Investigating additional population indices within the Tier 5 random effects model

"The SSC supports the author's plan to explore the feasibility of incorporating longline survey abundance indices for use in estimating biological reference points and possibly area apportionments. If the longline survey is added to the assessment, the SSC and the PT notes that methods will need to be developed to estimate area apportionments for assessments that utilize more than one survey." (SSC, December 2015)

"Secondly, a few assessments incorporate multiple indices that could also be used for apportionment. The Team recommends an evaluation on how best to tailor the RE model to accommodate multiple indices." (Plan Team, November 2015)

Example species: GOA Shortspine thornyhead (SST; w/ AFSC/ABL/MESA sablefish survey)

Outline:

1. Preliminaries: 2015 data/model structure, longline data

2. Evaluate 2015 Random Effects model assumptions: Data structure & Model parameters

3. Background on model structure to incorporate longline index

4. Details on incorporating longline index

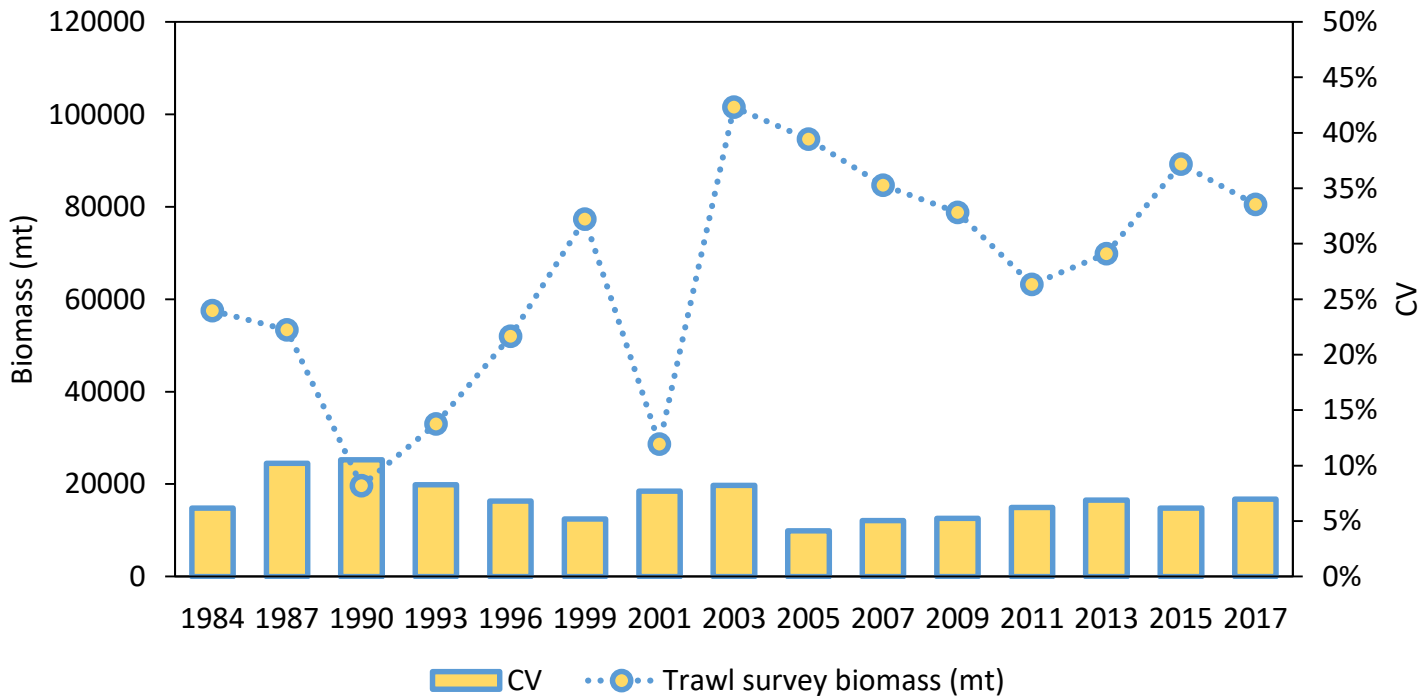
5. Results from Random effects model with longline data
   a. GOA-wide data fit comparisons
   b. Regional data fit comparisons
   c. Apportionment

6. Conclusions/Discussion

7. Remaining issues/questions

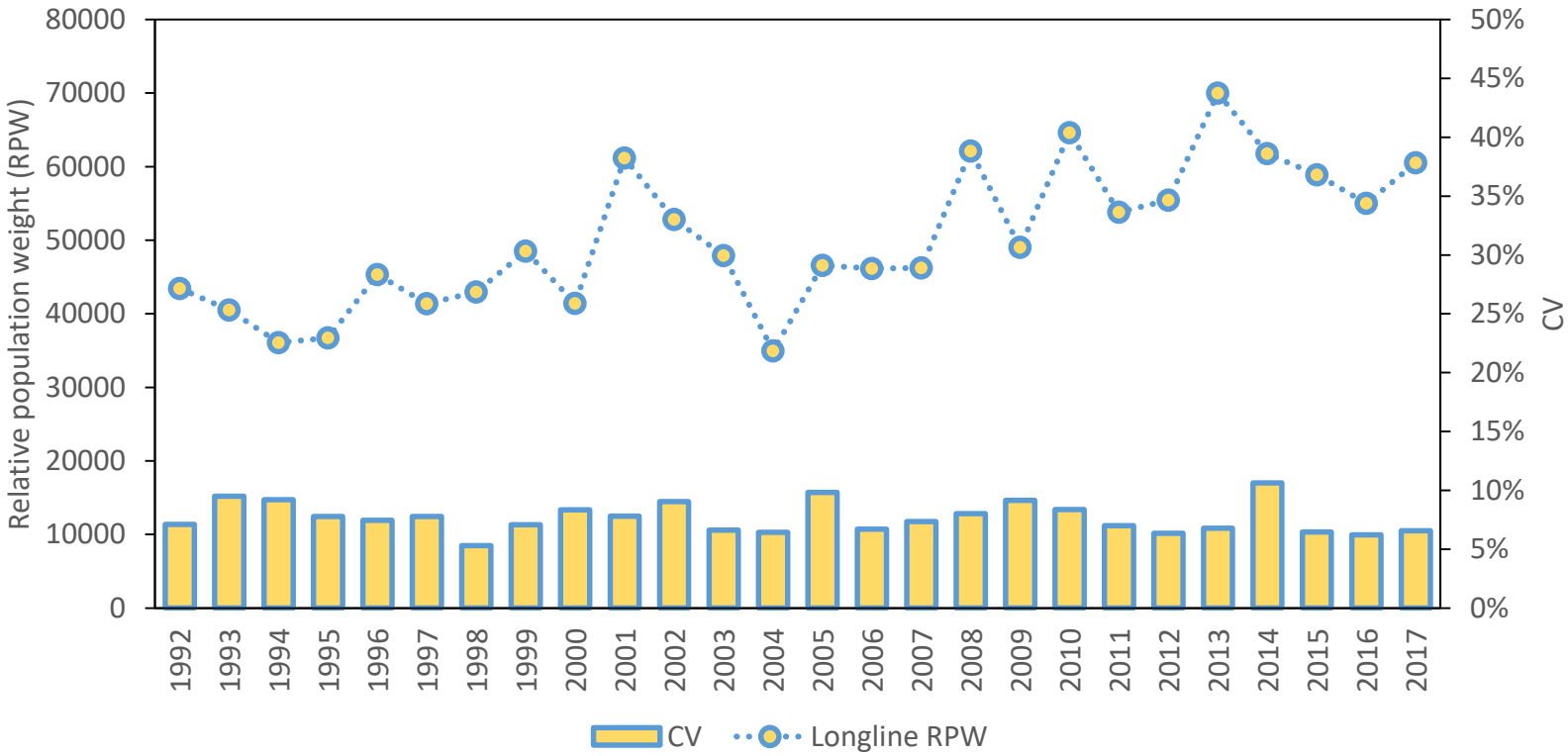
Preliminaries

- Data/model structure reminder:
  - Random effects (RE) model adopted in 2015
  - Data: split by region (W/C/EGOA) and depth strata (6 depth strata) – 18 strata total
  - Model: Single process error (PE) parameter estimated to constrain all region/depth random effect time series



Preliminaries

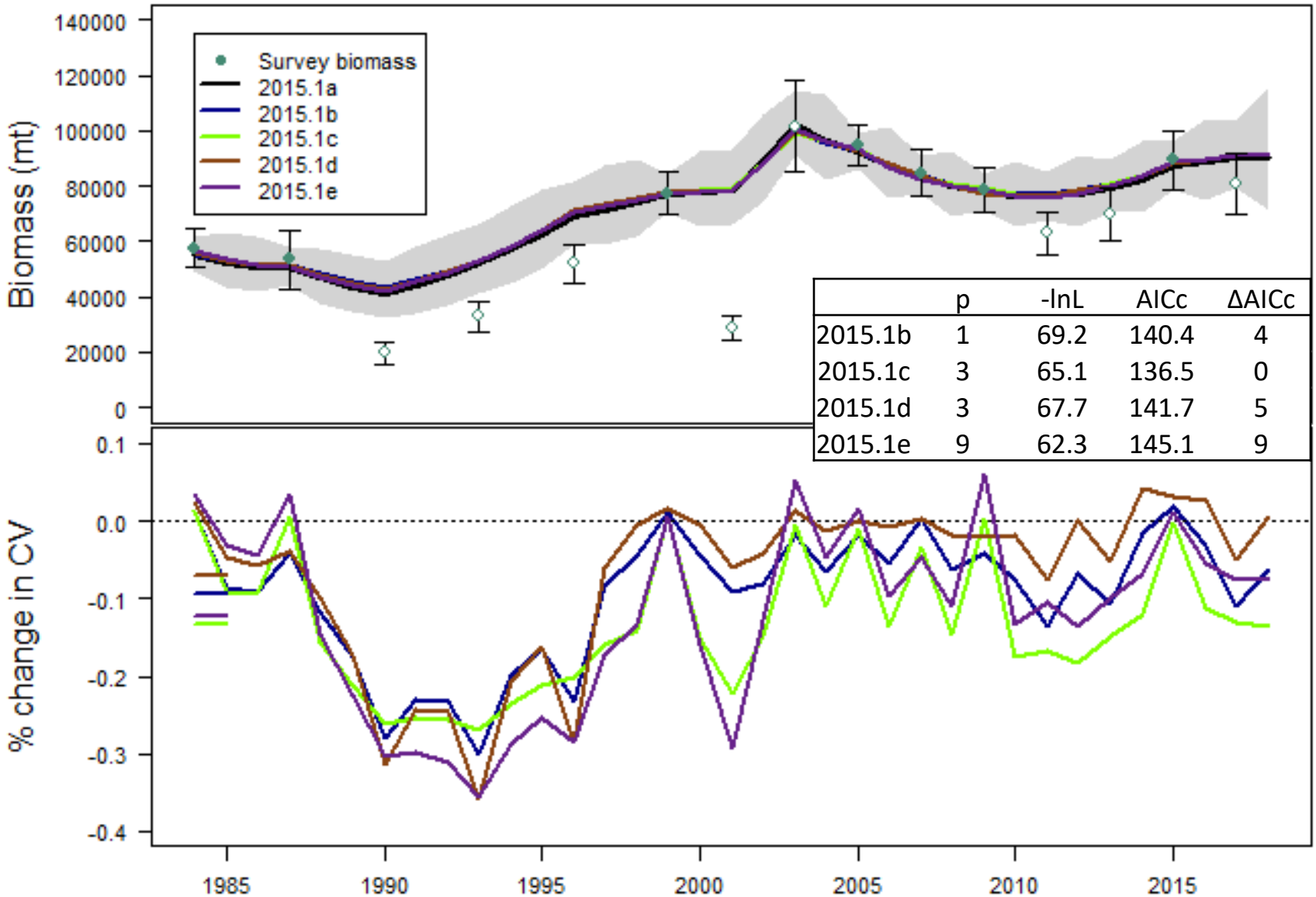
- Also sampled frequently by AFSC/ABL/MESA sablefish longline survey:
  - Longline index not used for assessment purposes (setting ABC, etc.)
  - With implementation of RE model, possible avenue to include longline survey as alternative index



Data/process error scenarios

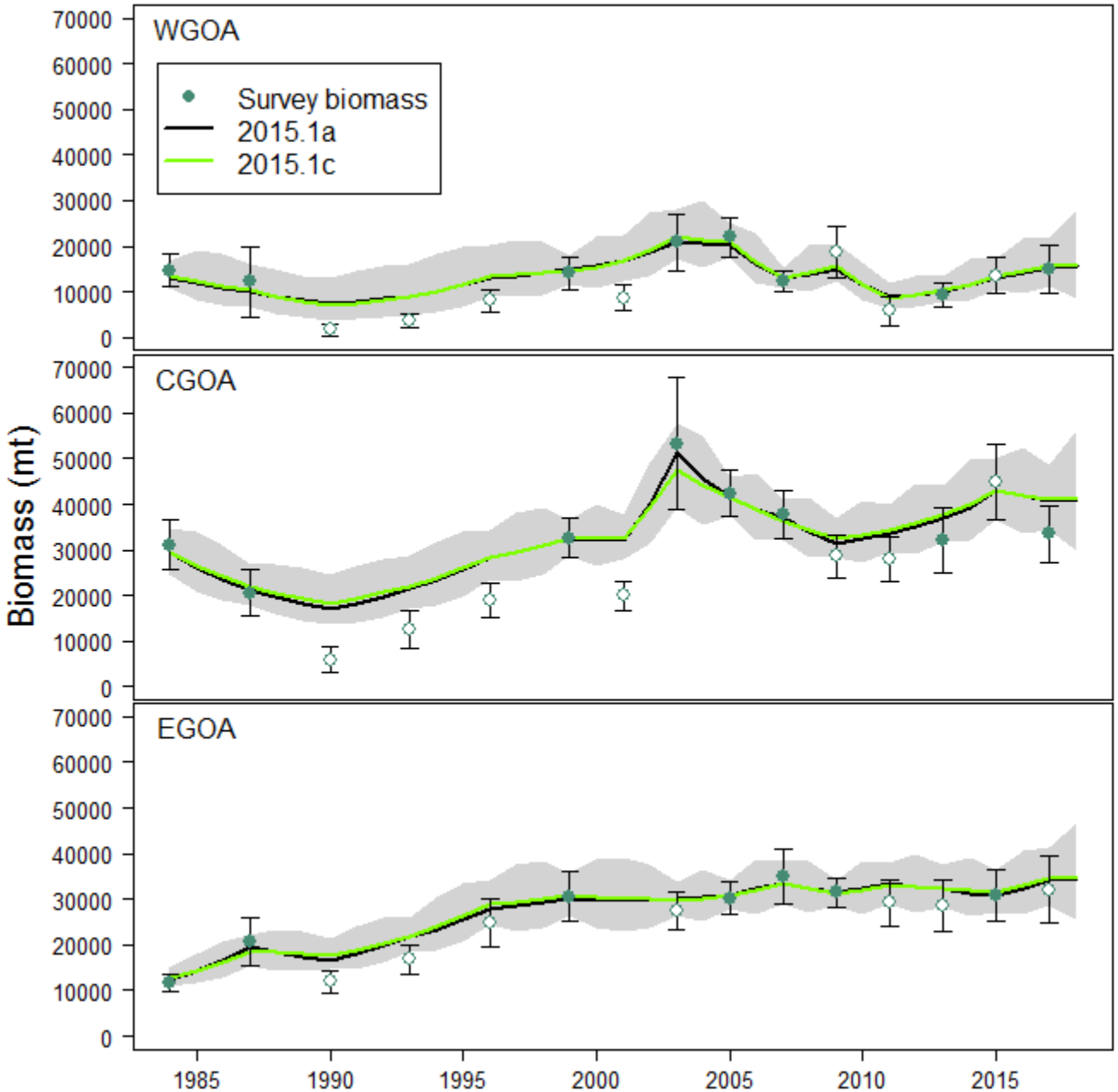
- Re-evaluated structure of data and application of PE parameters:
  - 2015.1a – Accepted model from 2015
    - Data: Split by region & depth strata
    - Model: Single PE parameter
  - 2015.1b
    - Data: Split by region & depth strata, depth strata ≤500m combined
    - Model: Single PE parameter (same as 2015.1a)
  - 2015.1c
    - Data: Same as 2015.1b
    - Model: Separate PE parameters by region
  - 2015.1d
    - Data: Same as 2015.1b
    - Model: Separate PE parameters by depth strata
  - 2015.1e
    - Data: Same as 2015.1b
    - Model: Separate PE parameters for region & depth strata

Data/process error scenarios



	p	-lnL	AICc	ΔAICc
2015.1b	1	69.2	140.4	4
2015.1c	3	65.1	136.5	0
2015.1d	3	67.7	141.7	5
2015.1e	9	62.3	145.1	9

Data/process error scenarios



Random effects model structure:

- Basics of random effects model: Parameters
  - Random effects: estimate unobserved state (biomass)
  - Hyper-parameter: constrains process error in random effects

- Model likelihood: 2 components
  - Observation error: fit of random effects to observed pop'n index

$$\sum_{Y}\sum_{R}\sum_{S}\frac{1}{2}\left[ln\left(2\pi\sigma^2_{T,y,r,s}\right)+\frac{1}{\sigma^2_{T,y,r,s}}\left(\hat{\theta}_{y,r,s}-lnI^{T}_{y,r,s}\right)^2\right]$$

  - Process error: constrains how much random effects can vary from year-to-year (random walk structure)

$$\sum_{y=2}^{Y}\sum_{R}\sum_{S}\frac{1}{2}\left[ln\left(2\pi\hat{\sigma}^2_{\theta}\right)+\frac{1}{\hat{\sigma}^2_{\theta}}\left(\hat{\theta}_{y-1,r,s}-\hat{\theta}_{y,r,s}\right)^2\right]$$

Incorporating longline index

- Main idea: random effects are estimate of unobserved biomass

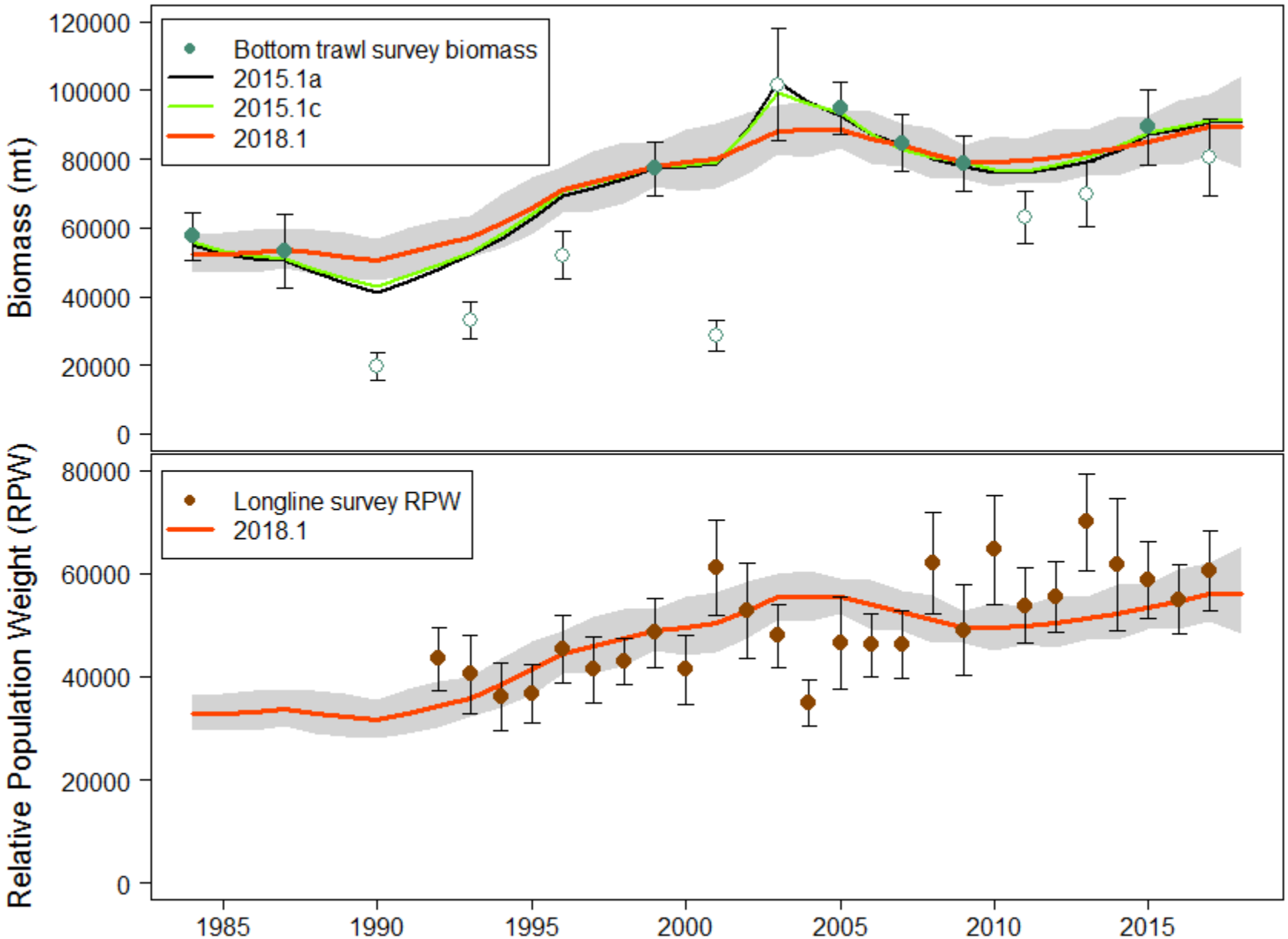
- For SST, random effects provide biomass estimates by region/depth strata

- Longline Relative Pop'n Weights (RPW) index available (with estimates of uncertainty) by region
  - Sum of random effects biomass estimates across depth strata within a region provides biomass estimates by region
  - Scaling regional biomass by an estimated *q* would provide estimates of RPW index (only adds 1 parameter to model)

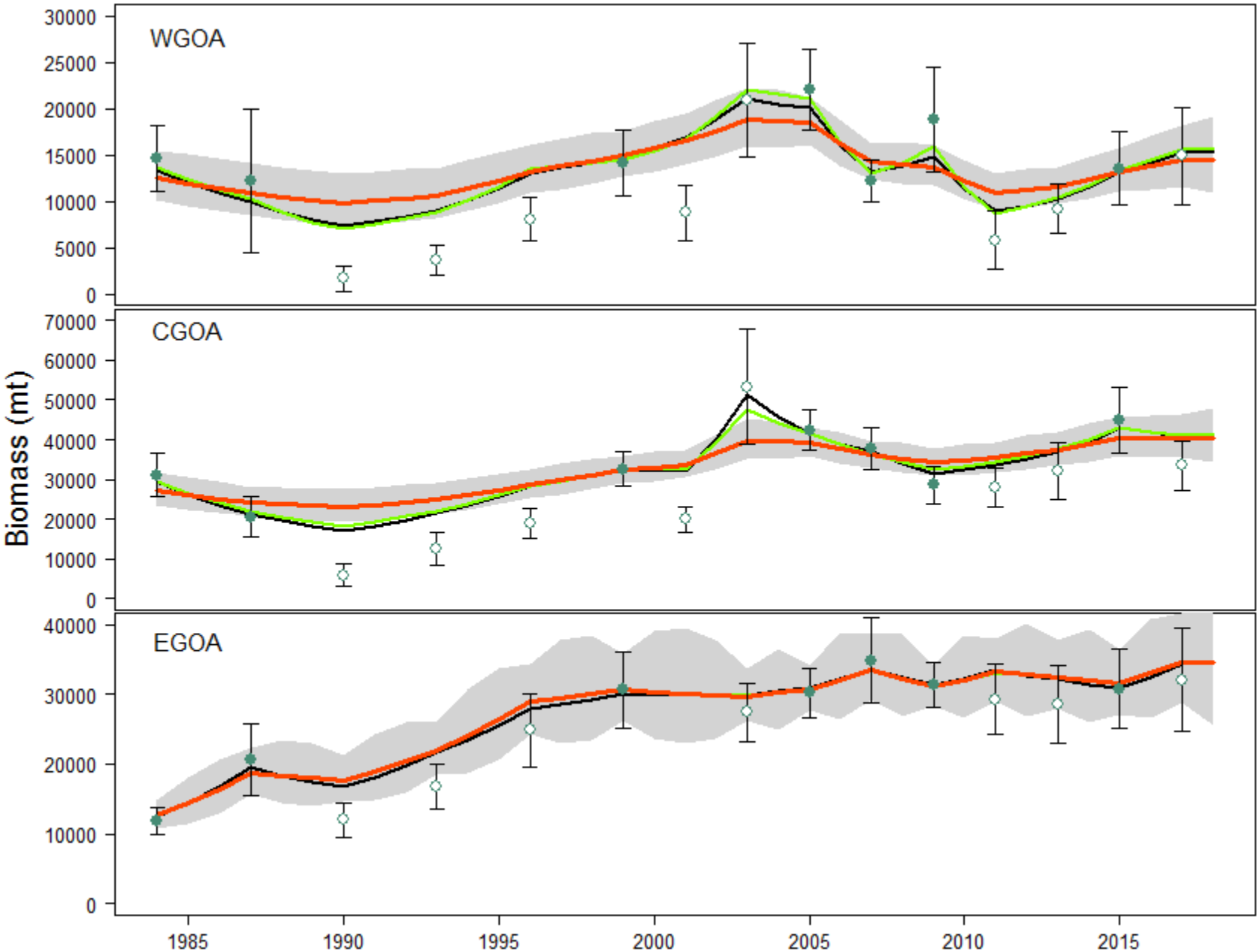
$$\hat{I}^{L}_{y,r} = q \sum_{S} e^{\widehat{\theta}_{y,r,s}}$$

  - Addition of observation error for Longline index into model likelihood would make regional random effects estimates dependent upon fit to both trawl and longline surveys

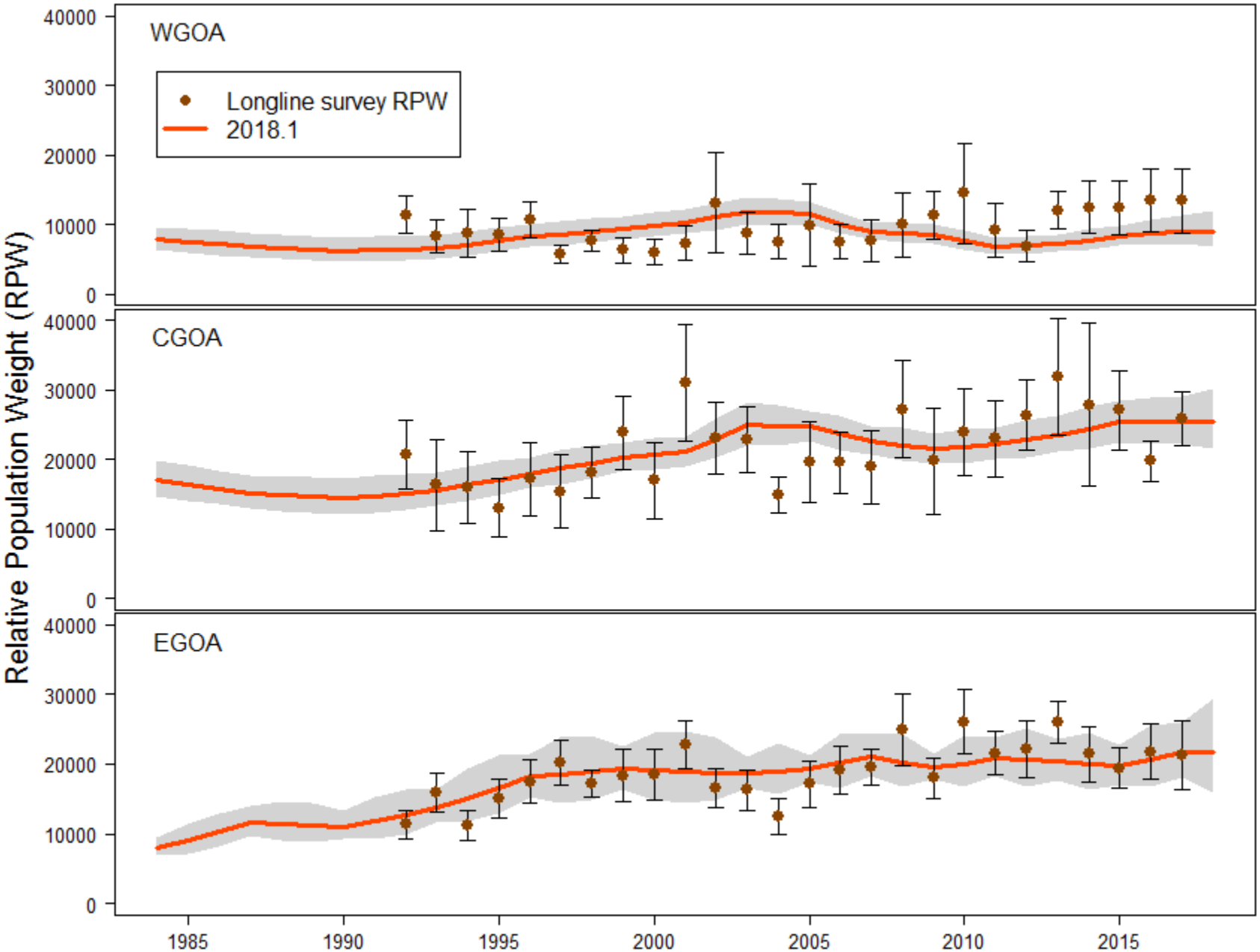
SST – current vs combined



SST – current vs combined

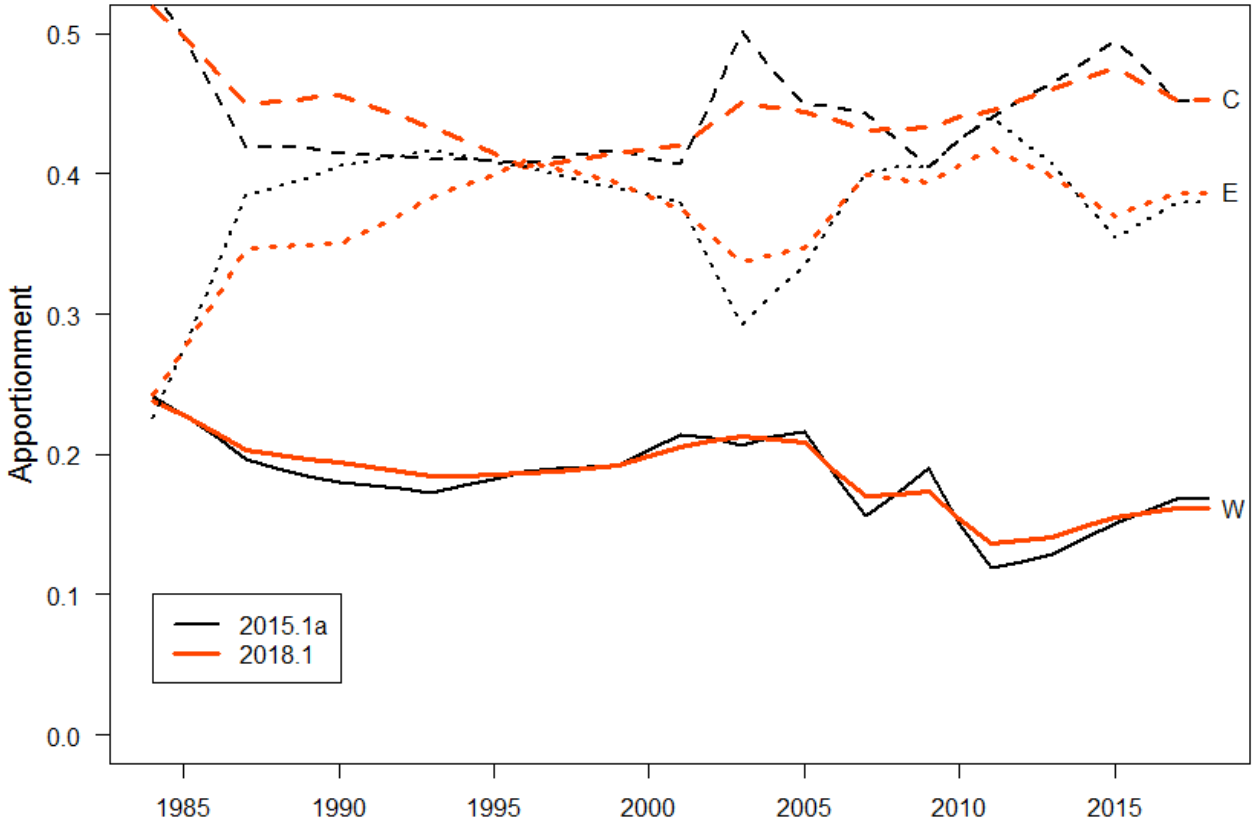


SST – current vs combined



SST – current vs combined

- With regional (W/C/EGOA) biomass estimates that are dependent on fits to both trawl and longline surveys – straight forward way to implement additional index to apportionment



Conclusions/Discussion

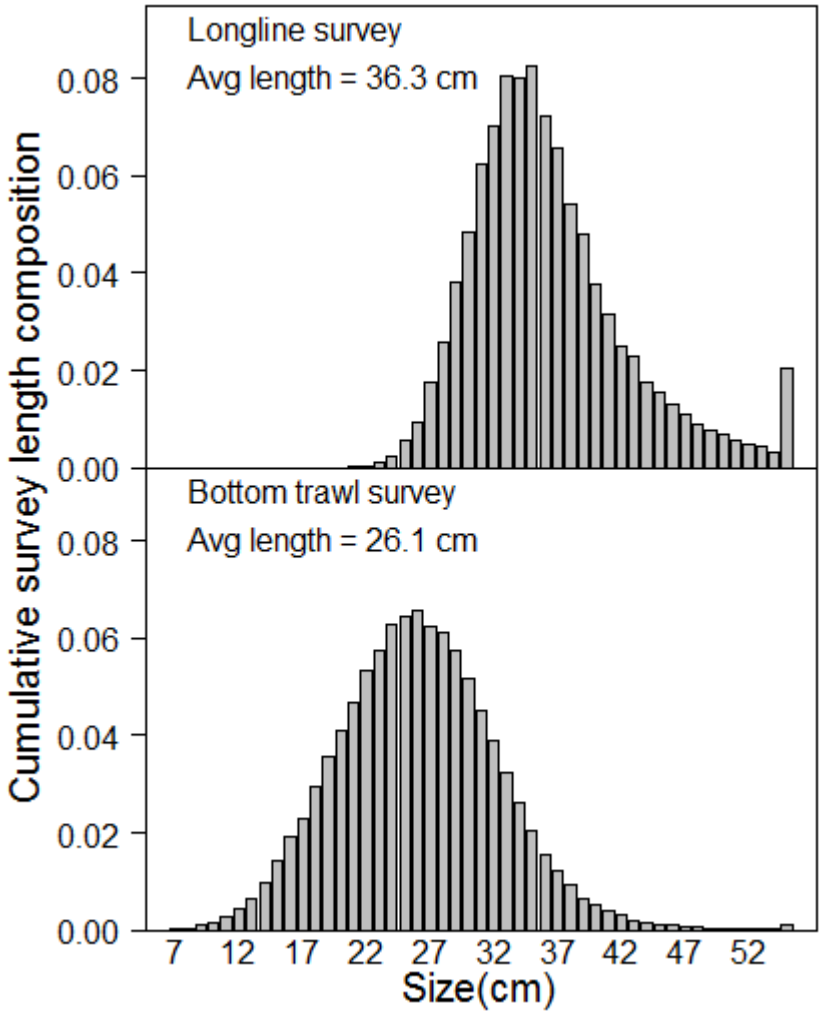
- In general, simple method to incorporate longline index to random effects model
  - Provides method to incorporate more sources of information to assessment (in particular, setting OFL/ABC and apportionment)

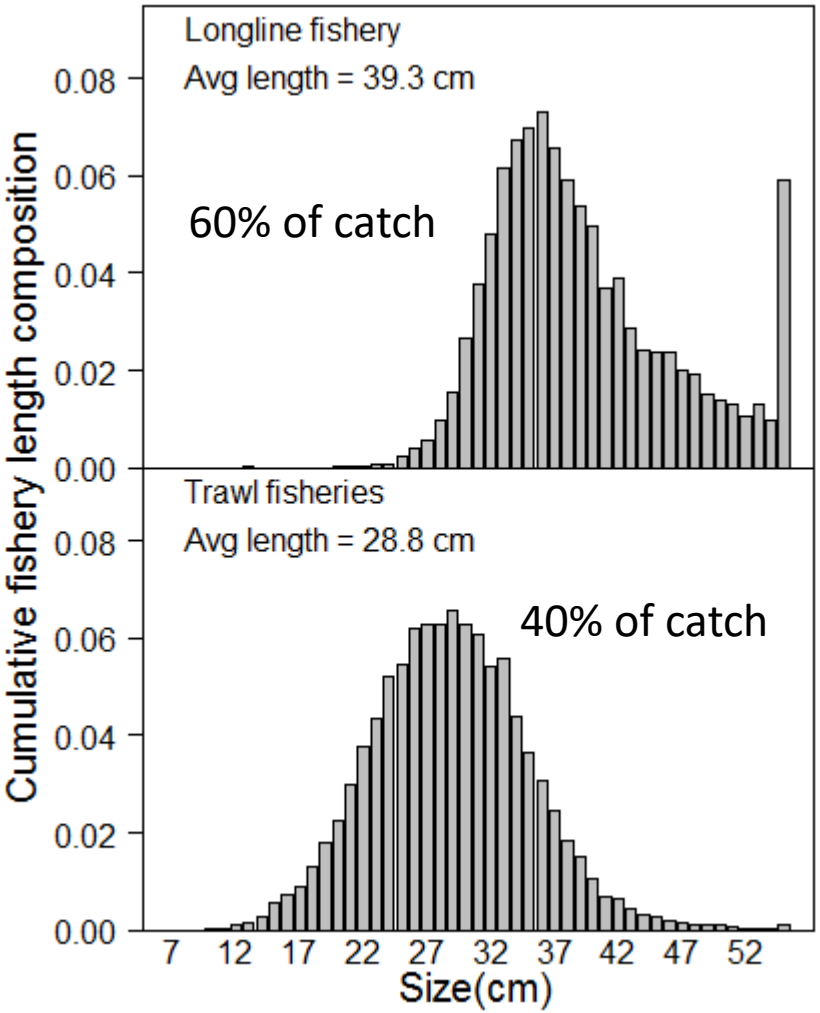
- For SST, main result is a further smoothing of biomass time-series
  - Reduces ‘over-fit’ to trawl survey
  - Results in more stable apportionment
  - Exposes data differences (maybe not conflicts) between indices

- Still some remaining issues/questions
  - Not necessarily deal-breakers for implementation of this method

Remaining issues/questions

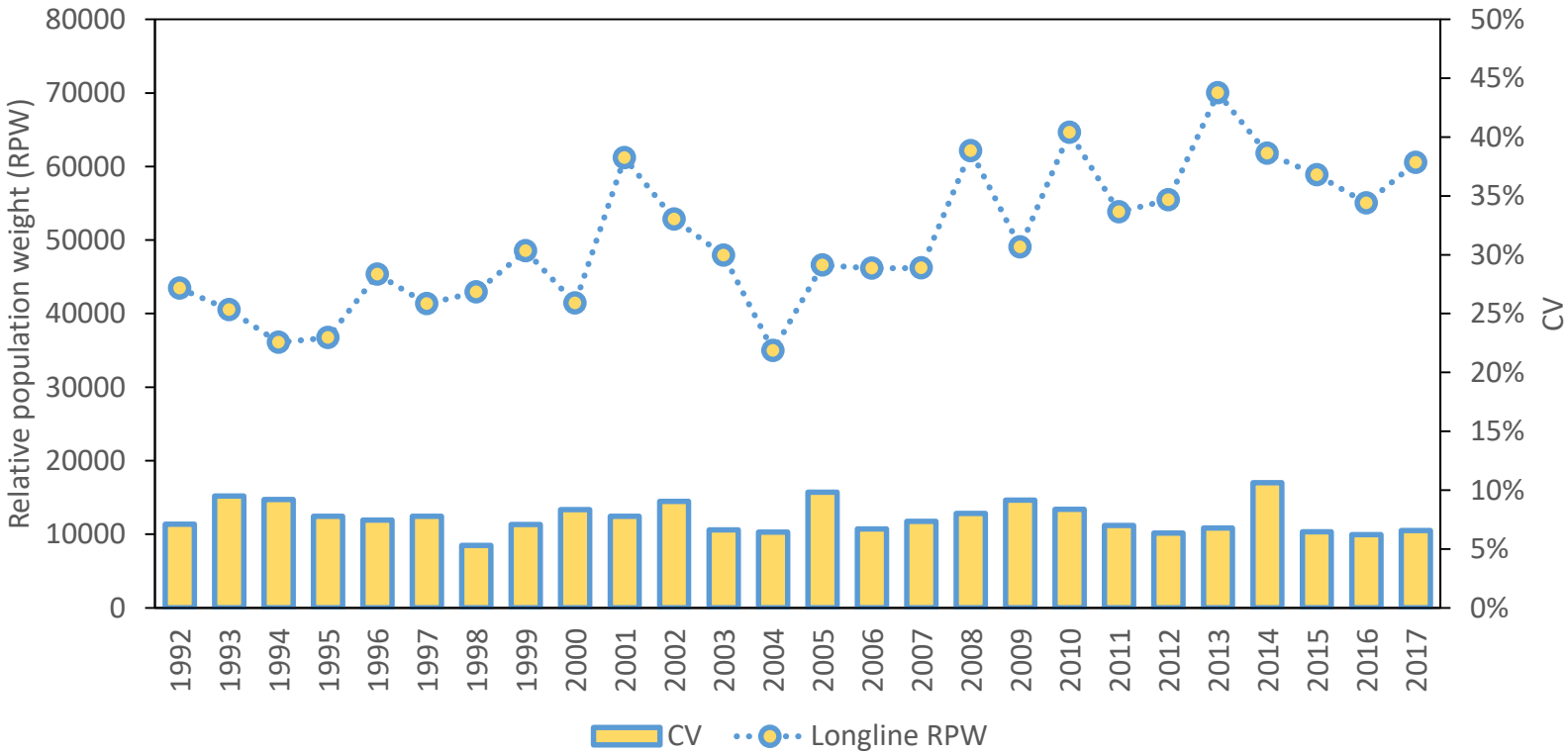
- What about differing selectivities?
  - Trawl/longline sampling different portions of the pop'n, is this a big deal? What can we do about it in Tier 5 setting?





Remaining issues/questions

- What about annual vs bi-annual surveys?
  - More logistical, but will have RPWs available for longline survey each year
  - As example, for this November, do we update w/ 2018 survey? Do we update again next year?



Questions?