Response to the CIE review of the Bayesian surplus production model proposed for SEO yelloweye rockfish

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Background

- Bayesian Surplus Production model presented to Plan Team in September 2022
  - GOA Southeast Outside Yelloweye Rockfish part of DSR complex
- Team and SSC recommended CIE-type review
- CIE review in September 2023
  - Kevin Stokes
  - Robin Cook
  - Kotaro Ono
- Members of Plan Team discussed review in January 2024

CIE Review Terms of Reference (ToRs)

1. Evaluate the use of the model for managing Yelloweye rockfish
   a) Would this approach be best included in Tier 5?
   b) Should biomass estimates from the production model be used in lieu of random effects estimates?
2. Evaluate the management of the SEO DSR complex as a whole
3. Review methods used for estimating yelloweye bycatch in the directed Pacific halibut fishery
4. Provide advice and recommendations on a framework for simulation testing and evaluating its performance in comparison to an age-structured assessment

Reviewer comments for ToR 1

1. Evaluate the use of the model for managing Yelloweye rockfish:
   - Generally positive about appropriateness of the model
   - Acknowledgment that model needs development before use in management
   - Agreement that model estimates of F_{MSY} better than ad hoc estimates of *M*
   - Advice to simplify model, compare to REMA, then add complexity
   - No need to extend catch time series back to 1880s
   - Develop model in simulation framework to ensure accurate parameter estimation
   - Advice on parameterization, switching from JAGS to STAN, development of IPHC CPUE index

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General agreement from Plan Team

Reviewer comments for ToR 2

2. Evaluate the management of the SEO DSR complex as a whole
   - The Tier 6 approach for the non-yelloweye DSR species was the best available and there is no reason why the ABCs should not be summed together simply because they arise from different methods.

General agreement from Plan Team

Reviewer comments for ToR 3

3. Review methods used for estimating yelloweye bycatch in the directed Pacific halibut fishery
    - Generally, positive about the approach provided the uncertainty in the estimates is considered in the assessment
    - Encouraged that derived estimates were similar to contemporary landings when full retention came into effect
    - Concern from one reviewer that possible lack of independence between using IPHC FISS data in both the CPUE index and to derive bycatch rates
        - Other reviewer disagreed with that because response variables were different.

Reviewer comments for ToR 3

3. Review methods used for estimating yelloweye bycatch in the directed Pacific halibut fishery

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- Concern from one reviewer that possible lack of independence between using IPHC FISS data in both the CPUE index and to derive bycatch rates
  - Other reviewer disagreed with that because response variables were different.

General agreement from Plan Team

Reviewer comments for ToR 4

4. Provide advice and recommendations on a framework for simulation testing and evaluating its performance in comparison to an age-structured assessment
   - Initial assessment should consist of simulation testing of the REMA versus the SPM
   - Reviewers not convinced that an age-structured comparison was necessary or useful given uncertainty inherent in age-structured operating model
   - Acknowledged that an MSE would be necessary to include SPM into Council process and tier system.
   - If age-structure approach performed recommend Winker et al. (2020) approach.

Reviewer comments for ToR 4

Plan Team disagreed with this point.

- MSE would be required for adoption by council (reviewers agreed on this point)
- Team believed MSE would require evaluation of model in an age-structured framework.
- Acknowledgement that this would entail substantial work

- [illegible] was necessary or useful given uncertainty inherent in age-structured operating model.
- Acknowledged that an MSE would be necessary to include MSE into Council process.
- If age-structure approach performed recommend Winker et al. (2020) approach.

Questions on the CIE review?

… If not, moving on to updates on SPM development

SPM Progress since the review

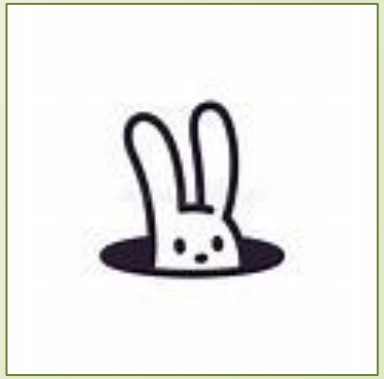
- I have a new job with ADF&G Sport Fish Division
- Collaborating with Kotaro Ono on model development

- **Step 1**: Strip down the model and move it to STAN
  - Model much faster, converged on simulated parameters
  - Much better diagnostics than JAGS
  - However…

SPM Progress since the review

- Conundrum #1: **Divergent transitions**
  - Hamiltonian Monte Carlo algorithm tunes itself
  - "A divergence arises when the simulated Hamiltonian trajectory departs from the true trajectory as measured by departure of the Hamiltonian value from its initial value. **When this divergence is too high, the simulation has gone off the rails and cannot be trusted**. The positions along the simulated trajectory after the Hamiltonian diverges will never be selected as the next draw of the MCMC algorithm, potentially reducing Hamiltonian Monte Carlo to a simple random walk and biasing estimates by not being able to thoroughly explore the posterior distribution."
  - Multiple failed attempts to reparametrize the model

down the rabbit hole…



SPM Progress since the review

- Kotaro reformulated the model and got the divergences to go away
  - Index only with process and observation error assumed equal
  - Treated SPM as transformed parameter in STAN
  - However, model showed that it needed more informative data to get rid of divergent transitions
- Developed several models based on Kotaro's initial model.
- Simulation testing

Data	Observation and Process Error
Index Only	OE only (ignore PE)
	OE = PE
	OE ≠ PE
Index + Biomass est.	OE only (ignore PE)
	Index OE = PE Biomass OE ≠ PE
	Index & Biomass OE ≠ PE

Operating model

Surplus Production Model

Parameters	Values	
Strata; s	3	SEO has 4 areas
Process σ	0.05	
Index observation σ	0.05	
Biomass observation σ	0.15	
r_s (rate of increase)	lognormal(0.05,0.025)	Slow pop growth rate = rockfish
K_s (unfished biomass)	uniform(100000, 200000)	
q_s (index catchability)	uniform(0.00001, 0.0001)	

Simulations

Simplified mock-up of SEO yelloweye data:

- 3 areas (strata)
- 50 years of catch data
- Unfished biomass in year 1
- Index starts in year 6
- Biomass estimates every 3rd year starting in year 11
- 6 harvest strategies
  - Wide range of contrast in fishing pressure and biomass
  - 1-way and 2-way trips

For each simulation record:

- True parameters and BRPs
- Contrast in biomass
- Rebound in biomass (end bio – low bio)
- Length of rebound (years from low bio to end of time series)

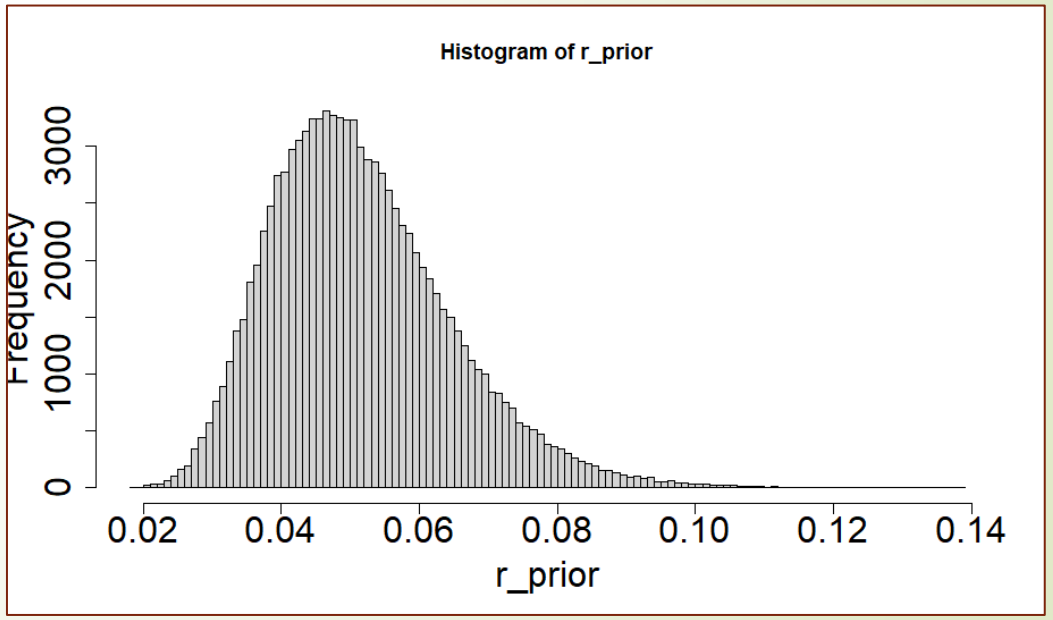
Ran all 6 models:

- Bias in parameter estimates
- Whether posterior credibilitiy intervals contain true parameter
- Divergent transitions

Simulations

Model priors:

- Process error: 1 / sqrt(isigma2)
- Isigma2 ~ gamma(100, 0.25)
- r ~ lognormal(log(0.05), 0.25) ← Fairly informative
  → Shared across strata
- K ~ lognormal(12, 0.5)
- q ~ 1 / uniform(100,1000000)



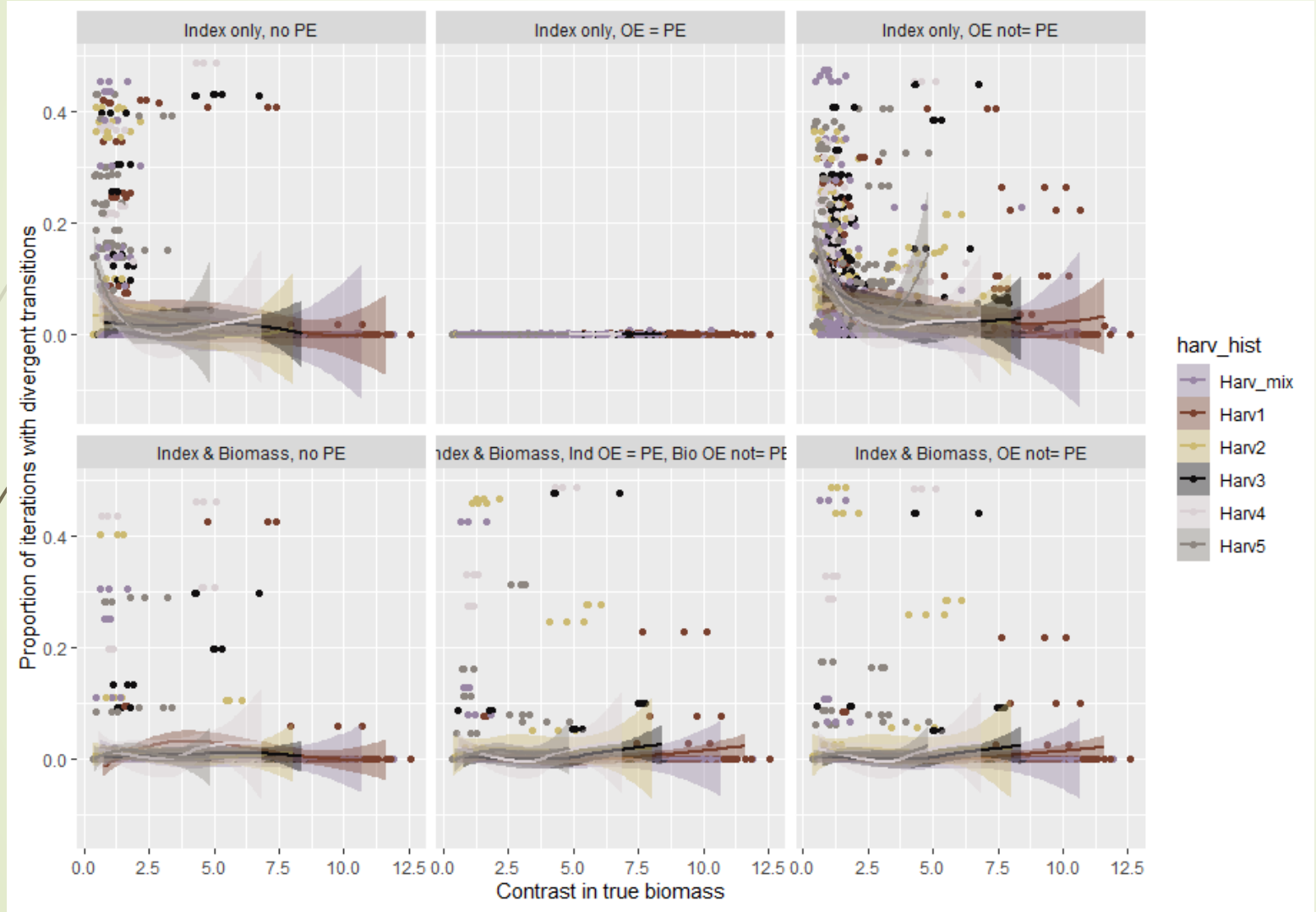
Preliminary Results

- The model works!
- Divergent transitions present to small degree
  - → Associated with data quality
  - → Associated with bias in parameter estimates
- Some small bias in parameters
  - → Tradeoff b/w r and K
    - → so less bias in BRPs
  - → Posteriors contained true parameter and BRP values

Preliminary Results: Divergent Transitions

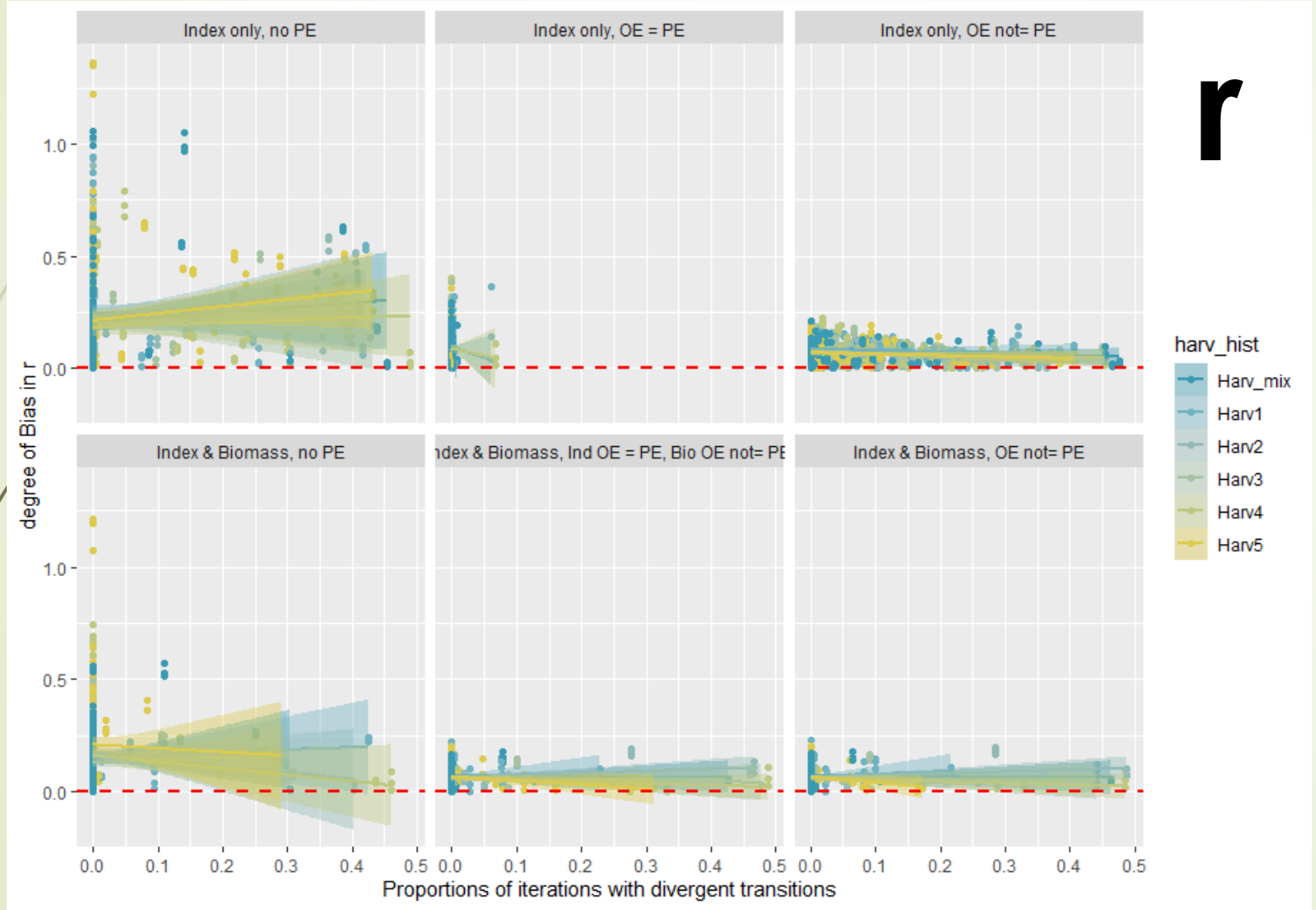
Model	Iterations	Proportion of sims that had at least 1 divergent transition	Mean proportion of transitions that were divergent
Index only, no PE	618	11.81%	2.45%
Index only, OE = PE	614	13.84%	0.01%
Index only, OE not= PE	615	69.59%	5.32%
Index & Biomass, no PE	619	4.36%	0.77%
Index & Biomass, Ind OE = PE, Bio OE not= PE	616	6.82%	0.84%
Index & Biomass, OE not= PE	616	6.66%	0.82%

Preliminary Results: Divergent Transitions



- Best behaved model is index only that assumes OE = PE
- Divergences marginally influenced by contrast in the data

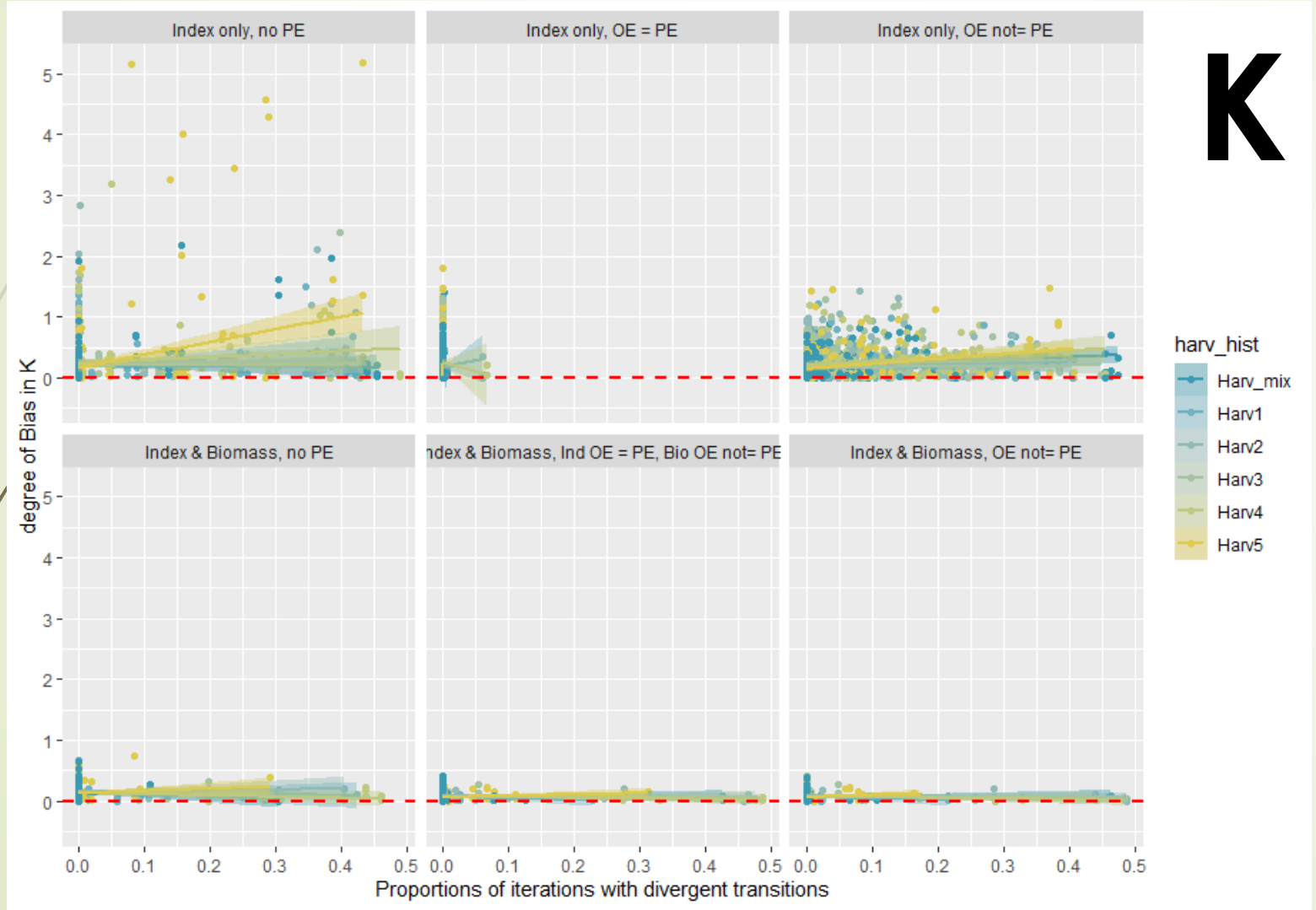
Preliminary Results: Divergent Transitions



- Divergences mildly correlated with degree of bias in K and q (but not r)

➢ r also had the most informative prior

Preliminary Results: Divergent Transitions

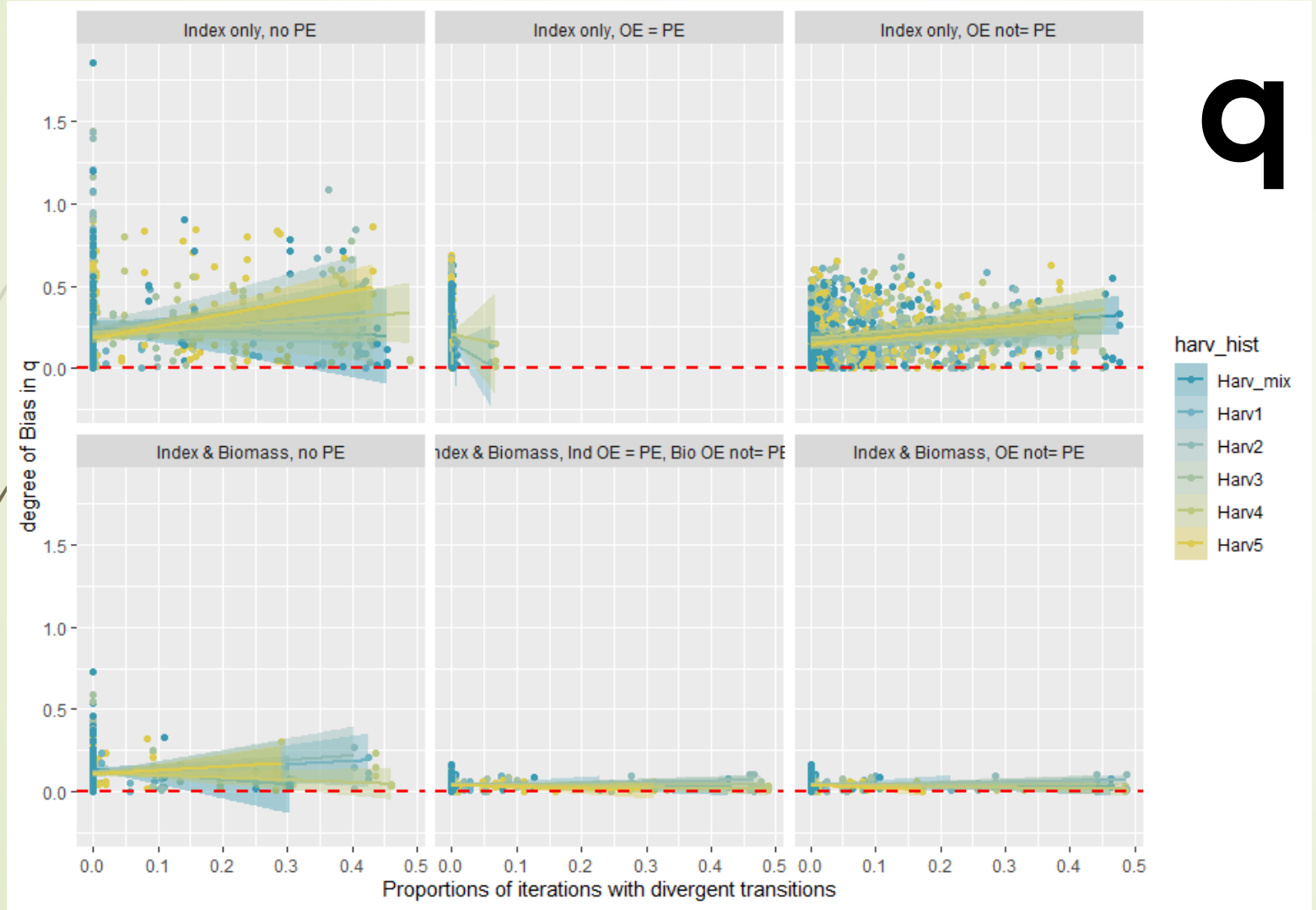


K

- Divergences mildly correlated with degree of bias in K and q (but not r)

➢ Plots show absolute bias

Preliminary Results: Divergent Transitions



q

- Divergences mildly correlated with degree of bias in K and q (but not r)

➢ Plots show absolute bias

Preliminary Results: **r** estimation

Model	Mean Bias	SD of Bias	Prop. of 90% CI containing true parameter
Index only, no PE	-1.23%	28.40%	23%
Index only, OE = PE	-3.74%	8.60%	100%
Index only, OE not= PE	-5.95%	5.50%	98%
Index & Biomass, no PE	-4.37%	20.00%	20%
Index & Biomass, Ind OE = PE, Bio OE not= PE	-3.48%	6.50%	95%
Index & Biomass, OE not= PE	-3.43%	6.50%	95%

* Process error important to include, even when it's minor

Preliminary Results: **K** estimation

Model	Mean Bias	SD of Bias	Prop. of 90% CI containing true parameter
Index only, no PE	5.30%	35.60%	11.30%
Index only, OE = PE	15.70%	25.60%	91.90%
Index only, OE not= PE	15.40%	23.70%	86.70%
Index & Biomass, no PE	1.40%	16.60%	11.30%
Index & Biomass, Ind OE = PE, Bio OE not= PE	2.70%	8.90%	91.20%
Index & Biomass, OE not= PE	2.70%	8.90%	91.10%

* Process error important to include, even for small amount of process error

Preliminary Results: **absolute process error estimation**

Model	Mean Bias	SD of Bias	Prop. of 90% CI containing true parameter
Index only, no PE	NA	NA	NA
Index only, OE = PE	1.70%	16.20%	100.00%
Index only, OE not= PE	2.70%	16.00%	100.00%
Index & Biomass, no PE	NA	NA	NA
Index & Biomass, Ind OE = PE, Bio OE not= PE	1.80%	15.80%	100.00%
Index & Biomass, OE not= PE	2.50%	15.90%	100.00%

* Process error important to include, even for small amount of process error

Preliminary Results: **q** estimation

Model	Mean Bias	SD of Bias	Prop. of 90% CI containing true parameter
Index only, no PE	3.80%	31.50%	
Index only, OE = PE	-11.80%	18.80%	
Index only, OE not= PE	-11.80%	18.00%	
Index & Biomass, no PE	0.50%	14.60%	
Index & Biomass, Ind OE = PE, Bio OE not= PE	-2.20%	4.00%	
Index & Biomass, OE not= PE	-2.40%	4.00%	Bug in code

* Process error important to include, even for small amount of process error

Preliminary Results: **MSY** estimation

Model	Mean Bias	SD of Bias	Prop. of 90% CI containing true parameter
Index only, no PE	-0.60%	35.10%	16.80%
Index only, OE = PE	12.10%	28.10%	92.50%
Index only, OE not= PE	8.60%	22.90%	92.00%
Index & Biomass, no PE	-4.10%	22.10%	10.50%
Index & Biomass, Ind OE = PE, Bio OE not= PE	-0.80%	10.00%	95.10%
Index & Biomass, OE not= PE	-0.70%	10.00%	95.50%

* BRPs better than parameter estimates; r and K balance out somewhat

Preliminary Results: B_{MSY} estimation

Model	Mean Bias	SD of Bias	Prop. of 90% CI containing true parameter
Index only, no PE	5.30%	35.60%	11.30%
Index only, OE = PE	15.70%	25.60%	91.90%
Index only, OE not= PE	15.40%	23.70%	86.70%
Index & Biomass, no PE	1.40%	16.60%	11.30%
Index & Biomass, Ind OE = PE, Bio OE not= PE	2.70%	8.90%	91.20%
Index & Biomass, OE not= PE	2.70%	8.90%	91.10%

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Preliminary Results: F_{MSY} estimation

Model	Mean Bias	SD of Bias	Prop. of 90% CI containing true parameter
Index only, no PE	-1.20%	28.40%	23.10%
Index only, OE = PE	-3.70%	8.60%	99.50%
Index only, OE not= PE	-5.90%	5.50%	97.60%
Index & Biomass, no PE	-4.40%	20.00%	20.20%
Index & Biomass, Ind OE = PE, Bio OE not= PE	-3.50%	6.50%	95.00%
Index & Biomass, OE not= PE	-3.40%	6.50%	94.80%

* BRPs better than parameter estimates; r and K balance out somewhat

Preliminary Results: **Stock Status** estimation

Model	Mean Bias	SD of Bias	Prop. of 90% CI containing true parameter
Index only, no PE	1.00%	15.30%	18.90%
Index only, OE = PE	3.40%	10.60%	91.20%
Index only, OE not= PE	2.90%	10.40%	91.50%
Index & Biomass, no PE	0.90%	14.30%	17.40%
Index & Biomass, Ind OE = PE, Bio OE not= PE	0.40%	9.00%	92.40%
Index & Biomass, OE not= PE	0.40%	9.00%	92.20%

* BRPs better than parameter estimates; r and K balance out somewhat

Next steps

1. Formerly analyze simulation results
    - Random forest approach

<u>Next round of simulations</u>

1. Add in REMA model for comparison
2. Less informative r prior
3. Vary degree of process and observation error
4. Add autocorrelation to process error
    - Mimic age-structured dynamics with PE drawn from highly skewed distribution
5. Comparison with age-structured OM and EM (MSE)
    - Graduate project

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<u>Goal for Phil and Kotaro</u>:

- Publication that provides guidance on use of production models based on
  - → Observation error
  - → Process error
  - → Information quality of data (contrast, etc.)
- Interpretation of diagnostics (divergent transitions)
- Prior recommendations

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Originally intended for SEO yelloweye assessment

ROV program on hiatus:
- A word from Jan…