- worse fit to winter com. size comps
- otherwise similar fits to 24.0, 24.0a, 24.0b6

Bridging: fits



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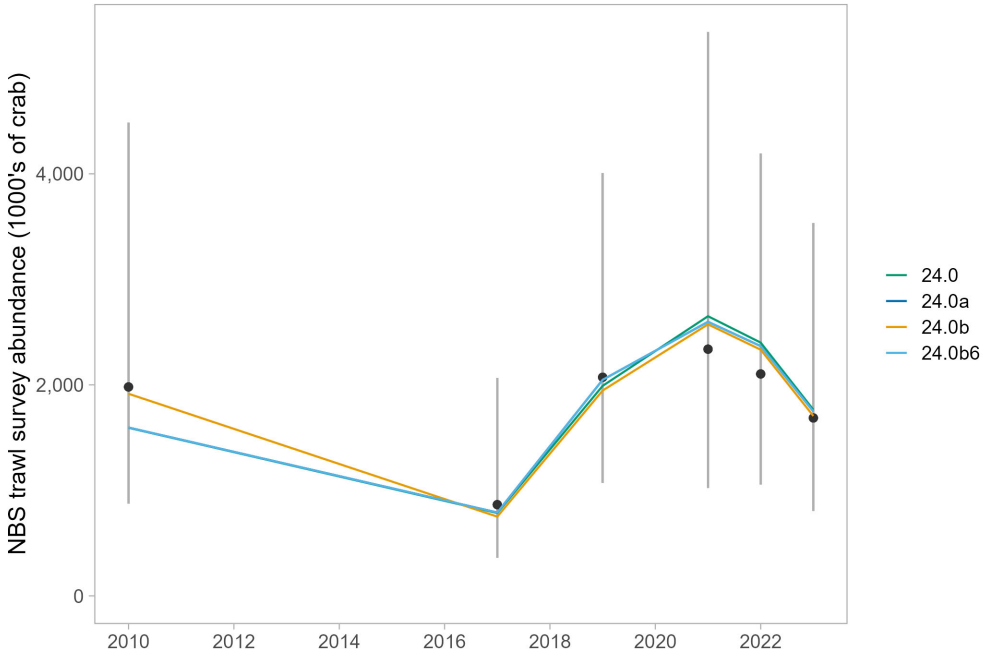
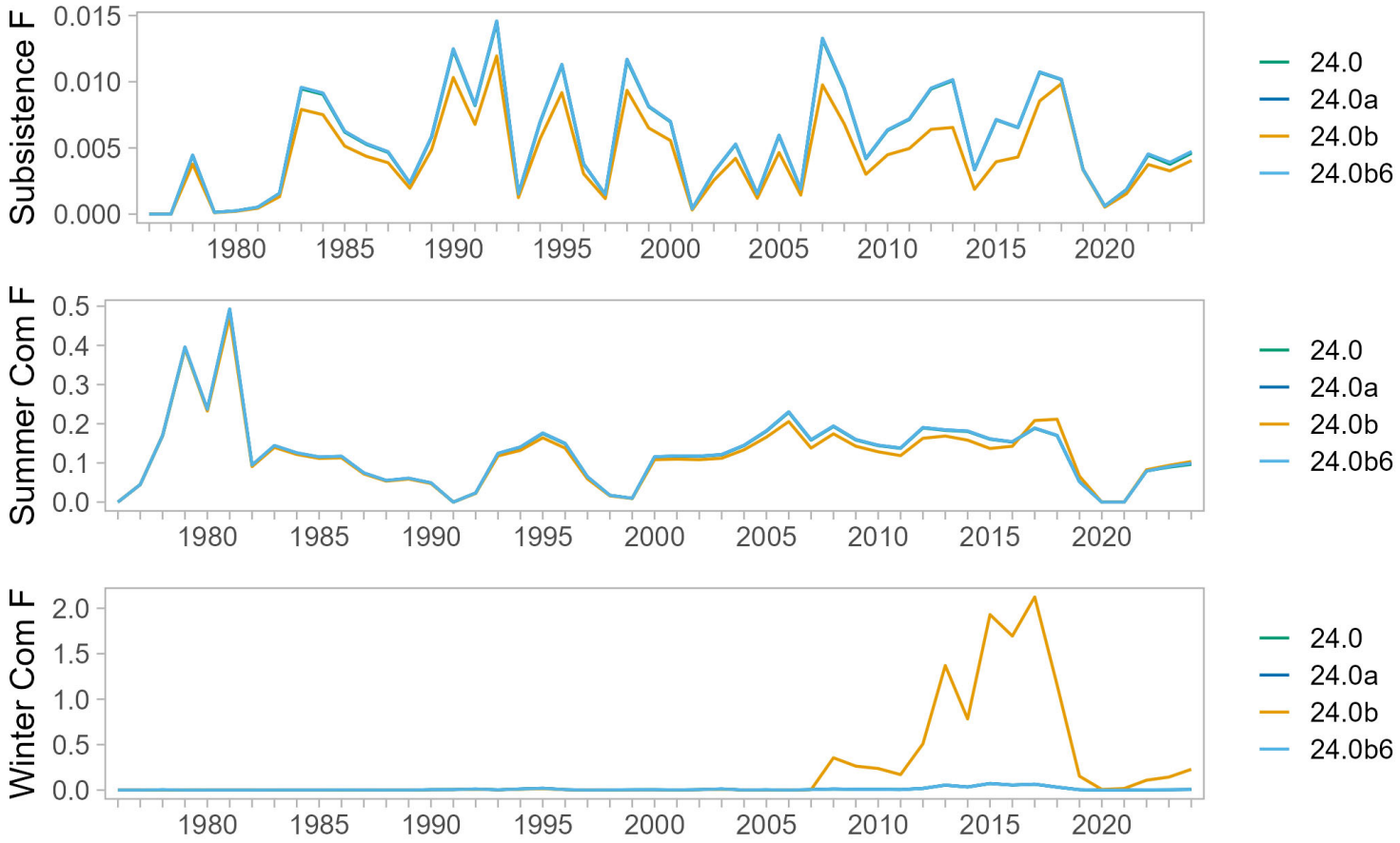
Bridging: fits



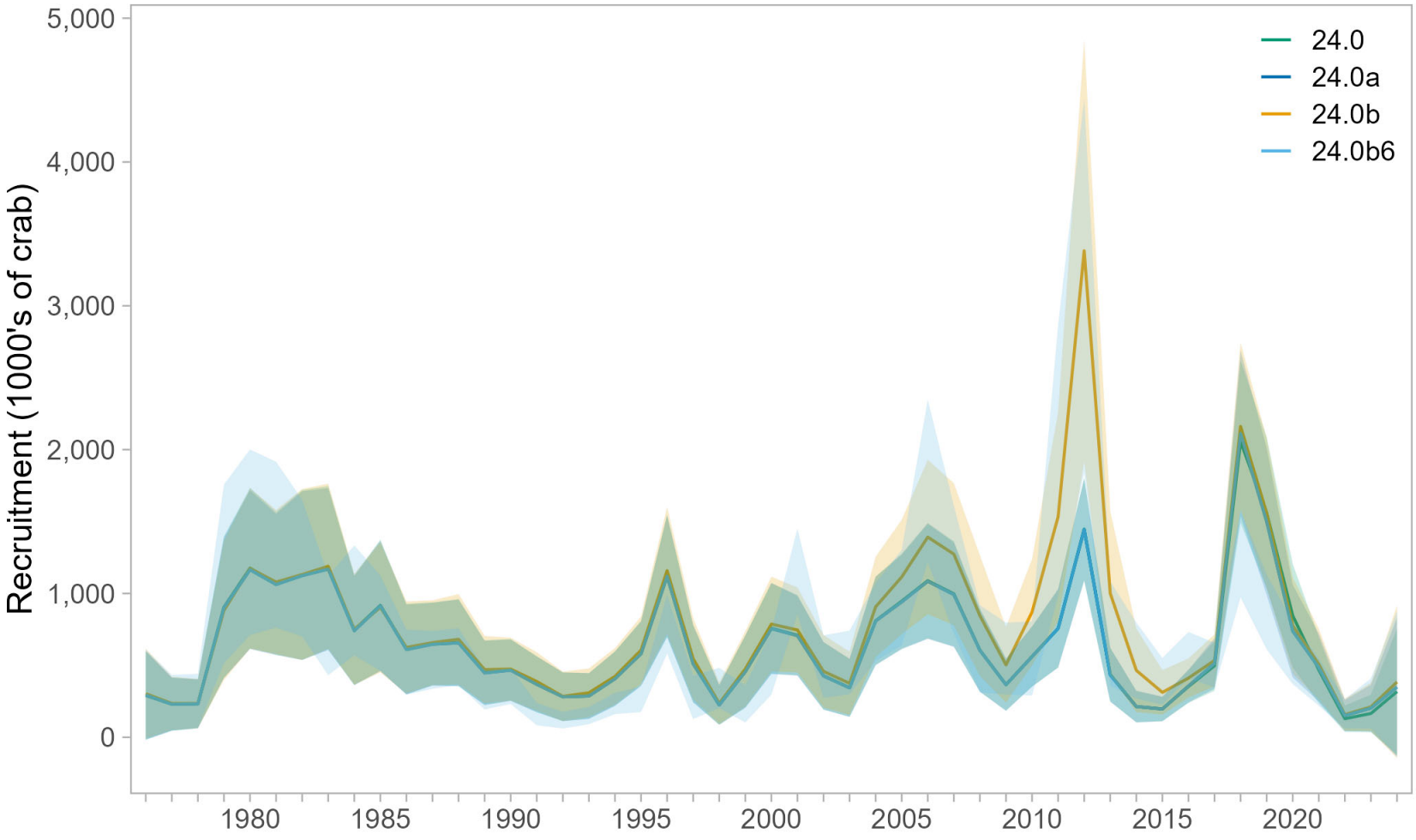
24.0b has:

- better fits to all 3 trawl survey indices and size comps
- worse fit to winter com. size comps
- otherwise similar fits to 24.0, 24.0a, 24.0b6

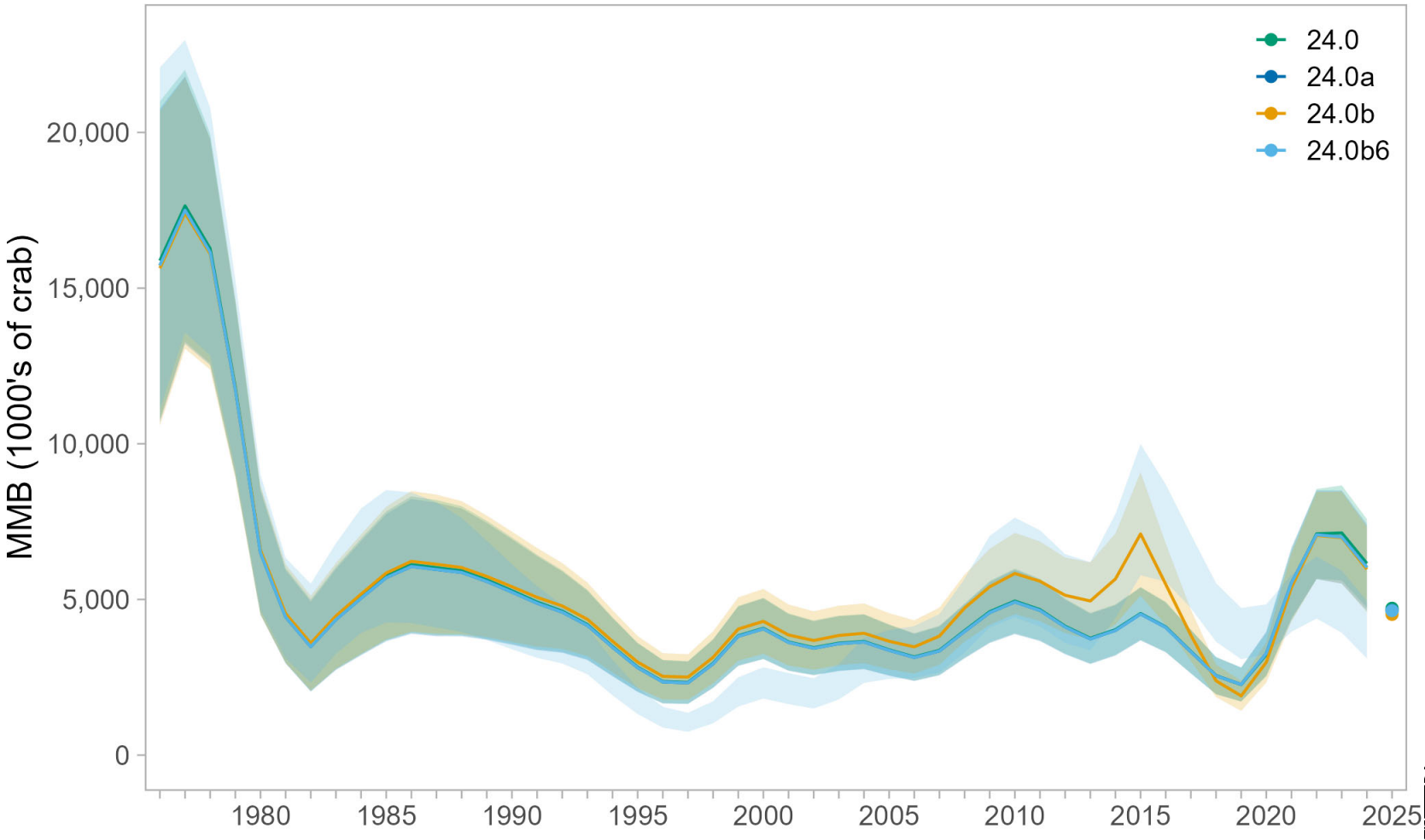
Bridging: fishing mortality



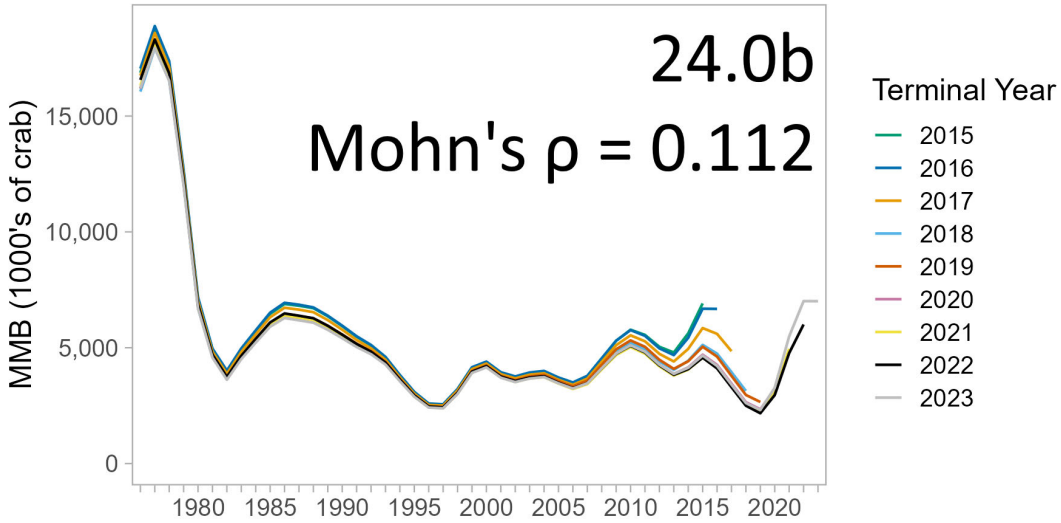
Bridging: recruitment

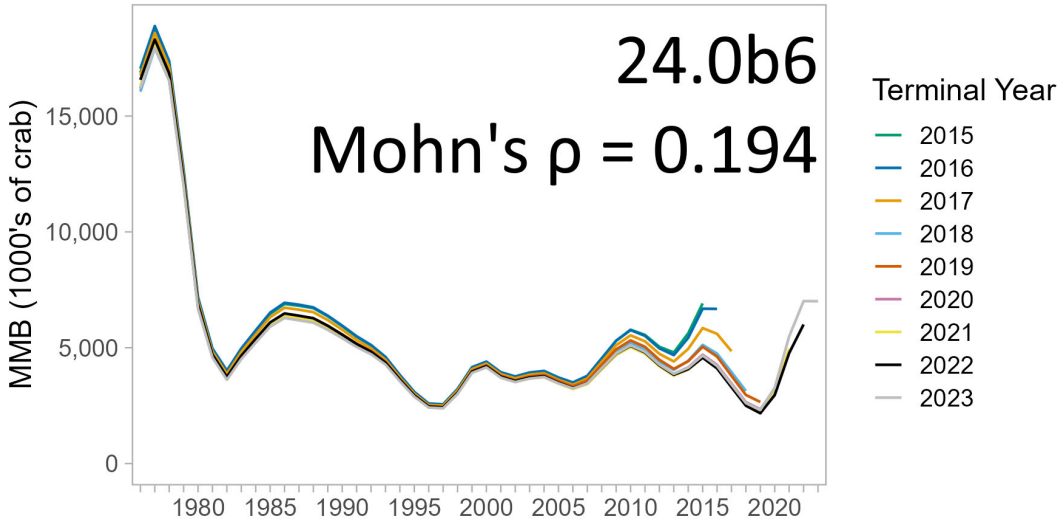


Bridging: MMB trajectories



Bridging: retrospective patterns





Bridging: reference points

	24.0	24.0a	24.0b	24.0b6
MMB_{2025}	2139	2105	2051	2105
B_{MSY}	1963	1949	2115	1949
MMB/B_{MSY}	1.09	1.08	0.97	1.08
F_{OFL}	0.18	0.18	0.12	0.01
OFL_{2025}	520	511	114	262
ABC_{2025}	364	358	79	183

units: metric tons

Bridging analysis summary

- 24.0b:
  - lowest objective function value
  - better fits to trawl survey indices
  - better retrospective pattern
  - high *F* for winter commercial fishery
  - lower stock status (higher B_{MSY})
- 24.0b6: 2nd lowest objective function value, more similar to accepted model

feedback: use 24.0b or 24.0b6 as new base model? If 24.0b6, what can we learn from 24.0b?

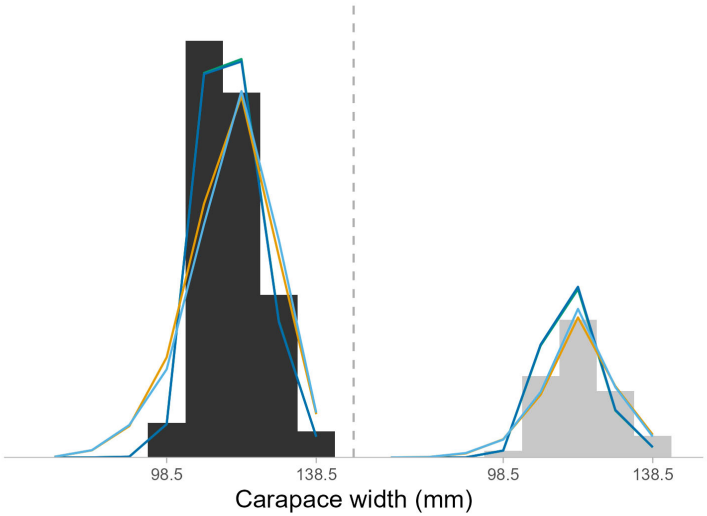
Shell condition

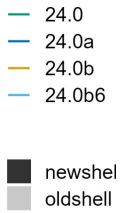
SSC comment: *review shell condition effects on size comp fits*

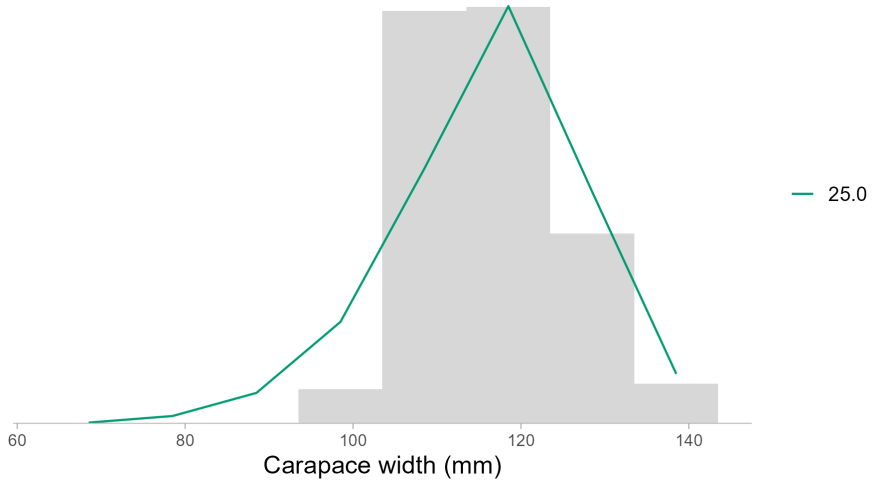
24.0b - new base model

25.0 - 24.0b with shell condition removed from size comp. data

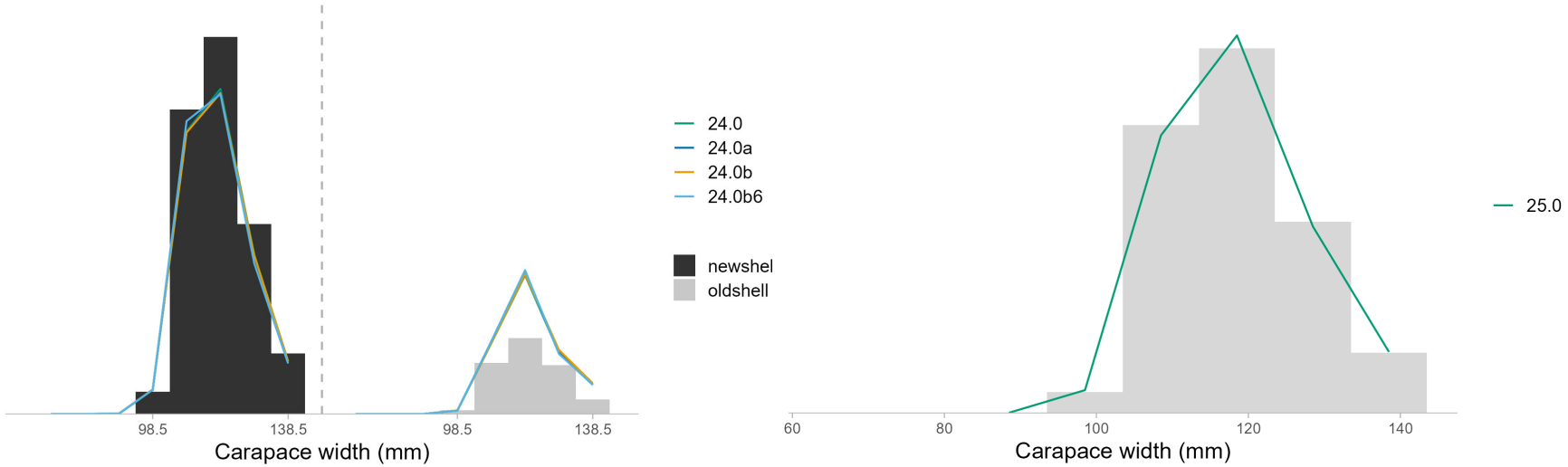
Shell condition: winter com. retained



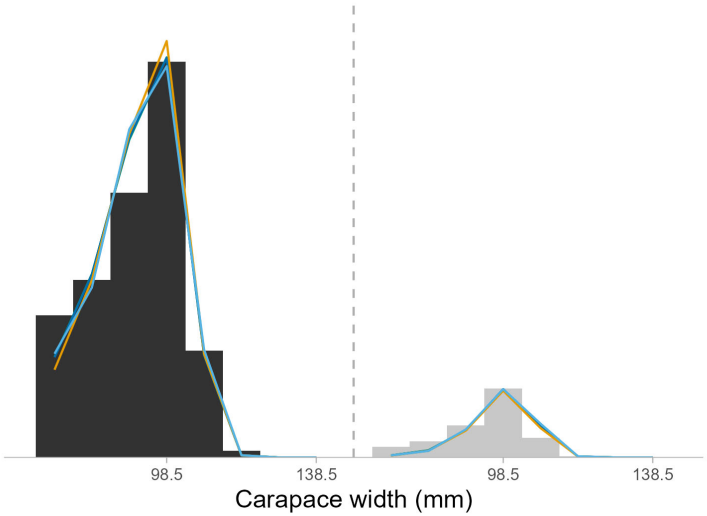


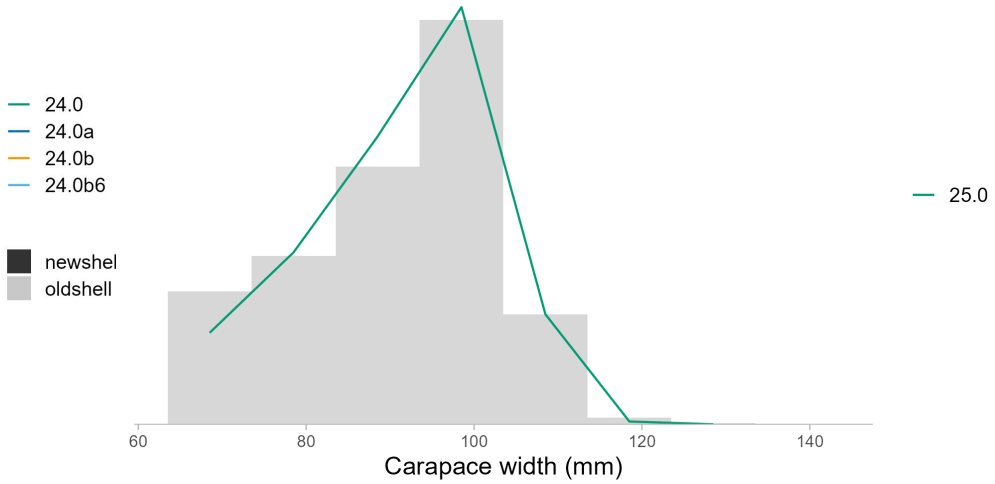


Shell condition: summer com. retained

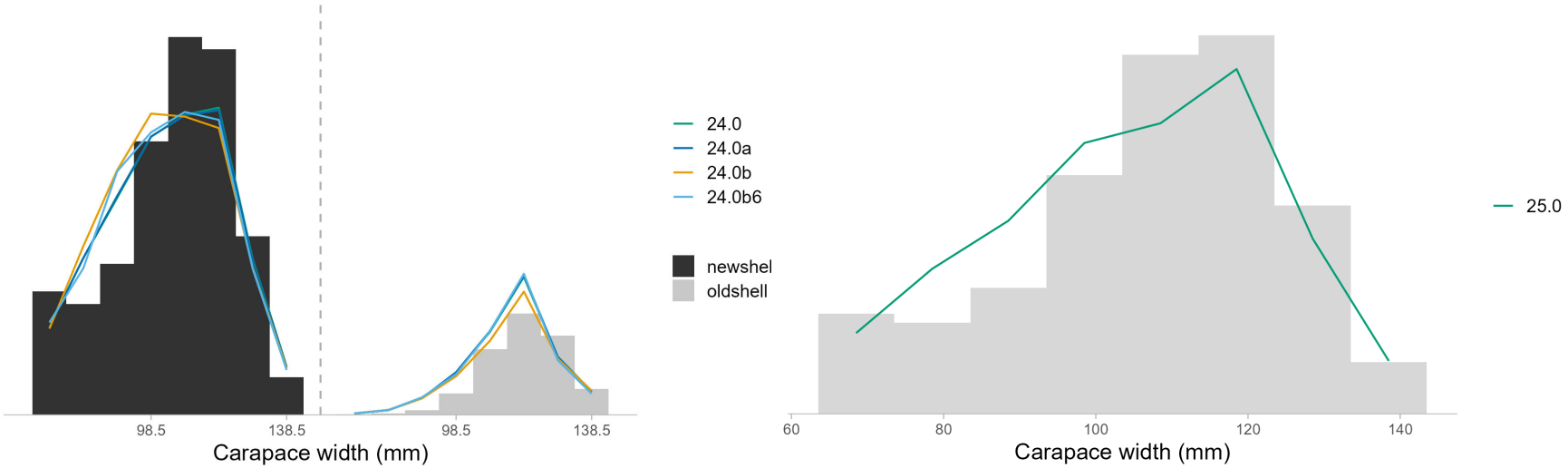


Shell condition: Summer com. discards

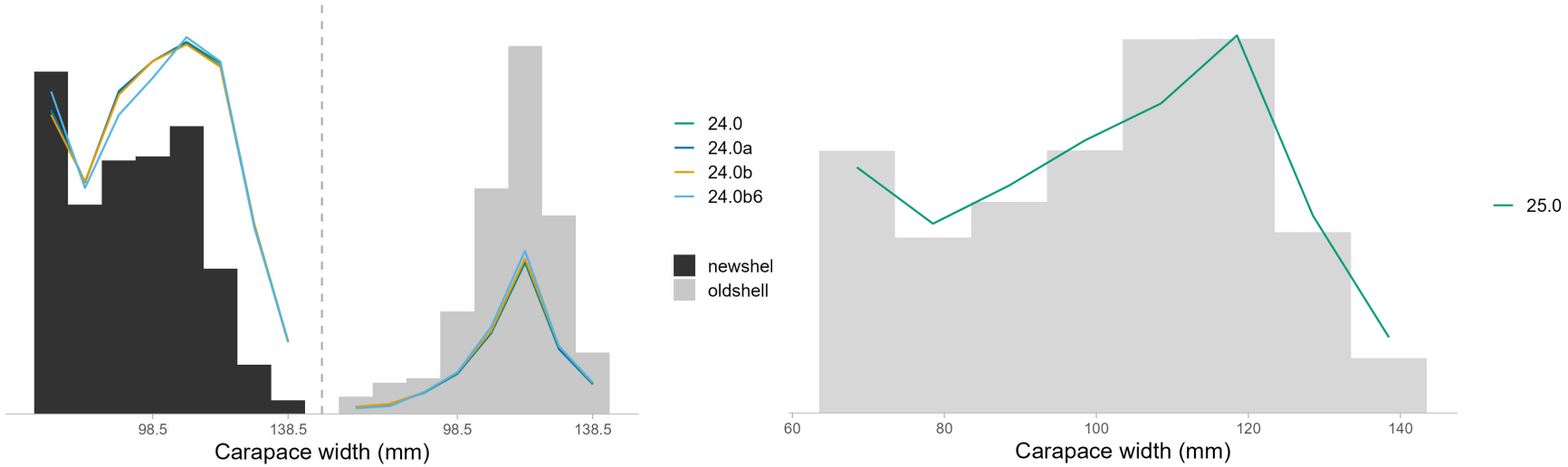




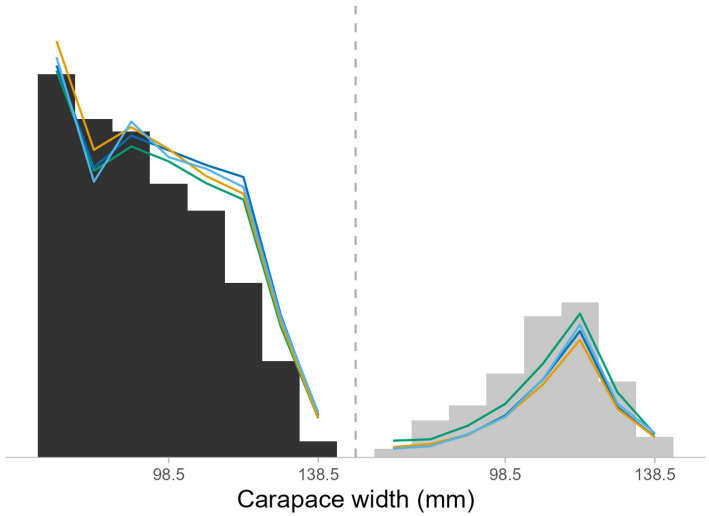
Shell condition: Summer com. total

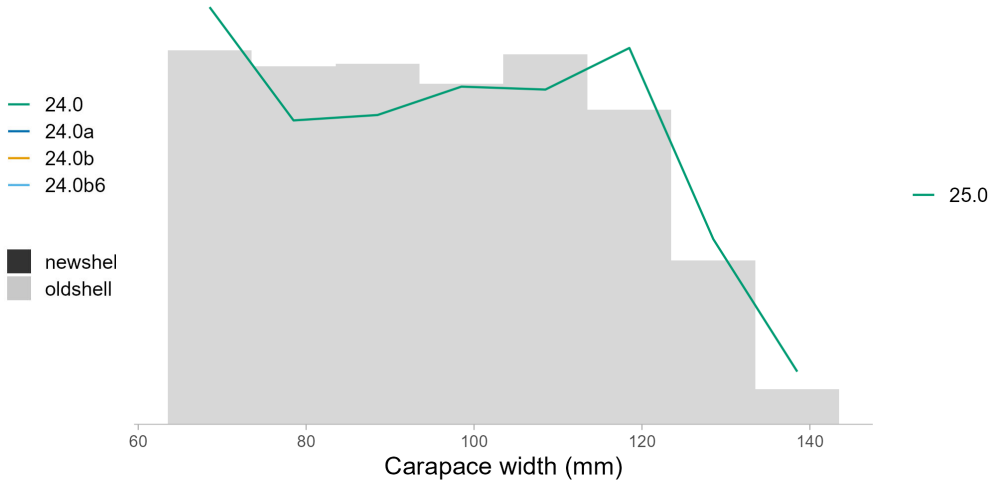


Shell condition: NOAA NS survey

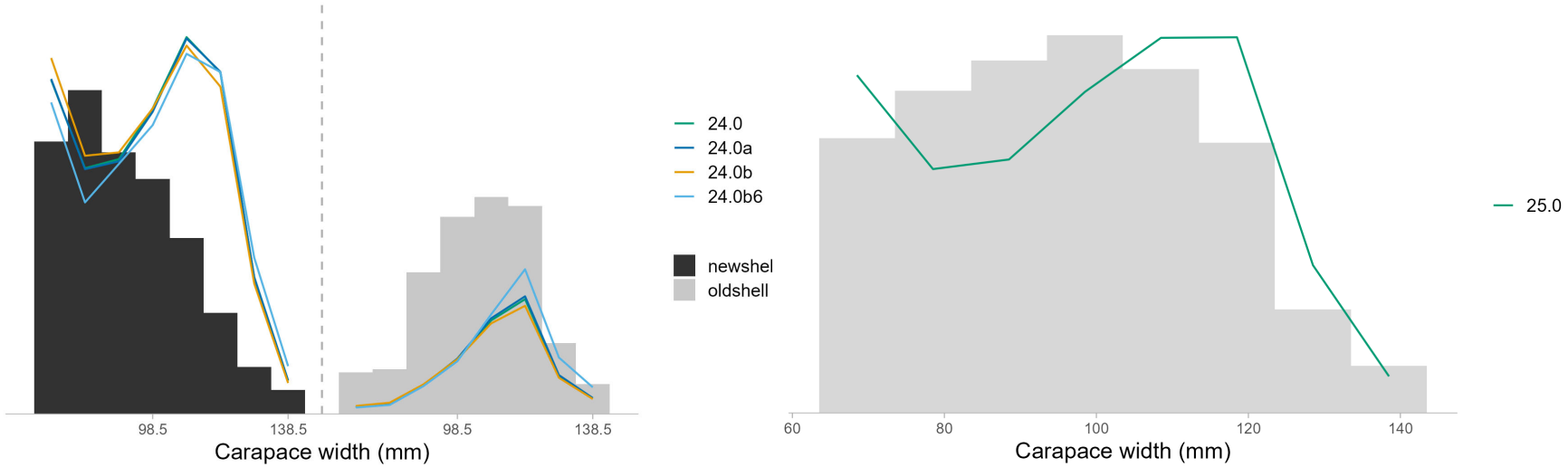


Shell condition: ADF&G trawl survey

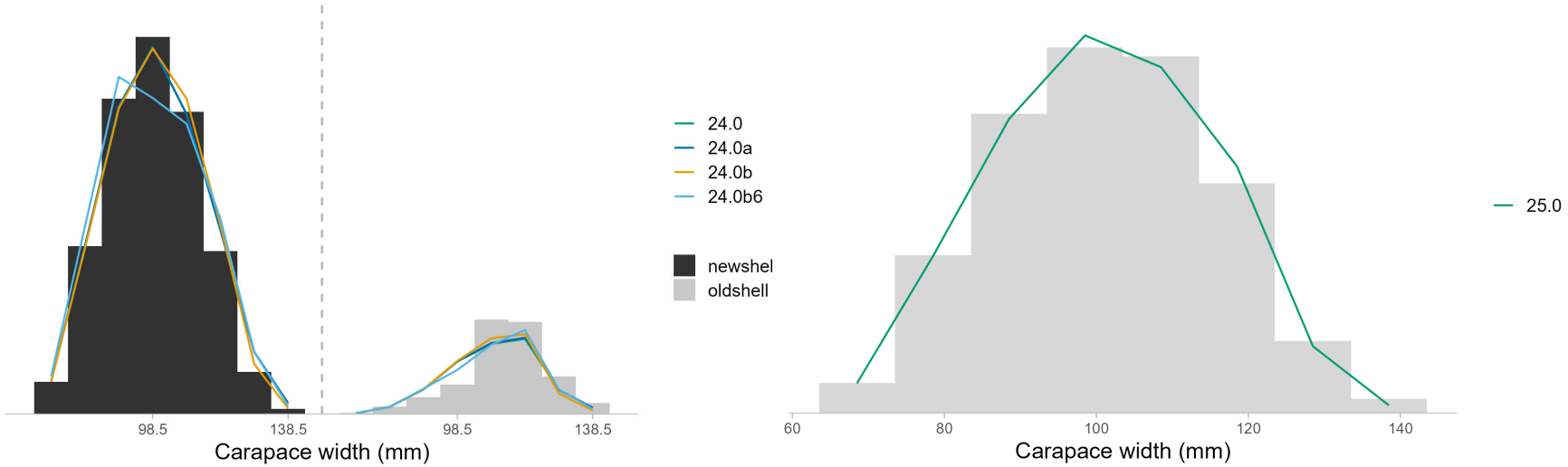




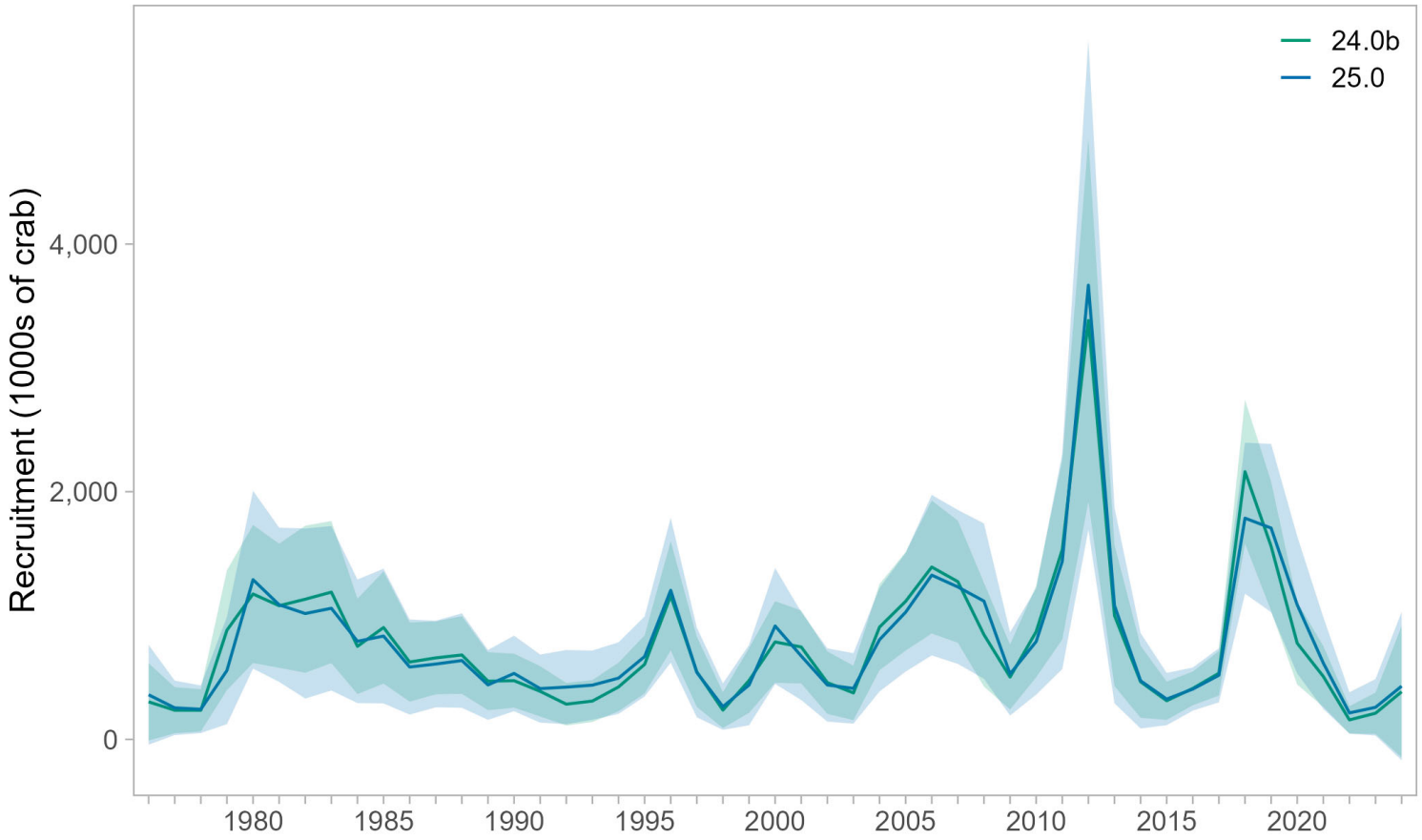
Shell condition: NOAA NBS survey



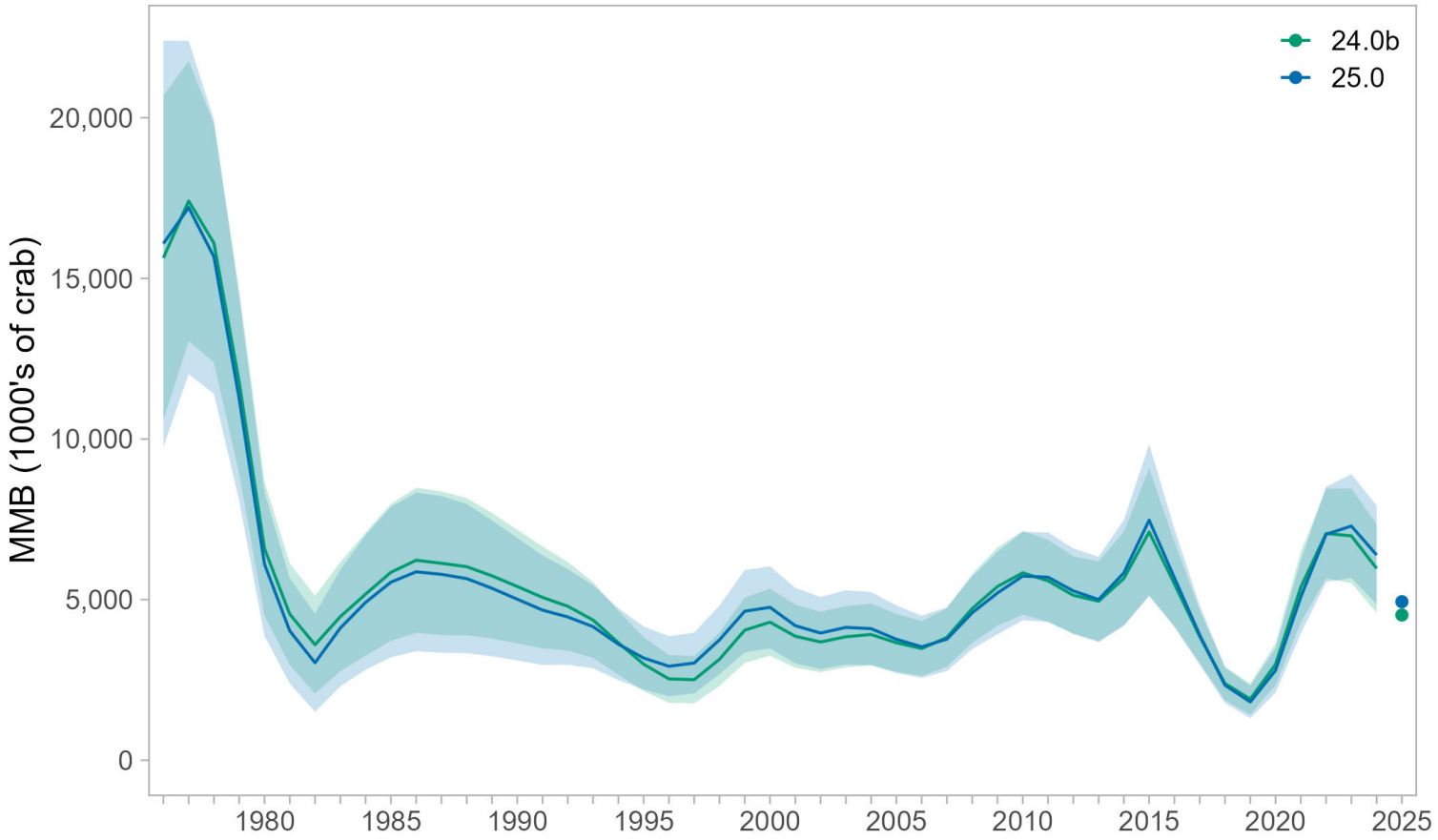
Shell condition: ADF&G pot survey



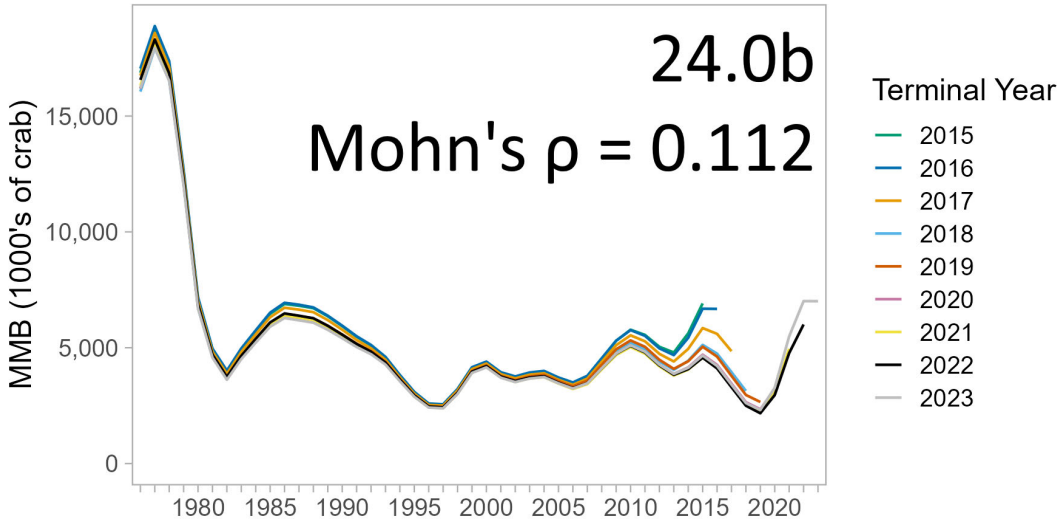
Shell condition: recruitment

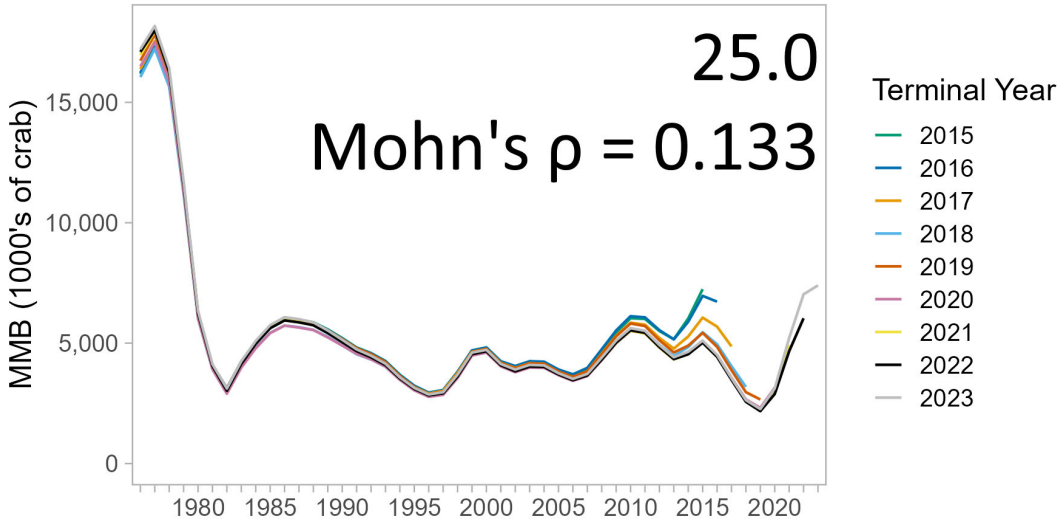


Shell condition: MMB



Shell condition: retrospective pattern





Shell condition: reference points

	24.0b	25.0
MMB_{2025}	2051	2238
B_{MSY}	2115	2108
MMB/B_{MSY}	0.97	1.06
F_{OFL}	0.12	0.12
OFL_{2025}	114	123
ABC_{2025}	79	86

units: metric tons

Shell condition summary

SSC comment: *review shell condition effects on size comp fits*

Removing shell condition:

- removes source of error unaccounted for in the model
- may improve fits to size comps
- slightly worsens retrospective pattern
- leads to slightly higher stock status
- **feedback:** should future models include shell condition?

Shell condition summary

SSC comment: *review shell condition effects on size comp fits*

Removing shell condition:

- removes source of error unaccounted for in the model
- may improve fits to size comps
- slightly worsens retrospective pattern
- leads to slightly higher stock status
- **feedback:** should future models include shell condition?

SSC comment: *address overestimation of largest male crab*

Does removing shell condition mean that size-dependent *M* is no longer needed to improve size comp. fits?

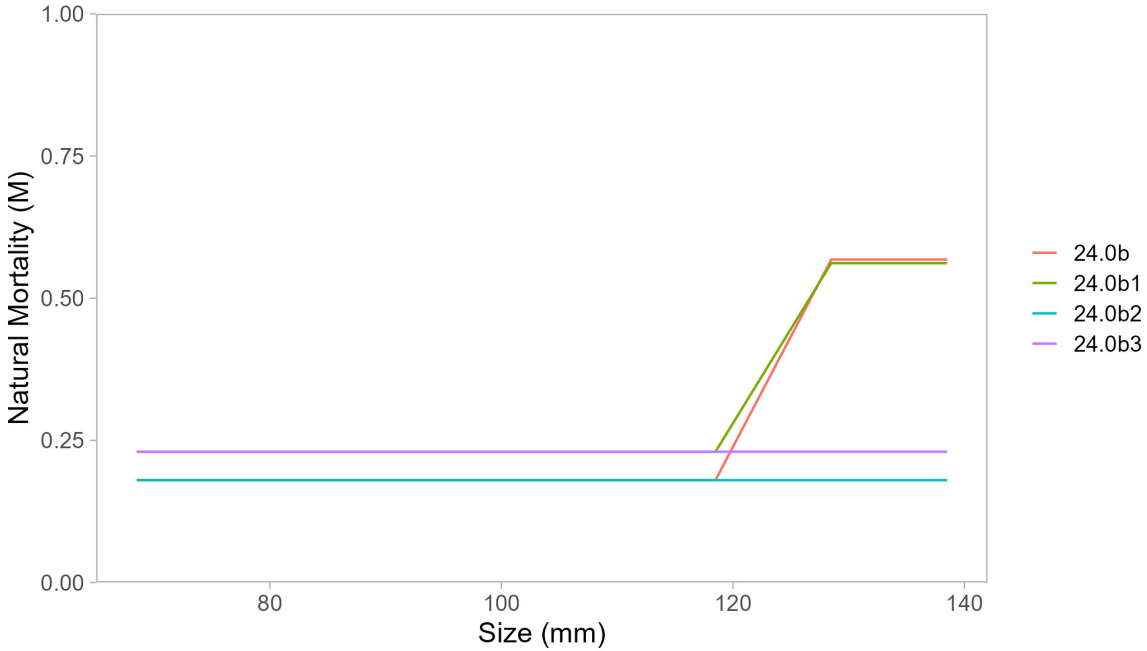
Natural mortality

SSC comments:

- *Evaluate use of size-dependent natural mortality*
- *Use prior from BBRKC for size-independent natural mortality*
- *Address overestimation of largest male crab*

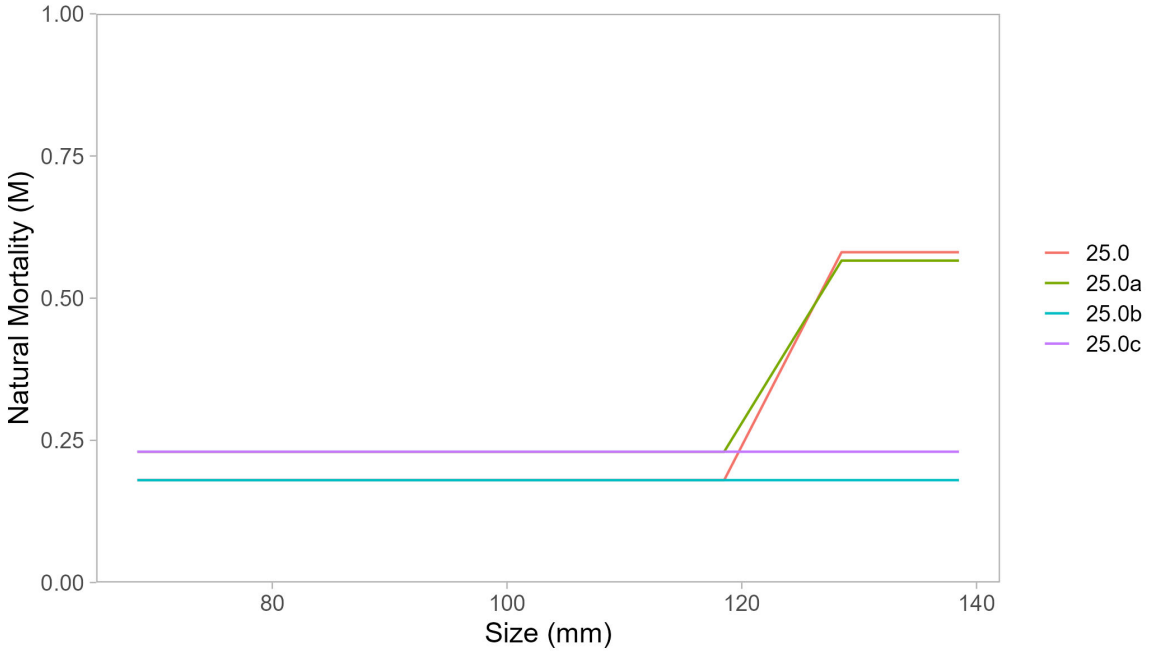
Natural mortality: base model

- 24.0b - M = 0.18 for CL $\leq$ 123 mm, est. for CL $>$ 123 mm
- 24.0b1 - M = 0.23 for CL $\leq$ 123 mm, est. for CL $>$ 123 mm
- 24.0b2 - M = 0.18 for all sizes (size-independent M)
- 24.0b3 - M = 0.23 for all sizes (size-independent M)



Natural mortality: no shell condition

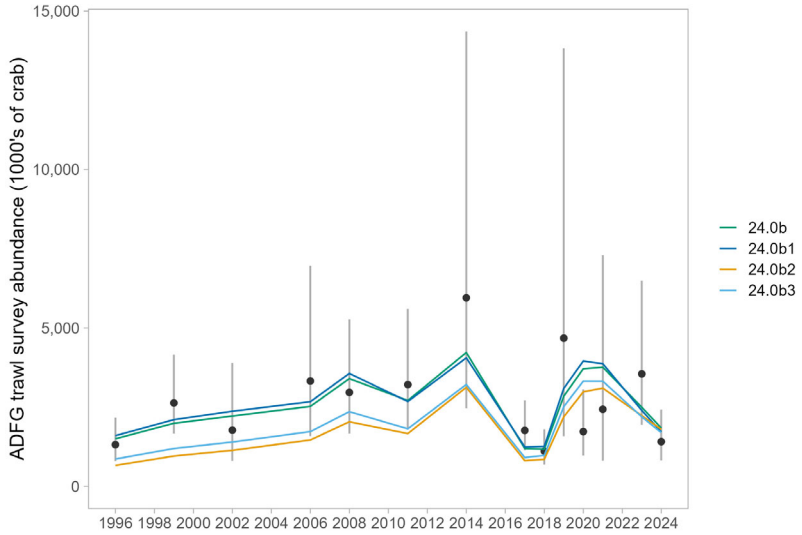
- 25.0 - M = 0.18 for CL $\leq$ 123 mm, est. for CL $>$ 123 mm
- 25.0a - M = 0.23 for CL $\leq$ 123 mm, est. for CL $>$ 123 mm
- 25.0b - M = 0.18 for all sizes (size-independent M)
- 25.0c - M = 0.23 for all sizes (size-independent M)

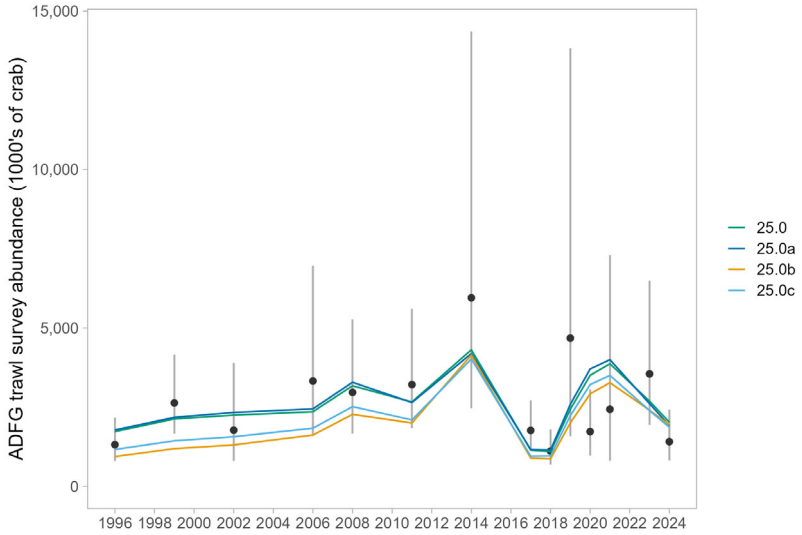


Natural mortality: results

- little change in fits to catch time series
- indices:
  - little change in fits to survey indices with > size-dep. *M*
  - better fits to survey indices with size-dep. than size-ind. *M*
  - when *M* is size-independent, better fits with higher *M*
  - slightly better fits to fishery CPUE indices with *M* = 0.23
  - smaller differences among models for those without shell condition
- worse fits to summer com. retained size comps when *M* size-independent, both and without shell condition
- retrospective patterns less extreme with size-dependent *M*, higher *M*
- stock status higher with size-independent *M*

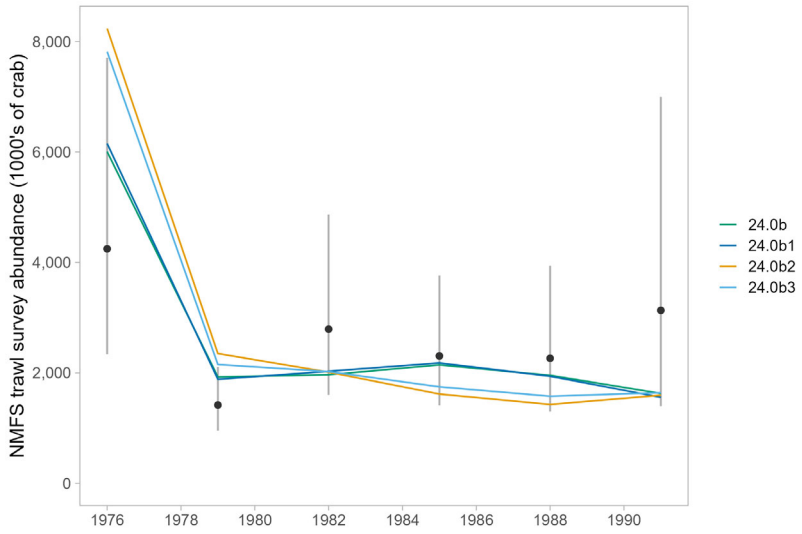
Natural mortality: fits to indices

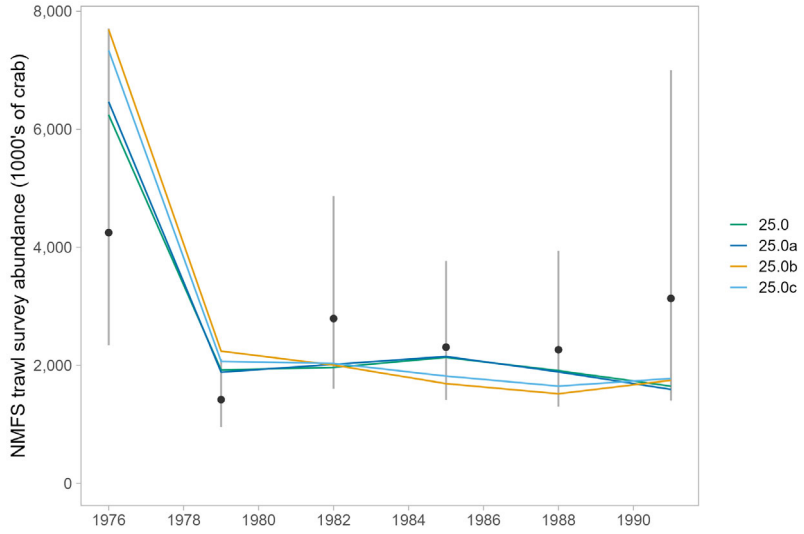




- better fits when *M* is size-dependent
- when *M* is size-independent, better fits with higher *M*

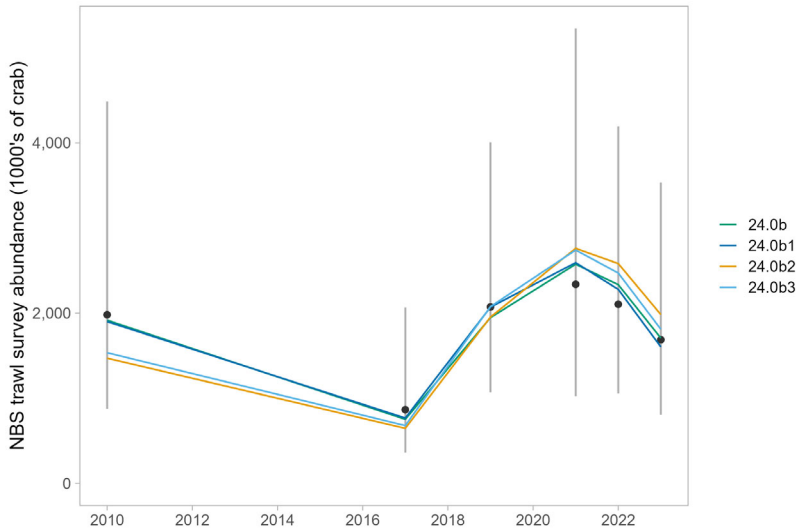
Natural mortality: fits to indices

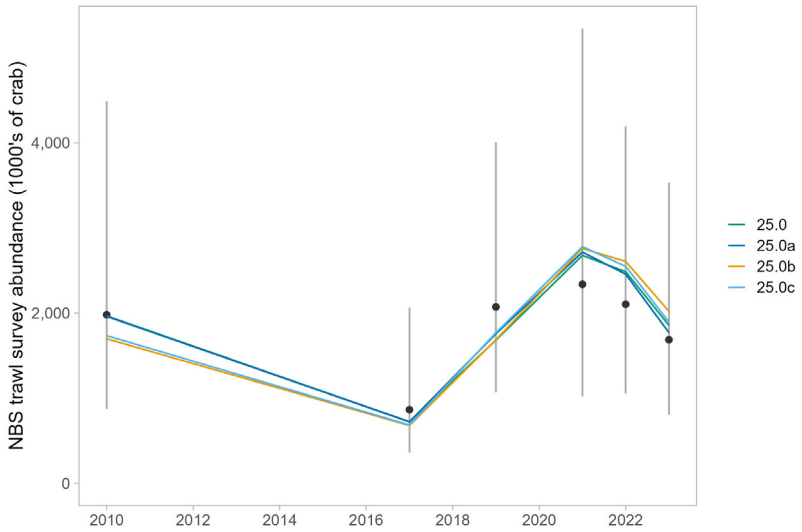




- better fits when *M* is size-dependent
- when *M* is size-independent, better fits with higher *M*

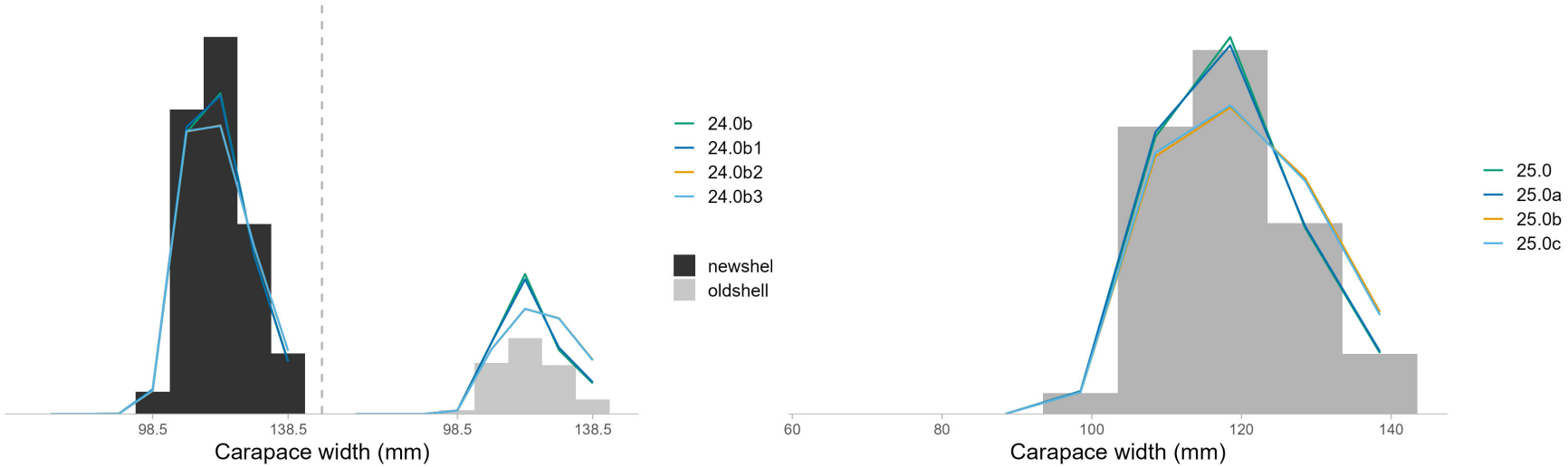
Natural mortality: fits to indices





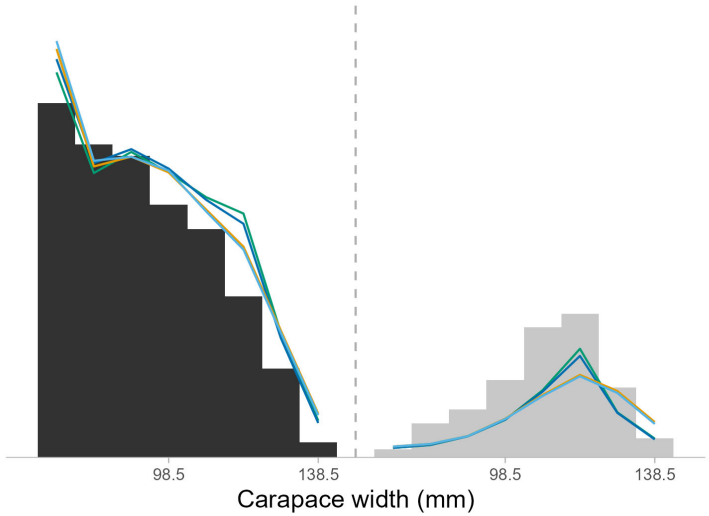
- better fits when *M* is size-dependent
- when *M* is size-independent, better fits with higher *M*

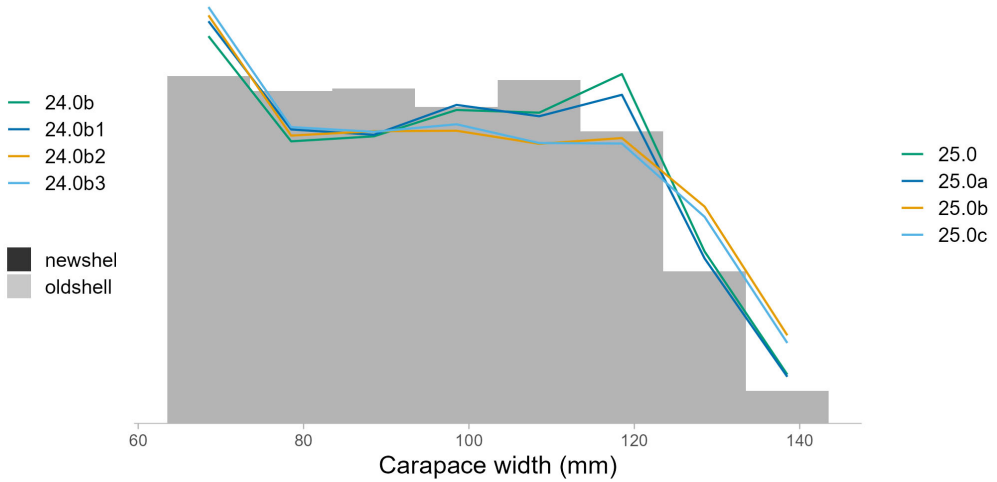
Natural mortality: fits to size comps



- better fits to summer com. retained catch size comps when *M* is size-dependent (~5% difference)
- effects on fits to other size comps relatively minor (~3% for ADF&G survey)

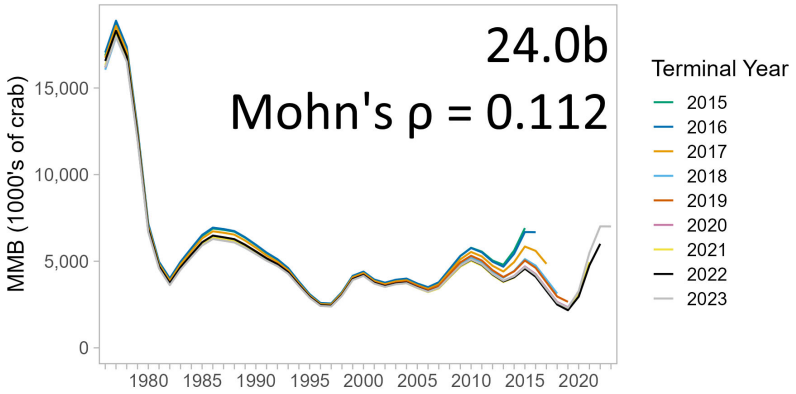
Natural mortality: fits to size comps

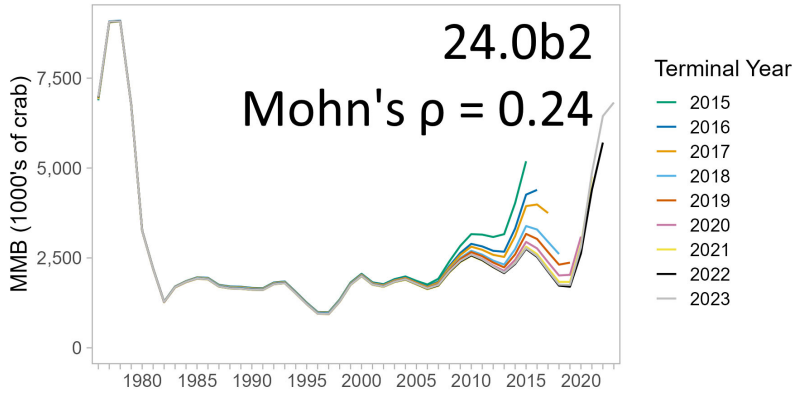


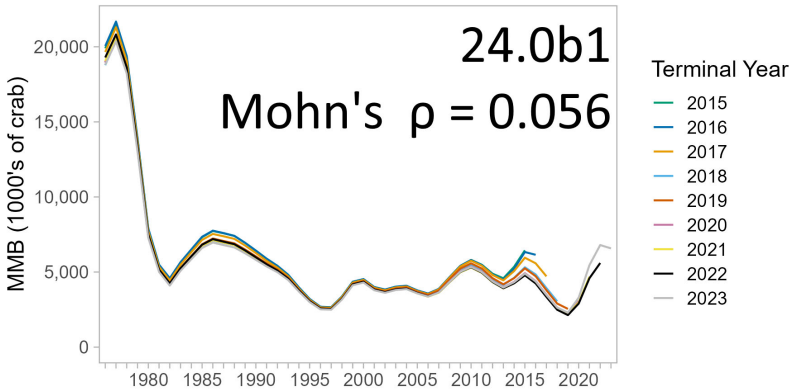


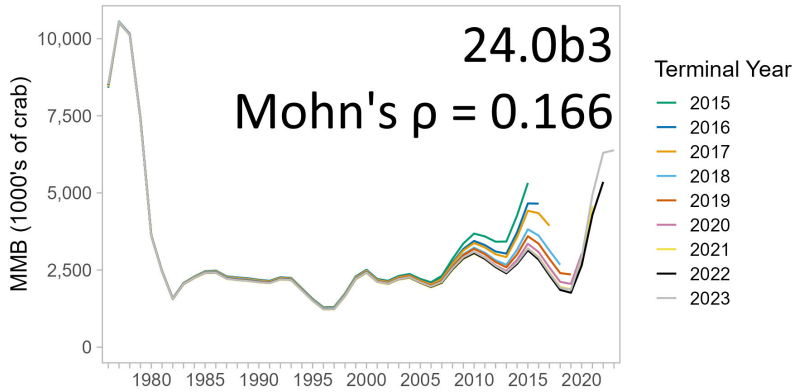
- better fits to summer com. retained catch size comps when *M* is size-dependent (~5% difference)
- effects on fits to other size comps relatively minor (~3% for ADF&G survey)

Natural mortality: base retros





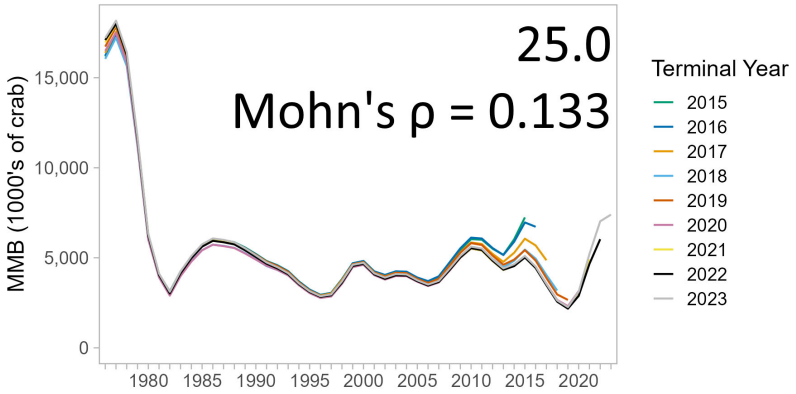


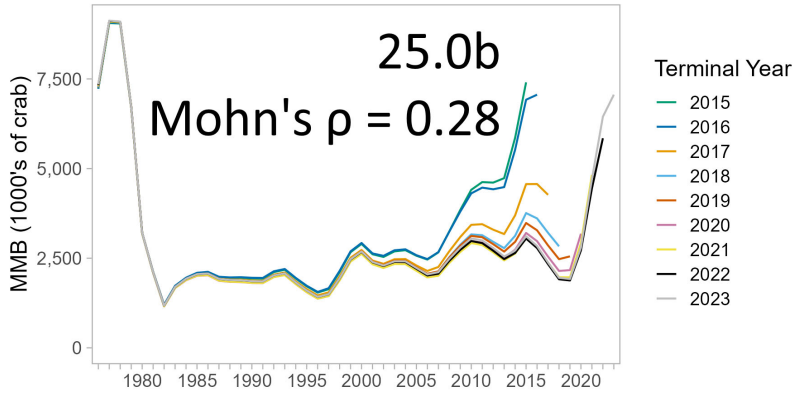


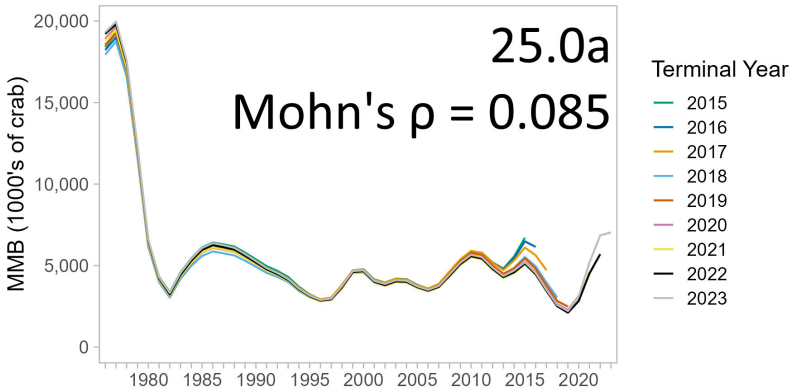
size-dependent

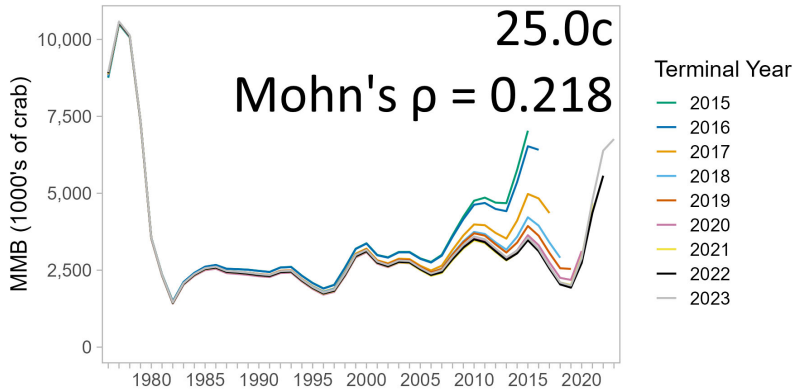
size-independent

Natural mortality: no shell retros







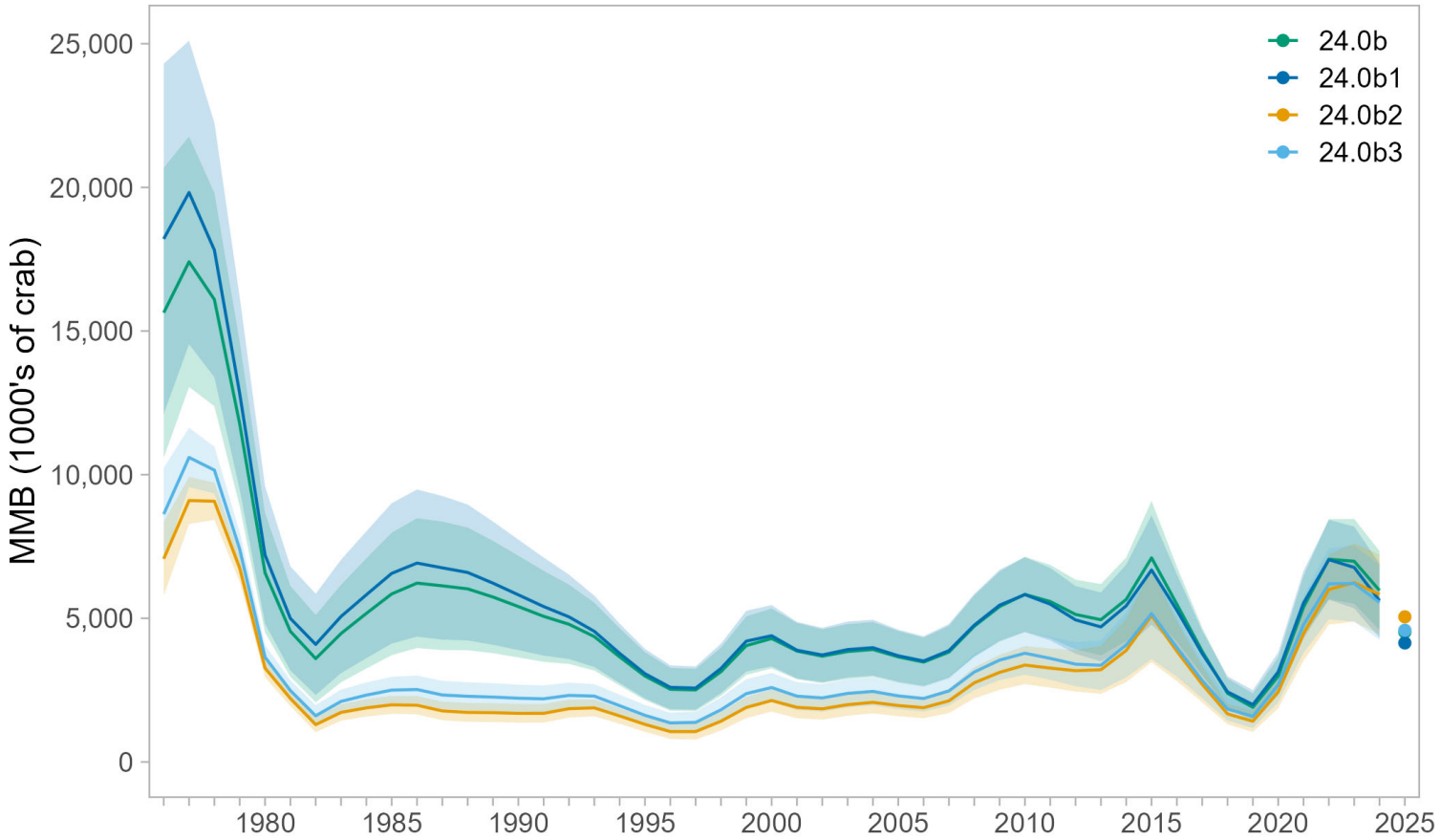


size-dependent

size-independent

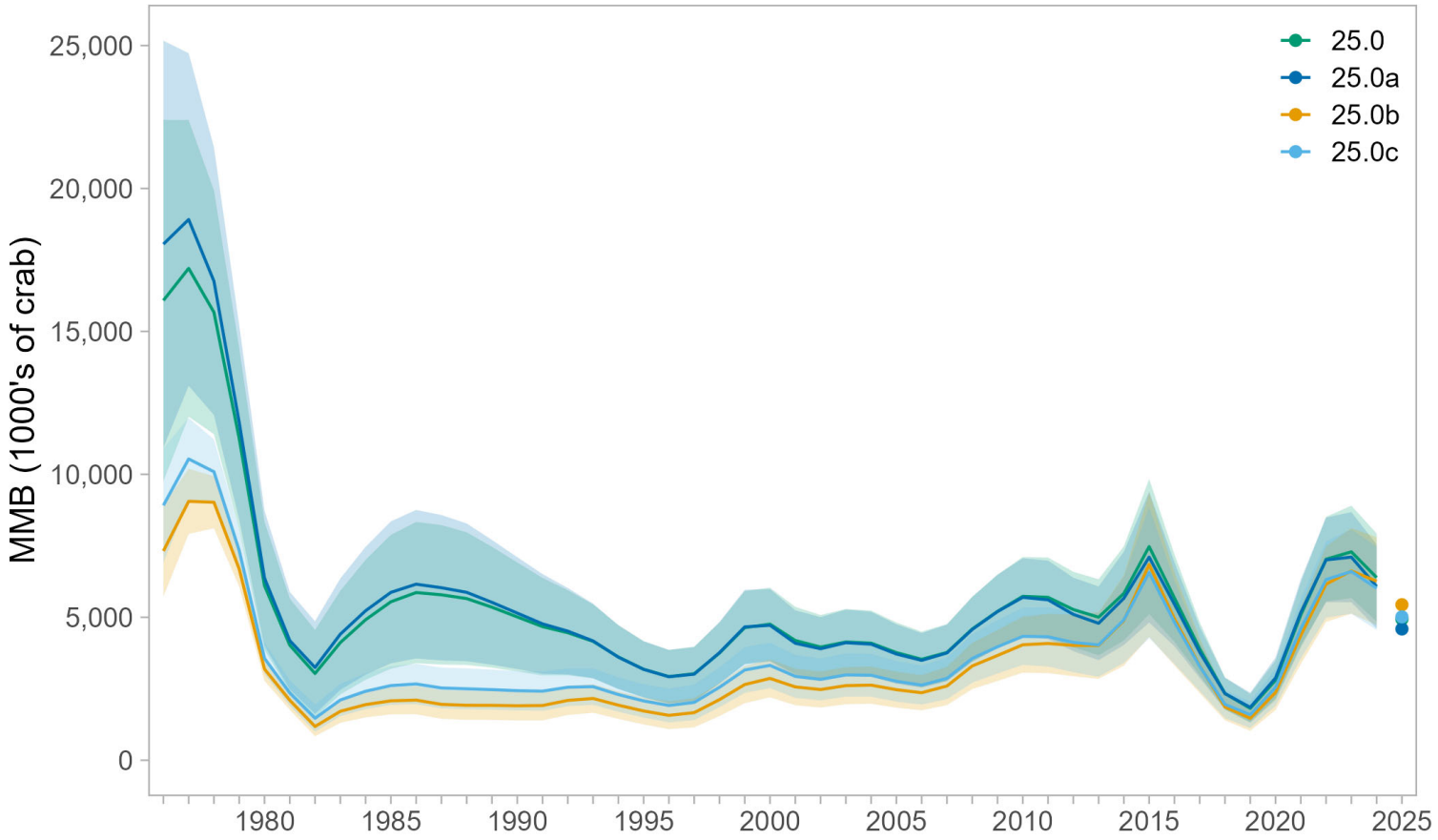
ALASKA DEPARTMENT OF FISH AND GAME

Natural mortality: MMB trajectory



with shell condition

Natural mortality: MMB trajectory



without shell condition

Natural mortality: reference points

	24.0b	24.0b1	24.0b2	24.0b3
MMB_{2025}	2051	1879	2291	2079
B_{MSY}	2115	2181	1143	1293
MMB/B_{MSY}	0.97	0.86	2.004	1.61
F_{OFL}	0.12	0.12	0.09	0.11
OFL_{2025}	114	133	189	218
ABC_{2025}	79	93	132	152

units: metric tons

Natural mortality: reference points

	25.0	25.0a	25.0b	25.0c
MMB_{2025}	2238	2083	2467	5014
B_{MSY}	2108	2115	1336	3233
MMB/B_{MSY}	1.06	0.98	1.846	1.55
F_{OFL}	0.12	0.14	0.11	0.14
OFL_{2025}	123	161	167	436
ABC_{2025}	86	113	117	305

units: metric tons

Natural mortality summary

SSC comments:

- *Evaluate use of size-dependent natural mortality*
- *Use prior from BBRKC for size-independent natural mortality*
- *Address overestimation of largest male crab*

When *M* size-independent,

- worse fits to indices
- better fits to indices with higher *M*
- worse fits to summer com. retained catch size comps
- worse retrospective patterns
- higher stock status

feedback: adopt *M* from BBRKC? Use size-independent *M*?

Model-based indices

SSC comment: *address inconsistencies in area used to calculate abundance among trawl surveys*

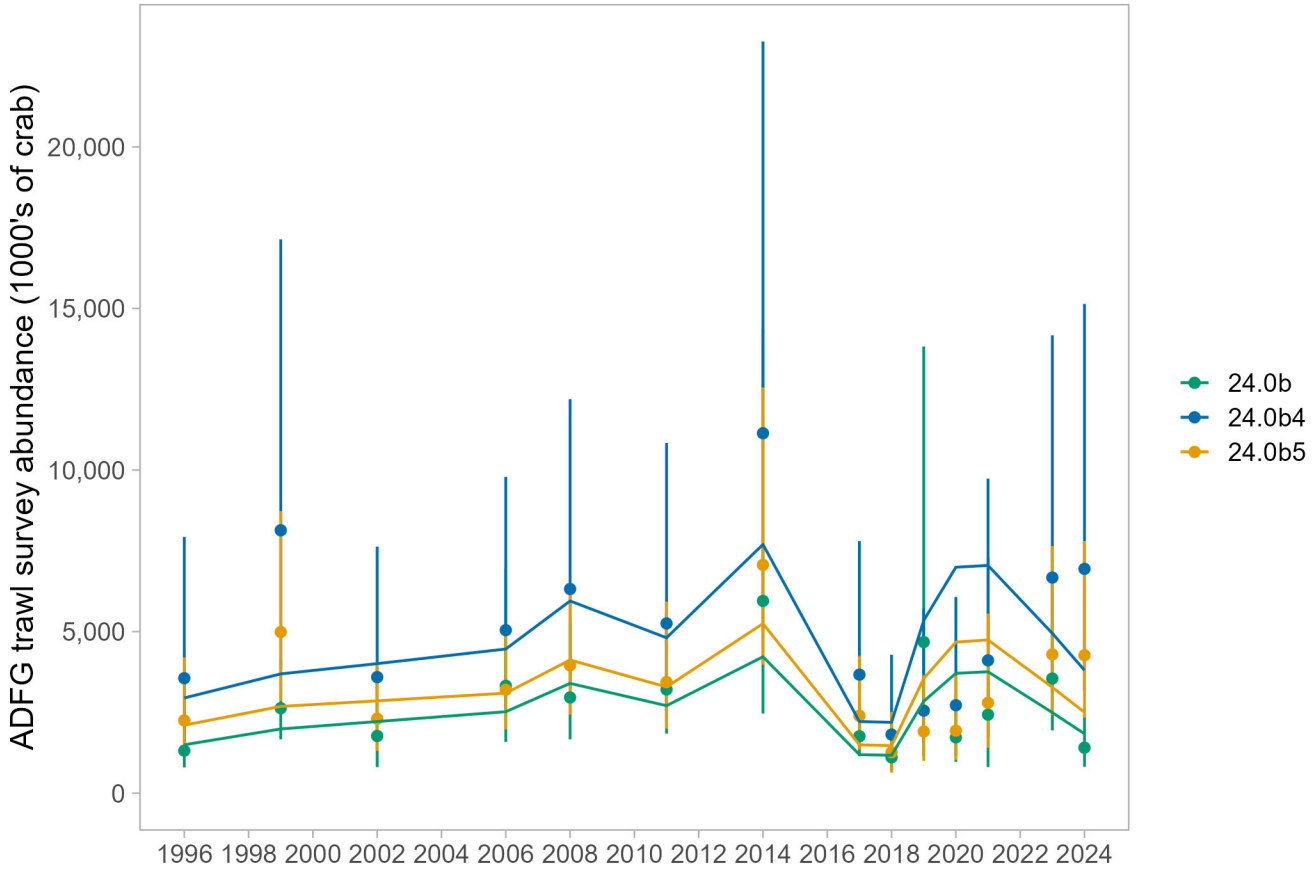
Model 24.0b4:

24.0b with design-based indices for the three trawl surveys replaced by model-based indices estimated over the **larger** prediction area

Model 24.0b5:

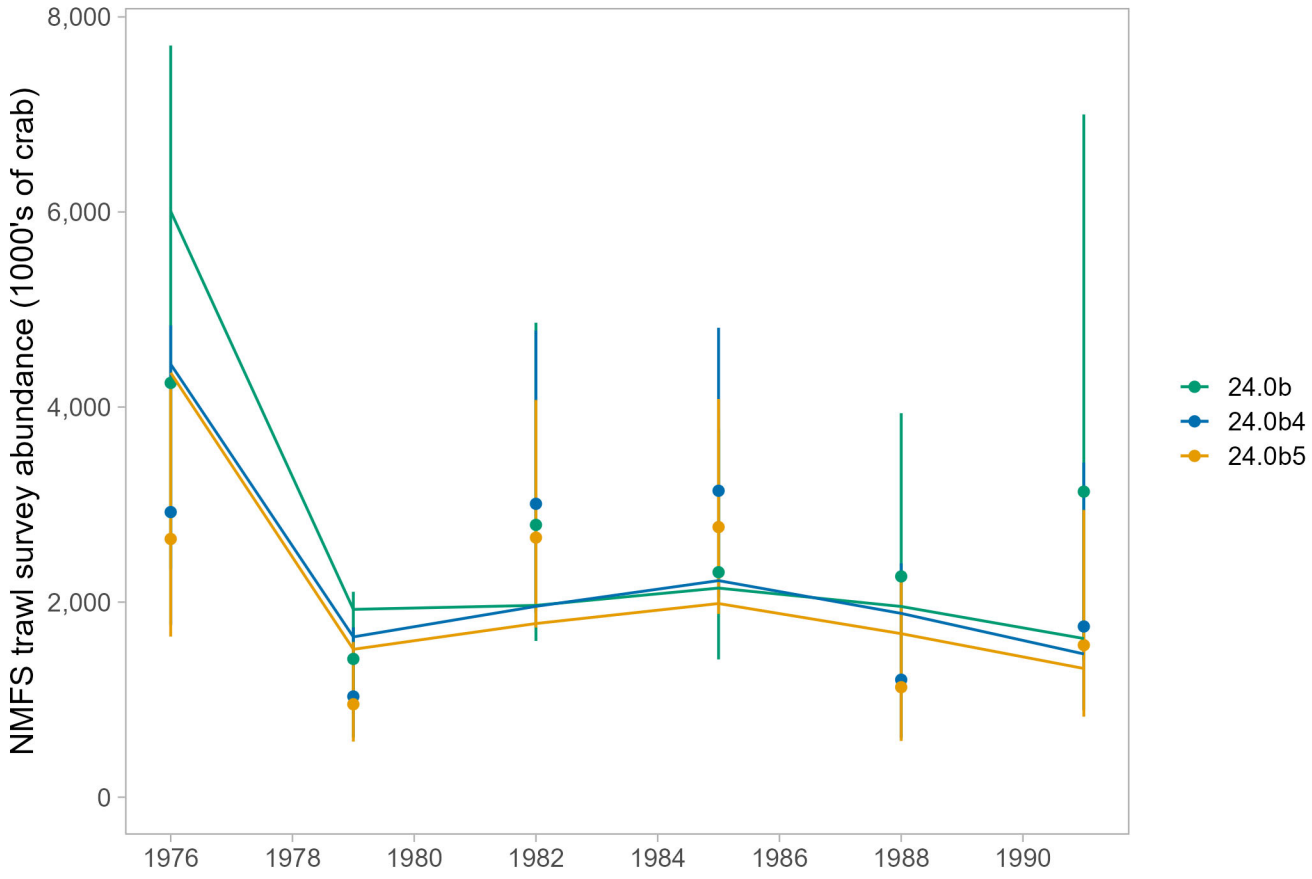
24.0b with design-based indices for the three trawl surveys replaced by model-based indices estimated over the **smaller** prediction area

Model-based indices: fits



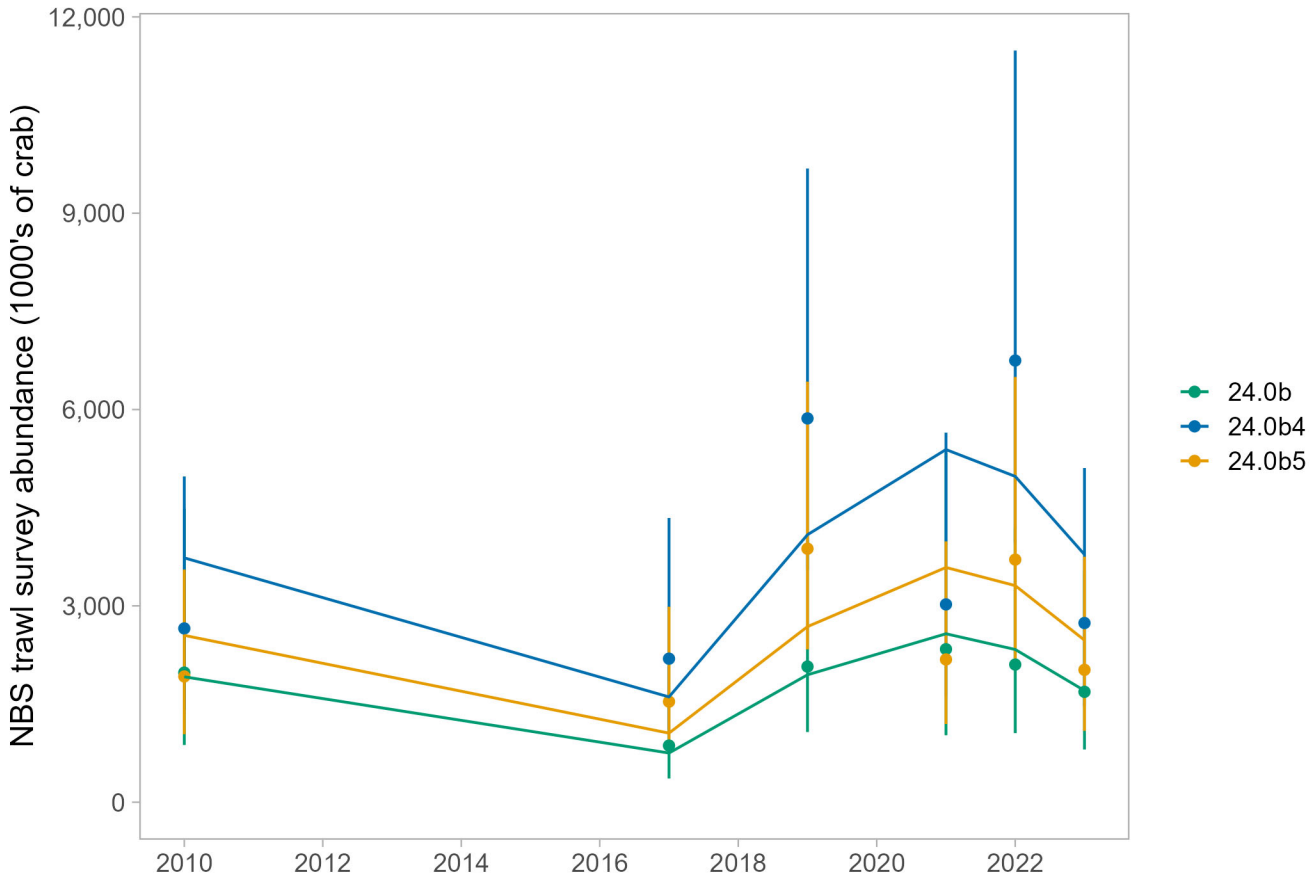
24.0b4 and 24.0b5: poorer fits to all 3 trawl survey indices

Model-based indices: fits



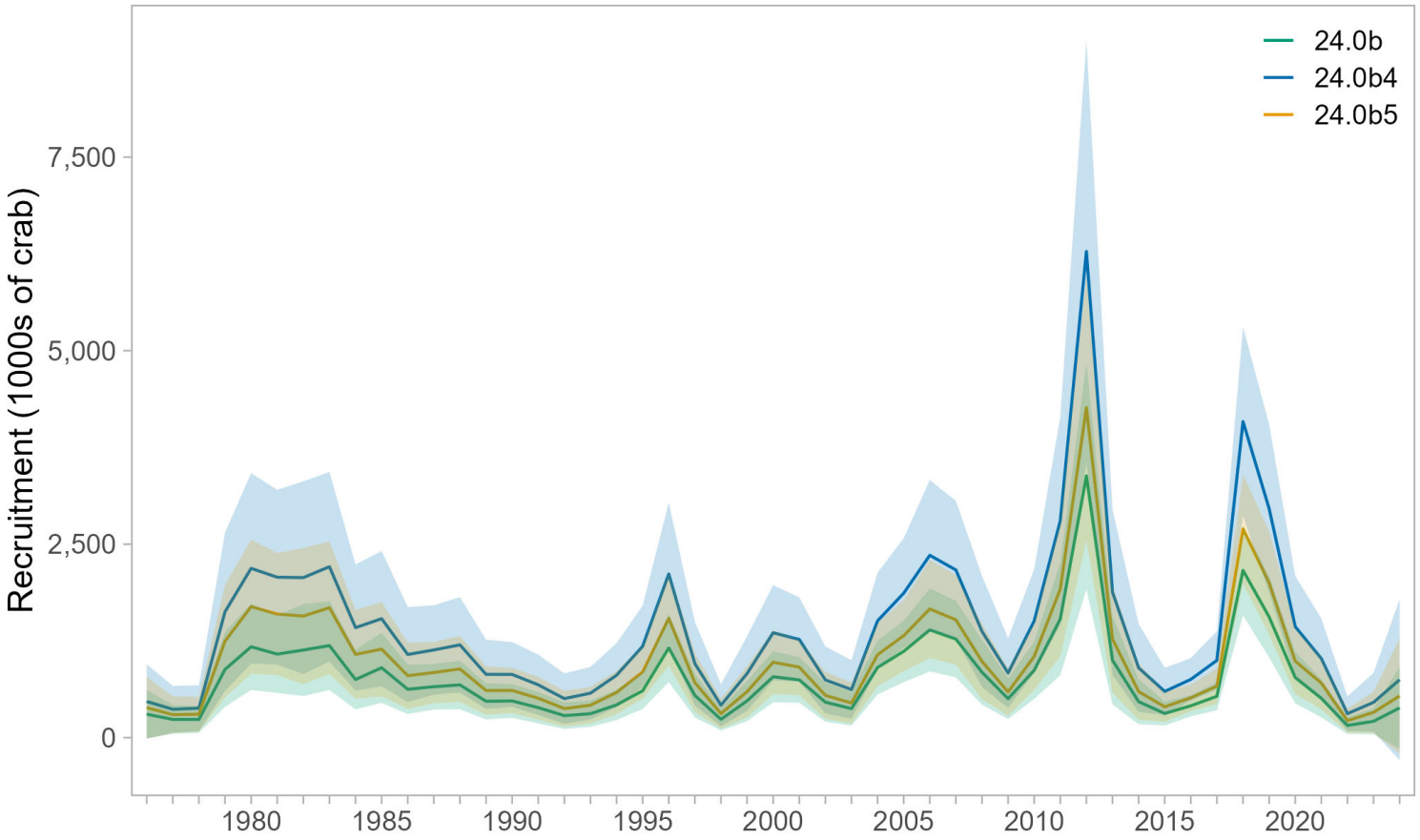
24.0b4 and 24.0b5: poorer fits to all 3 trawl survey indices

Model-based indices: fits

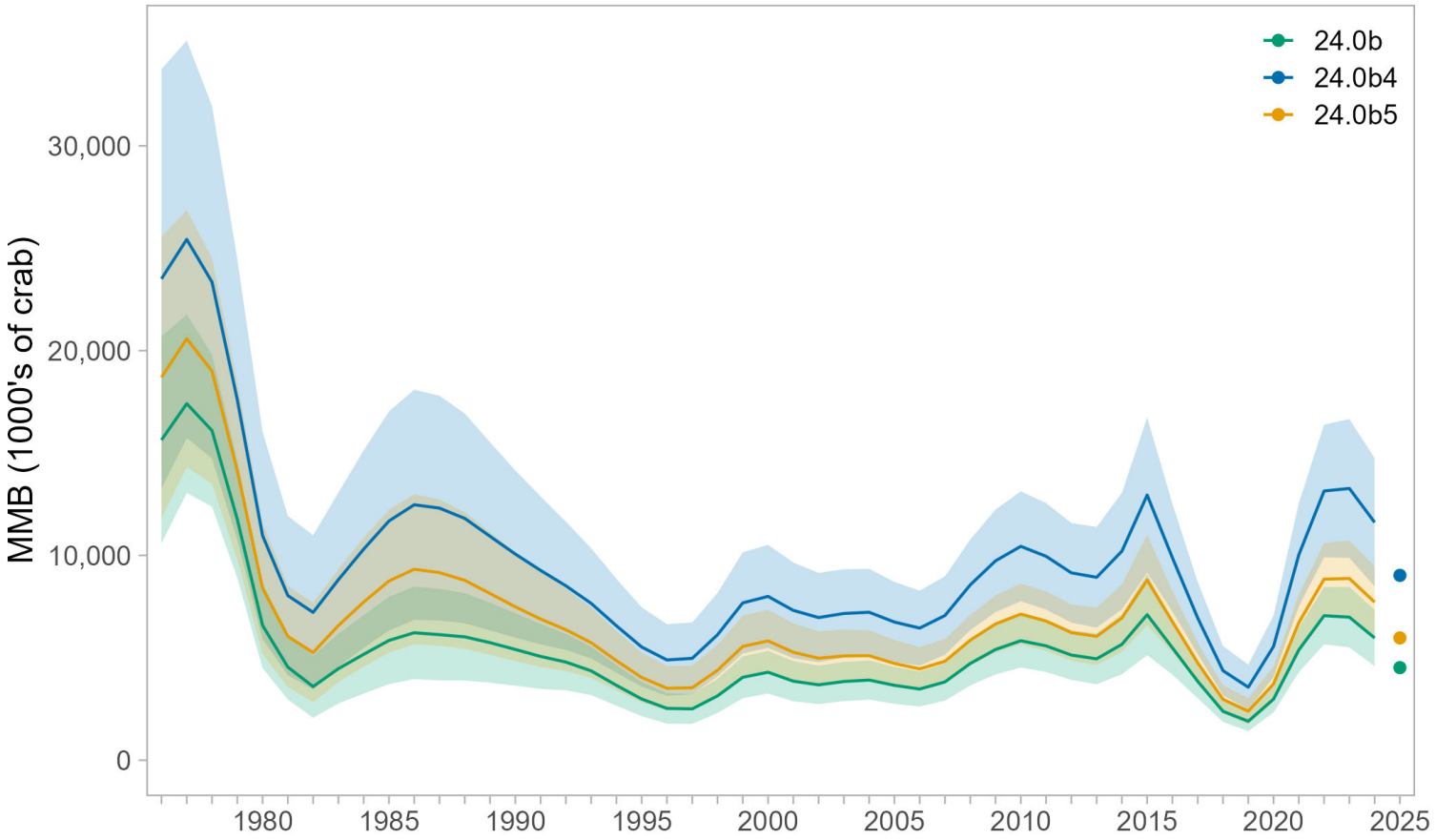


24.0b4 and 24.0b5: poorer fits to all 3 trawl survey indices

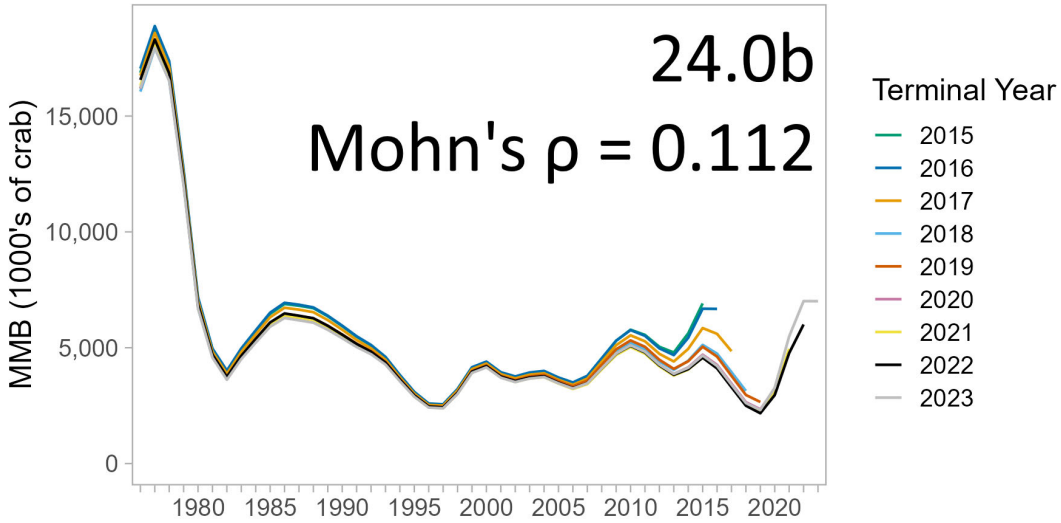
Model-based indices: recruitment

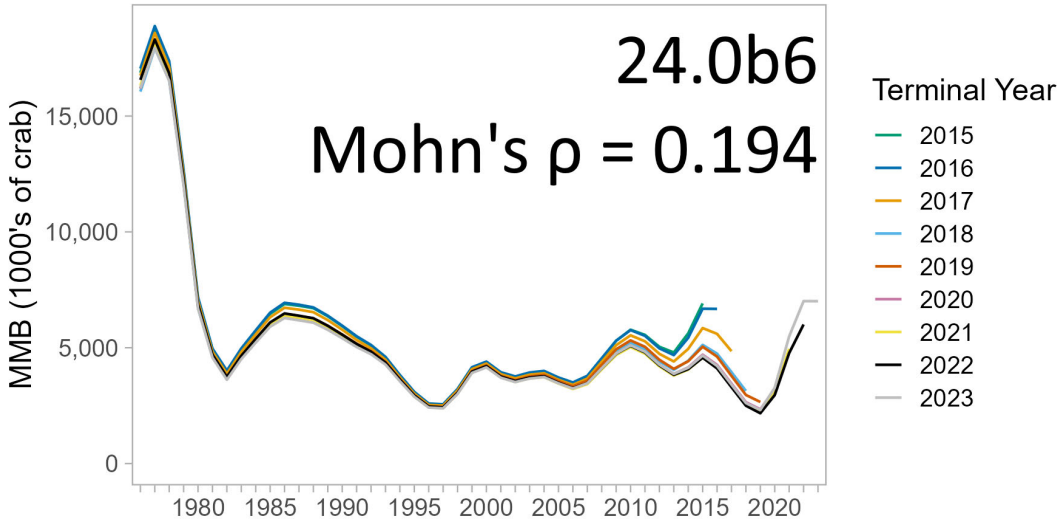


Model-based indices: MMB trajectories

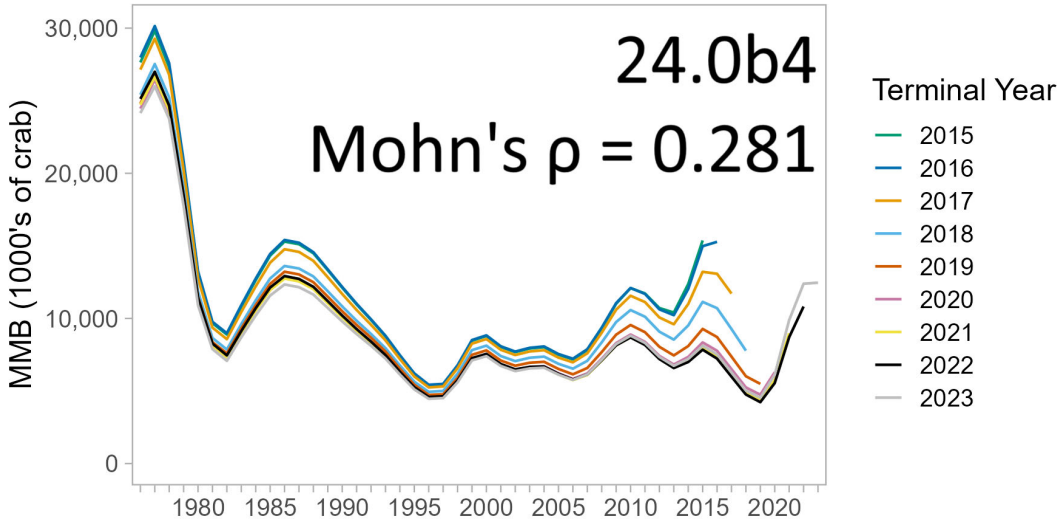


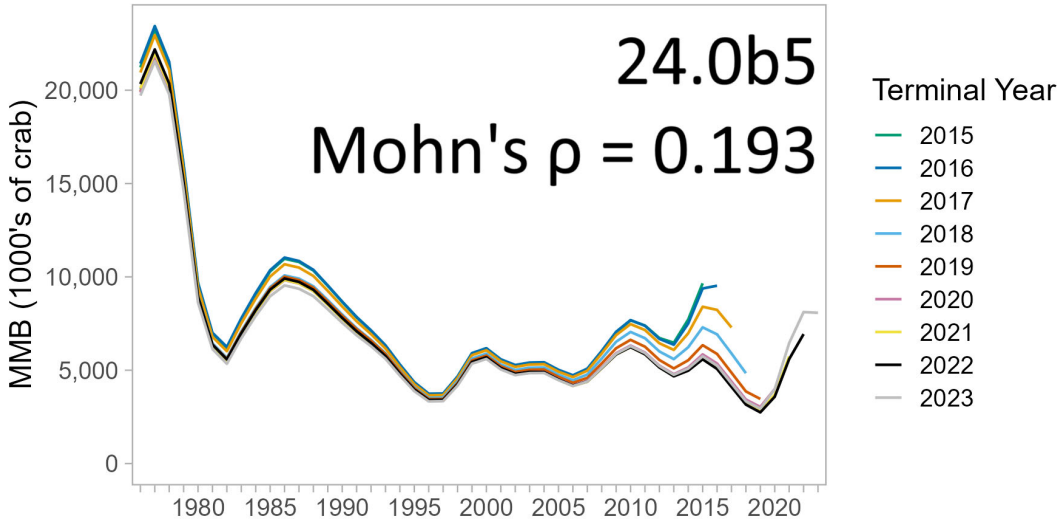
Model-based indices: retrospectives





Model-based indices: retrospectives





Model-based indices: reference points

	24.0b	24.0b4	24.0b5
MMB_{2025}	2051	4095	2709
B_{MSY}	2115	3942	2803
MMB/B_{MSY}	0.97	1.039	0.97
F_{OFL}	0.12	0.15	0.13
OFL_{2025}	114	158	124
ABC_{2025}	79	110	87

units: metric tons

Model-based indices summary

When using model-based indices for the three trawl surveys,

- fits to catch time series almost identical
- poorer fits to trawl survey indices
- fits to size comps overall similar (slightly worse for ADF&G survey, better for NBS survey)
- scale of population higher (more so with larger prediction area)
- worse retrospective patterns
- stock status similar

feedback: prediction area to use, using combined survey index

Decision points for model development

Bridging analysis:

- use 24.0b or 24.0b6 as new base model?
- what can we learn from 24.0b given better retros, fits?

Shell condition: exclude shell condition in future?

Natural mortality:

- adopt *M* from BBRKC?
- use size-independent *M*?

Model-based indices:

- prediction area?
- model with surveys combined into single index?

Thanks!