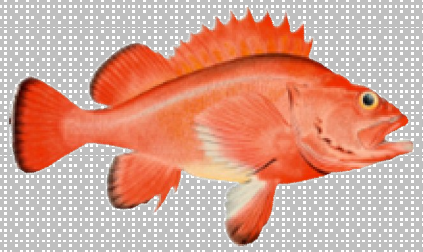
An age-structured assessment model for yelloweye rockfish (*Sebastes ruberrimus)* in Southeast Alaska Outside Waters



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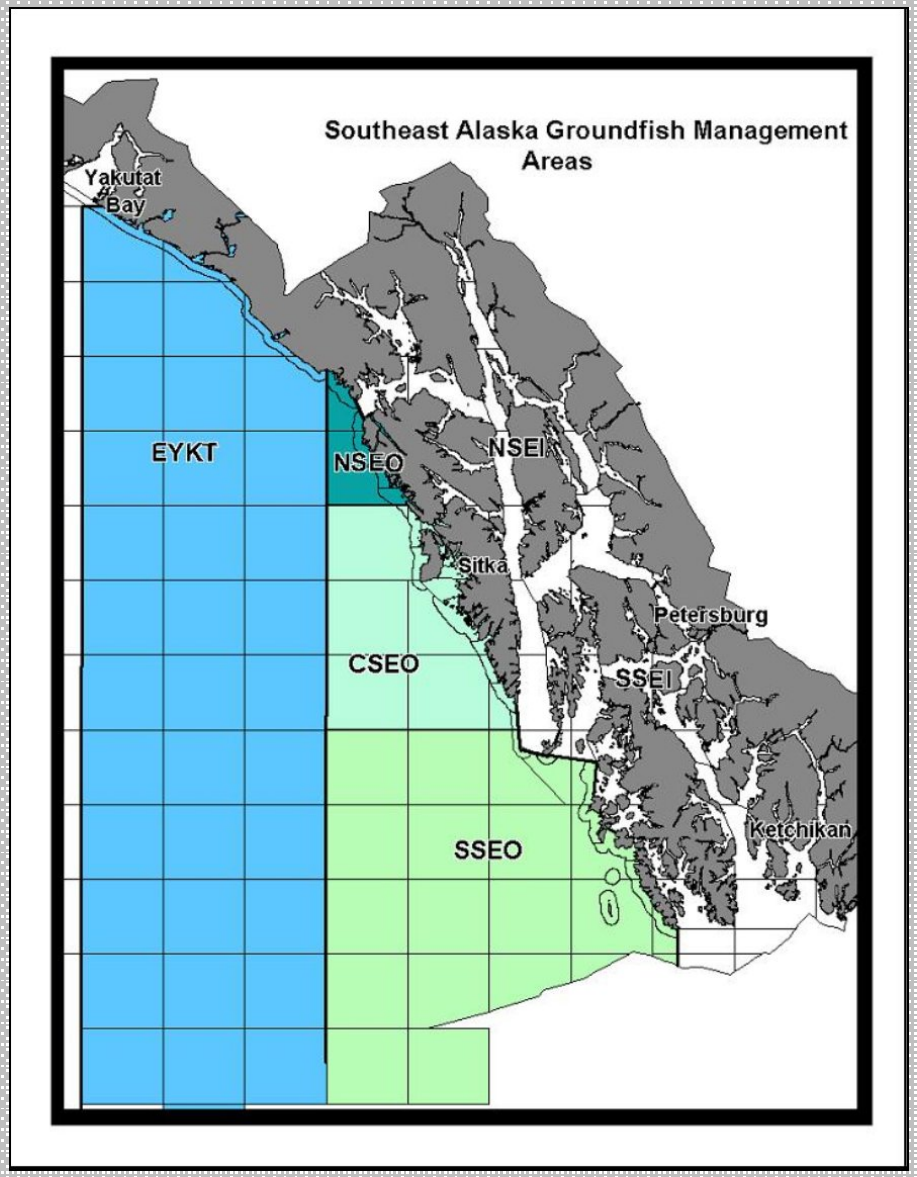
Southeast Alaska Outside Waters



Changes to model data & structure

<u>Data updated through 2015</u>

1. Total annual catch:
   Commercial fishery, sport fishery, halibut fishery bycatch
2. Age composition:
   Commercial fishery, halibut fishery bycatch
3. Density:
   ROV survey

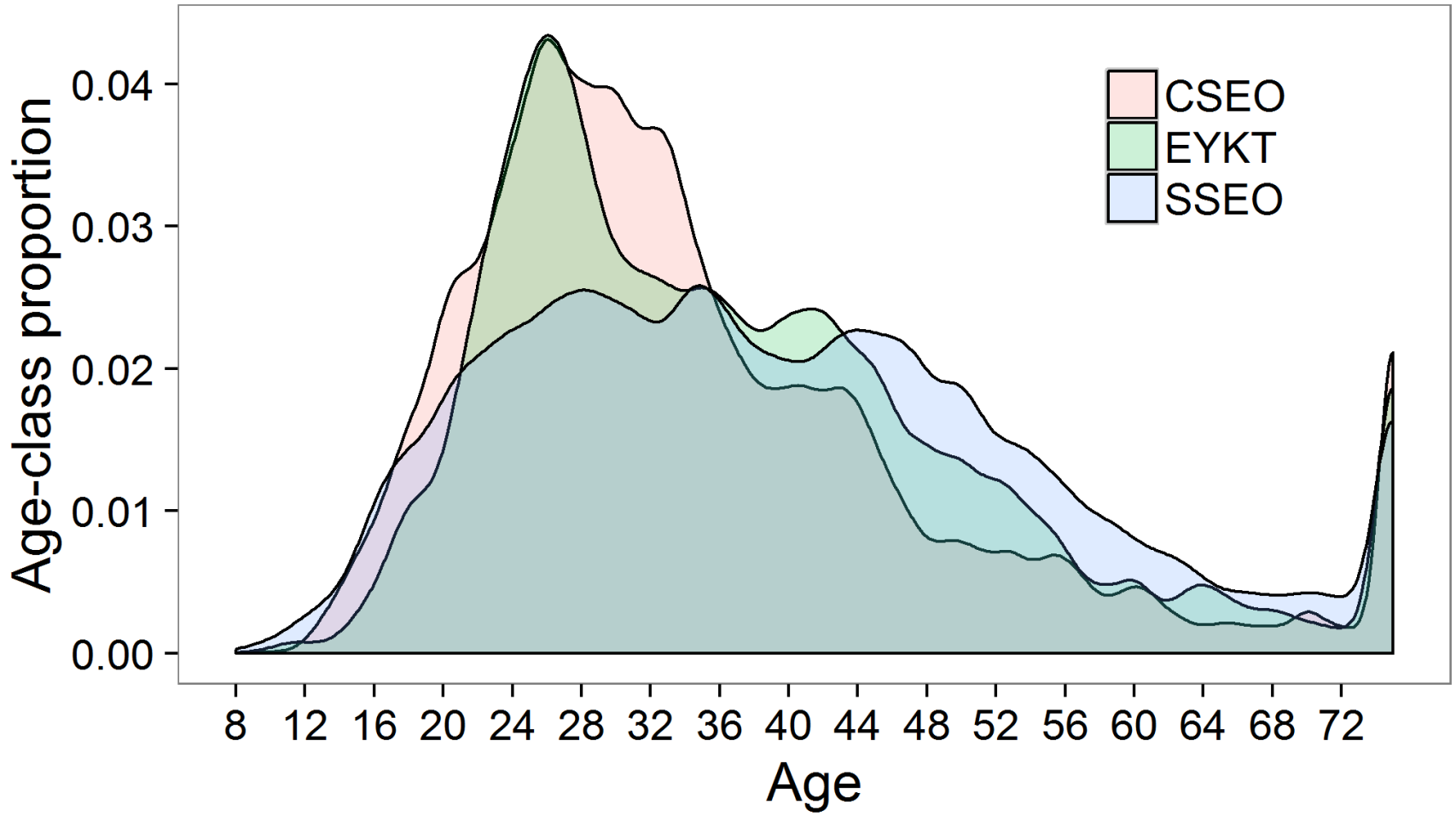
<u>Structural changes</u>

1. Terminal plus-class changed from 97+ to 75+
2. Natural mortality is estimated
3. CPUE scaled
4. Lower 90% CI for model-estimated biomass, F_{xx}, and ABC used when evaluating potential harvest levels
5. Additional sigma parameter for density from last year's assessment removed due to confounding with estimating natural mortality

Changes to model structure

Plus-class changed from 97+ to 75+

- number of age classes was reduced
- proportion of individuals in the plus-class did not exceed any sub-plus-class age proportion



Four model structures

Model 1:

1. Regionally-distinct data and likelihood;
2. Asymptotic fishery selectivity-at-age

Model 2:

1. Regionally-distinct data and likelihood;
2. Common parameters:
   a. natural mortality
   b. commercial fisheries catchability
   c. IPHC survey catchability
3. Asymptotic fishery selectivity-at-age

Model 3:

1. Regionally-distinct data and likelihood;
2. Common parameters:
   a. natural mortality
   b. commercial fisheries catchability
   c. IPHC survey catchability
3. Dome-shaped fishery selectivity-at-age option

Model 4: (global)

1. Data and likelihood merged over regions;
2. Common parameters:
   a. natural mortality
   b. commercial fisheries catchability
   c. IPHC survey catchability
   d. mean age-8 recruitment
   e. mean year-1 abundance
   f. sigma for year-1 abundance deviation vector
   g. mean full-recruitment fishing mortality
   h. selectivity curve parameters
   i. annual deviation vectors for recruitment, abundance, and fishing mortality
3. Asymptotic fishery selectivity-at-age

Four model structures

Alternative structures

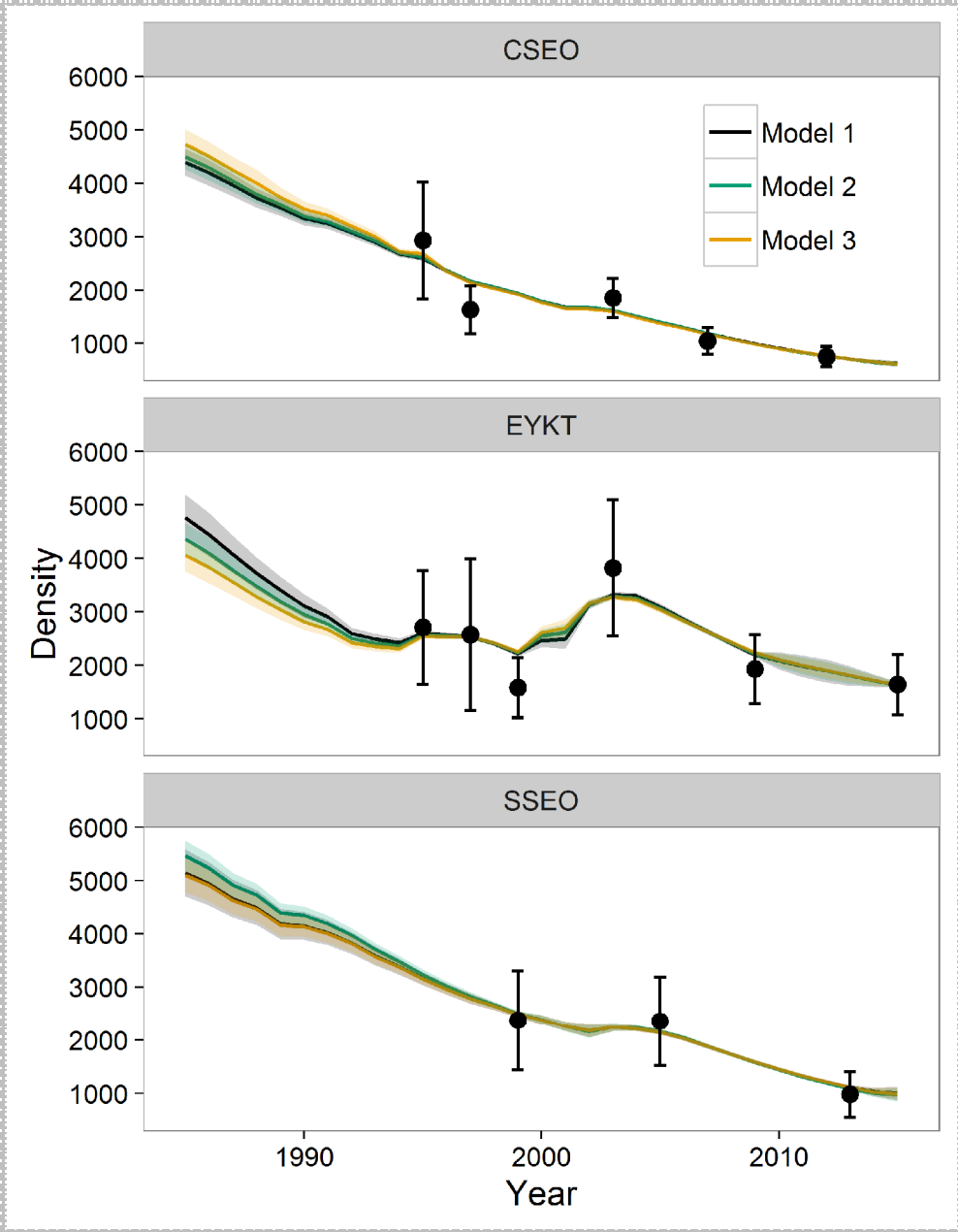
Multivariate logistic likelihood for age composition

Partitioning global dataset to fit regional likelihoods

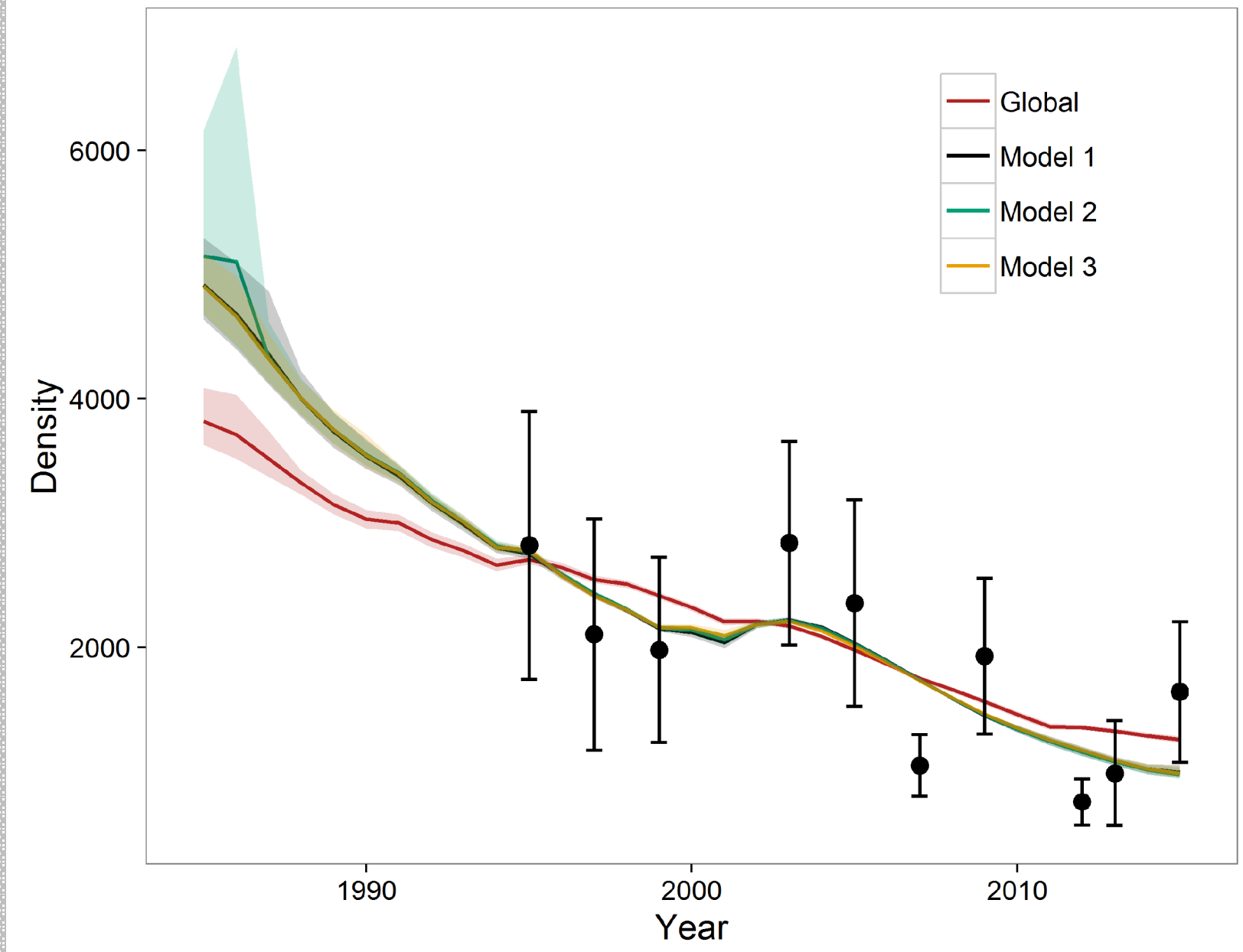
Spawner-recruit curves

Global recruitment partitioned into region-specific recruitment

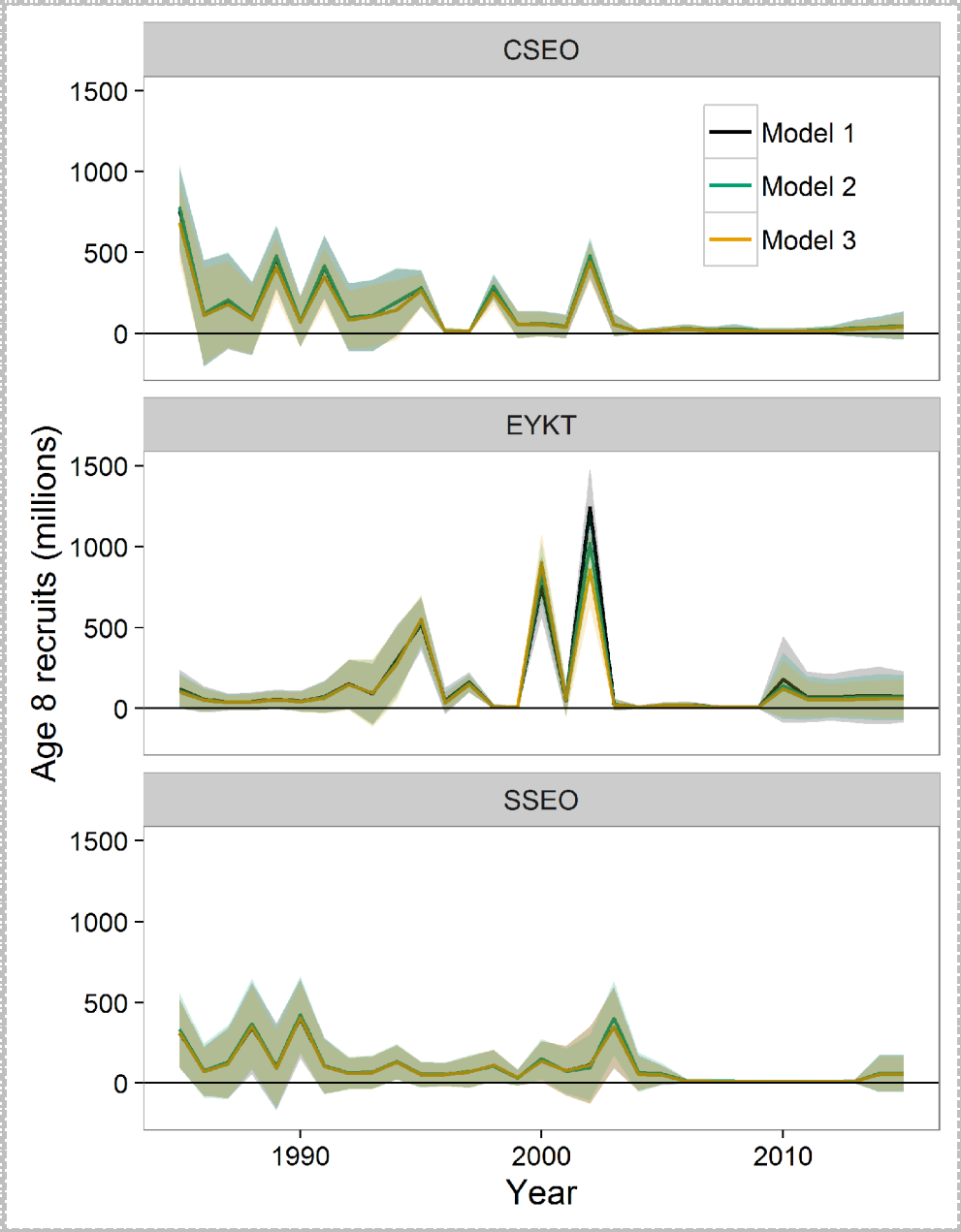
Results: Regional density



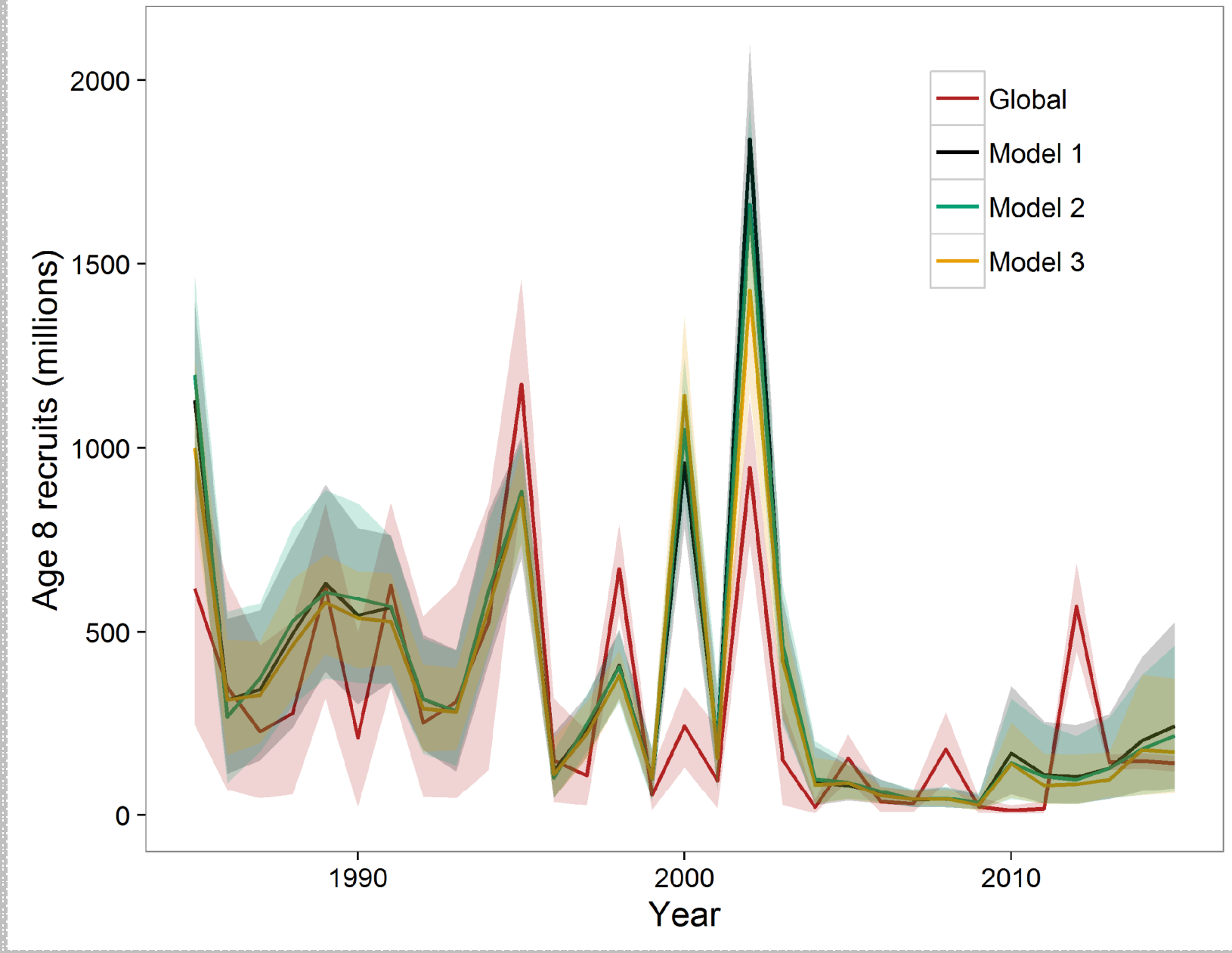
Results: Total density



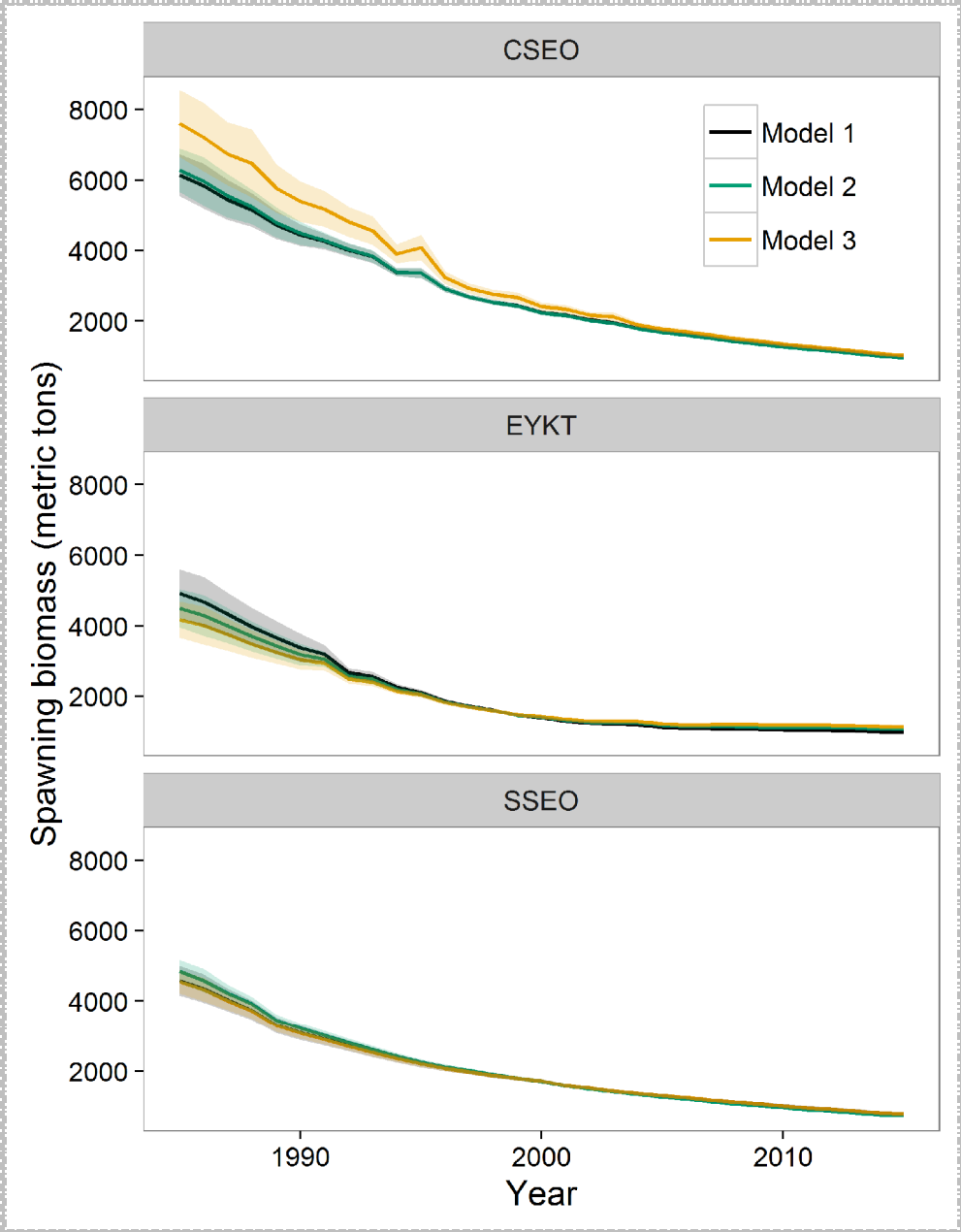
Results: Regional recruitment



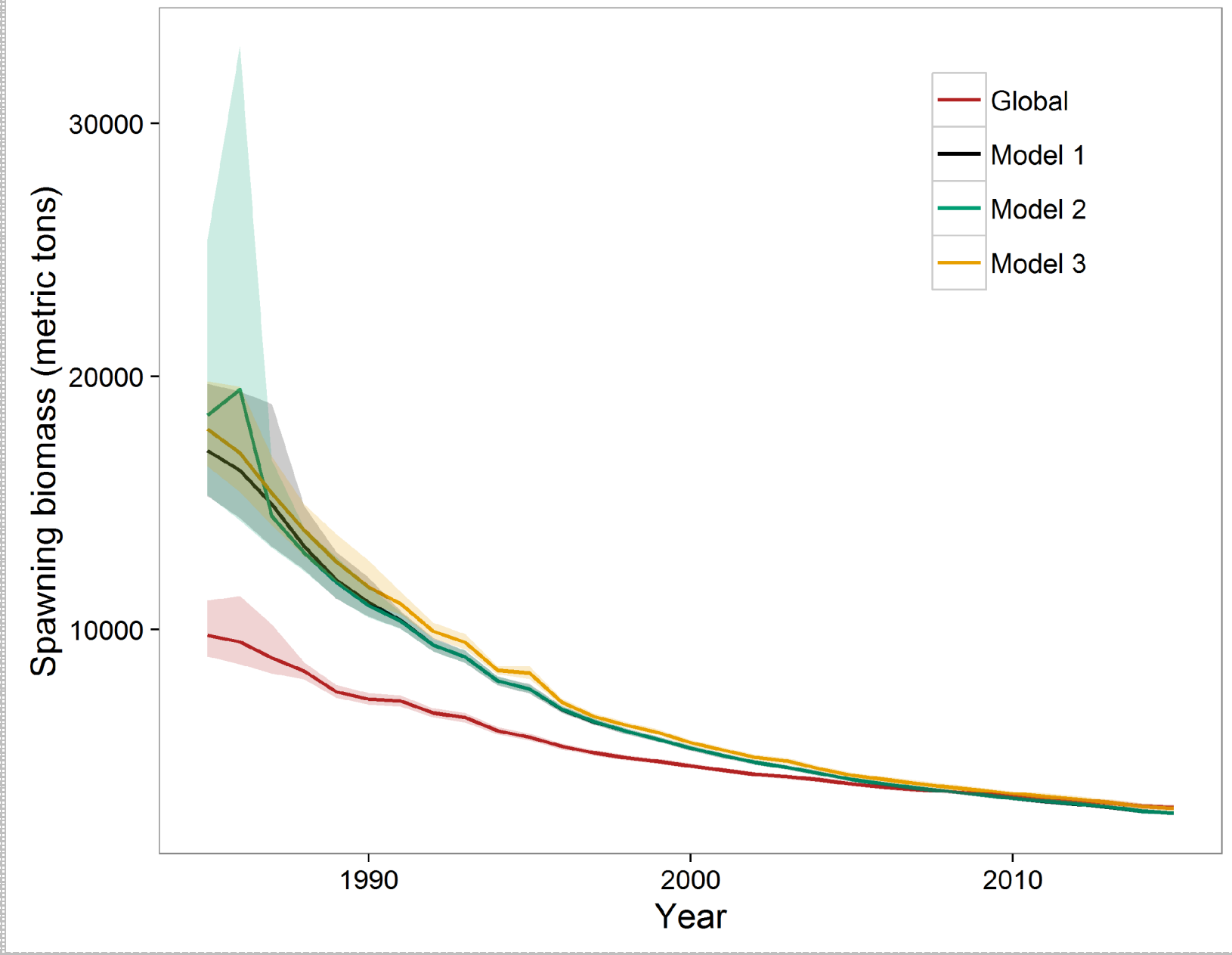
Total recruitment



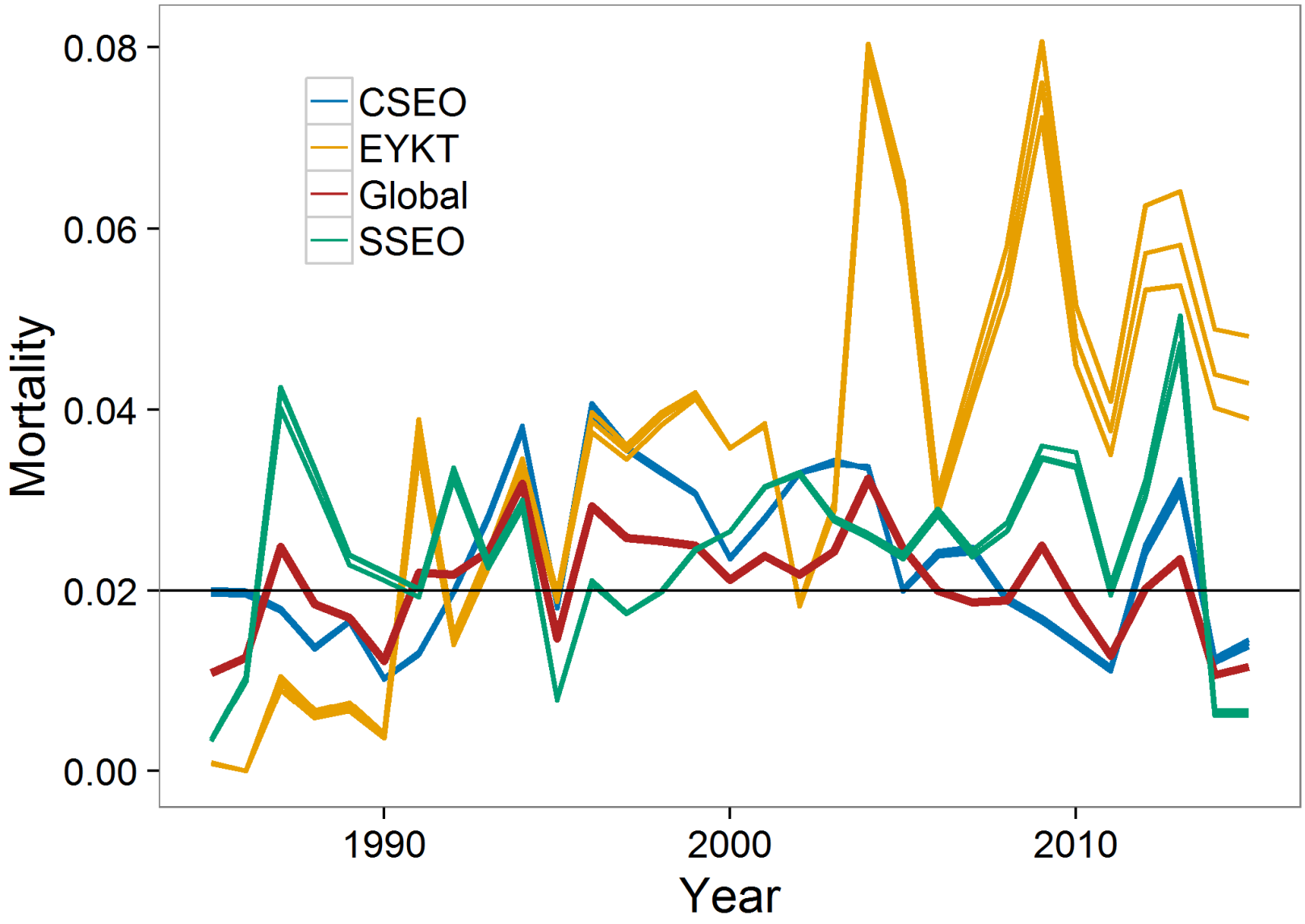
Results: Regional spawning biomass



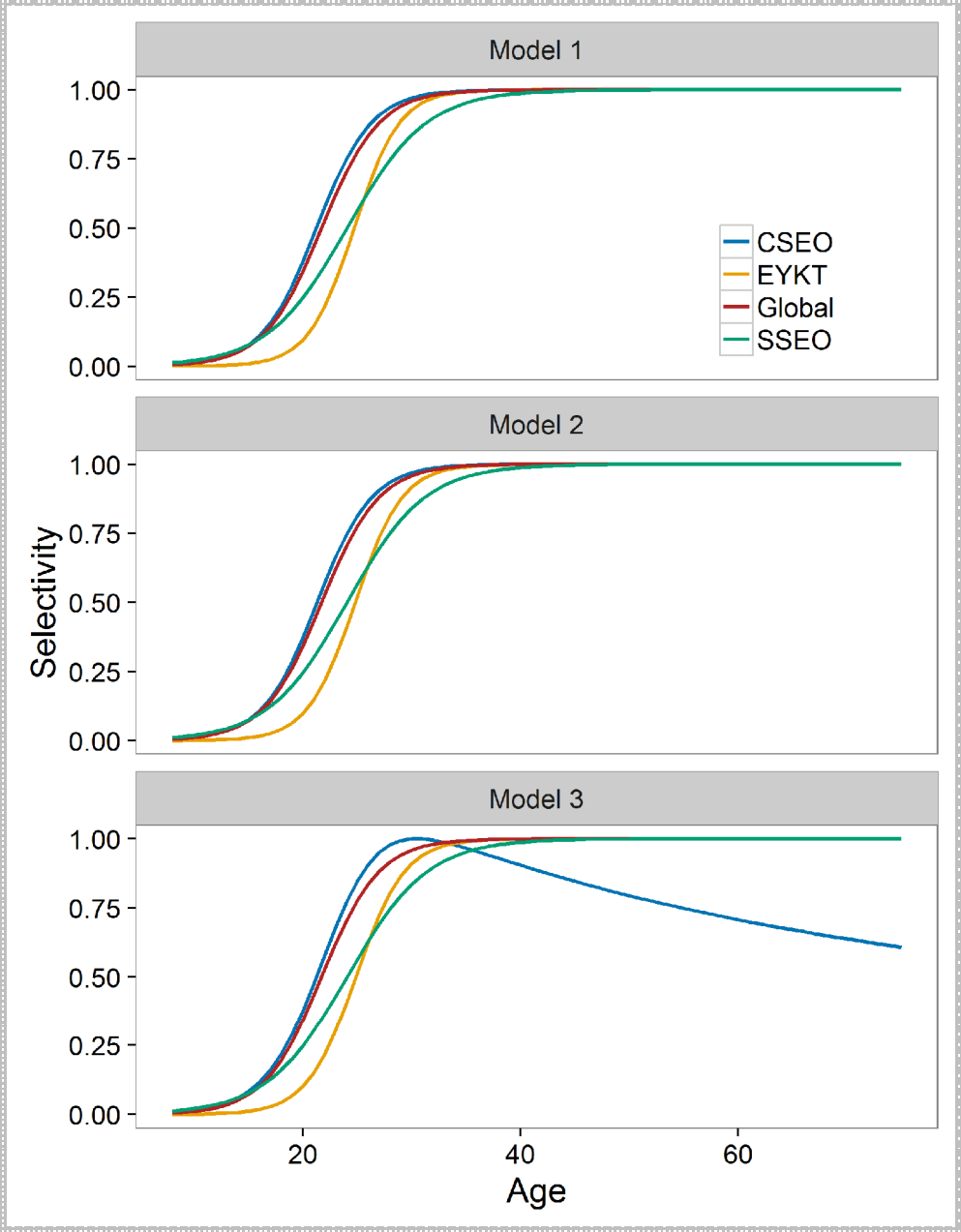
Result: Total spaning biomass



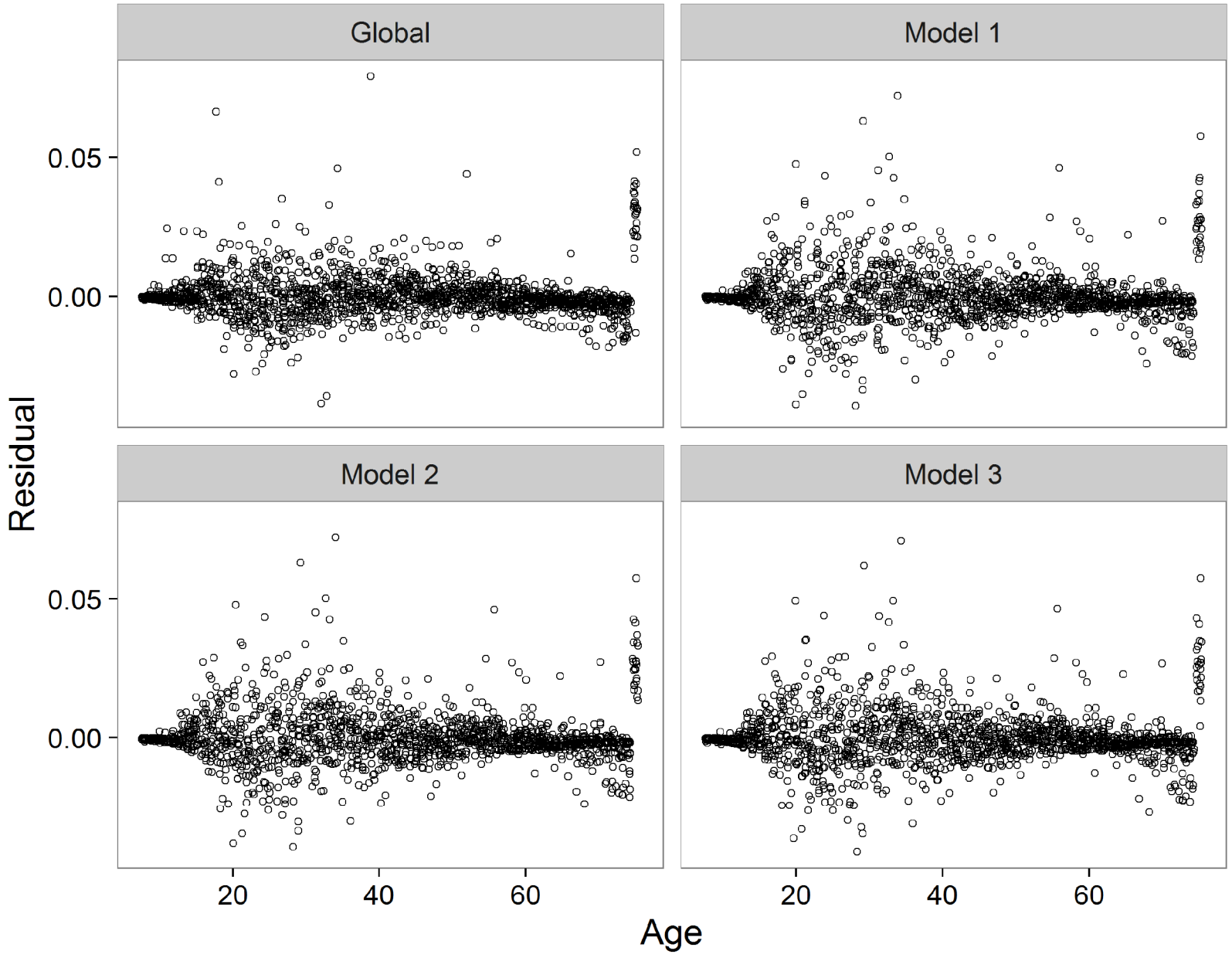
Results: Full-recruitment fishing mortality



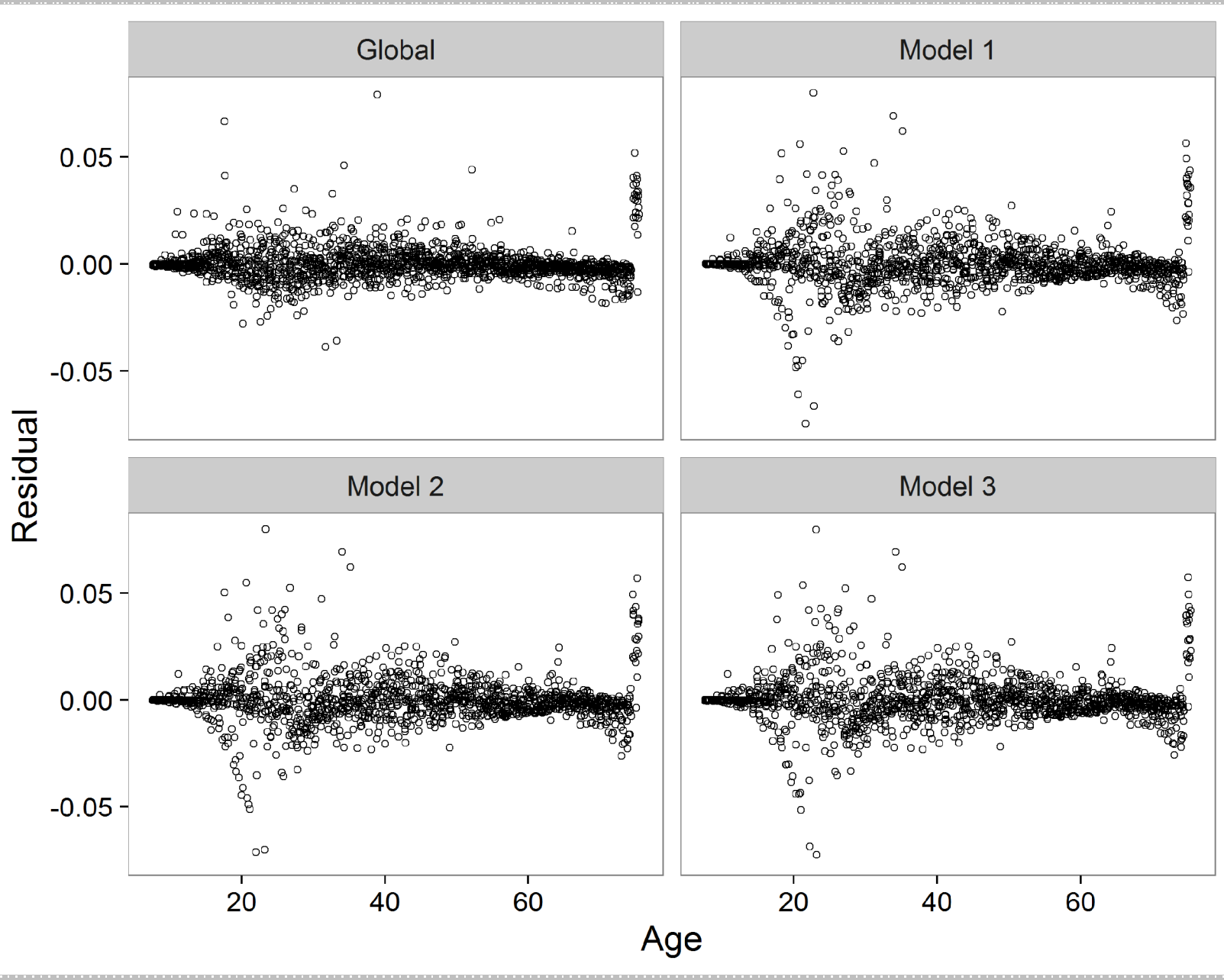
Results: Fishery selectivity



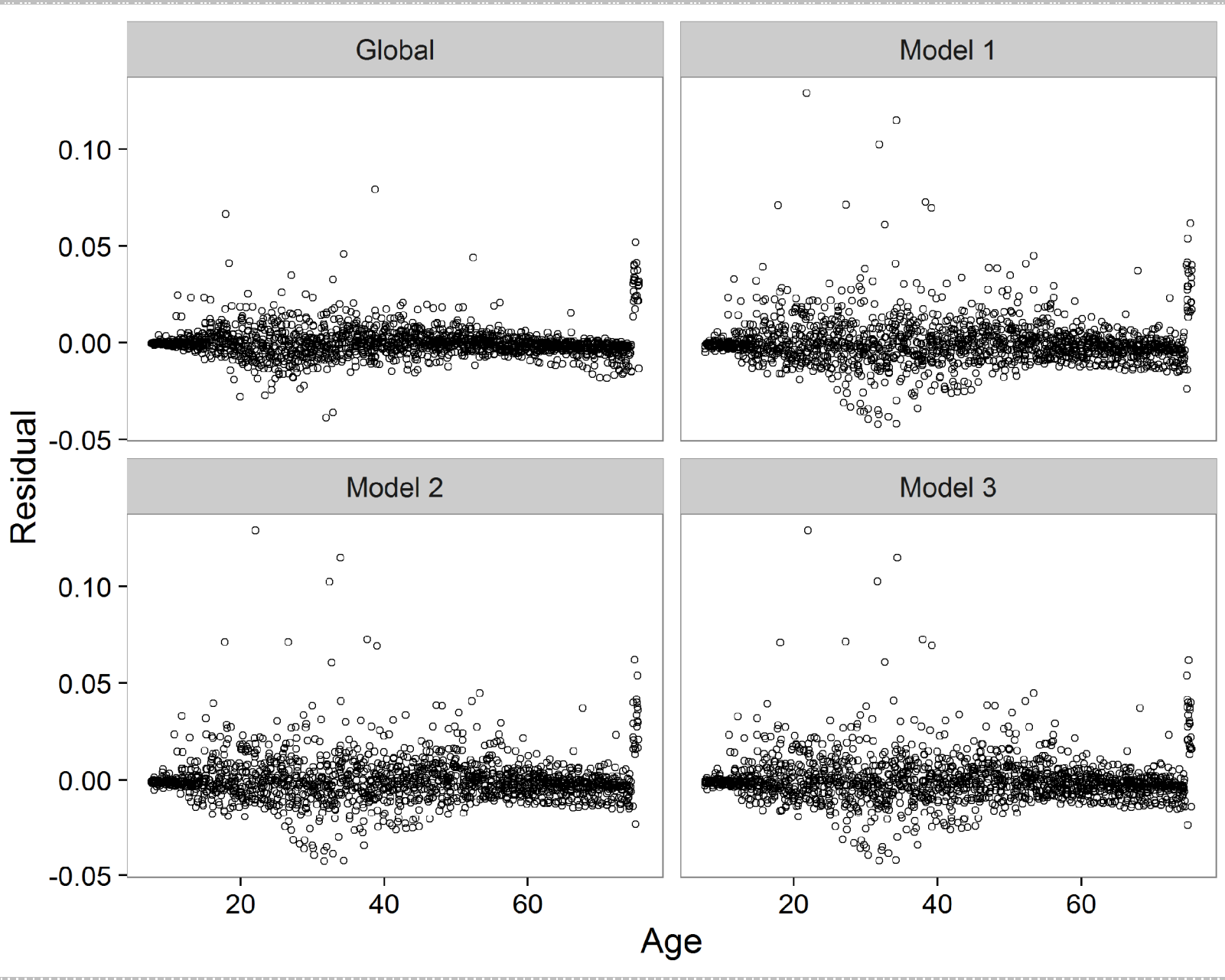
Results: Catch-age residuals - CSEO



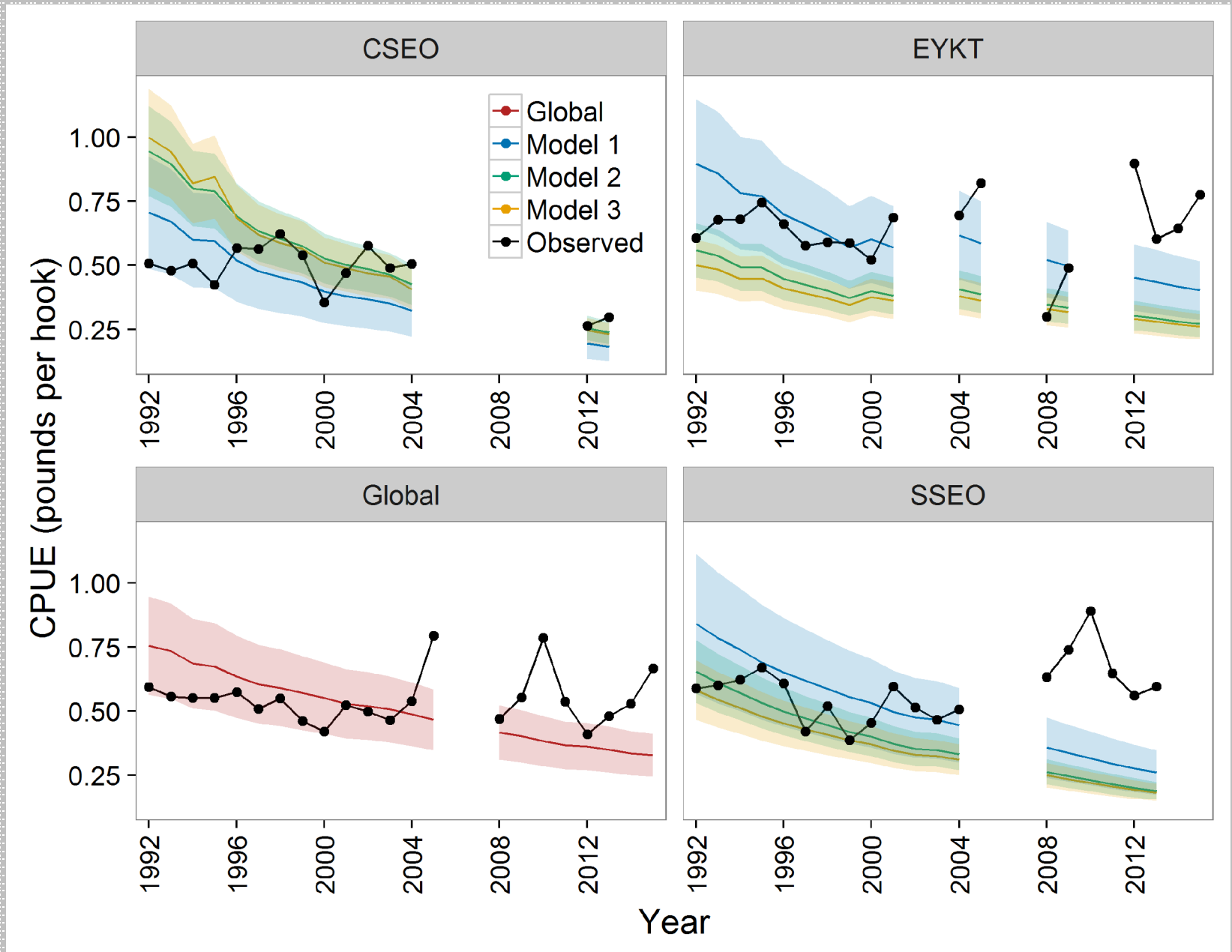
Results: Catch-age residuals - SSEO



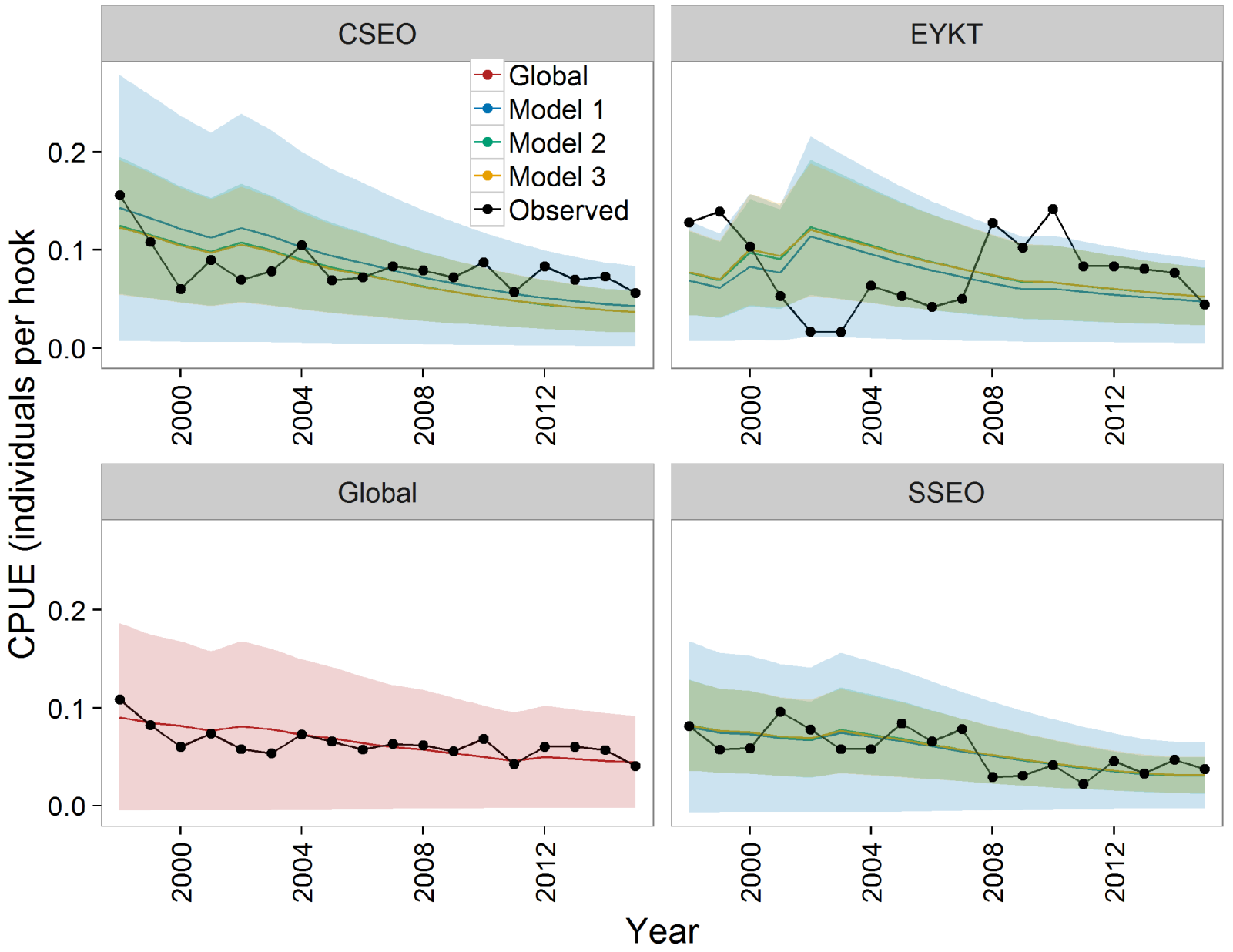
Results: Catch-age residuals - EYKT



Results: Commercial fisheries CPUE



Results: IPHC survey CPUE



Model Results: Shared parameters

Natural mortality *M*

Model 1	Model 2	Model 3	Model 4
CSEO – 0.0831			
SSEO – 0.0804	0.0850	0.0798	0.0791
EYKT – 0.0915			

Commercial fishery CPUE catchability

Model 1	Model 2	Model 3	Model 4
CSEO – 0.0697			
SSEO – 0.1233	0.0927	0.0858	0.0341
EYKT – 0.1431			

Full-recruitment F_{45}

Model 1	Model 2	Model 3	Model 4
CSEO – 0.1203	0.1263	0.111	
SSEO – 0.1562	0.1736	0.154	0.1331
EYKT – 0.3271	0.2636	0.2225	

IPHC survey CPUE catchability

Model 1	Model 2	Model 3	Model 4
CSEO – 0.0464			
SSEO – 0.0396	0.0405	0.0406	0.0117
EYKT – 0.0363			

Model Results: Comparisons

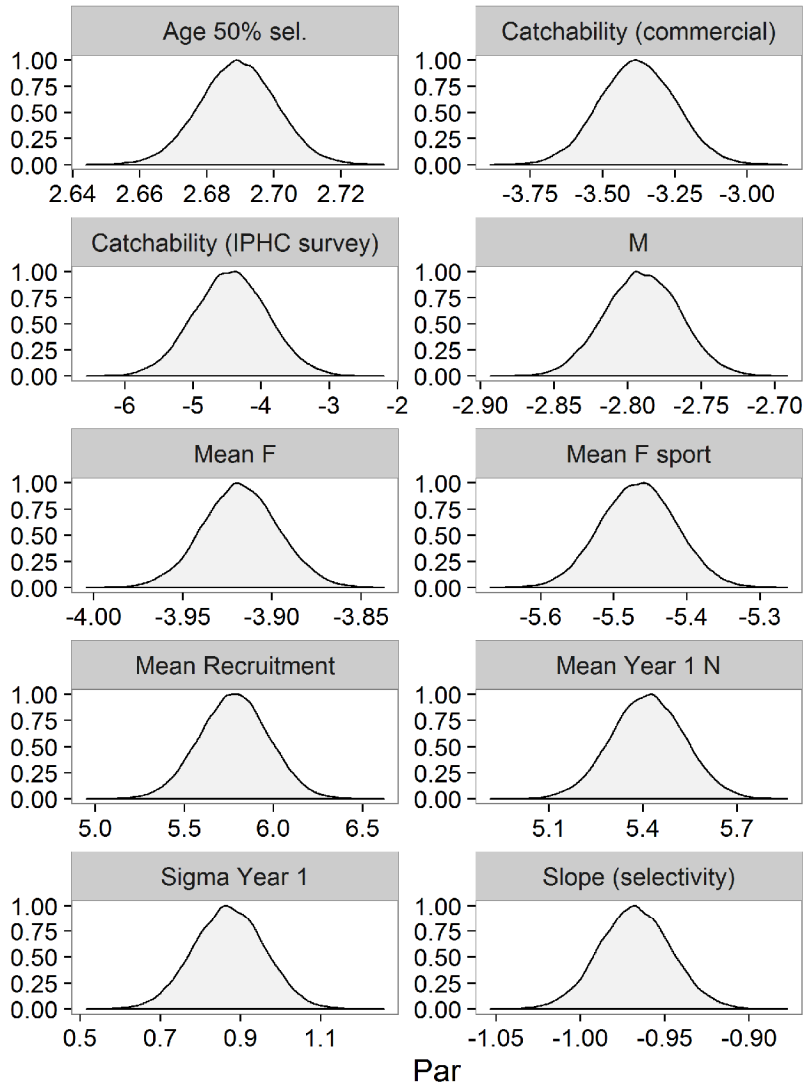
Deviance Information Criterion

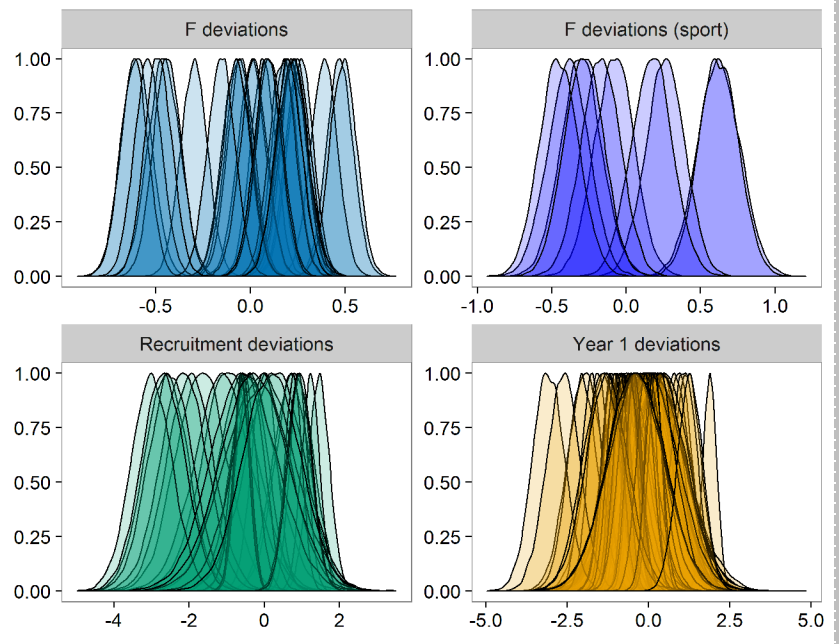
DIC values for all models from 2,000,000 MCMC iterations, saving every 100th

MODEL ONE		**MODEL THREE**	
Expectation of log-likelihood	11797	Expectation of log-likelihood	11724
Expectation of theta	13421	Expectation of theta	11787
Number of estimated parameters	439	Number of estimated parameters	441
Effective number of parameters	**-1624**	Effective number of parameters	**-63**
DIC	**10173.5**	**DIC**	**11661**
MODEL TWO		**MODEL FOUR (Global)**	
Expectation of log-likelihood	11814	Expectation of log-likelihood	9743
Expectation of theta	13482	Expectation of theta	10374
Number of estimated parameters	433	Number of estimated parameters	149
Effective number of parameters	**-1667**	Effective number of parameters	**-632**
DIC	**10147**	**DIC**	**9111**

Global model evaluation

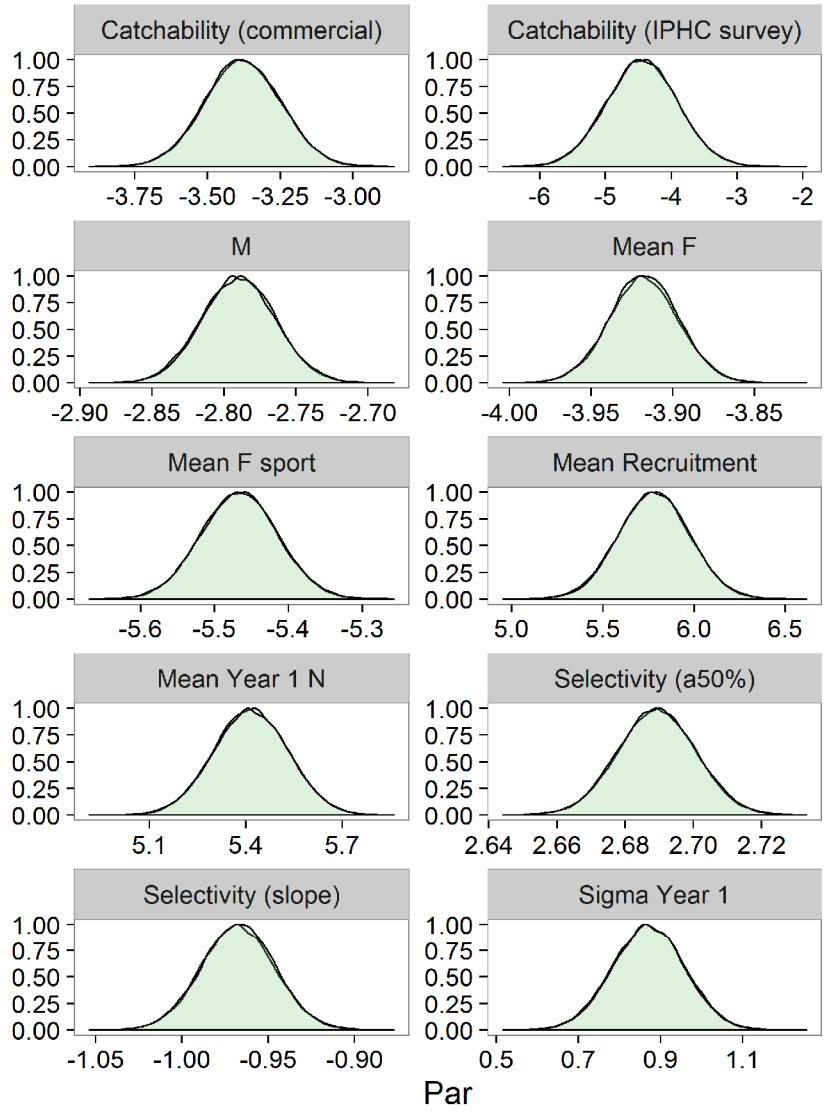
20,000 parametric bootstrap draws:
Full parameter space explored; no bound constraints

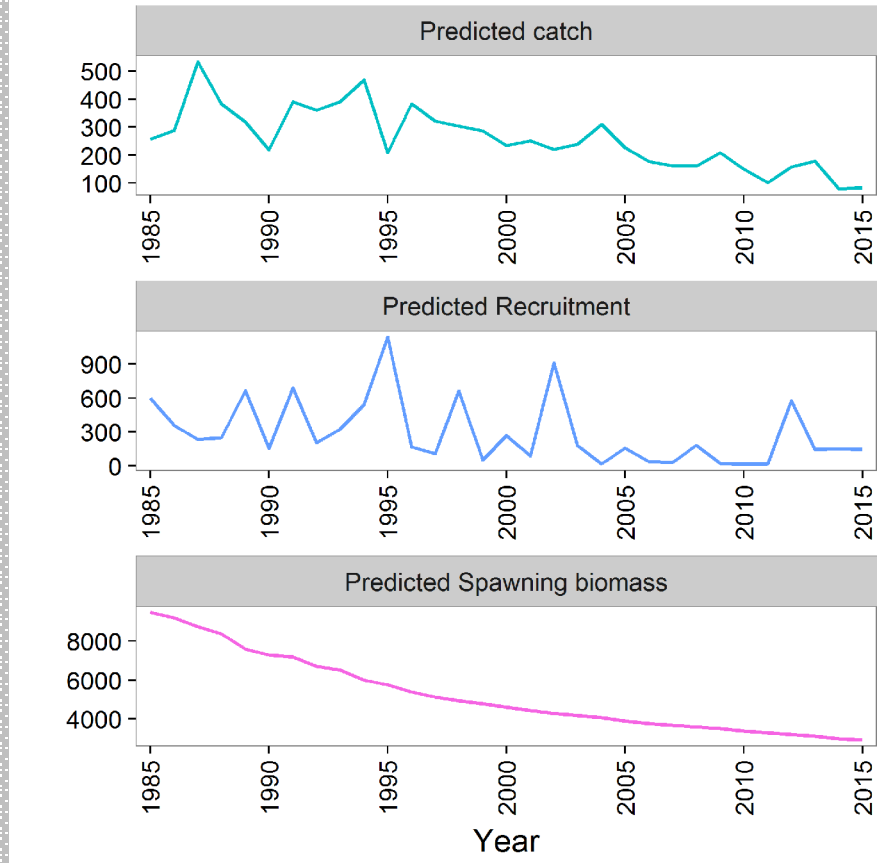




Global model evaluation

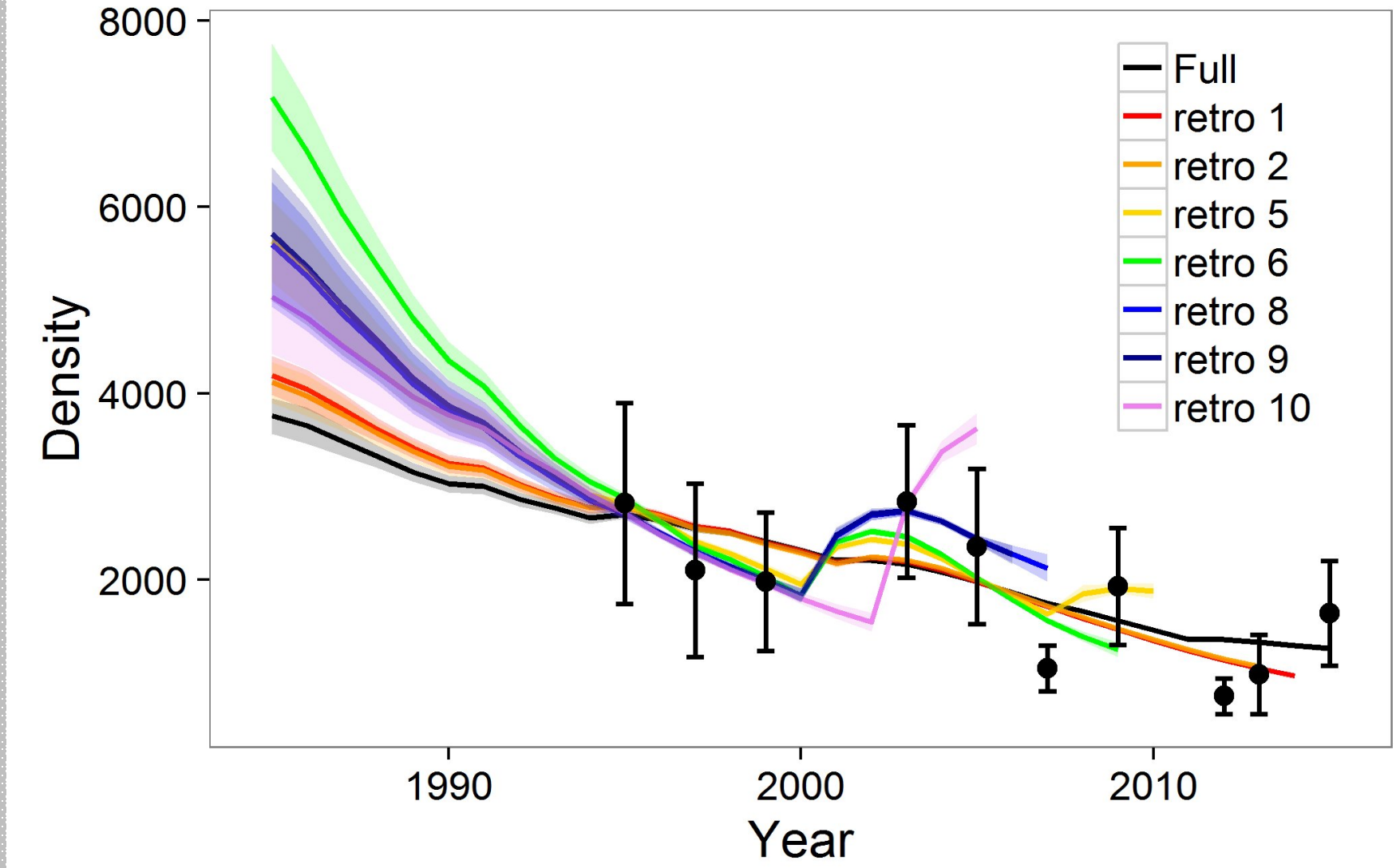
Self-test





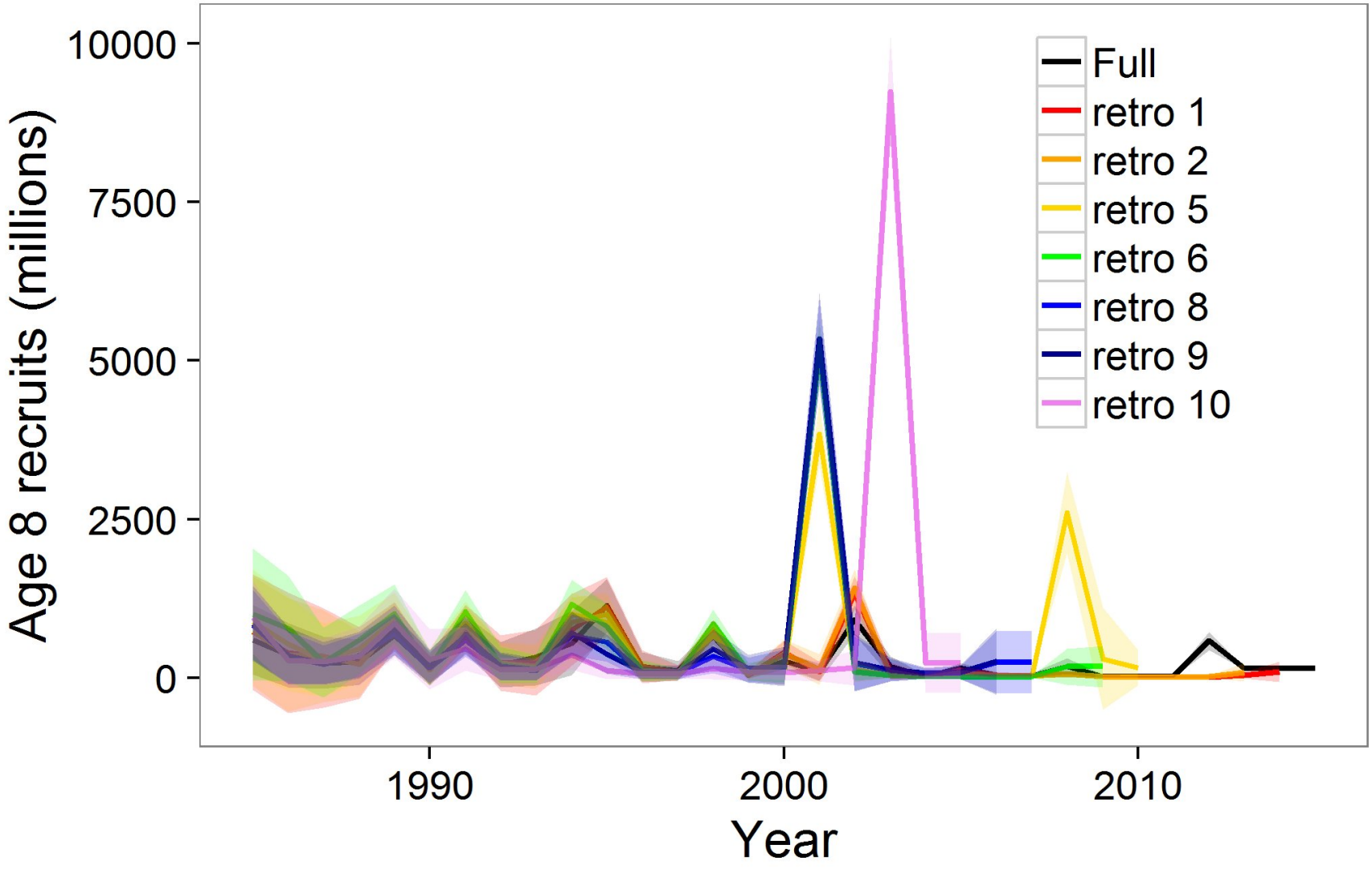
Global model evaluation

Retrospective analysis: density



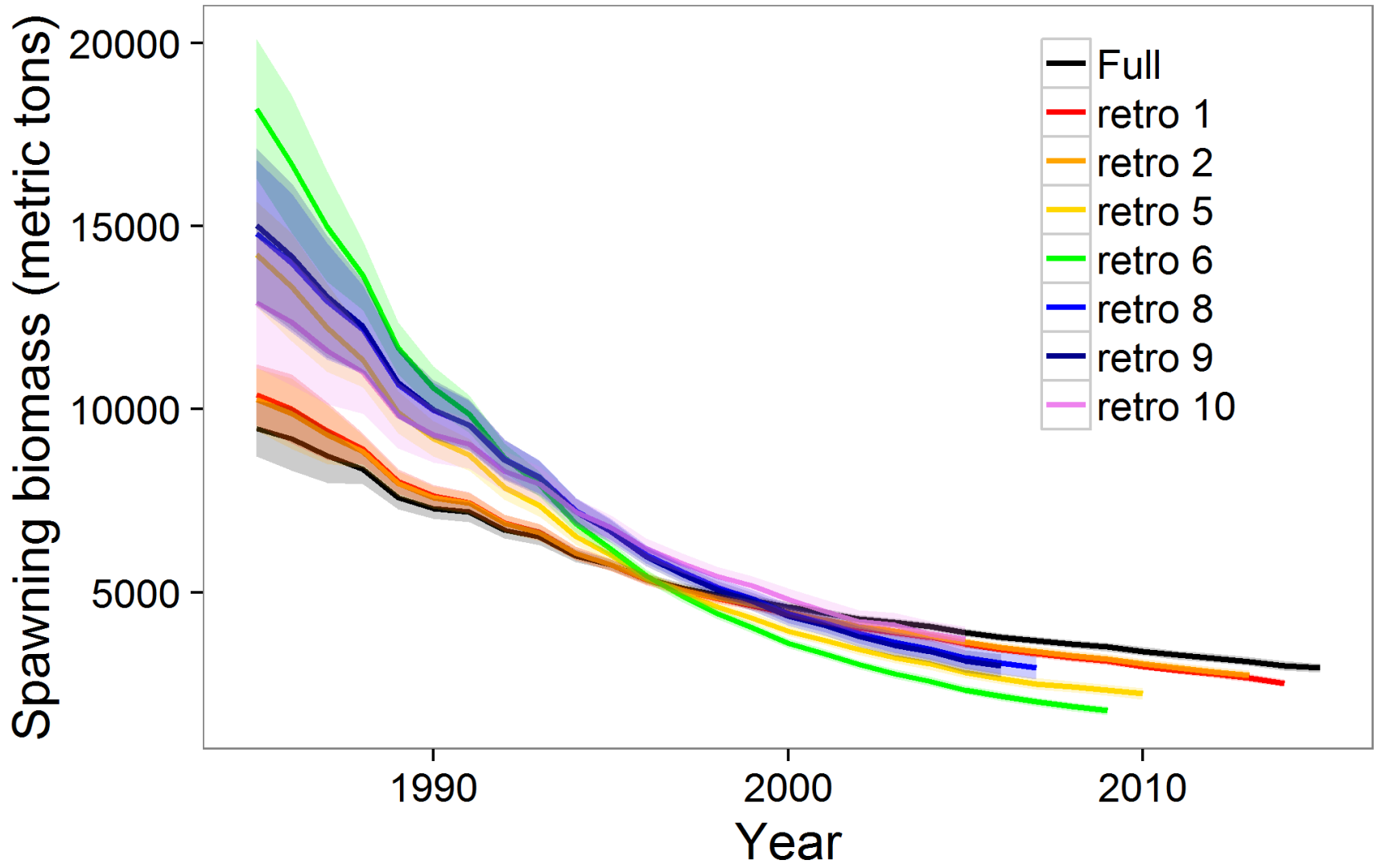
Global model evaluation

Retrospective analysis: age 8 recruitment



Global model evaluation

Retrospective analysis: spawning biomass



Global model evaluation

Estimating natural mortality

Confounded with extra variance term

M goes to zero

$$\sigma^2_{dens} = \log(1 + \sigma_{distance} / obs\_den^2)$$ (Burnham *et al.* 1987)

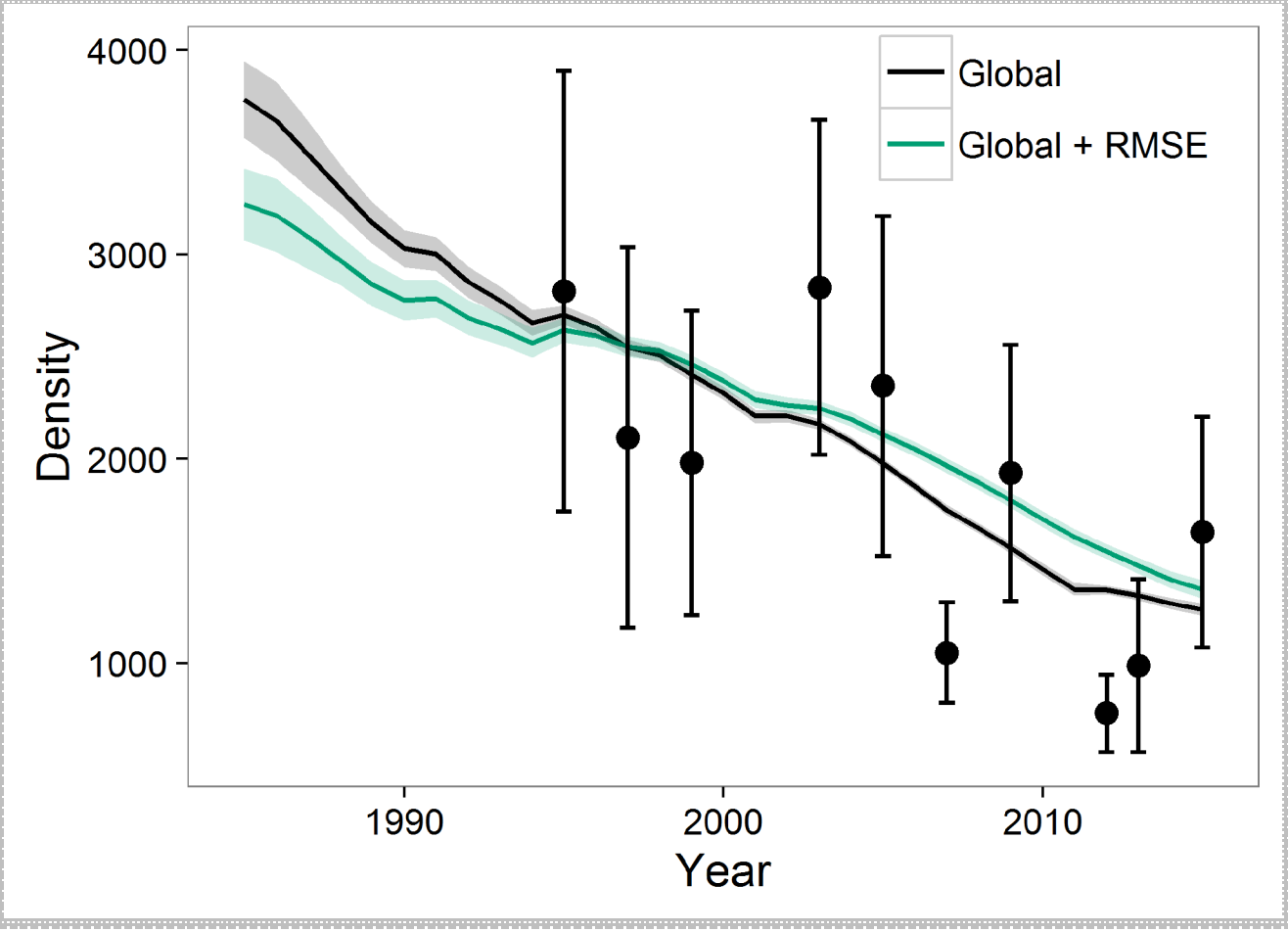
1. Evaluated root mean-squared error (RMSE) for density surveys inside model structure with no extra variance term;
2. Used the fixed RMSE as additional variance term

$$\sigma^2_{dens} = \log(1 + (\sigma_{distance} + rmse) / obs\_den^2)$$

Global model evaluation

DIC values for all models from 2,000,000 MCMC iterations, saving every 100th

RMSE Global model		Global model	
Expectation of log-likelihood	6644	Expectation of log-likelihood	9743
Expectation of theta	6928	Expectation of theta	10374
Number of estimated parameters	149	Number of estimated parameters	149
Effective number of parameters	-283	Effective number of parameters	-632
DIC	6361	DIC	9111



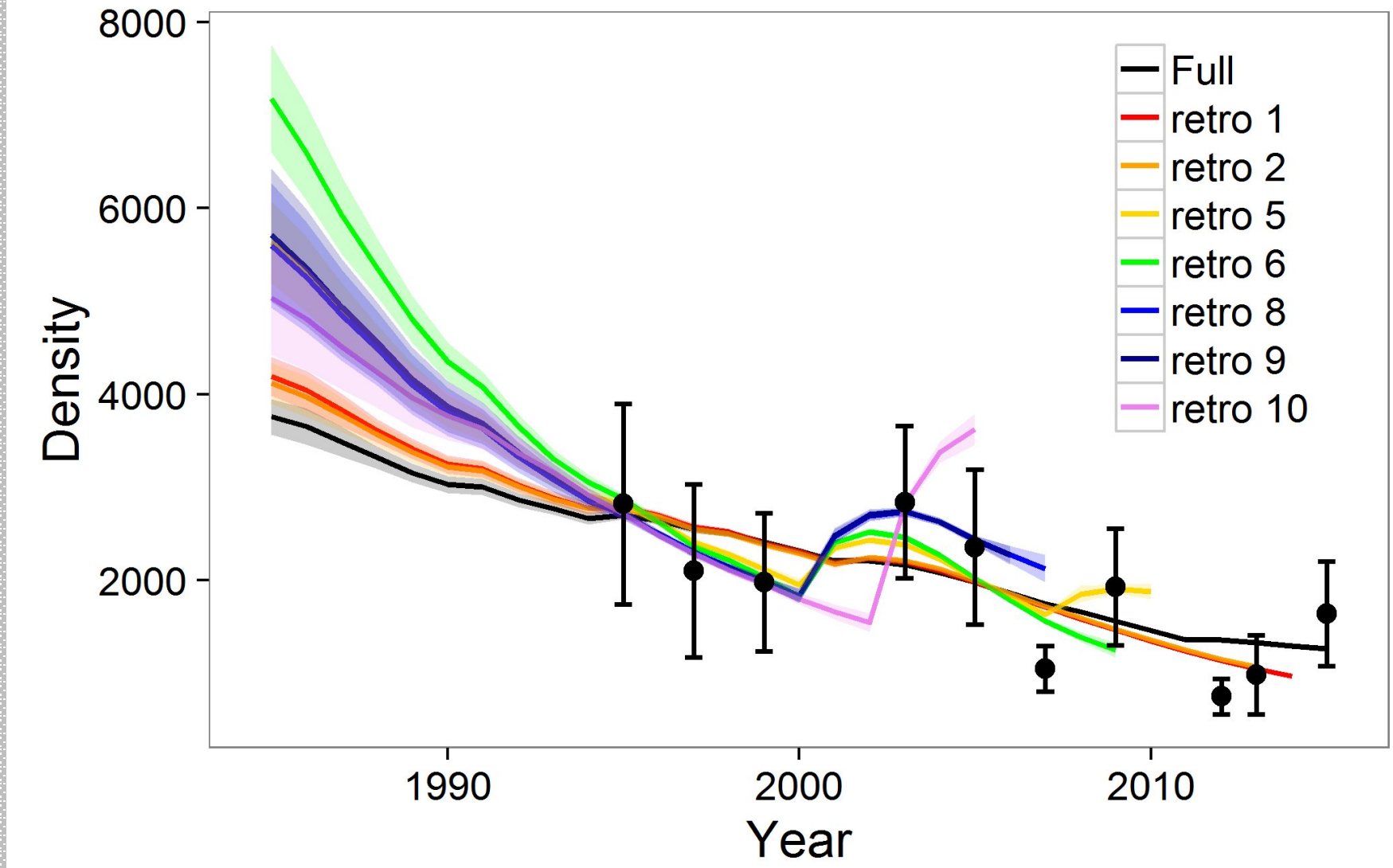
Natural mortality

Global: 0.791

RMSE: 0.467

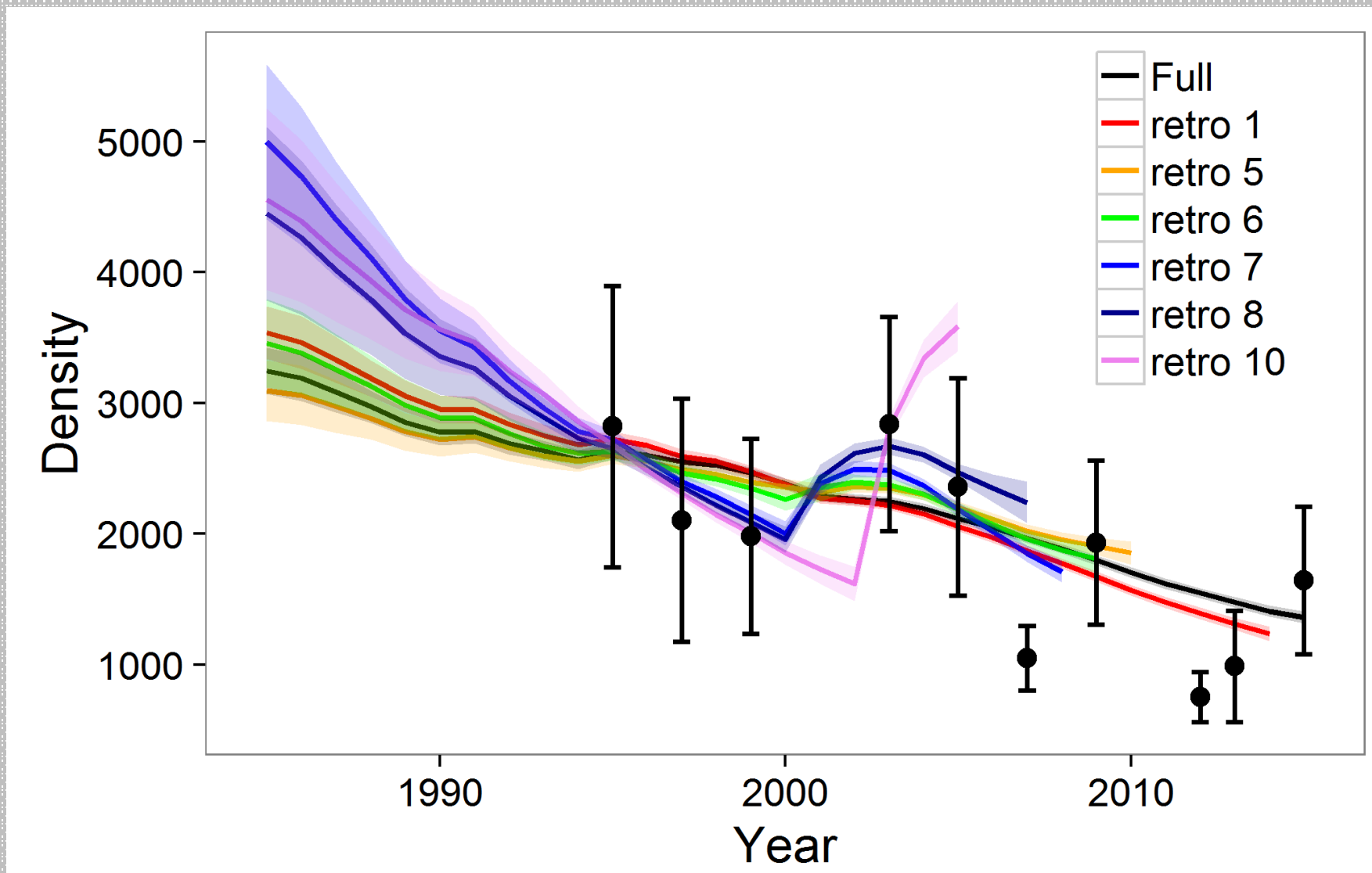
Model Results: Comparisons

Global model: density retrospective

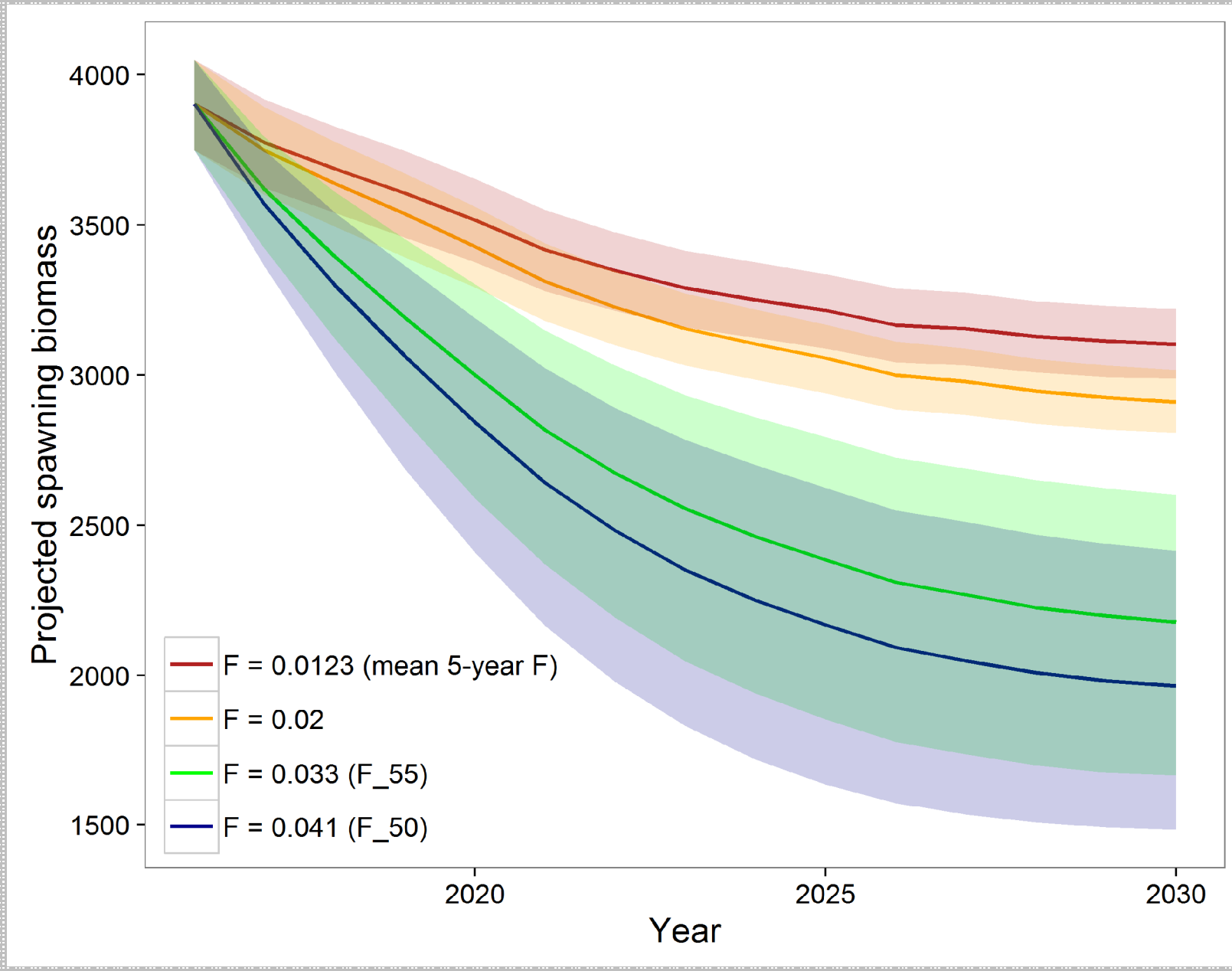


Model Results: Comparisons

RMSE global model retrospective: density



Spawning biomass projections



Model Recommendation

***F* level**	**Biomass** (metric tons)	**ABC**	**ABC** (metric tons)
$?_{??}$ (0.060)	L 90% CI (11,317)	Point-estimate	554
$?_{??}$ (0.049)	L 90% CI (11,317)	Point-estimate	454
$?_{??}$ (0.041)	L 90% CI (11,317)	Point-estimate	382
L 90% CI of $?_{??}$ (0.032)	L 90% CI (11,317)	Point-estimate	309
L 90% CI of $?_{??}$ (0.027)	L 90% CI (11,317)	Point-estimate	253
L 90% CI of $?_{??}$ (0.022)	L 90% CI (11,317)	Point-estimate	207
$?_{??}$ (0.060)	Point-estimate (11,697)	L 90% CI	314
$?_{??}$ (0.049)	Point-estimate (11,697)	L 90% CI	263
$?_{??}$ (0.041)	Point-estimate (11,697)	L 90% CI	216
CURRENT ABC (*F* = 0.02, assumes no selectivity)			**218**

If the RMSE-modified global model is accepted for purposes of management advice, the author recommends reducing harvest levels to $F_{??}$ and using the lower 90% confidence interval of the model-estimated ABC to set catch levels, which produces an ABC level for 2016 of 216 metric tons, which is essentially equivalent to the ABC of 218 metric tons under current management methods.

Priorities

1. Determine best approach for incorporating density uncertainty;

2. Re-analyze ADF&G survey data for global model;

3. Explore alternative methods for ROV survey – adaptive-cluster sampling for relative density zones across habitat