Quantifying Uncertainty Between and Among Assessments for Use in Setting Acceptable Biological Catch

SEFSC

GMFMC SSC Meeting

January 2023

Council Request

"The SSC requests that the SEFSC develop the σ_{min} using the Ralston et al. 2011 method for Gulf Tier 1 (data-rich) stocks. This analysis should also consult the recent update to the Ralston approach by Privitera-Johnson and Punt (2020), which suggests using probability-based harvest control rules to incorporate scientific uncertainty and risk tolerance when setting catch limits by scaling buffers between catch limits with scientific uncertainty."

Work to date

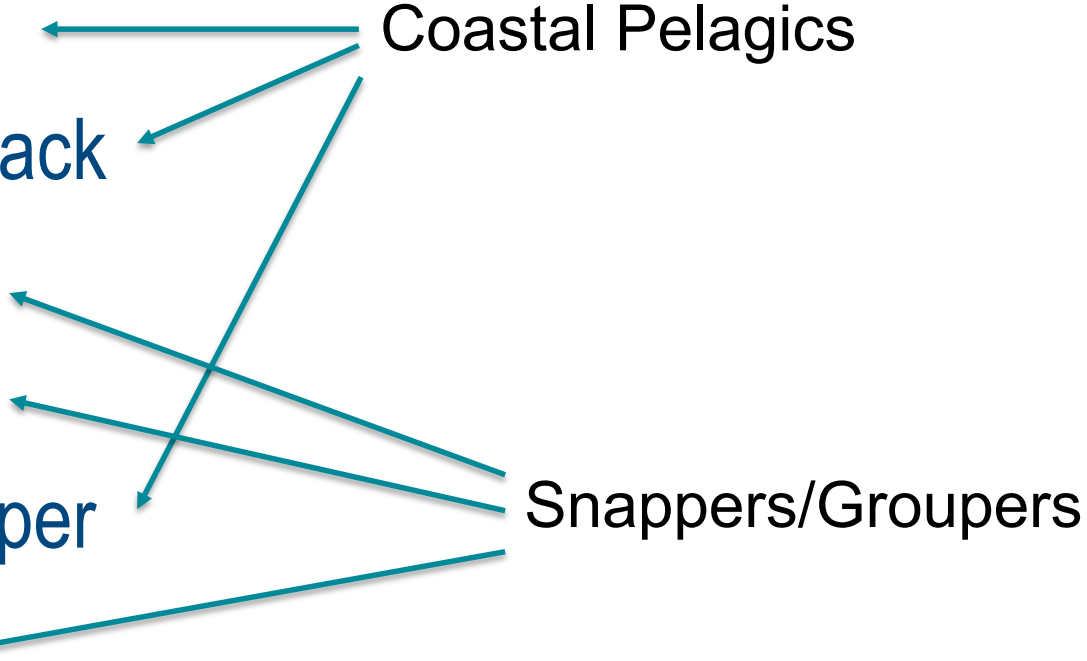
- Started with SS Models
  - Other models still need to be mined for data
- Issues with units for SSB
  - Metric tons
  - Fecundity (eggs)
    - Need to convert to weight in order to have an apples:apples comparison for the PJ-Punt method
  - Eggs per recruit
- Still considering how to incorporate assessments with structural changes (total vs female only SSB, etc.)

Methods used

- The SSC is familiar with the Restrepo et al. (1998) suggestion of 75% F_{msy} (or its proxy) to set the ABC. The SEFSC frequently provides these values in our projections.
- We started with the Ralston et al. (2011) analysis, and are in consultation with Kristin Privitera-Johnson for the projection-based estimates.
- The Center's workload prohibited more progress on this project at this time, but we will continue work and present the upcoming results at a future SSC meeting.

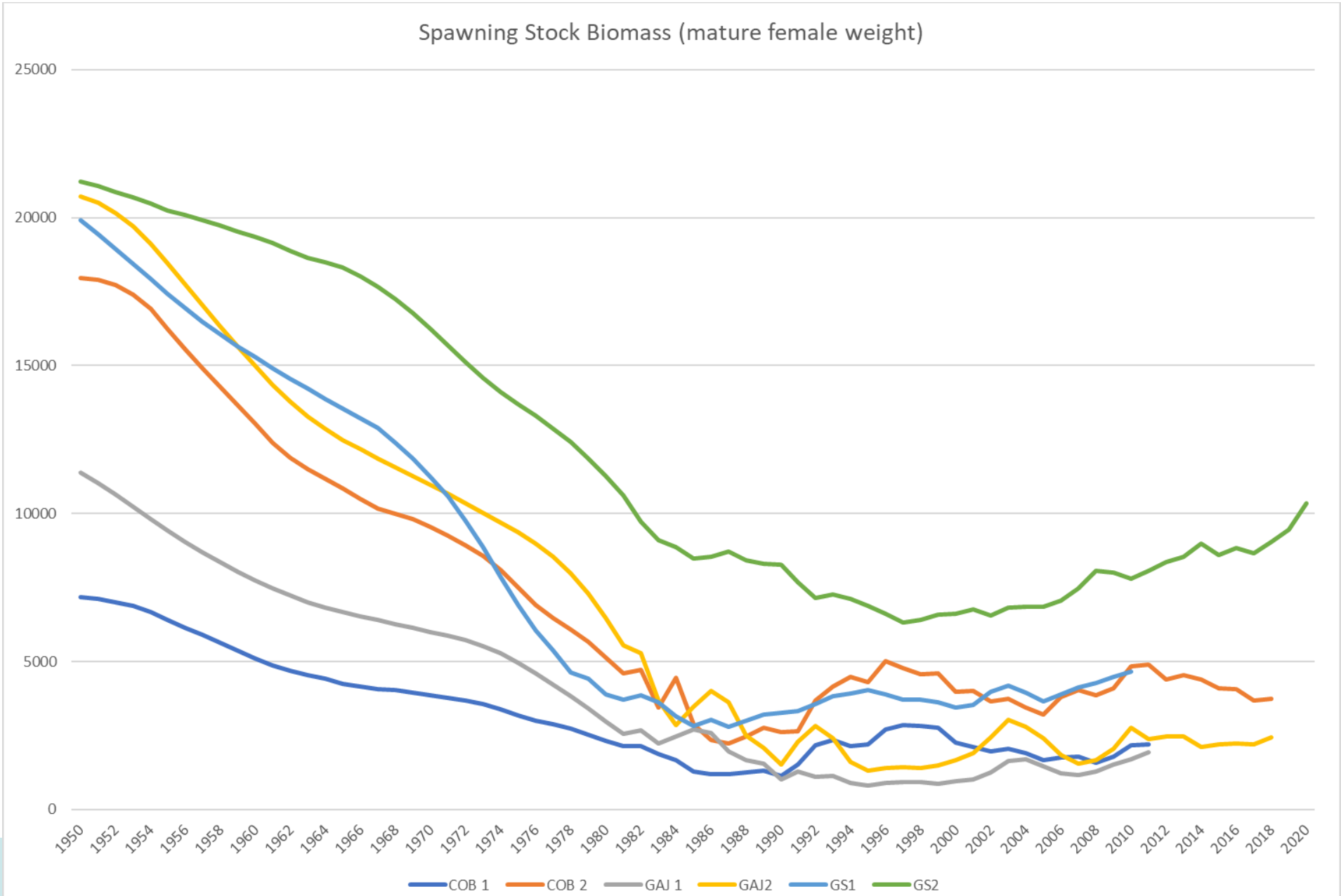
SS Assessments used

- Cobia
- Greater Amberjack
- Gray Snapper
- Red Grouper
- Vermilion Snapper
- Red Snapper

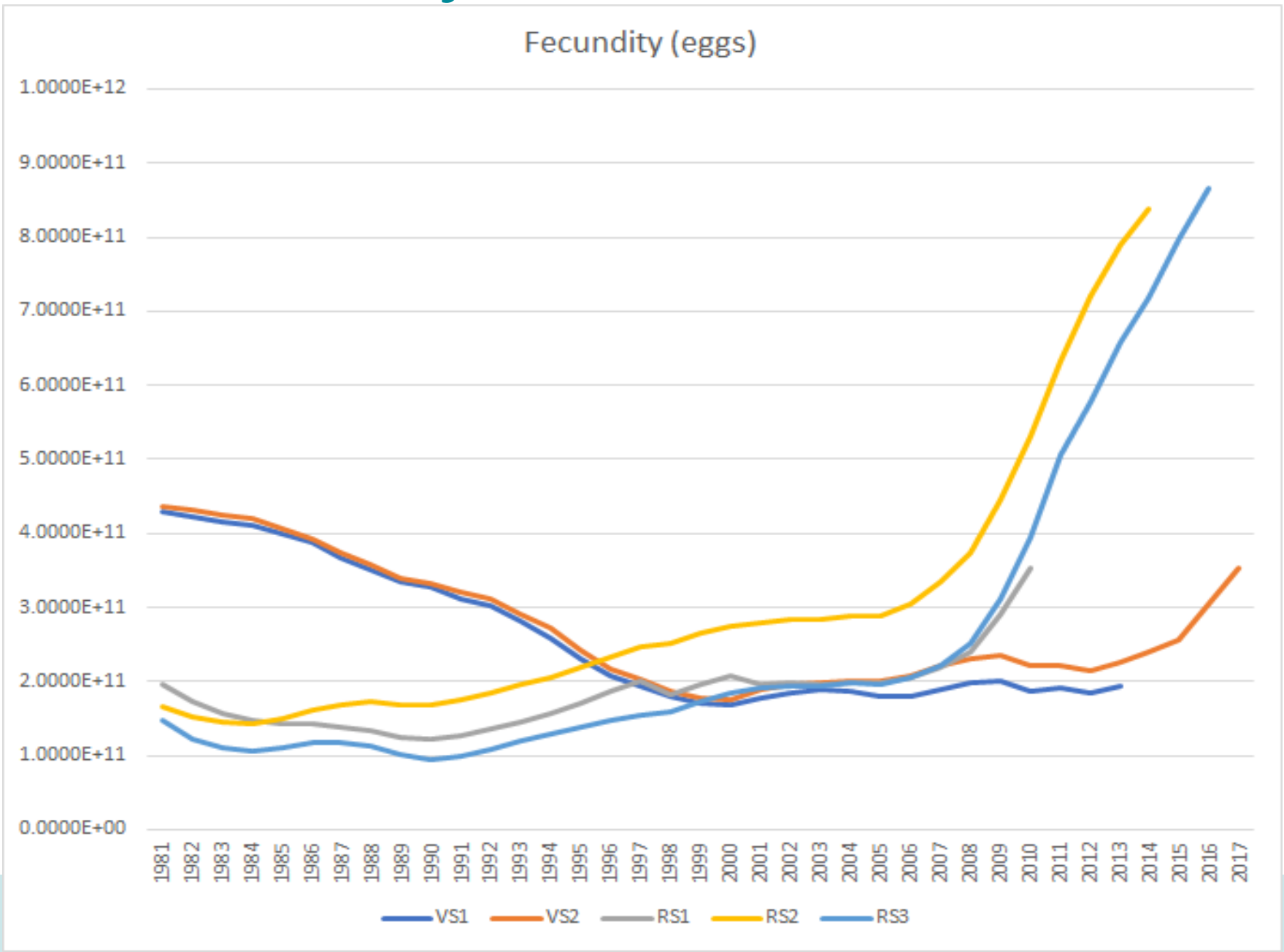


  - 7 species and 13 assessments
  - 3 species measured SSB in weight, 1 in eggs per recruit, and 2 in eggs.

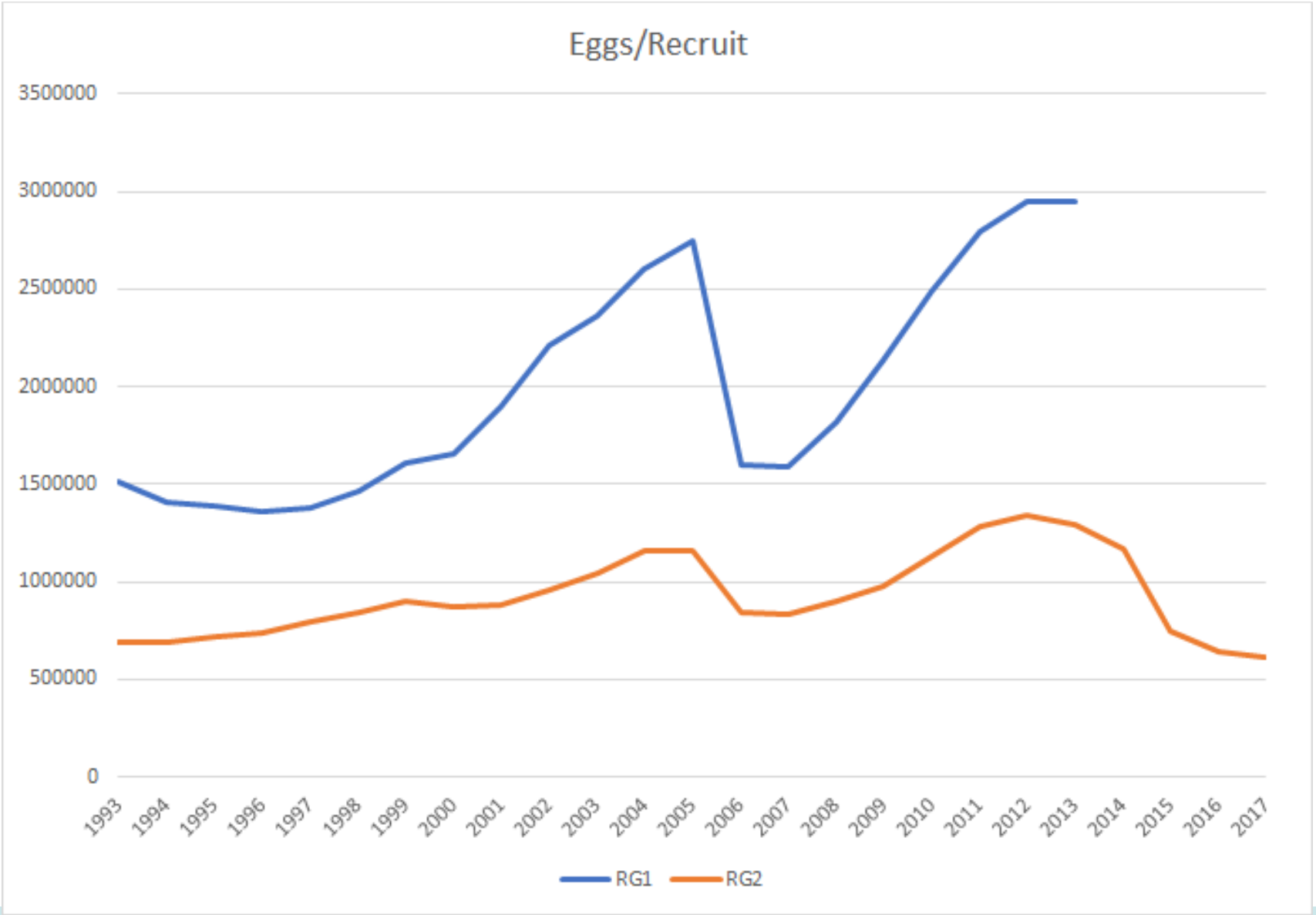
Historic SSB Estimates



Historic Fecundity Estimates

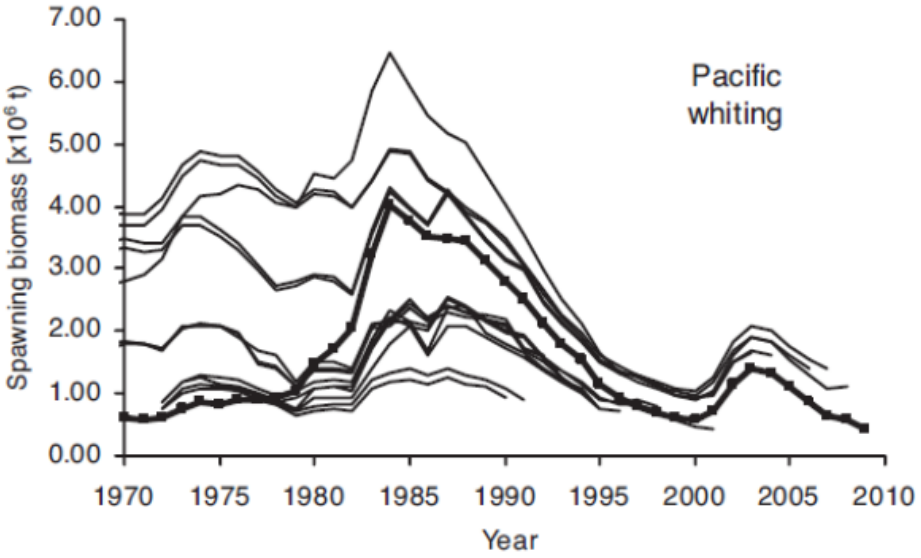


Historic Eggs/Recruit

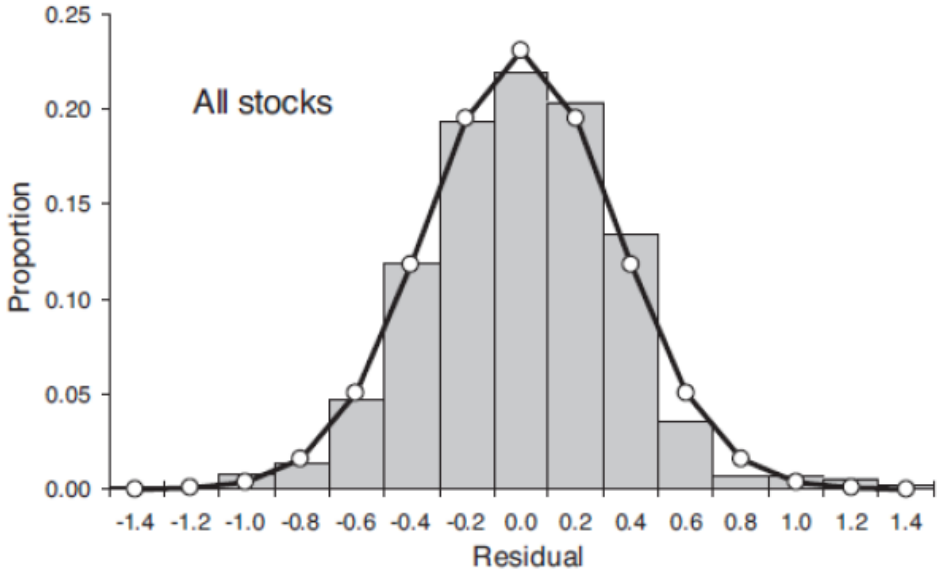


You've seen this before:

Ralston et. al 2011: Meta-Analysis of Assessment Uncertainty



Examined uncertainty by calculating log-scale deviations from mean biomass from all historical assessments (17 stocks).



Aggregate distribution of log-deviations pooled over all 17 stocks with the fit of a normal distribution shown as the line with symbols (s =0.36).

Ralston et al. 2011, Method 1

- For each estimate of biomass (*B*) for year *t* from assessments *i* and *j*, we calculated: $R_{i|j,t} = B_{i,t}/B_{j,t}$ i.e., the proportional deviation of assessment *i* using assessment *j* as a standard.
- Based on a symmetry argument, we also calculated $R_{j|i,t}$ and all the ratios were log transformed. Note that because $\ln(R_{i|j,t}) = -\ln(R_{j|i,t})$ the distributions were perfectly symmetrical.
- For each stock under consideration the standard deviation (σ*) of the ratios was calculated. This statistic is positively biased, however, because it is based on the ratio of two lognormal random variables ($B_{i,t}$ and $B_{j,t}$). The appropriate bias correction term ($\sqrt{2}$) was derived and applied so that the corrected estimator is $\sigma = \sigma^*/\sqrt{2}$

Ralston et al. 2011, Method 2

- The mean of biomass estimates in a year is treated as the best estimate of central tendency.
- In this approach, variation in biomass was measured as squared deviations from the annual mean in log space. Specifically, we calculated the mean log-biomass in year t as: $\overline{\ln[B_t]} = \frac{1}{n_t}\sum_i \ln[B_{i,t}]$

  where n_t is the number of available assessments in year t ($n_t \geq 2$). The standard deviation is then calculated as follows: $\sigma = \sqrt{\frac{1}{\sum_t n_t - 1}\sum_t \sum_i (\ln[B_{i,t}] - \overline{\ln[B_t]})^2}$

Method 3 – only used for Red Snapper

- The most recent stock assessment is considered the best estimate of central tendency. This approach is the same as the second, except that the mean ($\overline{\ln[B_t]}$) is replaced by the logarithms of the biomass estimates from the most recent stock assessment.
- With this approach, the most current information is assumed to represent the best estimate of the population mean.
- For lognormally distributed random variables. the CV on the arithmetic scale is equal to: $CV = \sqrt{\exp(\sigma^2) - 1}$

Between assessment uncertainty

- Following Ralston et al. (2011), we considered two methods of pooling stock-specific uncertainty:
  1) take the average of the stock-specific uncertainty, and
  2) aggregate all the residuals and calculate the standard deviation of the pooled set.
- The first method gives each species equal weight and does not overemphasize stocks that have been assessed more.
- Conversely, the second method treats each data point as an independent observation. Neither approach is ideal given the lack of independence in the data.

Among and Between Assessment Uncertainty

- Method 1 provides σ
- Method 2 and 3 are provided as a CV due to the weight vs. fecundity issue
- Two estimates are provided where possible
  - 1981 on, to reflect when the MRIP data started
  - 1993 on, to reflect when the rest of the data are commonly available (e.g. discards, etc.)

	Method 1 (1981 -)	Method 1 (1993 -)	Method 2 (1981 -)	Method 2 (1993 -)	Method 3 (1981 -)	Method 3 (1993 -)
Cobia	0.69	0.67	0.47	0.45		
Greater Amberjack	0.47	0.46	0.33	0.32		
Gray Snapper	0.71	0.66	0.48	0.45		
Red Grouper		0.72		0.49		
Vermilion Snapper	0.07	0.09	0.05	0.06		
Red Snapper	0.24	0.26	0.22	0.23	0.26	0.30
Totals	0.44	0.48	0.31	0.33		
Coastal pelagics	0.41	0.41	0.28	0.28		
Snappers/Groupers	0.47	0.55	0.35	0.39		

Between Assessment Uncertainty

- Estimates using pooled residuals to calculate a CV (weight only):
  - 1981 on – 0.41
  - 1993 on – 0.39

Privitera-Johnson and Punt (PJ and P, 2020)

- Updated Ralston analysis shows a σ value of 0.403 (compared to 0.36).
- We anticipate the PJ and P approach will account for more uncertainty that the historical biomass approach.
- The PJ and P approach will require more work due to the detailed data required for the analysis.
  - We may need to slightly modify the approach due to our region's use of allocations in the projections.
  - Some of our SS report files do not contain some necessary information, so we will have to revisit the assessment.

Future work

- Complete data mining exercise.
- Carry out the Privitera-Johnson and Punt projection-based method.