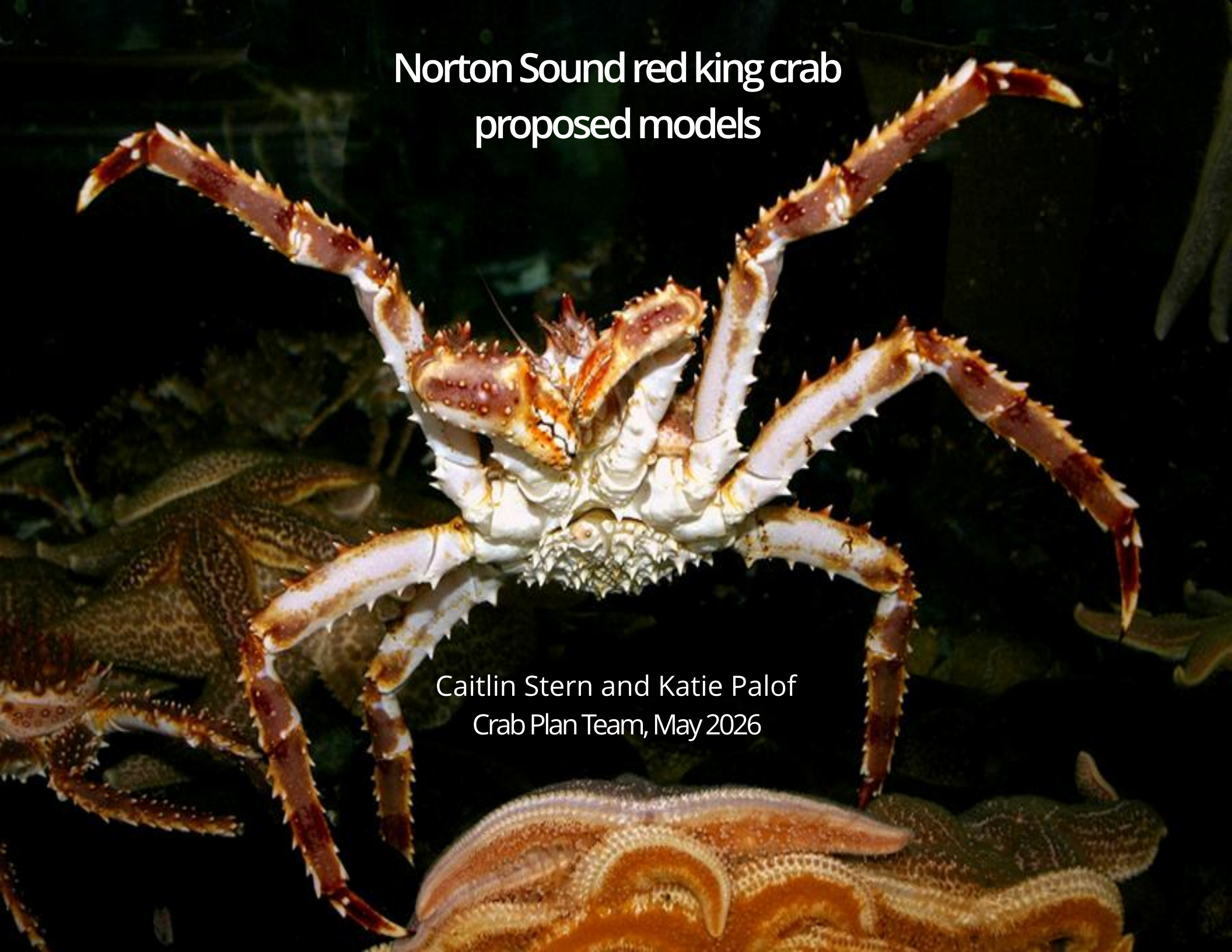
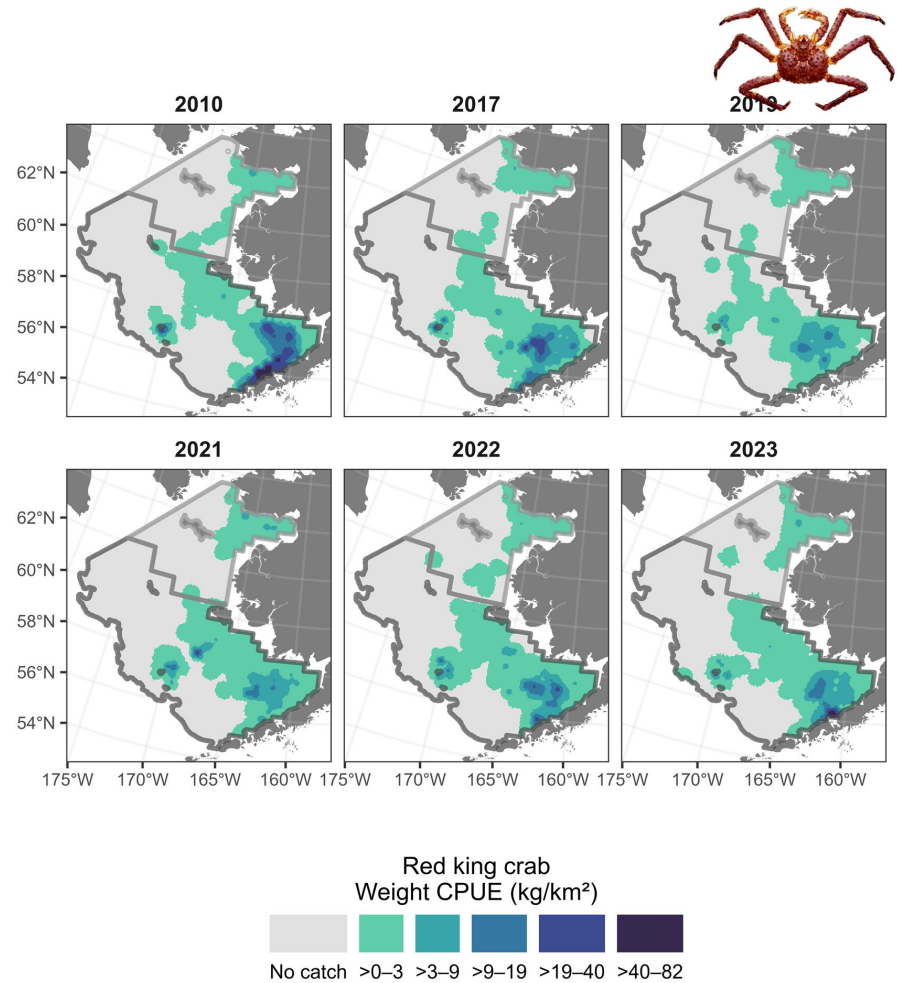


Norton Sound red king crab  
proposed models

Caitlin Stern and Katie Palof  
Crab Plan Team, May 2026



# Norton Sound red king crab stock



# Norton Sound red king crab fisheries

Commercial: summer small vessel and winter through the ice

Subsistence: year-round



Photos: Johnnie Noyakuk, Scott Kent



# Topics

Priorities for the 2026 assessment cycle

Bridging to newer GMACS version

Development of a model-based index (MBI)

Proposed models including the MBI



# Topics

Priorities for the 2026 assessment cycle

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Proposed models including the MBI



# SSC and CPT comments

*Prioritize further exploration of model-based index of abundance for this stock, given the concern about the apparent lack of overlap between the survey stock distributions.*

Addressed here.

*Prioritize aligning the footprint of the NBS bottom trawl survey abundance index and the length compositions*

If a model using the model-based index of abundance is adopted, these footprints will be aligned.

*Update and document the standardization of the fishery CPUE index*

Work underway but not yet complete.



# Topics

Priorities for the 2026 assessment cycle

Bridging to newer GMACS version

Development of a model-based index (MBI)

Proposed models including the MBI



# Bridging analysis

2025 accepted model: 25.0a2

- males  $\geq 64$  mm only, 8 size classes
- catch: winter com. retained, sub. retained, sub. total, summer com. retained
- relative abundance: 3 trawl surveys, standardized 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
- size-dependent  $M = 0.23$  for males with  $CL \leq 123$  mm, est. for  $CL > 123$  mm (2 largest size bins)
- fishery selectivity: logistic for summer com., winter com., and subsistence
- pot survey selectivity: dome-shaped for winter pot survey
- trawl survey selectivity: only estimated for NOAA NS trawl survey, other trawl survey selectivities mirrored to that value. Estimate = 1 for all size classes
- survey catchability = 1 for ADF&G trawl survey, estimated for other trawl surveys and fishery CPUE indices



# Bridging analysis

Model 26.0: 25.0a2 transitioned to GMACS 2.20.34a

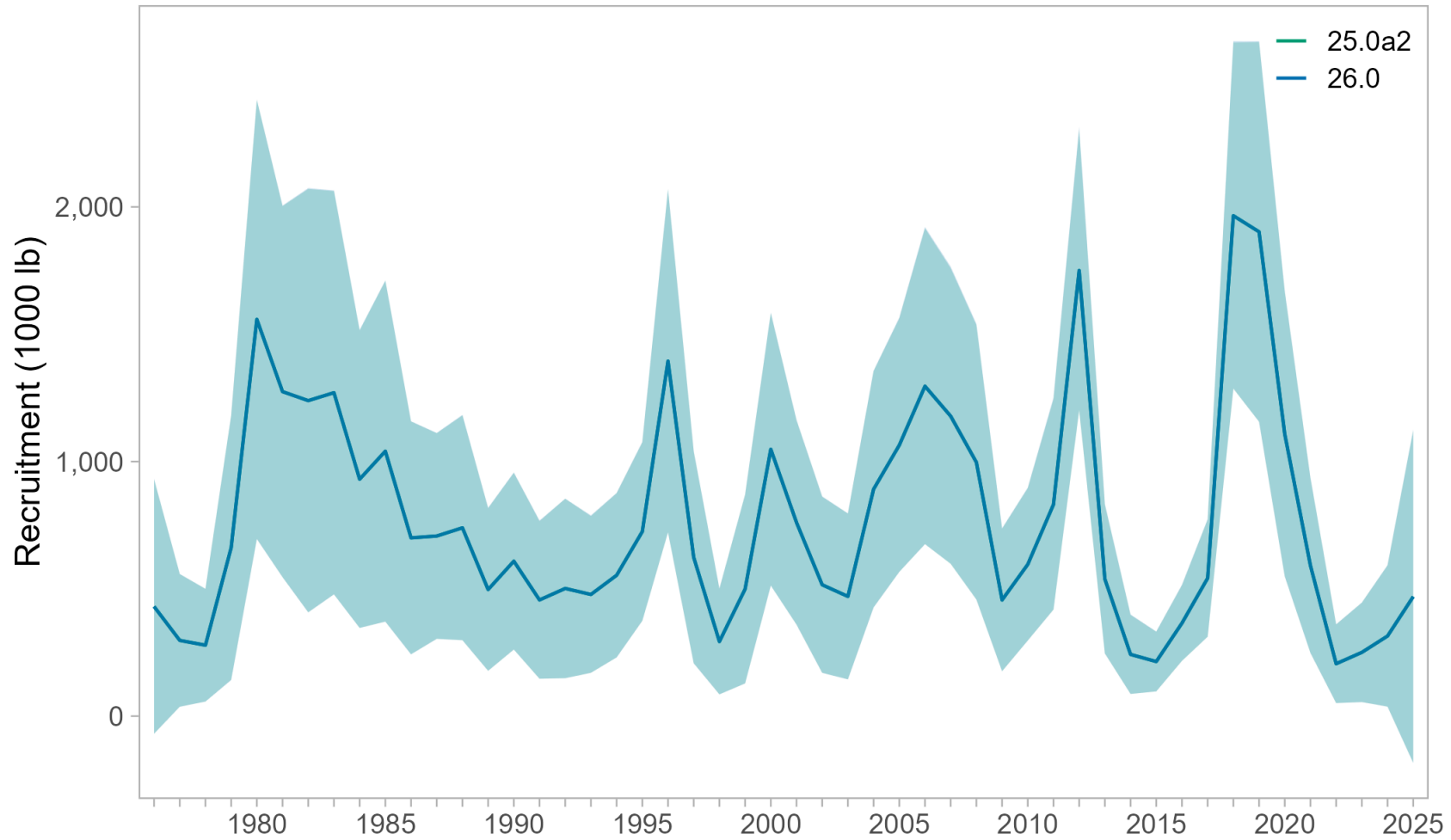
- moved phase of estimation of the  $\alpha$  parameter of the recruitment size distribution from 3 to 5
- upper bound for the  $\beta$  parameter of growth reduced from 20 to 1, to avoid allowing negative growth at the bound

	25.0a2	26.0
$MMB_{2026}$	1.56	1.56
$B_{MSY}$	2.005	2.005
$MMB/B_{MSY}$	0.78	0.78
$F_{OFL}$	0.17	0.17
$OFL_{2026}$	0.193	0.193
$ABC_{2026}$	0.135	0.135

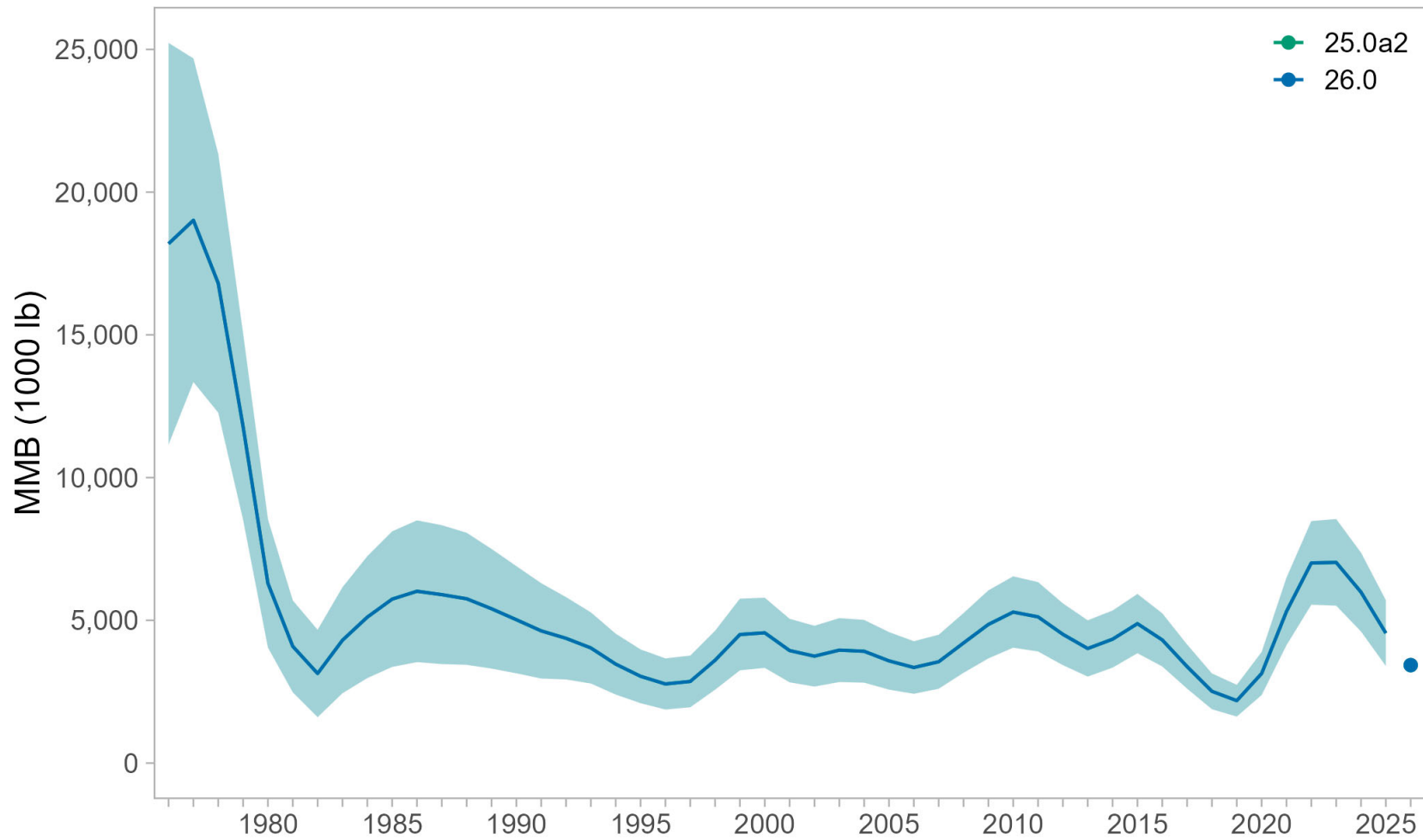
units: metric tons



# Recruitment trajectory unchanged



# MMB trajectory unchanged



# Topics

Priorities for the 2026 assessment cycle

Bridging to newer GMACS version

Development of a model-based index (MBI)

Proposed models including the MBI

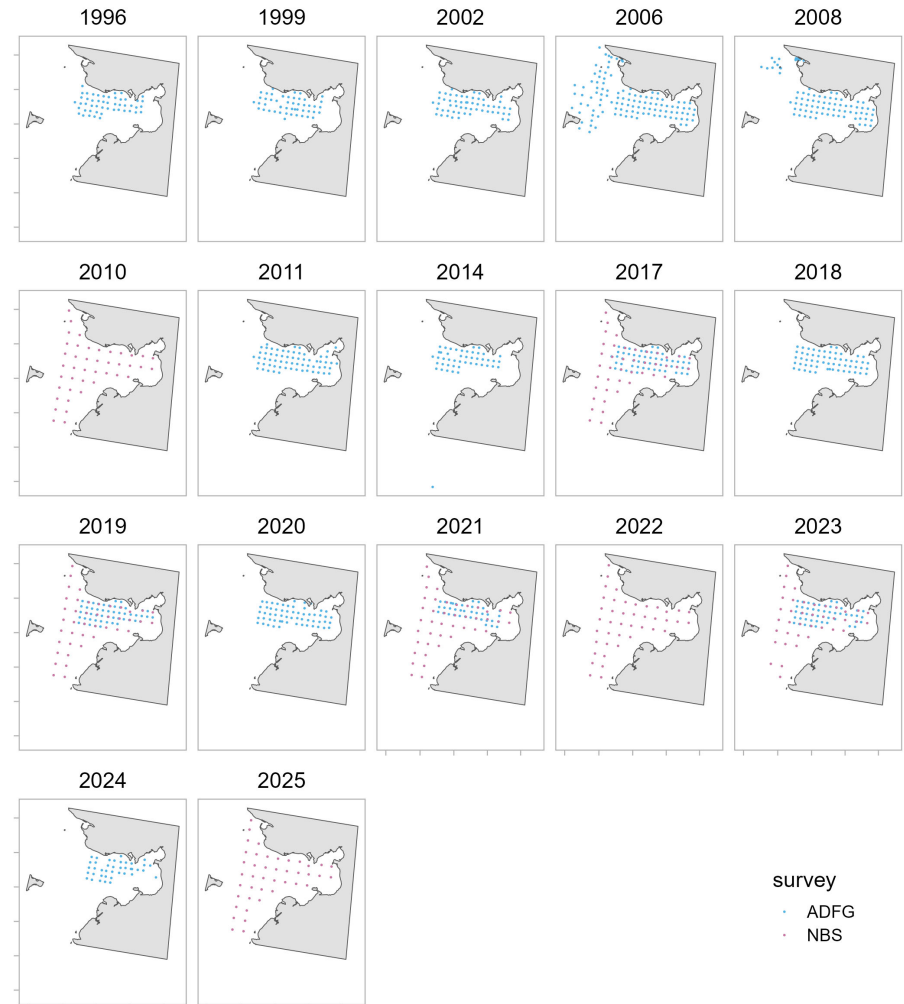


# Model-based index development

Design-based ADF&G and NBS survey estimates calculate abundance over the area targeted for commercial harvest

Survey observations indicate that the stock range is likely larger

Accounting for spatiotemporal variation in survey catch expected to lead to more consistent abundance estimates

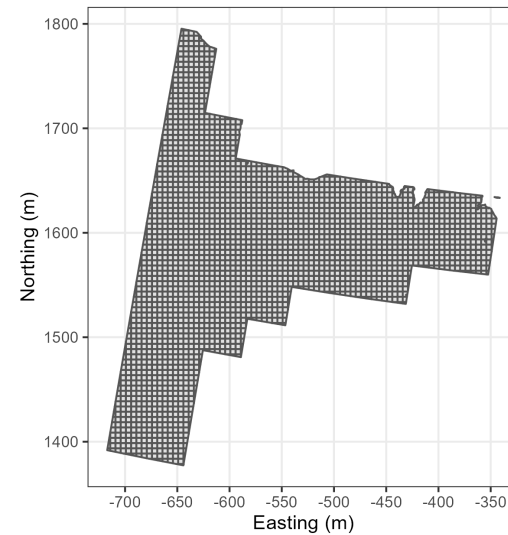
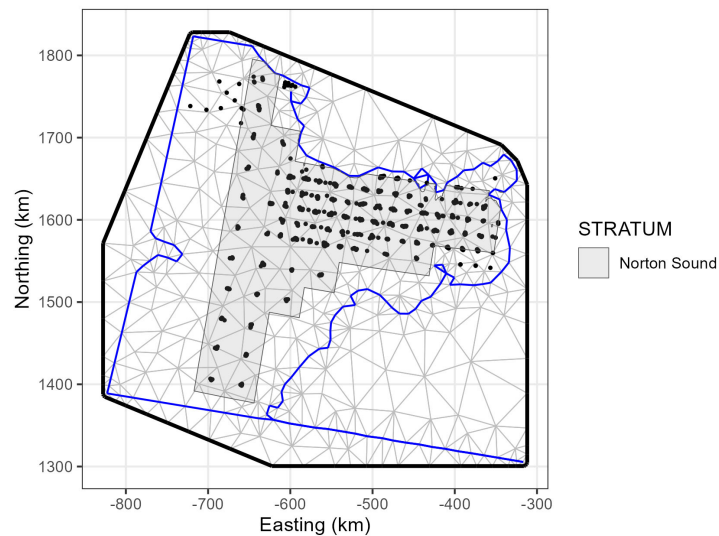


# Spatiotemporal model-based index standardization

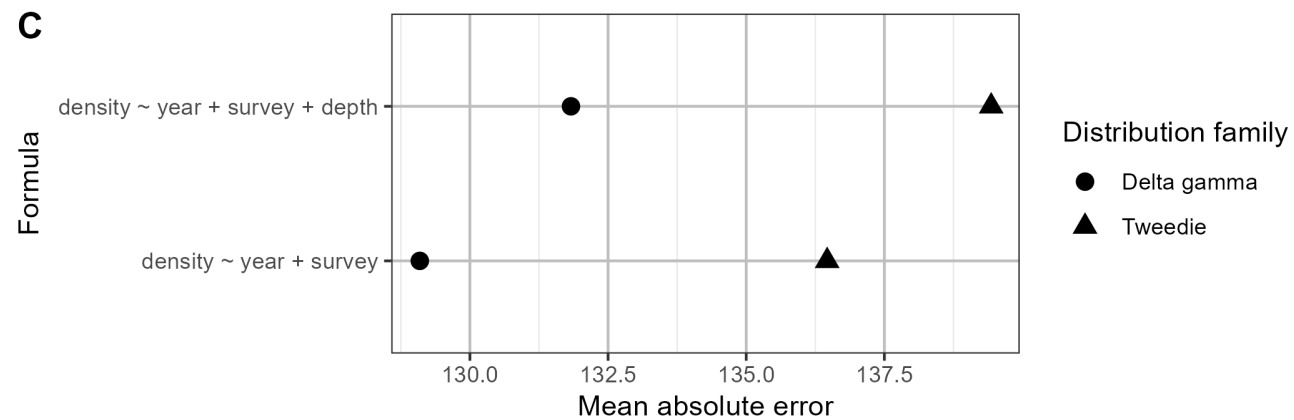
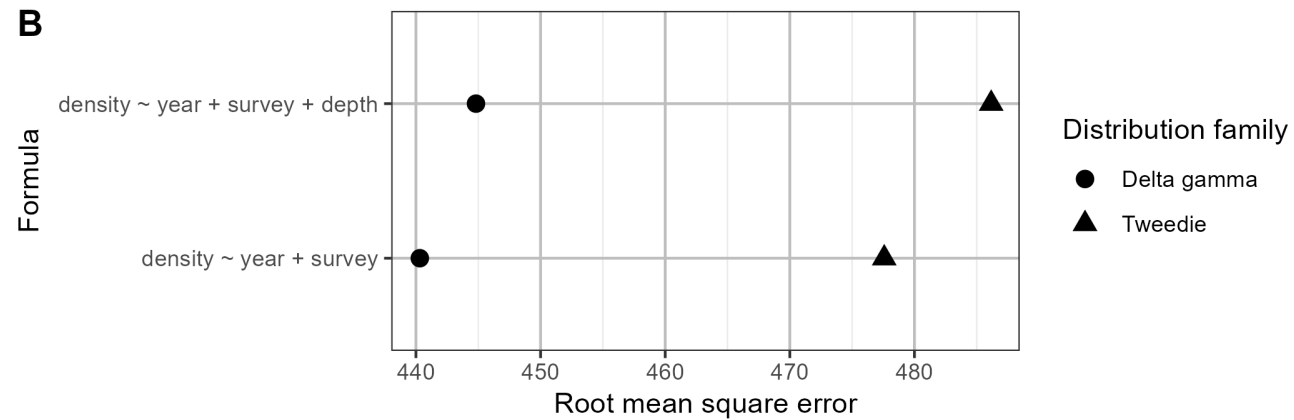
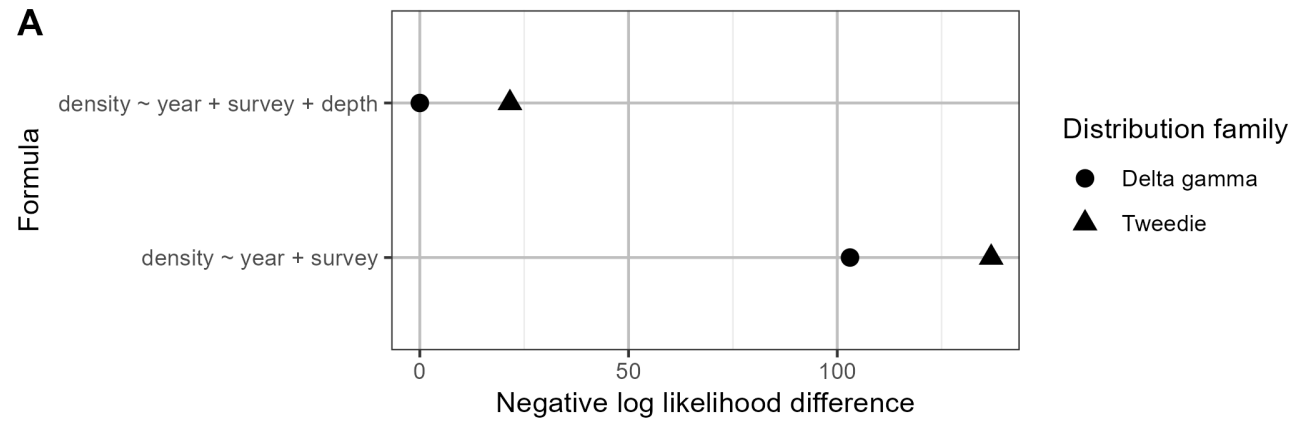
Fit geostatistical GLMMs with spatiotemporally correlated random effects to survey data using sdmTMB

Fixed effects: year, survey, depth

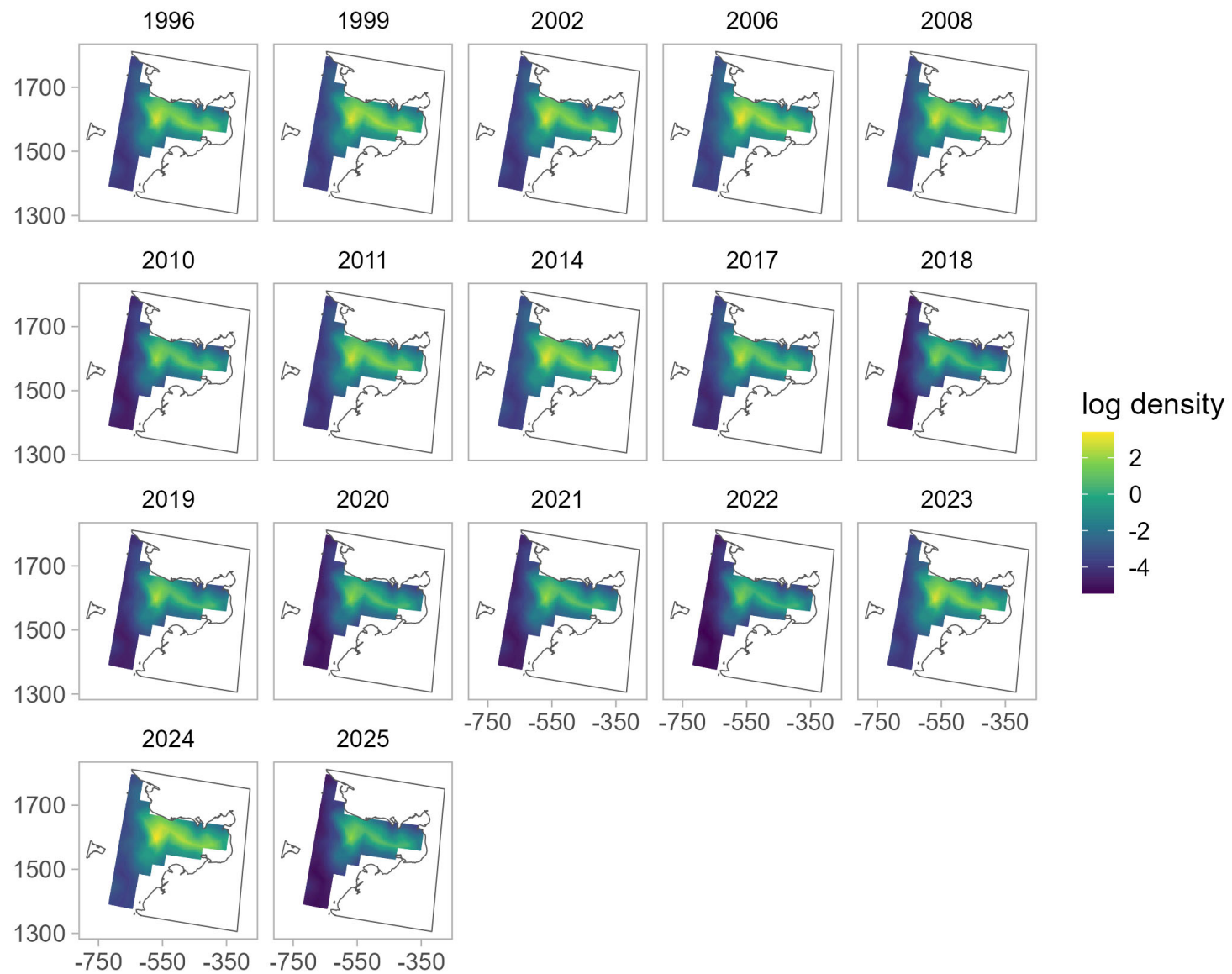
Distribution families: Tweedie, delta gamma, delta lognormal



# Model selection



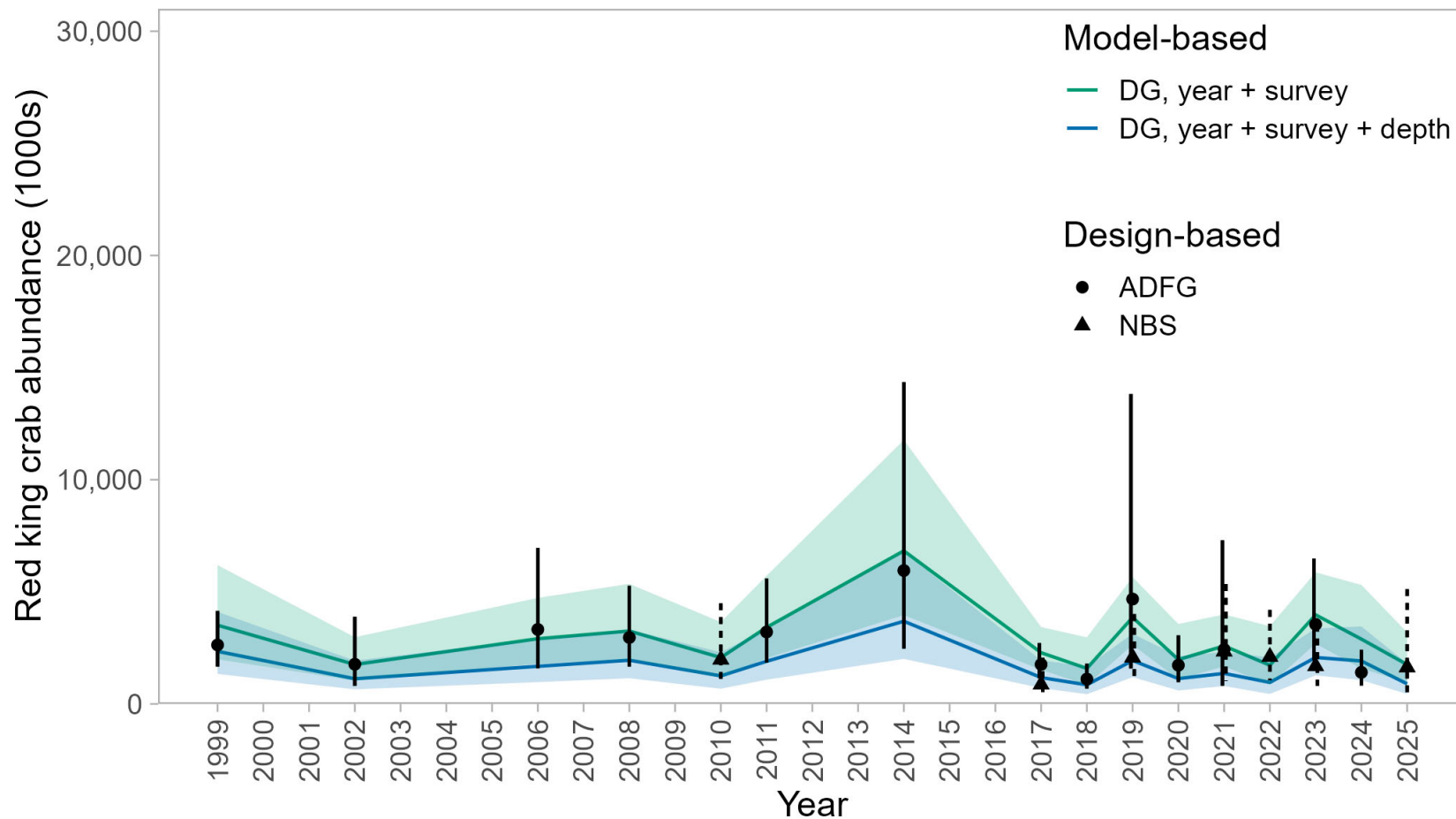
# Spatial predictions



# Model-based vs. design-based indices

Spatiotemporal model-based abundance indices can have reduced variability compared to design-based indices (Cao et al. 2017, Chen et al. 2024)

May be due to accounting for spatial variation in survey catch and/or including habitat variables



# Topics

Priorities for the 2026 assessment cycle

Bridging to newer GMACS version

Development of a model-based index (MBI)

Proposed models including the MBI



# Proposed models for 2026

26.1: 26.0 with the model-based index of abundance

- Catchability for the MBI fixed at 1, catchability for the historical Norton Sound survey index estimated
- Selectivity for NS survey estimated; ADFG and NBS survey selectivities mirrored.

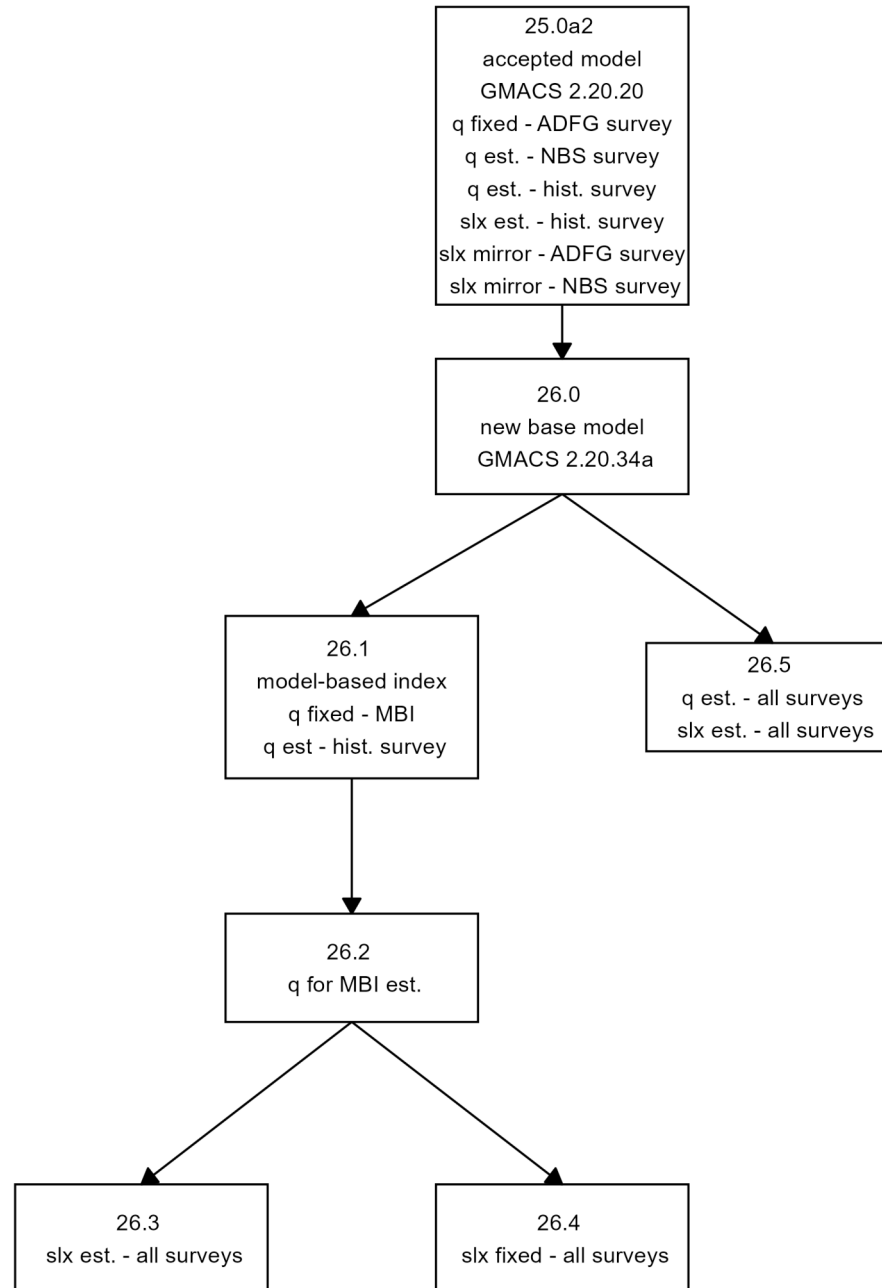
26.2: 26.1 with catchability for the MBI estimated

26.3: 26.2 with selectivities for all 3 trawl surveys estimated

26.4: 26.2 with selectivities for all 3 trawl surveys fixed



# Models flow chart



# Model results

- Catchability, selectivity
- Fishing mortality, natural mortality
- Fits to time series: catch, indices, size comps
- Recruitment, MMB
- Retrospectives
- Reference points

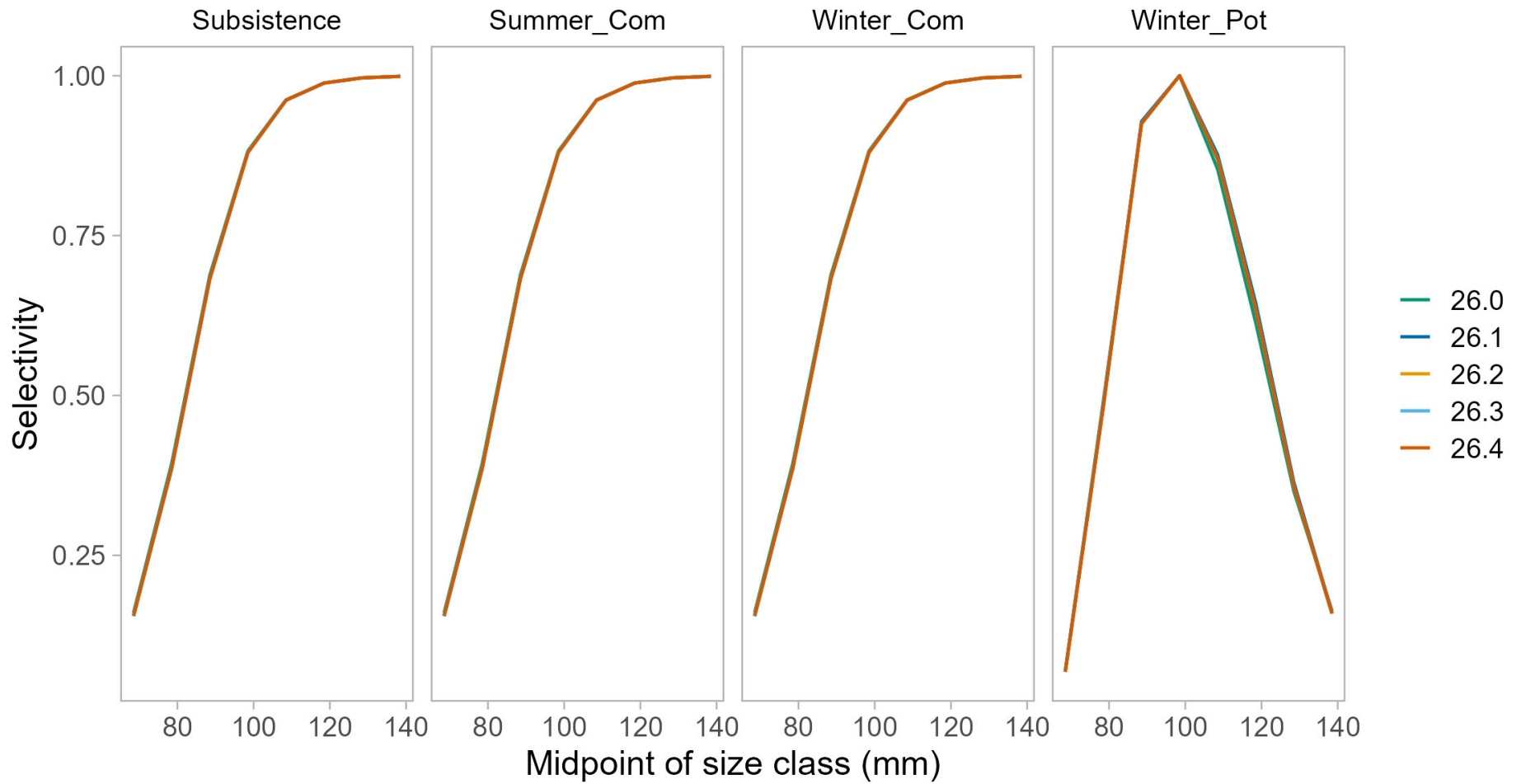


# Catchability

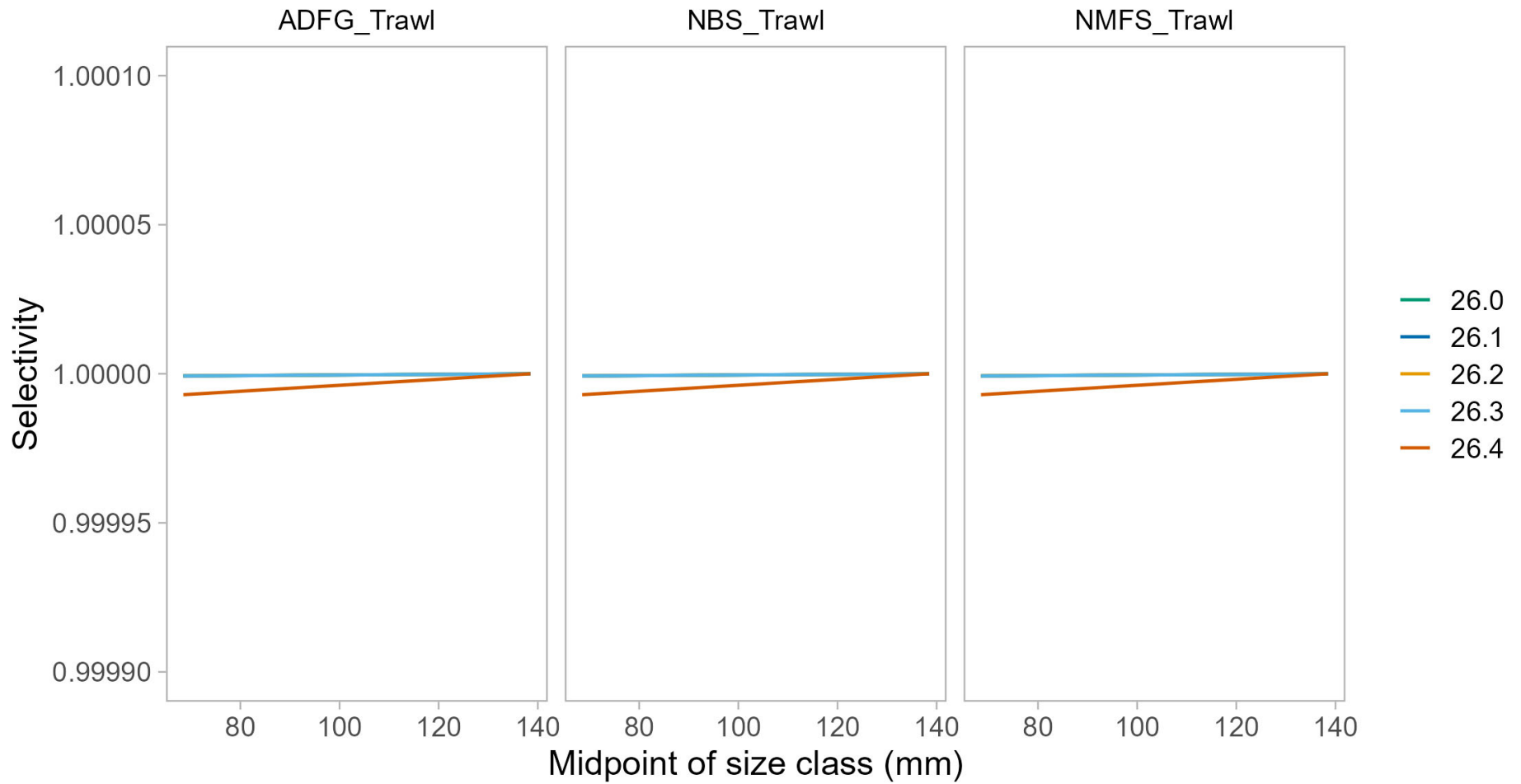
Index	26.0	26.5	26.1	26.2	26.3	26.4
Historical survey	0.7356	0.7356	0.9056	0.8488	0.8488	0.8488
ADFG survey	1.0000	1.0000				
NBS survey	0.7160	0.7160				
Model-based			1.0000	0.8950	0.8950	0.8950
CPUE series 1	0.0007	0.0007	0.0009	0.0008	0.0008	0.0008
CPUE series 2	0.0013	0.0013	0.0018	0.0017	0.0017	0.0017
CPUE series 3	0.0011	0.0011	0.0017	0.0015	0.0015	0.0015



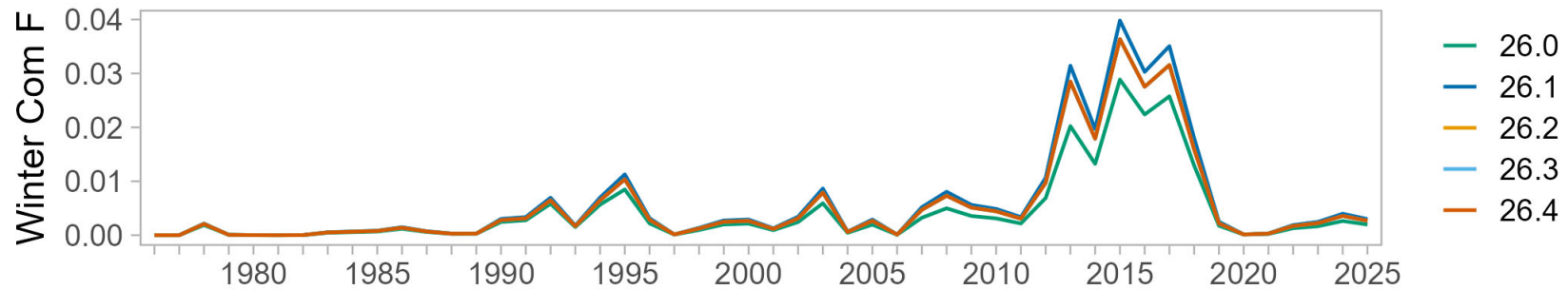
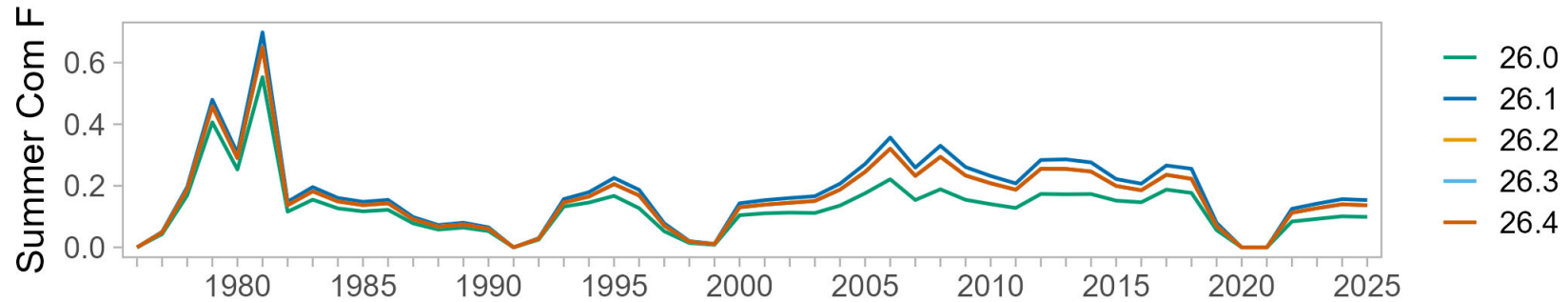
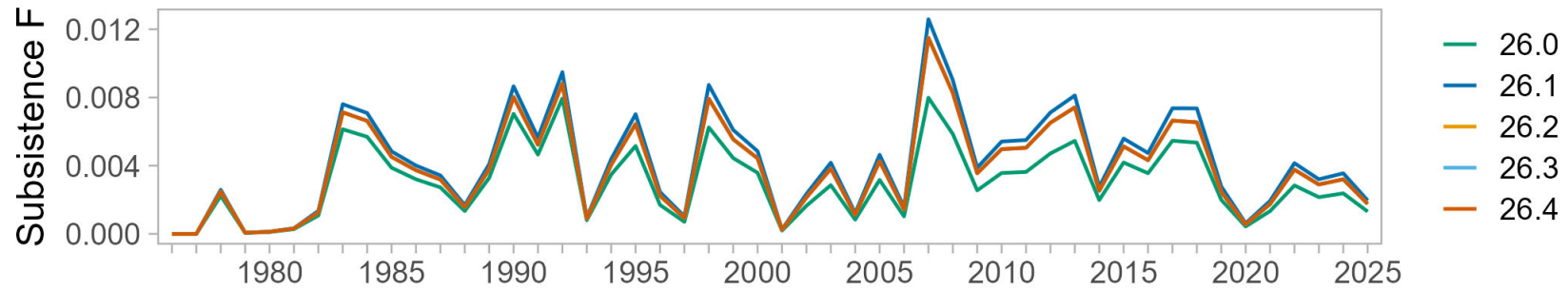
# Selectivity



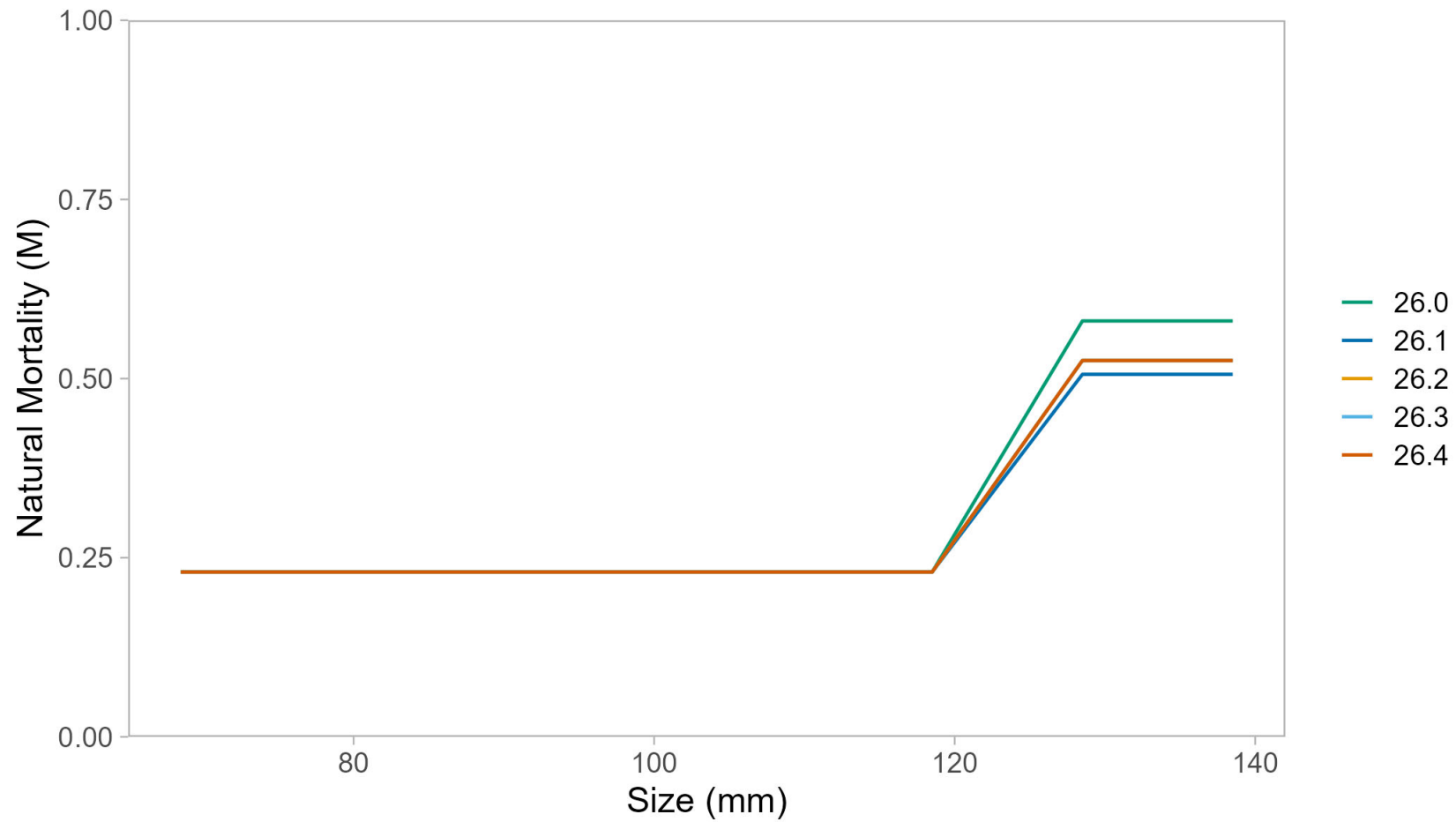
# Selectivity



# Fishing mortality



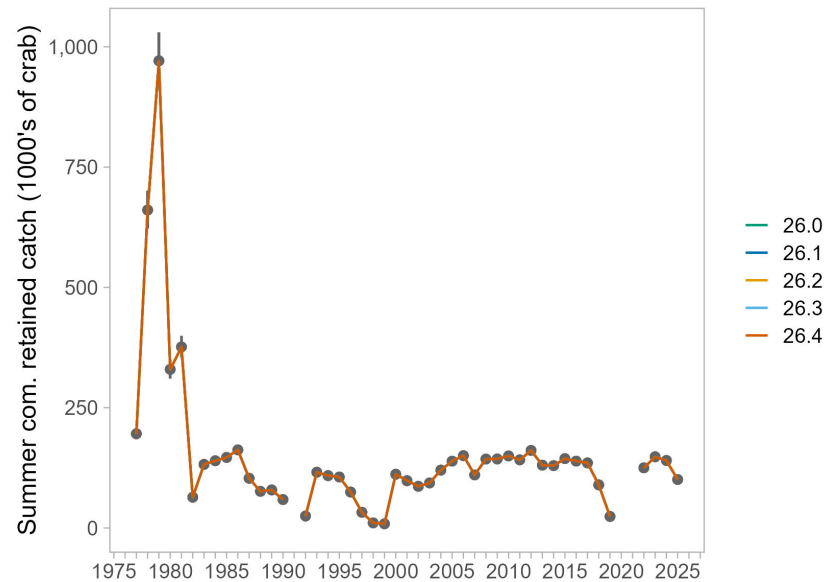
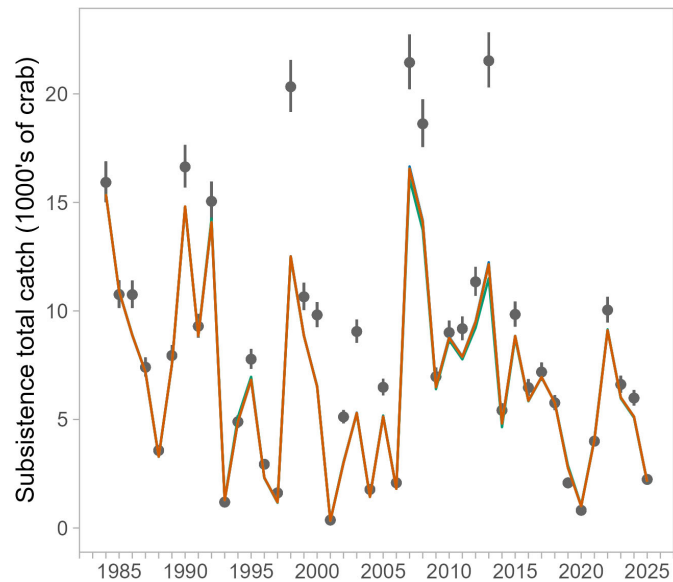
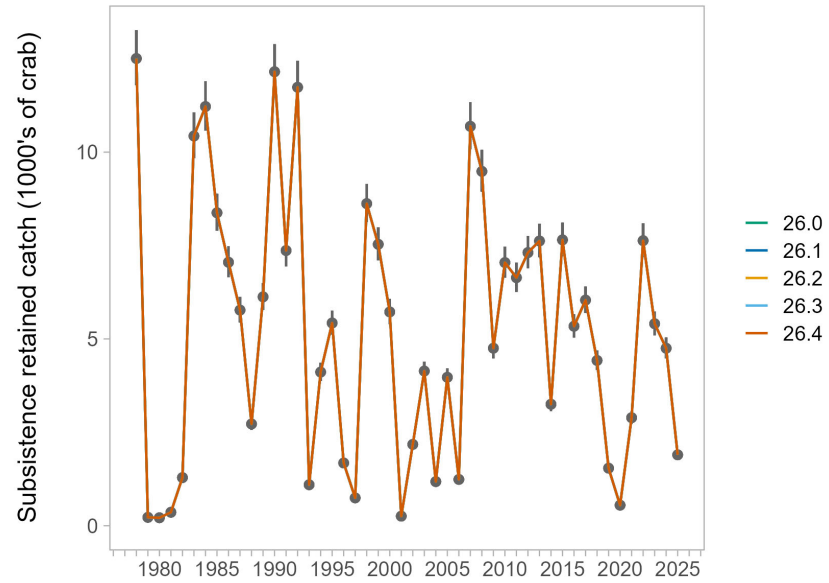
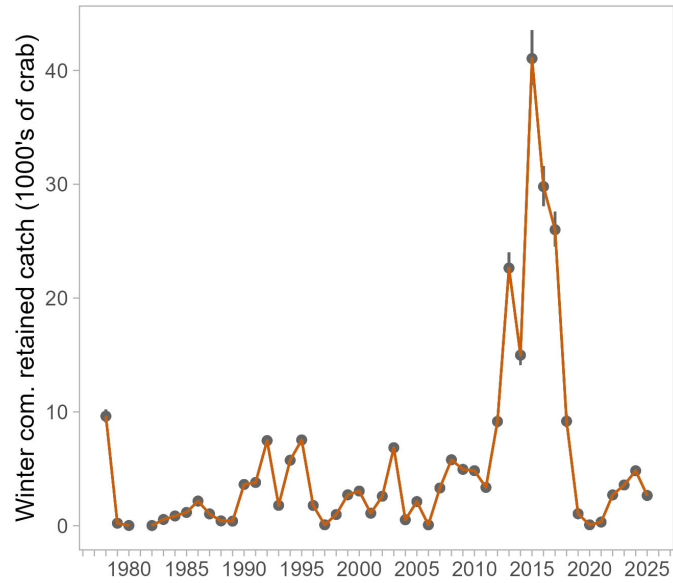
# Natural mortality



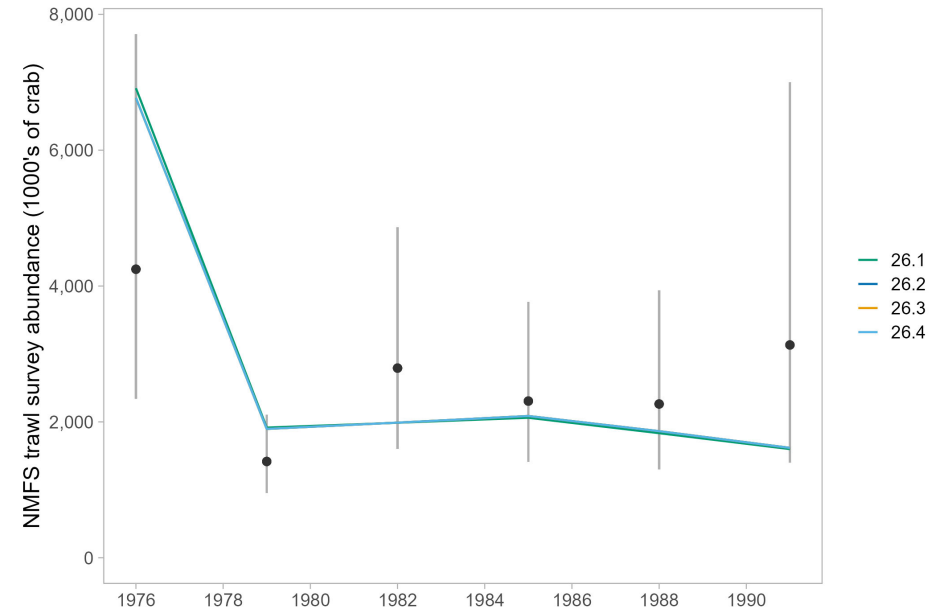
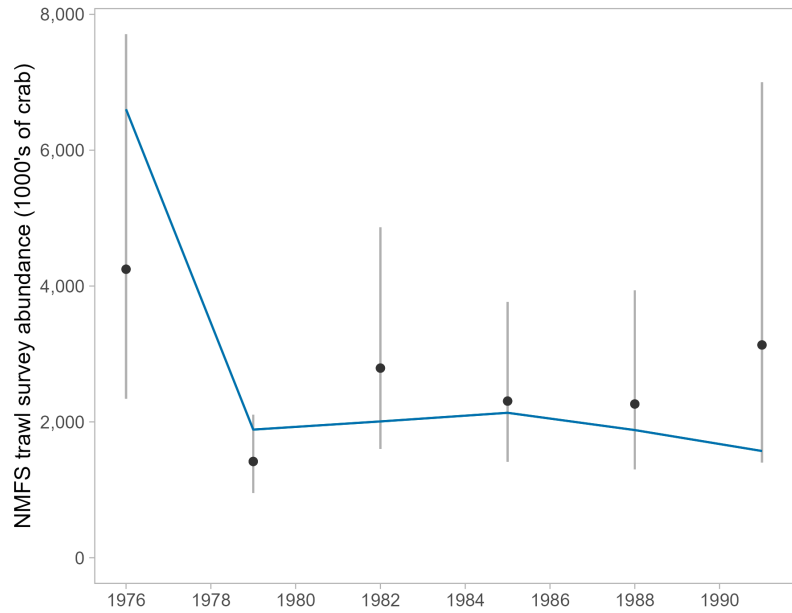
$M = 0.23$  for males  $\leq 123$  mm CL



# Fits to fishery catch data



# Fits to NOAA NS survey index

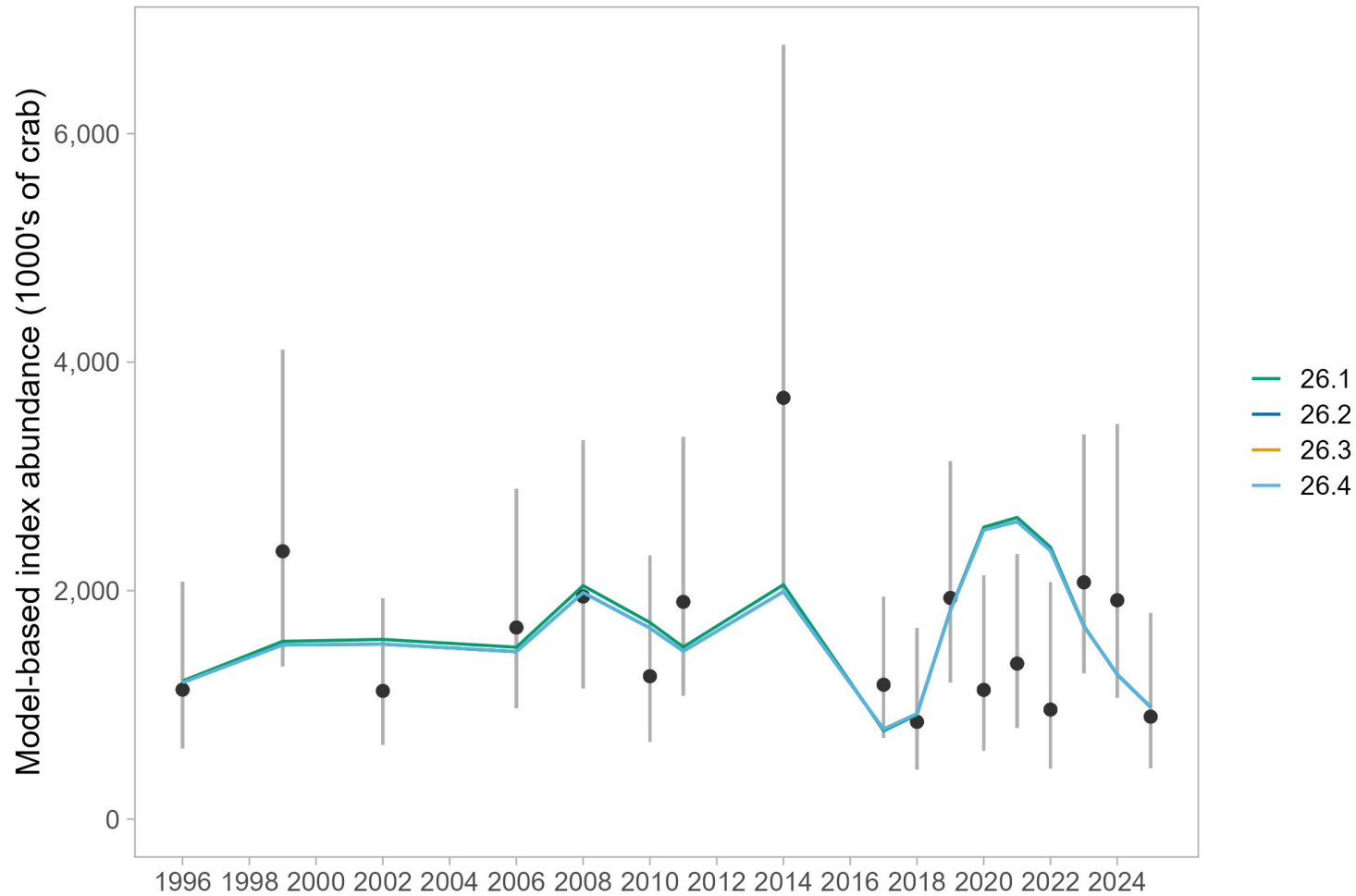


Ranking of fits, best to worst:

26.0 > 26.2 = 26.3 = 26.4 > 26.1



# Fits to model-based index

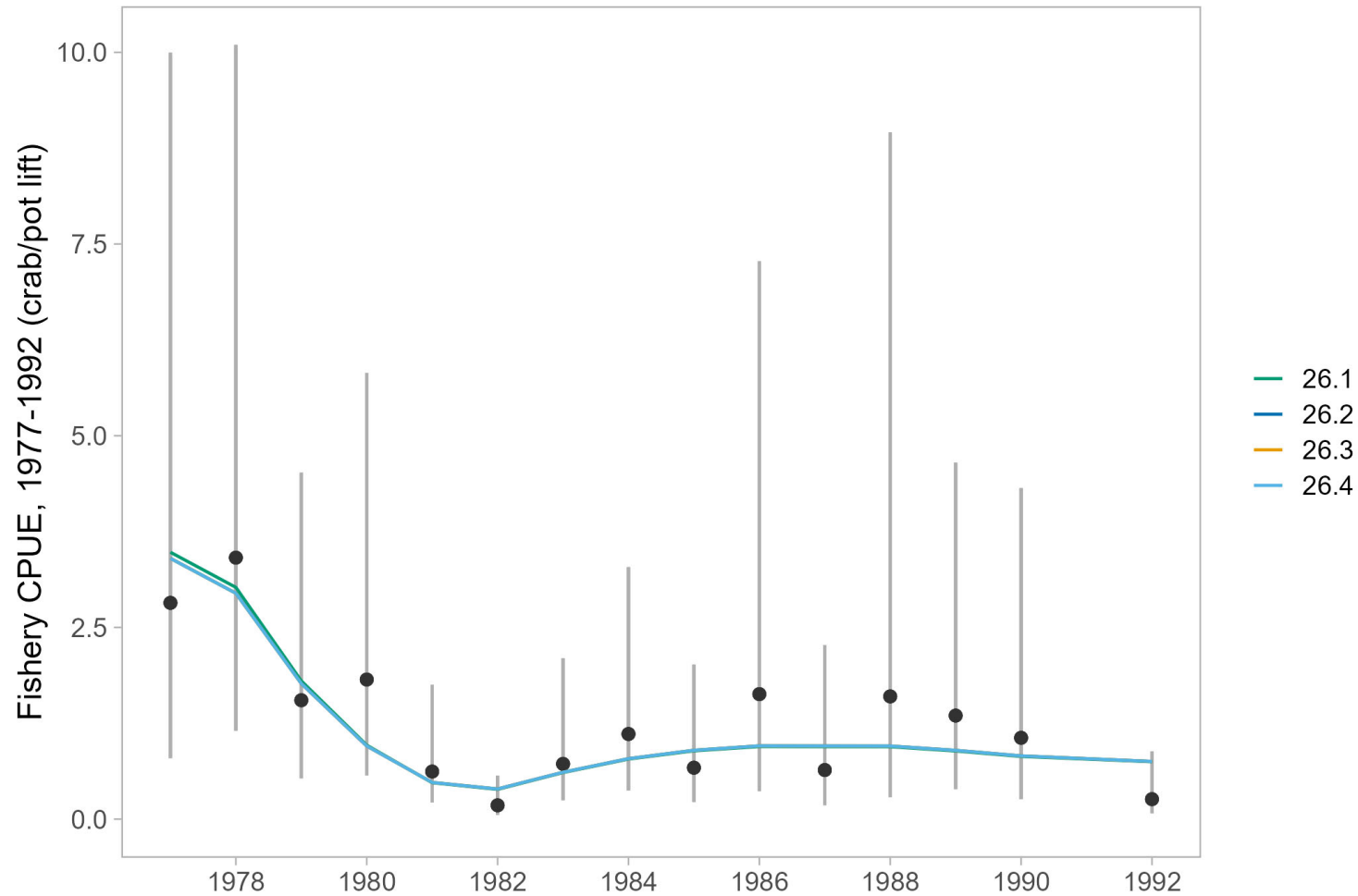


Ranking of fits, best to worst:

26.2 = 26.3 = 26.4 > 26.1



# Fits to CPUE index, 1977-1992

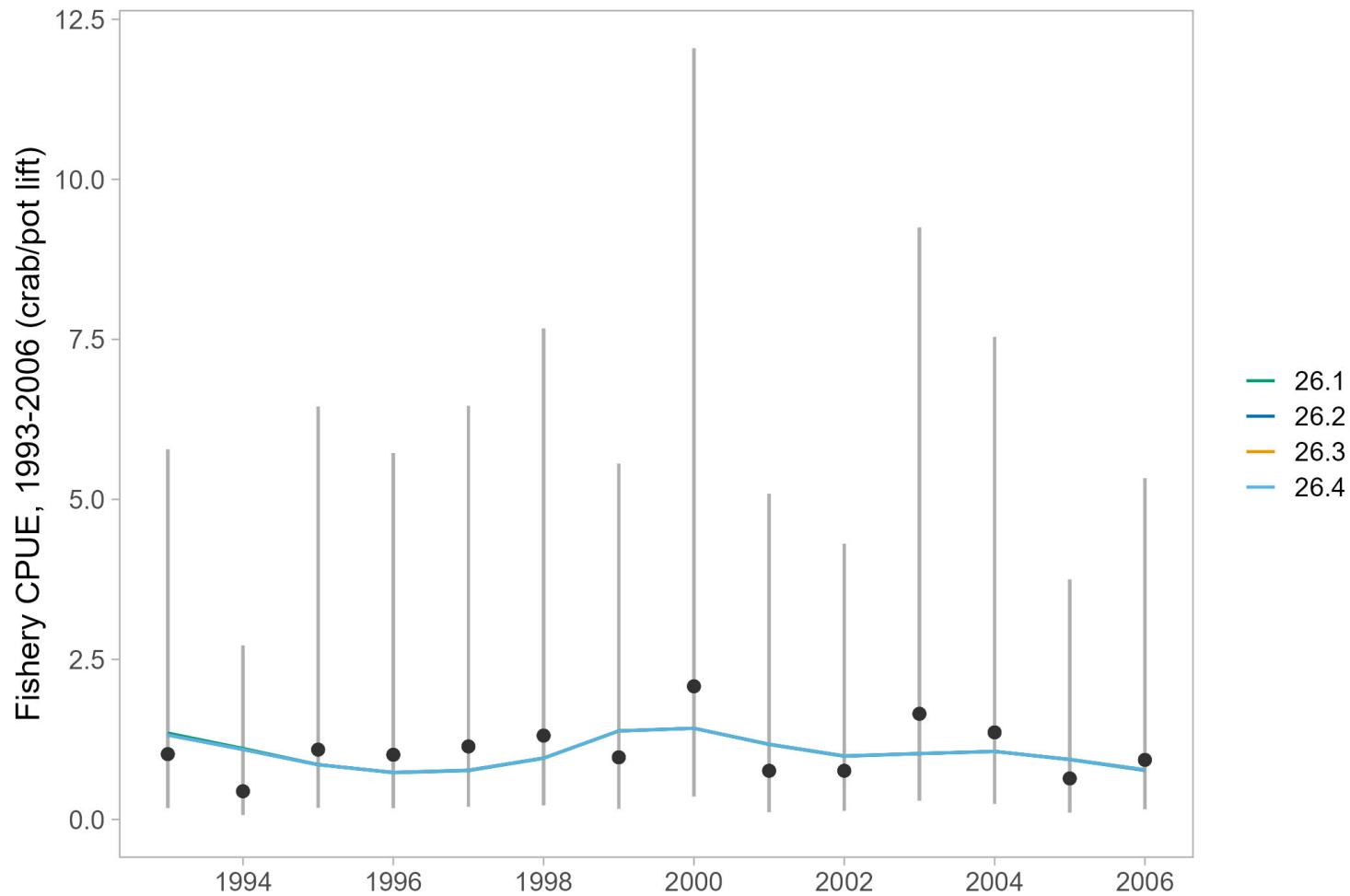


Ranking of fits, best to worst:

26.0 > 26.1 > 26.2 = 26.3 = 26.4



# Fits to CPUE index, 1993-2006

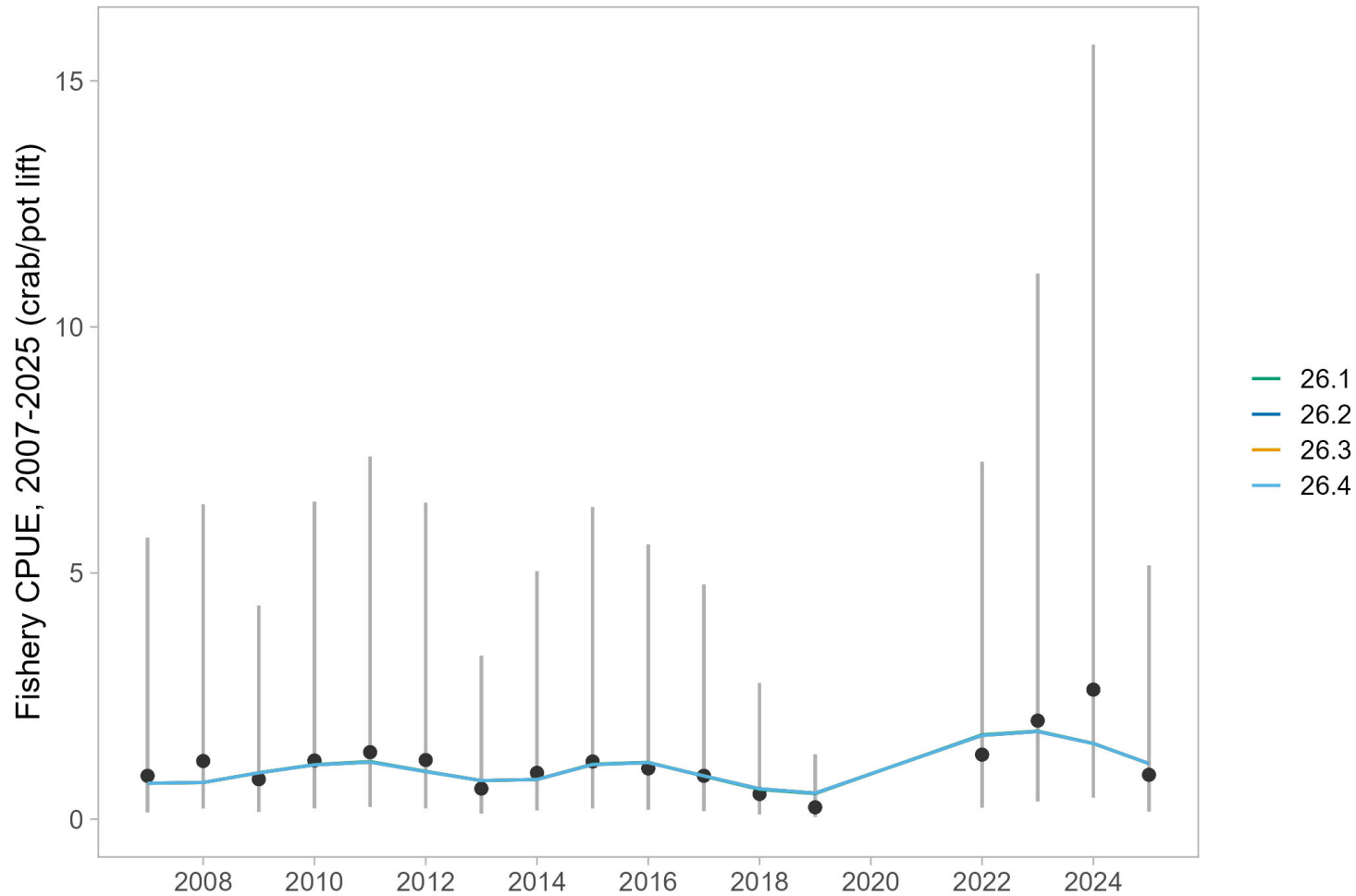


Ranking of fits, best to worst:

26.0 > 26.2 = 26.3 = 26.4 > 26.1



# Fits to CPUE index, 2007-2025

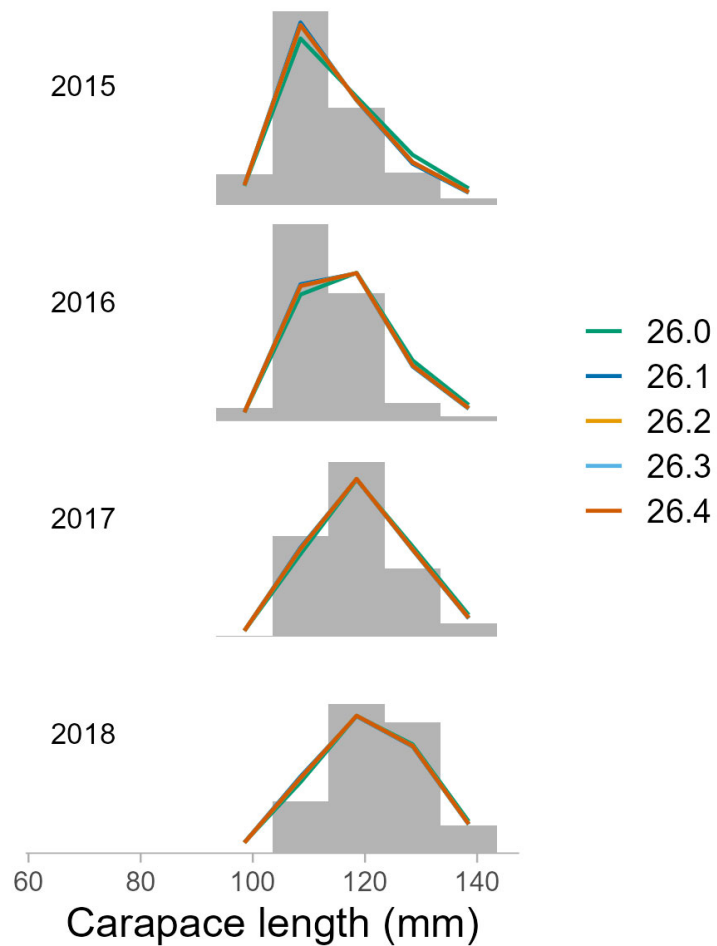


Ranking of fits, best to worst:

26.0 > 26.1 > 26.2 = 26.3 = 26.4



# Fits to size comps - winter retained



Ranking of fits, best to worst:

26.1 > 26.2 = 26.3 = 26.4 > 26.0



# Fits to size comps - summer retained

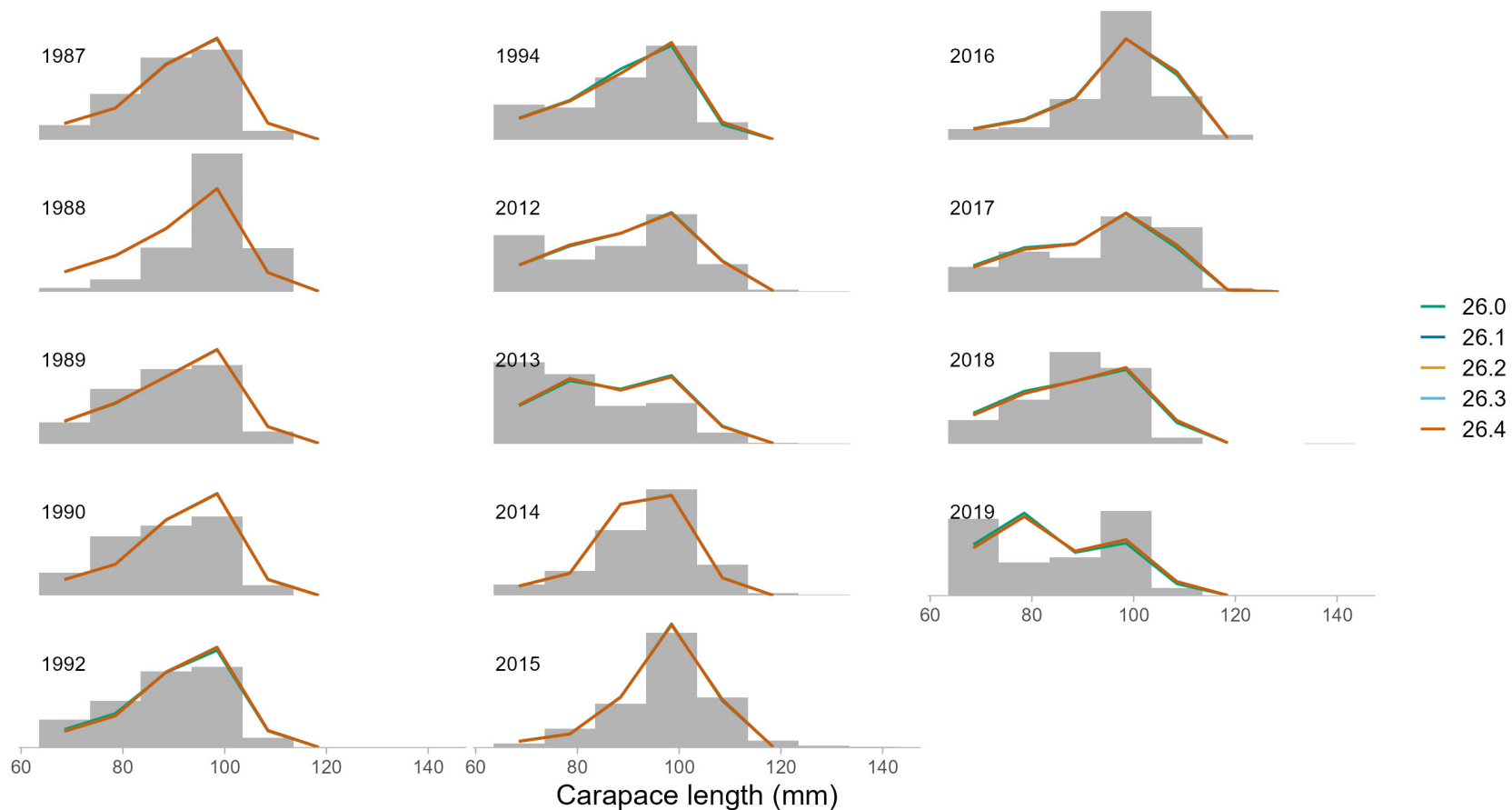


Ranking of fits, best to worst:

26.0 > 26.1 > 26.2 = 26.3 = 26.4



# Fits to size comps - summer discarded

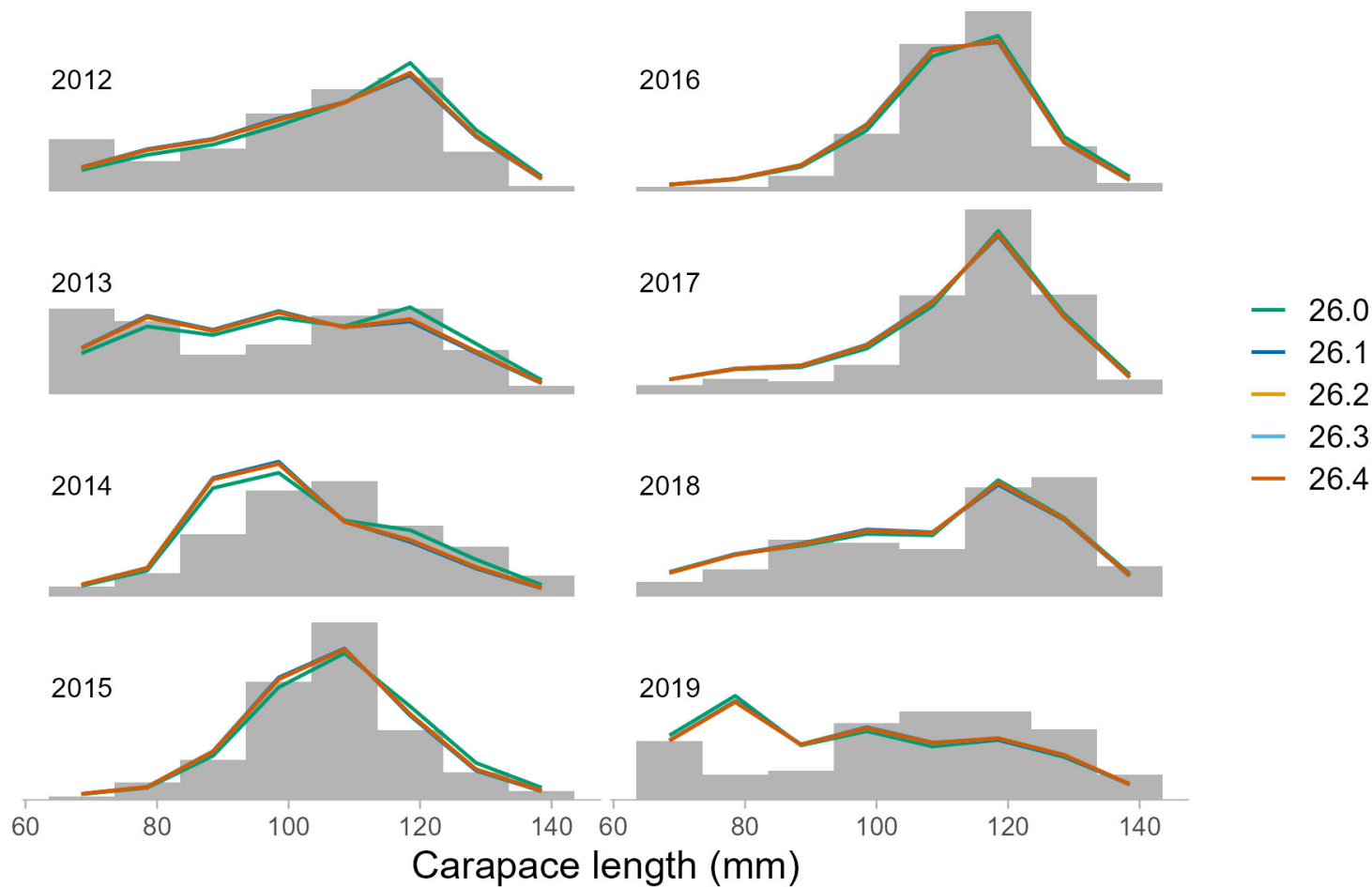


Ranking of fits, best to worst:

26.0 > 26.2 = 26.3 = 26.4 > 26.1



# Fits to size comps - summer total

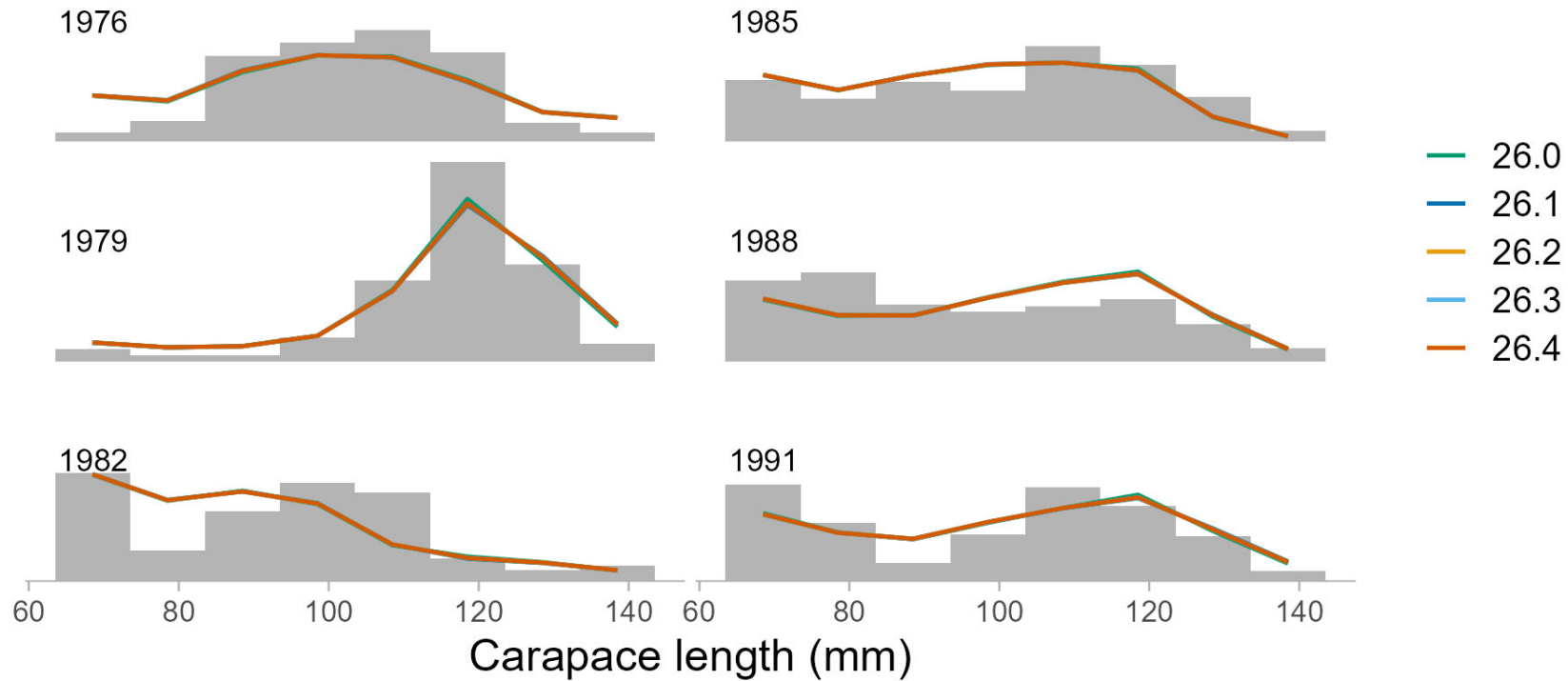


Ranking of fits, best to worst:

26.2 = 26.3 = 26.4 > 26.0 > 26.1



# Fits to size comps - NOAA NS survey

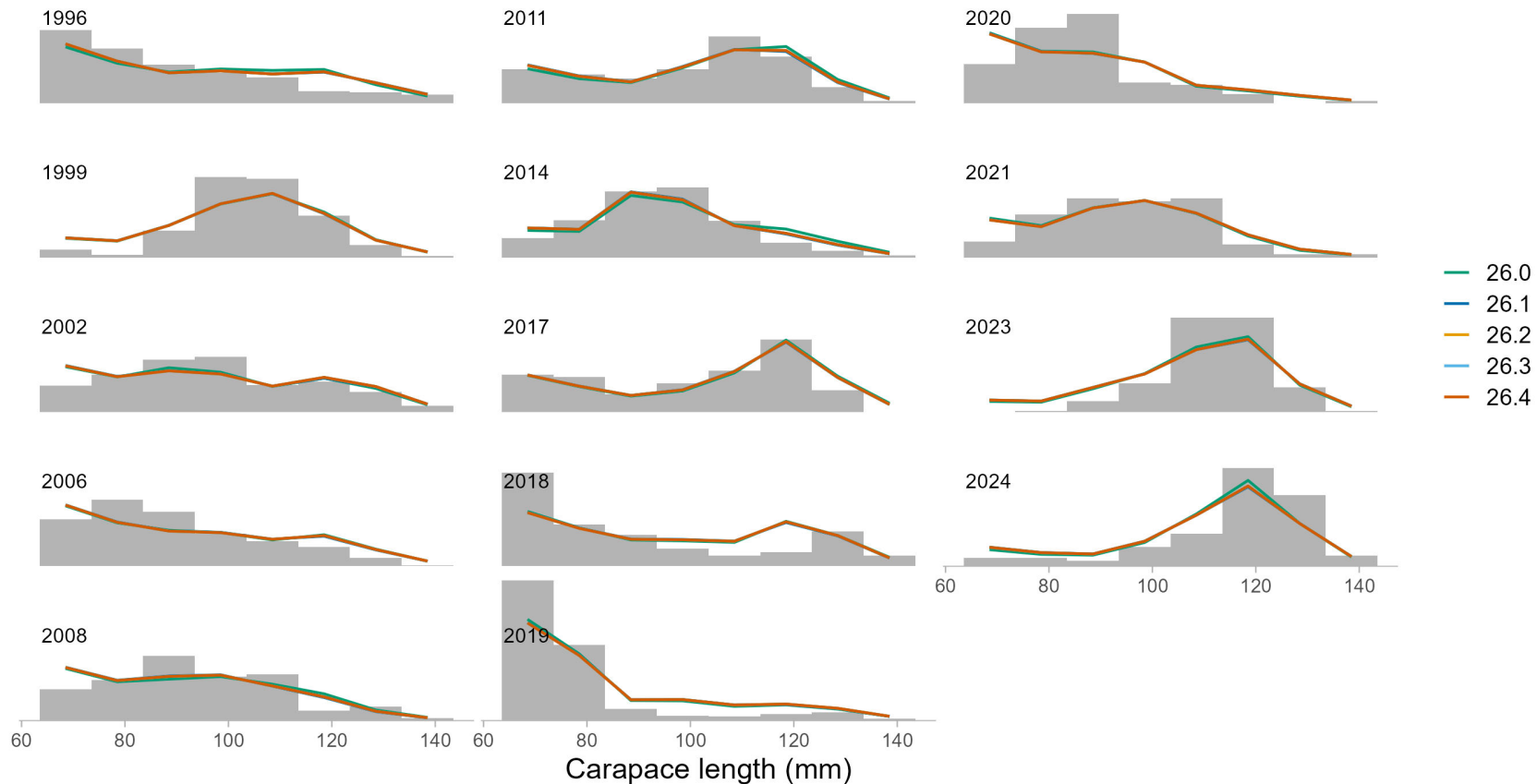


Ranking of fits, best to worst:

26.1 > 26.2 = 26.3 = 26.4 > 26.0



# Fits to size comps - ADF&G survey

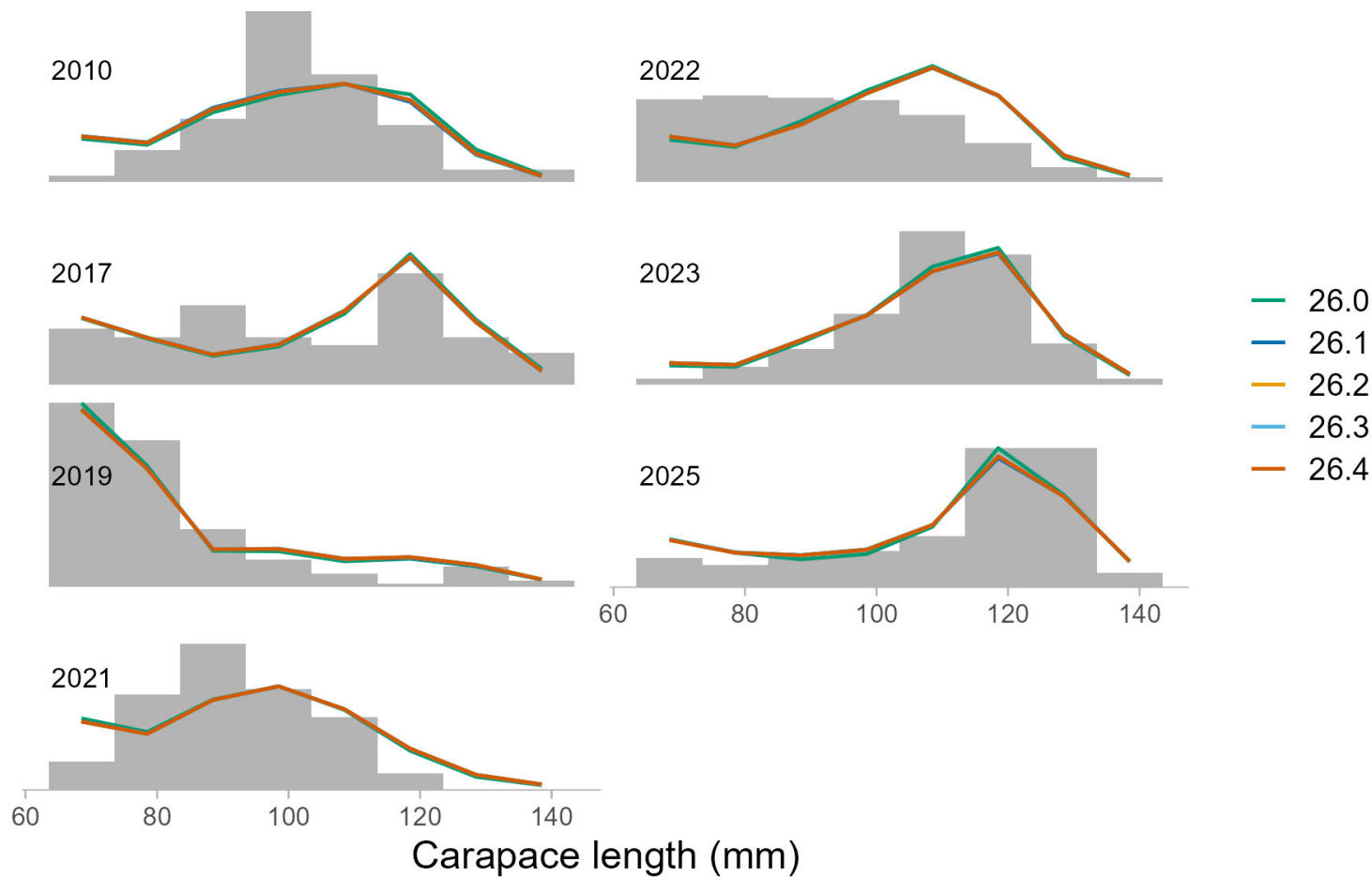


Ranking of fits, best to worst:

26.0 > 26.1 > 26.2 = 26.3 = 26.4



# Fits to size comps - NOAA NBS survey

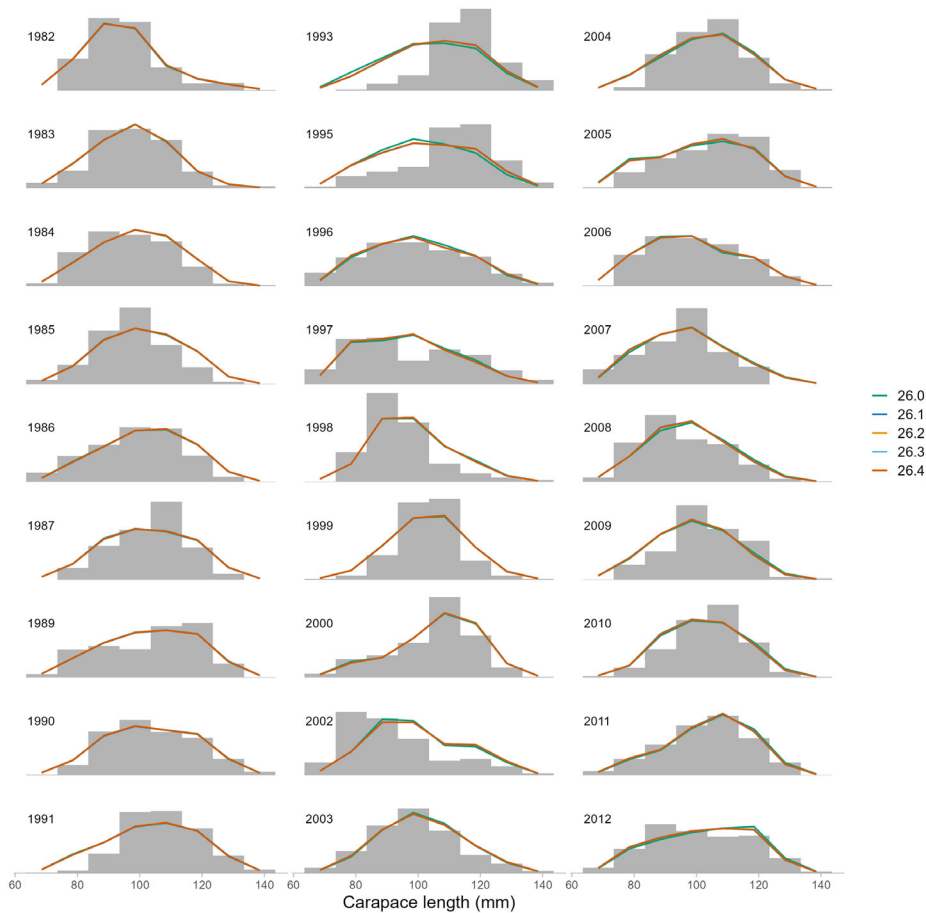


Ranking of fits, best to worst:

26.0 > 26.1 > 26.2 = 26.3 = 26.4



# Fits to size comps - winter pot survey

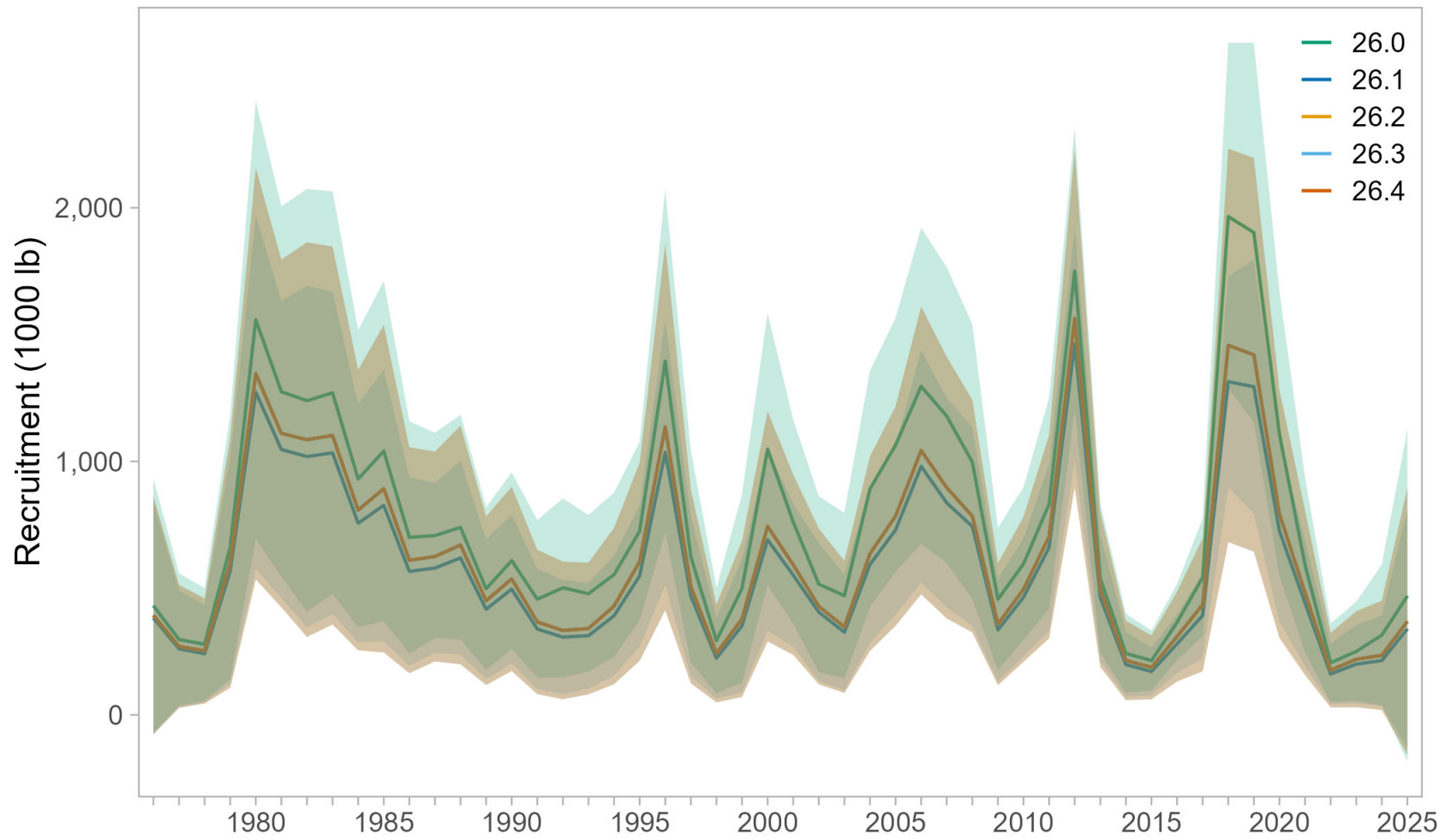


Ranking of fits, best to worst:

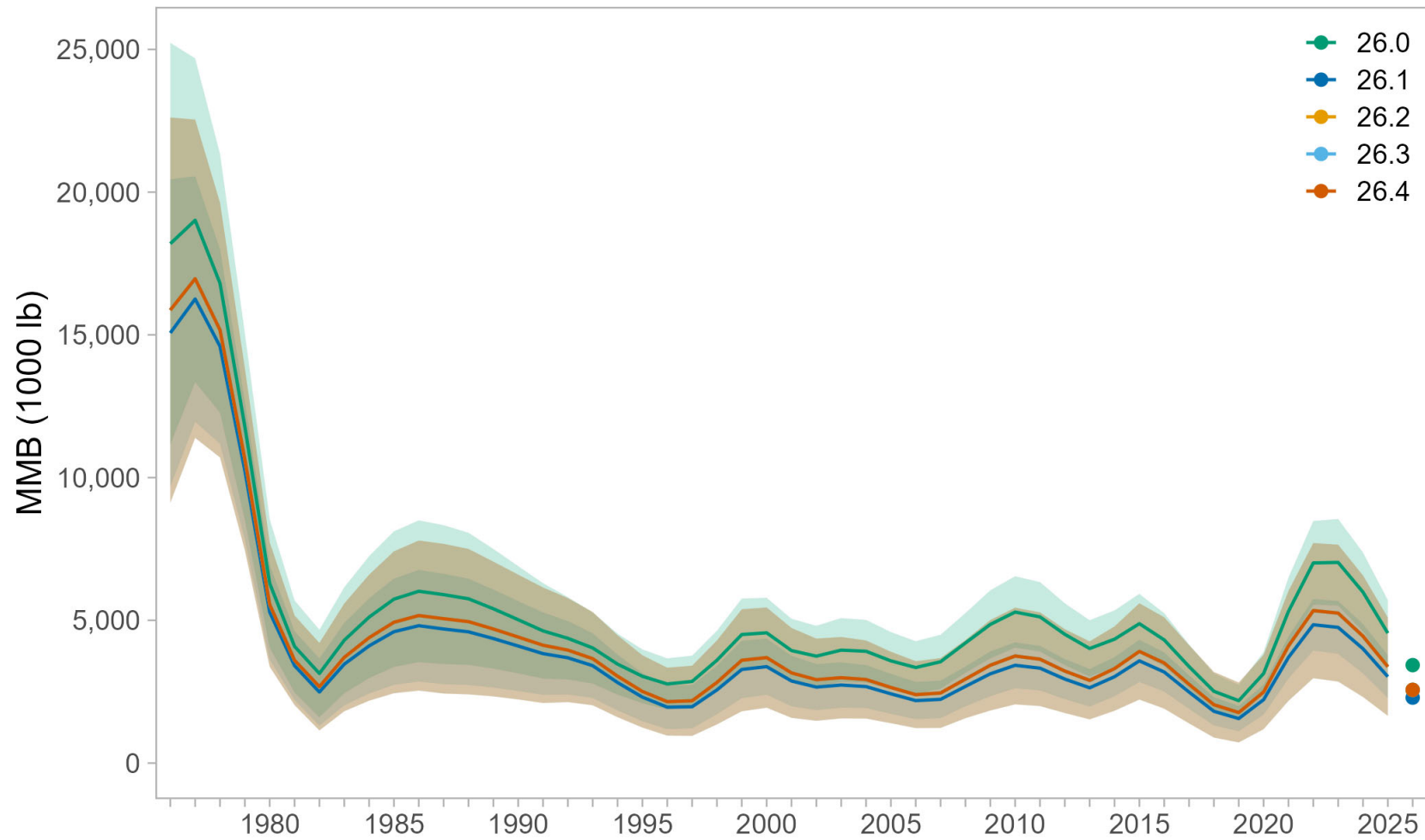
26.1 > 26.2 = 26.3 = 26.4 > 26.0



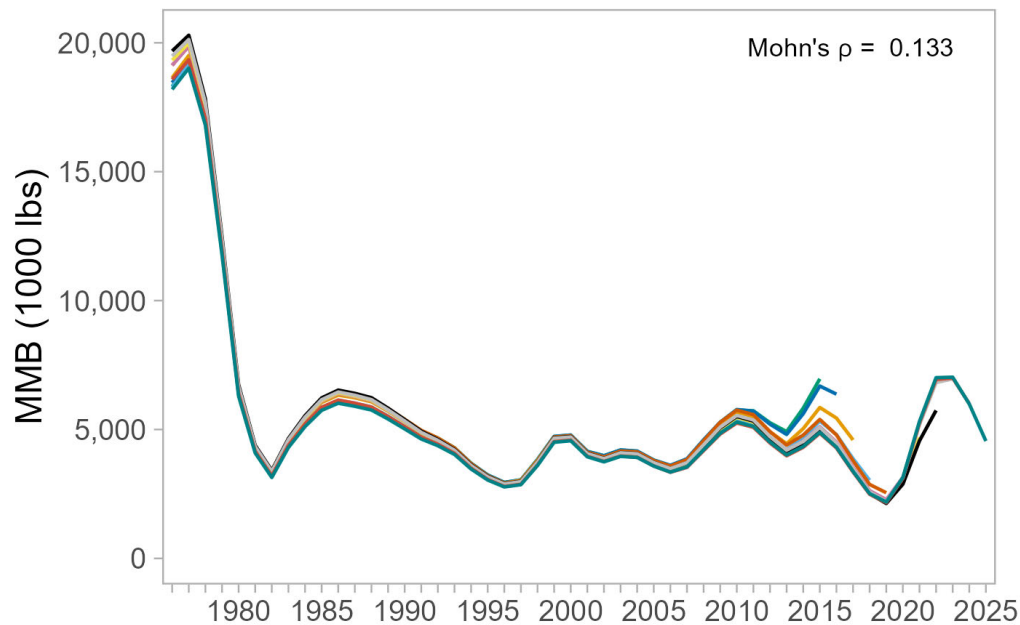
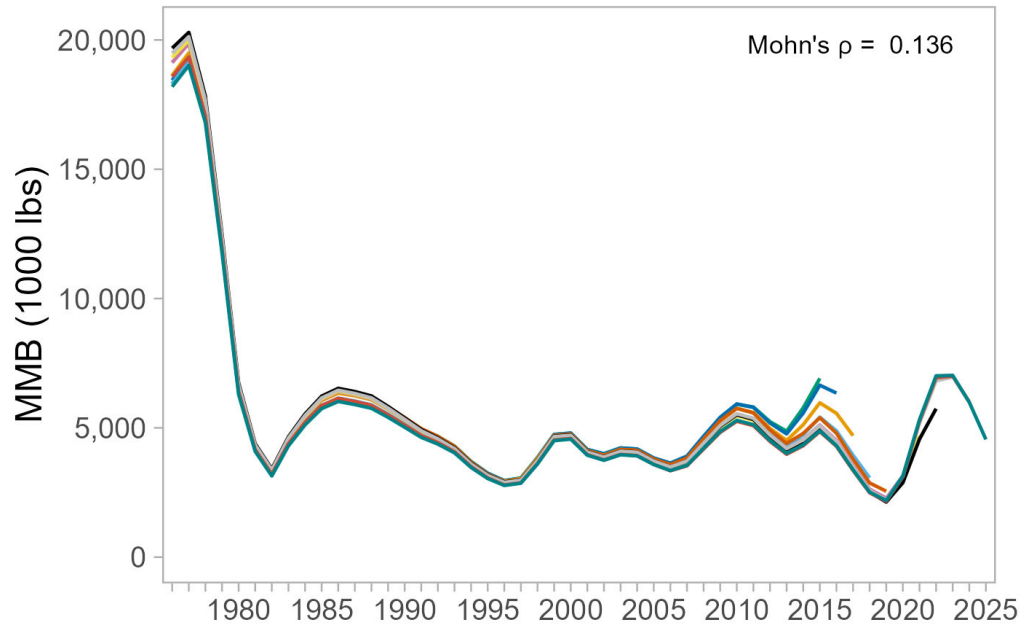
# Recruitment



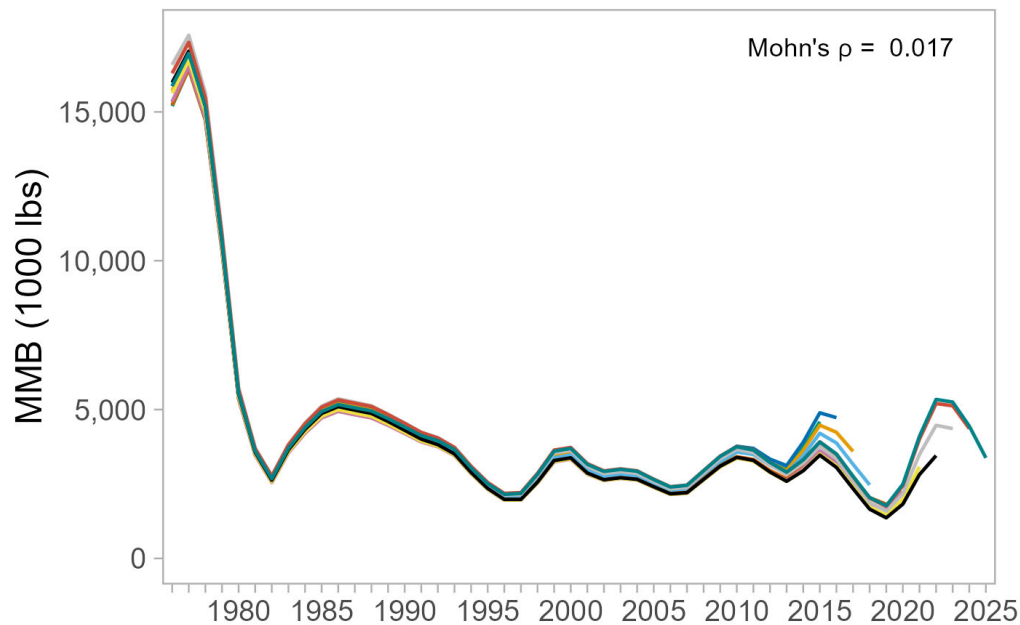
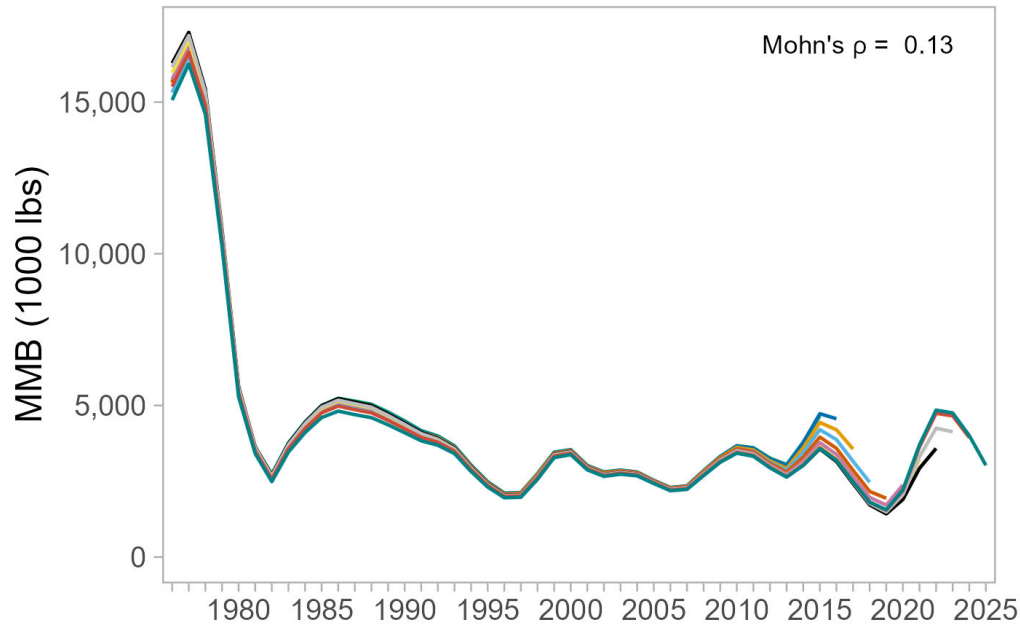
# Mature male biomass



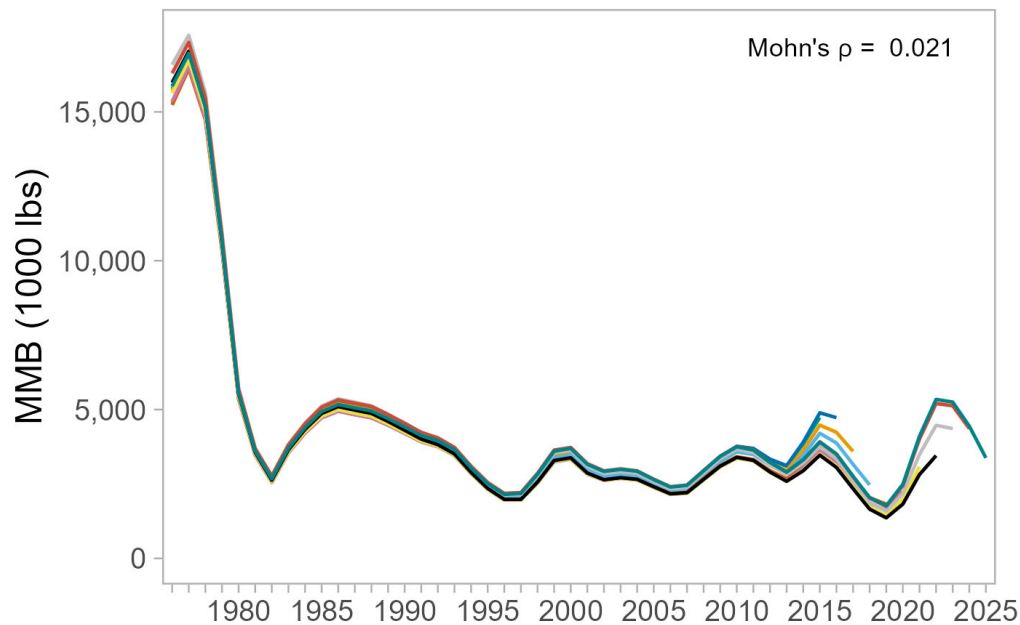
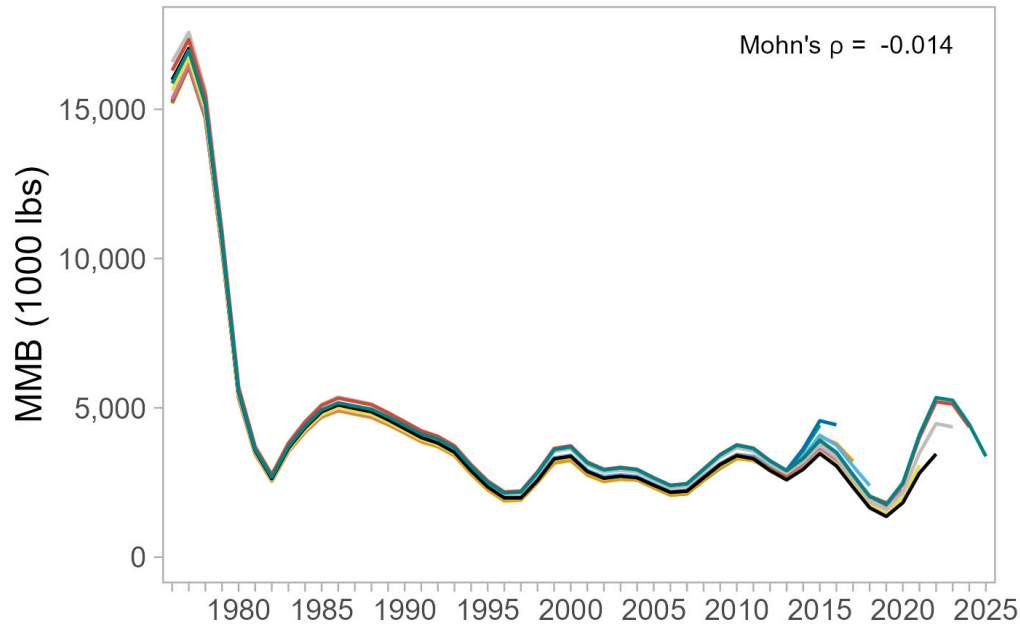
# Retrospective analysis - 26.0, 26.5



# Retrospective analysis - 26.1, 26.2



# Retrospective analysis - 26.3, 26.4



# Reference points

	26.0	26.1	26.2	26.3	26.4
$MMB_{2026}$	1.556	1.04	1.163	1.163	1.163
$B_{MSY}$	2.005	1.472	1.603	1.603	1.603
$MMB/B_{MSY}$	0.776	0.706	0.726	0.726	0.726
$F_{OFL}$	0.173	0.155	0.16	0.16	0.16
$OFL_{2026}$	0.193	0.117	0.135	0.135	0.135
$ABC_{2026}$	0.135	0.082	0.094	0.094	0.094

units: metric tons



# Comparison of model scenarios

Model-based index (MBI) of abundance

- combines data from the ADF&G and NBS trawl surveys
- addresses long-standing concerns about the comparability and spatial domain of the survey abundance estimates

Models 26.2, 26.3, and 26.4 include and estimate  $q$  for MBI

All three show improved retrospective patterns compared to:

- the base model (26.0)
- the model with the MBI added but  $q$  fixed (26.1)
- the base model with  $q$  and selectivity estimated (26.5)



# Author recommendations

Models 26.0, 26.2, and 26.4

- bring forward the base model (26.0) as an option
- 26.2 (MBI with catchability estimated): less extreme retro pattern than 26.0
- 26.4 (26.2 with trawl survey selectivities fixed): fewer parameters, slightly worse retro pattern than 26.2



# Future work

- explore model-based estimation of size compositions
- review, document, and update CPUE standardization methods
- add winter subsistence total catch and summer subsistence catch data



Thanks!

