



## Overview: Stock Synthesis

- Stock Synthesis (SS) is an integrated statistical catch-at-age model.
- Uses relatively unprocessed input data and incorporates many of the important processes (mortality, selectivity, growth, etc.) in conjunction with observed catch, size and age composition and CPUE indices.
- Since many of these inputs are correlated, the rationale behind SS is that they should be modeled together to ensure that uncertainties in the input data are properly accounted for in the assessment.



## Base Model Configuration

- Initial set up of Stock Synthesis based off of the configuration of the last assessment model for red snapper, CATCHEM.
- Done to replicate model results and ensure both modeling platforms produce the same results under the same conditions.
- Throughout assessment process, various model configurations explored with SS which included incorporating length data and age-length keys (age conditional on length), however length-based models revealed systematic biases in AAL fits that could not be resolved.



## Fleets

1. Handline East (1872 – 2011)
2. Handline West (1880 – 2011)
3. Longline East (1980 – 2011)
4. Longline West (1980 – 2011)
5. MRFSS/MRIP East (1950 – 2011)
6. MRFSS/MRIP West (1950 – 2011)
7. Headboat East (1950 – 2011)
8. Headboat West (1950 – 2011)
9. Shrimp Bycatch East (1950– 2011)
10. Shrimp Bycatch West (1946 – 2011)
11. Commercial Closed Season East (1991 – 2006)
12. Commercial Closed Season West (1991 – 2006)
13. Recreational Closed Season East (1997 – 2011)
14. Recreational Closed Season West (1997 – 2011)



## Indices of Abundance: Fishery Dependent

1. HL index East (retained catch) (1990 – 2006)
2. HL index West (retained catch) (1990 – 2006)
3. MRFSS/MRIP East (total catch) (1981 – 2011)
4. MRFSS/MRIP West (total catch) (1981 – 2011)
5. Headboat East (total catch) (1986 – 2011)
6. Headboat West (total catch) (1986 – 2011)
7. Shrimp Effort East (F) (1950 – 2011)
8. Shrimp Effort West (F) (1950 – 2011)



## Indices of Abundance: Fishery Independent

1. SEAMAP Video East (1993 – 2011)
2. SEAMAP Video West (1993 – 2011)
3. SEAMAP Plankton East (1987 – 2010)
4. SEAMAP Plankton West (1986 – 2010)
5. SEAMAP Summer Groundfish Trawl West (1982 – 2011)
6. SEAMAP Fall Groundfish Trawl West (1972 – 2011)
7. SEAMAP Summer Groundfish Trawl w/ DISL East (1982 – 2011)
8. SEAMAP Fall Groundfish Trawl w/ DISL East (1972 – 2011)
9. NMFS bottom longline w/ supplemental sampling East (1996 – 2011)
10. NMFS bottom longline w/ supplemental sampling West (1996 – 2011)



## Age Composition

1. Handline East (1991 – 2011)
2. Handline West (1991 – 2011)
3. Longline East (1991 – 2011)
4. Longline West (1993, 1998– 2011)
5. MRFSS/MRIP East (1991 – 2011)
6. MRFSS/MRIP West (1992 – 2011)
7. Headboat East (1992 – 2011)
8. Headboat West (1992 – 2011)
9. Shrimp Bycatch East (1992– 2011)
10. Shrimp Bycatch West (1992– 2011)
11. Summer Trawl East (1987 – 2011)
12. Summer Trawl West (1987 – 2011)
13. Fall Trawl East (1987 – 2011)
14. Fall Trawl West (1987 – 2011)
15. NMFS Bottom LL w/ supplemental sampling East (1999 – 2011)
16. NMFS Bottom LL w/ supplemental sampling West (2000 – 2011)



## Base Model Configuration

- Age structured model: ages 0 to 20+
- Ageing error not included because Panel felt it did not fully represent the true age estimation error (which is probably time varying and fleet specific).
- Age composition data were weighted by the number of fish observed with sample sizes capped at 200 fish.
- Two area model: east and west of Mississippi River
- Time series starts in 1872 when stock assumed to be virgin; time series ends 2011
- weight-length relationship, the maturity schedule, fecundity estimates, natural mortality vector, and growth all incorporated into the model as fixed parameters.



## Base Model Configuration

- Age-based selectivity specified for each age (0 to 20) using a random walk where the age-specific selectivity parameters represent the rate of change from the selectivity value for the previous age
  - For some of the age classes within a given fleet or survey, selectivity was set equal to selectivity for the previous age by fixing the rate of change equal to zero.
- NMFS bottom longline survey only fleet that did NOT use random walk – estimated using a two parameter logistic function
  - selectivity pattern for the NMFS bottom longline survey in the east was mirrored off of that in the west due to low sample sizes



# Base Model Configuration

- Several time varying processes explored:
  - Selectivity and Catchability – to account for change from J to circle hooks
  - Discard mortality – to account for changes in venting practices
  - Retention – to account for change in size limits

| Run  | Neg Log Like | N Parm | N Data | AIC      | AICc     | Delta AICc |
|--|--------------|--------|--------|----------|----------|------------|
| Time-varying Discard                               | 4883.68      | 1026   | 7914   | 11819.36 | 12125.36 | 787.77     |
| Time-varying Discard and Selectivity               | 4391.03      | 1100   | 7914   | 10982.06 | 11337.59 | 0.00       |
| Time-varying Discard and Catchability              | 4874.84      | 1034   | 7914   | 11817.68 | 12128.83 | 791.24     |
| Time-varying Discard, Selectivity and Catchability | 4383.28      | 1108   | 7914   | 10982.56 | 11343.70 | 6.11       |



## Base Model Configuration

- Final base model contains time-varying discard mortality, time-varying retention, and time-varying selectivity
  - An external study (SEDAR 31-AW-4) supports the fact that the change to circle hooks manifested as change in selectivity, not catchability
- Retention function specified as a four parameter logistic function. Parameters fixed to represent knife-edged retention at minimum size limit, except for fleets and time periods where discard age composition data were available, and the inflection point and asymptote were estimated (commercial handline east and west and long line east for 2007-2011, and headboat east for 2000-2011).



## Base Model Configuration

- Although two areas represented in SS, only one stock recruitment relationship estimated.
- Annually estimated recruits allocated to each area based on formula:

$$\text{rate}_i = e^{p_i} / \sum_{j=1}^N e^{p_j}$$

- Distribution of recruits to each are time-varying according to a white noise model from 1972 to 2011 (annual deviations around the baseline parameter value)



## Base Model Configuration

- Consistent with previous assessments, model tended to estimate values for steepness around 1.0 – panel decided to fix steepness near 0.99.
- Parameter controlling recruitment at virgin levels ( $R_0$ ) estimated as time-varying process to account for possible change in stock productivity over time.
  - Estimated recruitment in early data poor part of time series consistently lower than from later data rich period
  - Done via a multiplicative adjustment to the  $R_0$  parameter



## Base Model Configuration

- R-sigma parameter: penalizes deviations from the spawner-recruitment curve and it defines the offset between the arithmetic mean and the expected geometric mean
- R-sigma fixed at 0.3 because with the incorporation of time varying  $R_0$ , setting R-sigma at higher values (i.e. 0.6) leads to biologically implausible results because the model would be allowed too much flexibility in estimating recruitment.
- Stock Synthesis is hard-coded to model recruits as age 0 fish
- Annual deviations from the stock-recruit function are estimated in SS as a vector forced to sum to zero



## Base Model Configuration

- Stock Synthesis assumes a lognormal error structure for recruitment, therefore expected recruitments were bias adjusted.
- Full bias adjustment was only applied to data-rich years when age composition data are available (1990) and is linearly phased in from no bias adjustment prior to 1972.
- Prior to 1985, recruitment is estimated as a function of spawning stock biomass based on the stock-recruit parameters. This is done so SS will apply the full bias-correction only to those recruitment deviations that have enough data to inform the model about the full range of recruitment variability.
- Bias adjustment was phased out over the last two years (2010-2011), decreasing from full bias adjustment to no bias adjustment, because the age composition data contains little information on younger year classes for those years.



# Base Model Configuration

- All parameters have uninformative uniform priors, except for selectivity parameters.
- Selectivity parameters have normal priors to constrain random walk