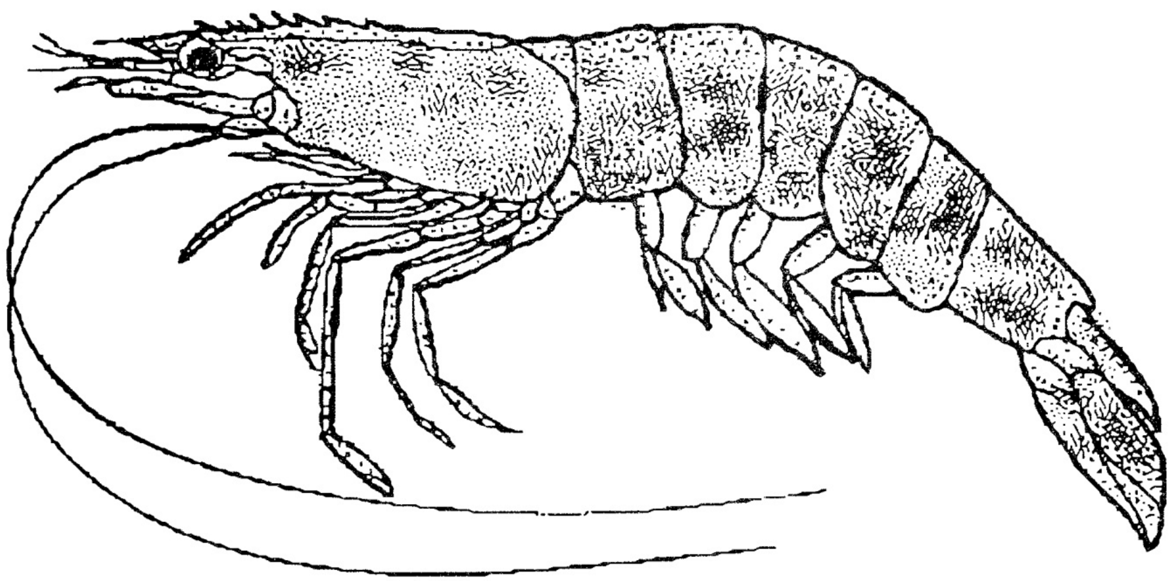
Tab D, No. 4(b)

Stock Assessment Update for Brown Shrimp (*Farfantepenaeus aztecus*) in the U.S. Gulf of Mexico for the 2017 Fishing Year



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1. ABSTRACT

This report documents a stock assessment update for the Gulf of Mexico brown shrimp (*Farfantepenaeus aztecus*) for the 1984-2017 time series. In this model fits to the CPUE estimates, size selectivity, spawning biomass, numbers of recruits, and fishing mortality estimates (F) were generated. In addition, the incorporation of direct fishery independent surveys (SEAMAP and Louisiana State Shrimp Surveys) of shrimp abundance into the model greatly improves the precision (i.e., tuning) of this assessment update.

Amendment 15 of the Gulf of Mexico Fisheries Management Plan (FMP) (GMFMC 2015) set new overfishing and overfished levels generated from the bench mark stock assessment. The criteria are based on SSBmsy and Fmsy and are 6.1 million pounds of tails and 9.12 per year respectively. Upon completion of the annual shrimp stock assessments the SSB and F values are compared to these management criteria.

The Stock Synthesis based shrimp stock assessment model generates fishing mortality (F) values, spawning stock biomass SSB outputs in terms of pounds of spawning biomass, and numbers of recruits. Fishing mortality was estimated to be 1.93. Spawning biomass and recruitment at the end of the 2017 fishing season were 26.8 million pounds and 27.8 billion individuals respectively. Using these results, there is no evidence that the Gulf of Mexico brown shrimp stocks are overfished or undergoing overfishing.

2. INTRODUCTION

The Gulf of Mexico penaeid shrimp stock synthesis based stock assessments have been vetted and reviewed by the Gulf of Mexico Fishery Management Council (GMFMC) Scientific and Statistical Committee (SSC) and Special Shrimp SSC since their inception in 2009. More recently, the assessment's resulting reference points were reviewed by these SSCs during several workshops

The acceptance and subsequent adoption of Amendment 15 of the GOM Shrimp FMP defines the overfished and overfishing reference points for penaeid shrimp. To measure if the stock is overfished or undergoing overfishing the Stock Synthesis based stock assessment models estimate a MSY and corresponding SSB at MSY and F at MSY for the terminal year of the stock assessment model. If the assessment year SSB is greater than the index SSBmsy than the stock is not overfished. Conversely, if the assessment year SSB is less than the index SSBmsy than the stock is overfished. Similar to the overfished reference point, the overfishing reference point F is compared to the calculated annual Fmsy estimate derived by the assessment model. The brown shrimp model is parameterized as an annual model. Therefore the models forecast SSBmsy and Fmsy can be directly compared to the annual SSB and F estimates generated in the assessments.

This report describes a stock assessment update for brown shrimp (*Farfantepenaeus aztecus*). This modeling methodology uses a generalized stock assessment model, Stock Synthesis (SS-3) (Methot 2009), and is parameterized with fishery data from 1984-2017, incorporating non-time varying selectivity, an estimated steepness value, and non-time varying R_0.

As noted, Amendment 15 of the Gulf of Mexico Fisheries Management Plan (FMP) set new overfishing and overfished levels using criteria generated from the bench mark shrimp stock assessment. These new management criteria are based on SSBmsy and Fmsy and are 6.1 million pounds of tails and 9.12 per year respectively. This annual shrimp stock assessment generates estimates of SSB and F values which are compared to the aforementioned management criteria.

3. METHODS

3.1. Model Overview

This Stock Synthesis assessment update was parameterized as an annual model, with 12 seasons. This allowed for a better fit of the highly cyclical recruitment pattern evident in the commercial and survey data. In addition, this model was parameterized with such complexities as a density dependent flexible Q, static recruitment deviations, static R_0 (unfished recruitment) and estimated steepness in the Beverton-Holt spawner-recruit.

3.2. Data Sources

The model was parameterized with data from 1984 through 2017. Two years of "dummy" data were entered into the model before the actual 1984 data to allow for a burn in period. This burn in period facilitated the development of recruitment deviations or cycles which were initiated prior to the actual starting year data being called into the model.

The Stock Synthesis model was developed using the time period 1984-2017. The model structure included 2 fleets:

1) Commercial Offshore shrimp catch statistics (statistical zones 7-21)
2) Commercial Inshore shrimp catch statistics (statistical zones 7-21)

and 3 indices of abundance:

1) SEAMAP Summer Groundfish Trawls (Fisheries-independent; 1987-2017)
2) SEAMAP Fall Groundfish Trawls (Fisheries-independent; 1987- 2017)
3) Louisiana Monthly Shrimp Trawl Surveys (Fisheries-independent; Western Subset of surveys, 1984-2017)

3.2.1. Commercial Catch Statistics – The Stock Synthesis assessment model was parameterized with brown shrimp commercial catch data including; directed fishing effort by year and month, i.e., effort for those trips where >90 percent of the catch were brown shrimp, used to calculate monthly CPUE. In addition, the model included total catch and catch by size, i.e., size composition data consisting of count of numbers of shrimp per pound; for statistical zones 7-21 from January 1984 through December 2017. To calculate CPUE catch statistics the methods outlined in Nance et al. (2008) were used. Beginning with pilot studies in 1999, an electronic logbook program (ELB) was initiated to augment shrimp fishing effort measurements. Gallaway et al. (2003a, 2003b) provides an in depth description of this ELB data collection program and data collection procedures. These ELB data have been used to supplement the effort and location data collected by NMFS port agents and state trip tickets since 2006.

Total catch in pounds of shrimp tails by month was a primary input. Eleven count categories from 1984 to 2017 were used. Beginning in 1984 shrimp catch data for the smallest sized shrimp, >67 count, were recorded at a finer scale, thus allowing us to partition this size category into four additional count categories, therefore having finer resolution for the smallest sized shrimp in the catch. This resulted in a total of 11 count categories for the data collected from 1984 to present; <15, 15-20, 21-25, 26-30, 31-40, 41-50, 51-67, 68-80, 81-100,101-115, and >115 (Hart and Nance 2010). These data are entered into the model as monthly catch in pounds for each of the eleven size bins for the years 1984-2017.

3.2.2. Growth Curve and other Population Level Rates - The growth parameters k and linf, derived and reported by Parrack (1981), were used as initial parameter values. Data inputs included a growth curve for each gender; natural mortality rate (3.24) per year as previously used in the historical VPA (Nichols 1984); and conversion factors to go from total length to the poundage breaks between the catch count categories (Brunenmeister 1980). These data were entered into SS-3 as parameters.

3.2.3. Size Selectivity - A dome shaped (double normal) selectivity pattern with 4 estimated parameters was used in each of the models. This resulting pattern provided a good fit to the data as will be shown in the results. In these model setups selectivity was not time varying.

3.2.4. Catchability Q – Catchability was set as a density dependent parameter in the model.

3.2.5. Louisiana Monthly Shrimp Survey Data – Shrimp data collected by the State of Louisiana from 1984 – 2017 were included in the models. These data were collected and provided by staff of the Louisiana Department of Wildlife and Fisheries (LDWF) (Hart 2012).

3.2.6. SEAMAP Data – SEAMAP data collected by both NOAA Fisheries research vessels and State Fisheries agency vessels were used in the Stock Synthesis model. For a complete description of the SEAMAP data collection procedures see Appendix 2 in Hart (2012). These SEAMAP sampling data inputs were collected from statistical zones 7-21. Sampling index data using the delta log normal index from 1987-2017 were survey model inputs. Size compositions for brown shrimp collected and measured in 1987-2017 during summer and fall cruises were also model inputs.

3.3. Model Configuration and Population Dynamics

3.3.1. Selectivity, Natural Mortality, and F Configurations

For each commercial fishing fleet (i.e., in- and offshore) I used a double normal selectivity setup with the same selectivity's for all years. For a more detailed technical description of fishery selectivity, natural mortality M, and fishing mortality F settings used in Stock Synthesis, consult Methot and Wetzel (2013).

3.3.2. Time-Varying Parameters

For this model, time varying R_0 was not allowed. In addition, since recruitment is not continuous for brown shrimp as evidenced by the survey data, I allowed recruitment to occur during the months of February, April, June, July, and August. Catchability varied as a density dependent function.

4. RESULTS

4.1. Parameter Estimates, Model Setups, and Model Fits

Stock Synthesis requires the model to be initialized with approximations for certain parameters which are then estimated by the model in preset phases. These initial approximations scale the parameters to biologically reasonable values, and facilitate the evaluation of parameters estimated in subsequent phases.

4.2. CPUE

Catch rate fluctuations, both within and between years, were revealed with a close fit of expected to observed catch rates. Figure 4.2.1 illustrates the catch rate model fits for each fleet and also show how the density dependent Q setups perform in the model.

The increase in the commercial fishery CPUE during the later portion of the time period evident in the commercial fishing fleet is also visible in the CPUE indices measured in the fishery independent SEAMAP and Louisiana survey data. Model fits to the Louisiana survey data are shown in Figure 4.2.2.

4.3. Generalized Size Comps

The model fit to the size composition of the catch for the commercial in- and offshore fishing fleet is shown in figure 4.3.1. These results illustrate how the inshore fleet catches predominately smaller sized shrimp compared to the offshore fleet. Fits to the size composition catch data from the Louisiana survey are shown in figure 4.3.2. These data fits are similar to the commercial inshore fleet's catch of smaller sized shrimp.

4.4. Fishery Selectivity for the Commercial Fleet and Louisiana Surveys

Selectivity curves were developed for each of the commercial fishery fleets. These curves were fit to the seasonal harvest of smaller shrimp inshore and the larger shrimp harvested offshore (Figure 4.4.1). Size selectivity fits for the Louisiana survey are shown in figure 4.4.2, illustrating the higher selectivity for those smallest sized shrimp. These curves are shown with the SEAMAP selectivity fits to better illustrate the selectivity patterns exhibited by these two different surveys.

4.5. SEAMAP Selectivity, CPUE, and Size Composition

Selectivity fits for summer and fall SEAMAP data are shown alongside of the Louisiana survey data in figure 4.4.2. The summer and fall SEAMAP cruises reveal a recent increase in CPUE, similar to the commercial fishery (Figure 4.5.1). Figure 4.5.2 shows the model fit to the size composition data for 1987-2017 for summer and fall SEAMAP surveys. The use of these fisheries independent data, in concert with the Louisiana surveys, have provided added information on some of the trends which were evident in the commercial shrimp fishery, thus allowing us to better tune the model's recruitment parameters.

4.6. Fishing Mortality

Stock Synthesis outputs F values by age and year. The model is also parameterized with two fleets, an offshore and an inshore fleet. The annual fishing mortality rate for 2017 is estimated to equal 1.73 (Figure 4.6.1).

4.7. Steepness, Spawning Biomass, and Recruitment

The model estimated a steepness value of about 0.99. Spawning biomass and recruitment at the end of the 2017 fishing season were 26.8 million pounds and 27.8 billion individuals respectively (Figures 4.7.1 and 4.7.2).

5. CONCLUSIONS

The Stock Synthesis model developed provides outputs for new overfished and overfishing definitions for the Gulf of Mexico brown shrimp fishery. This assessment revealed the fishery is not overfished nor undergoing overfishing. Spawning biomass and recruitment have fluctuated, decreasing in recent years while fishing mortality (F) increased during the later portion of the time series. This decrease in spawning biomass, recruitment, and increase in F warrant careful consideration as if this pattern of declining stocks and increasing fishing pressure continues at the current rate overfishing may become evident in this fishery in the very near future.

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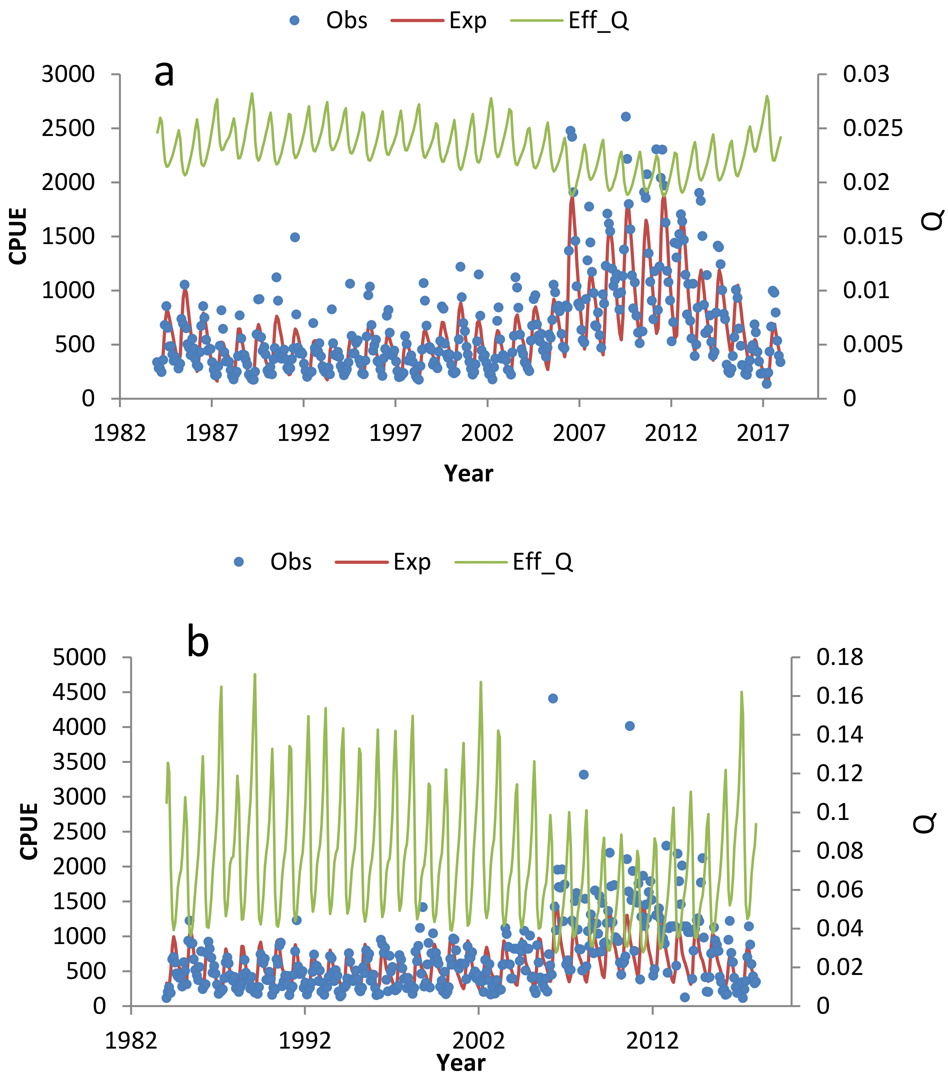


Figure 4.2.1. Brown shrimp CPUE and Q fits for Inshore and Offshore Fleets. Panel a is Inshore and panel b is Offshore.

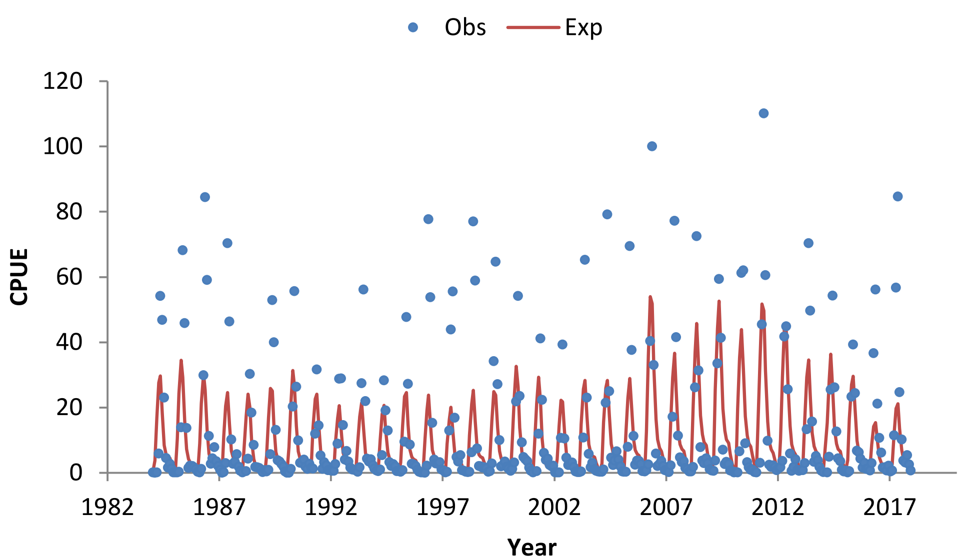


Figure 4.2.2 Brown shrimp Louisiana West Survey delta log normal CPUE fits.

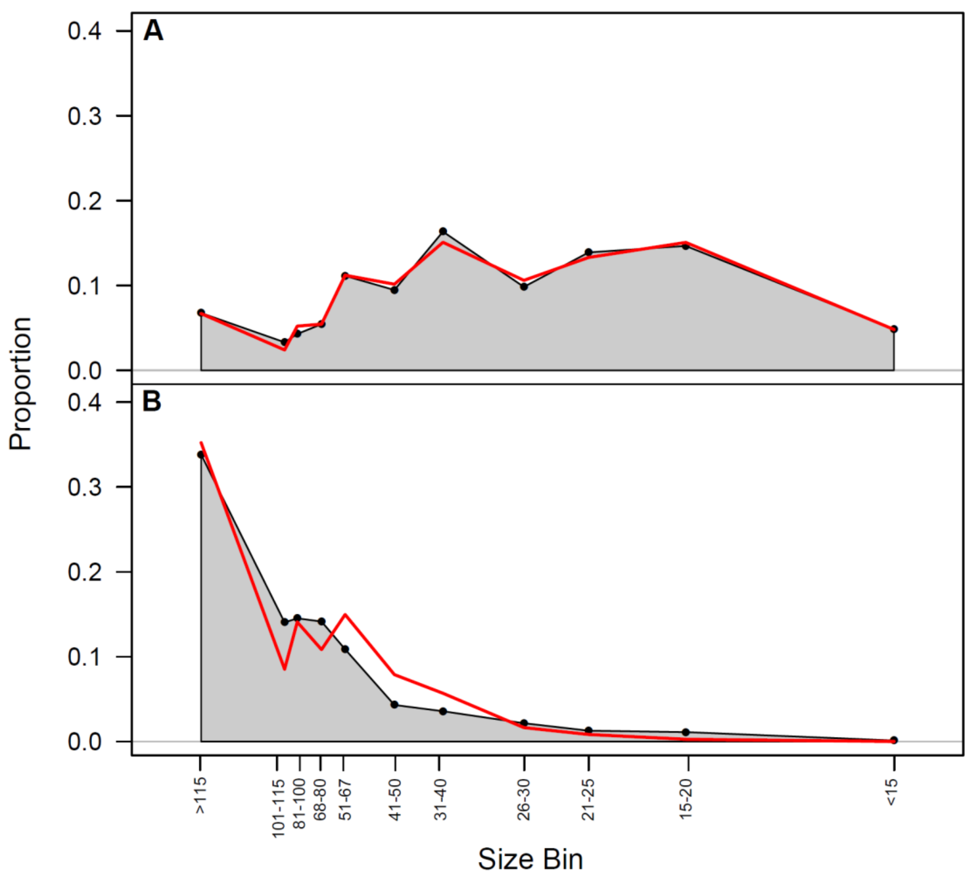


Figure 4.3.1. Brown shrimp size composition fits for Offshore and Inshore Fleets. Panel A is Offshore and panel B is Inshore.

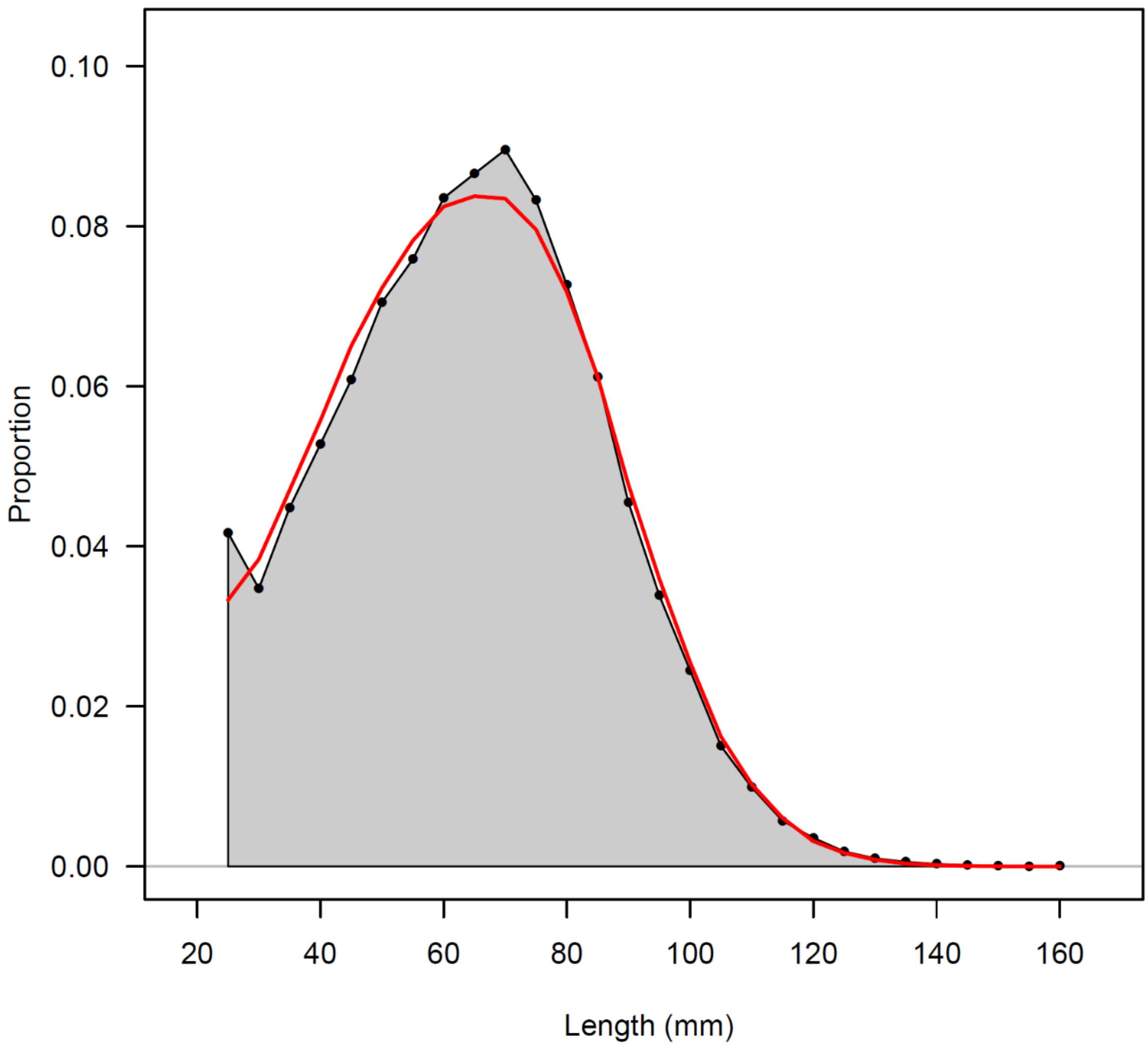


Figure 4.3.2 Brown shrimp size composition fits for Louisiana West Survey.

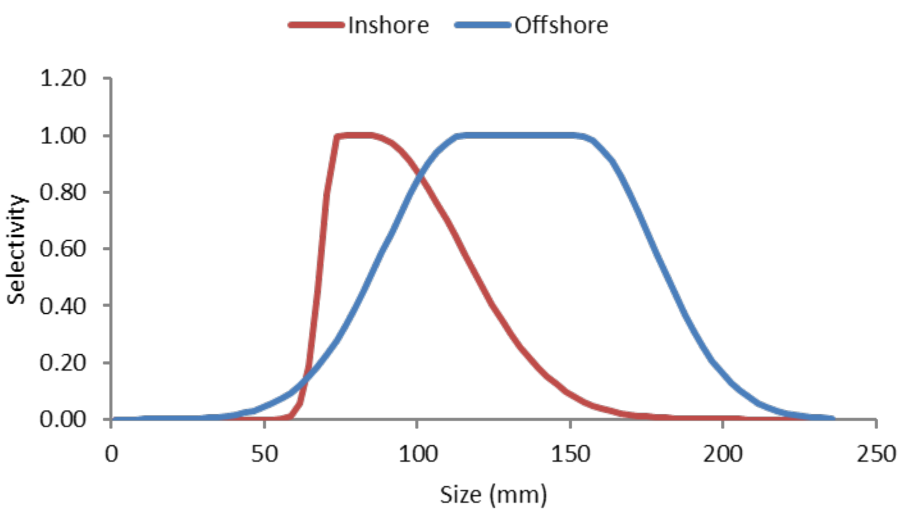


Figure 4.4.1. Brown shrimp commercial fishery size selectivity for the Inshore and Offshore fleets.

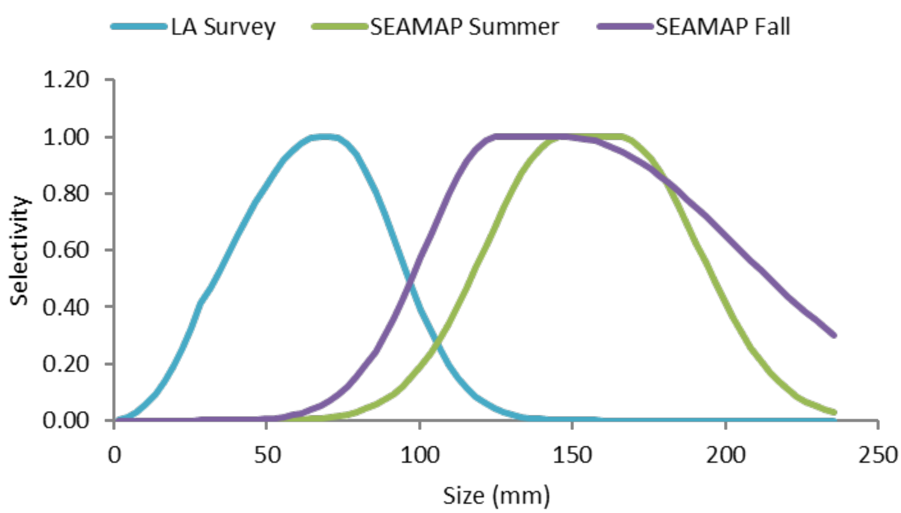
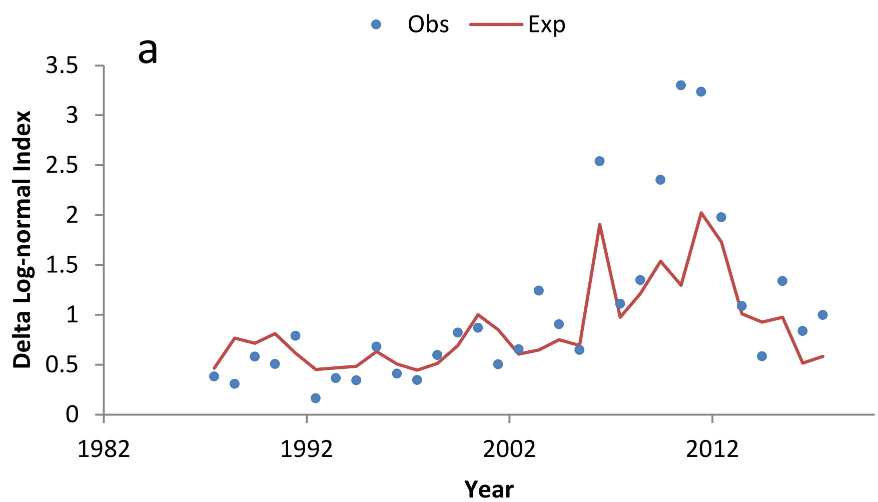


Figure 4.4.2. Brown shrimp size selectivity for Louisiana and SEAMAP surveys.



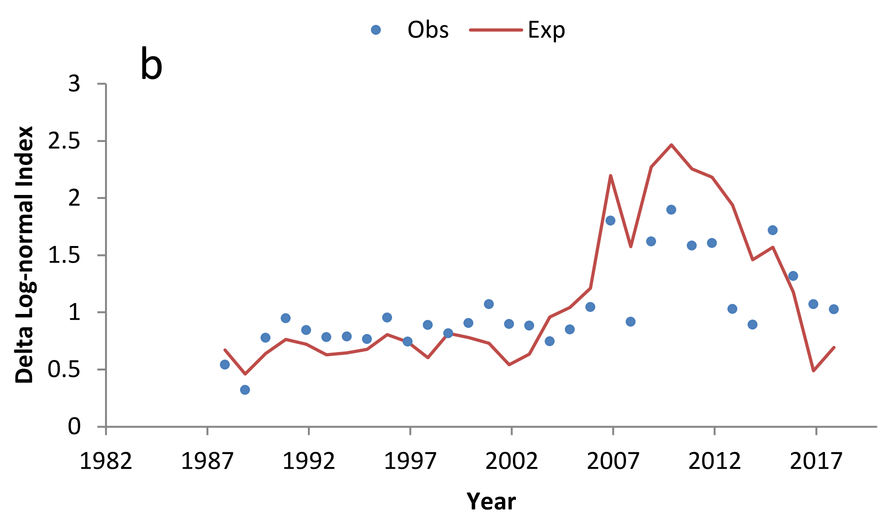


Figure 4.5.1 Brown shrimp SEAMAP Summer and Fall Survey Delta Lognormal fits. Panel a is Summer and panel b is Fall.

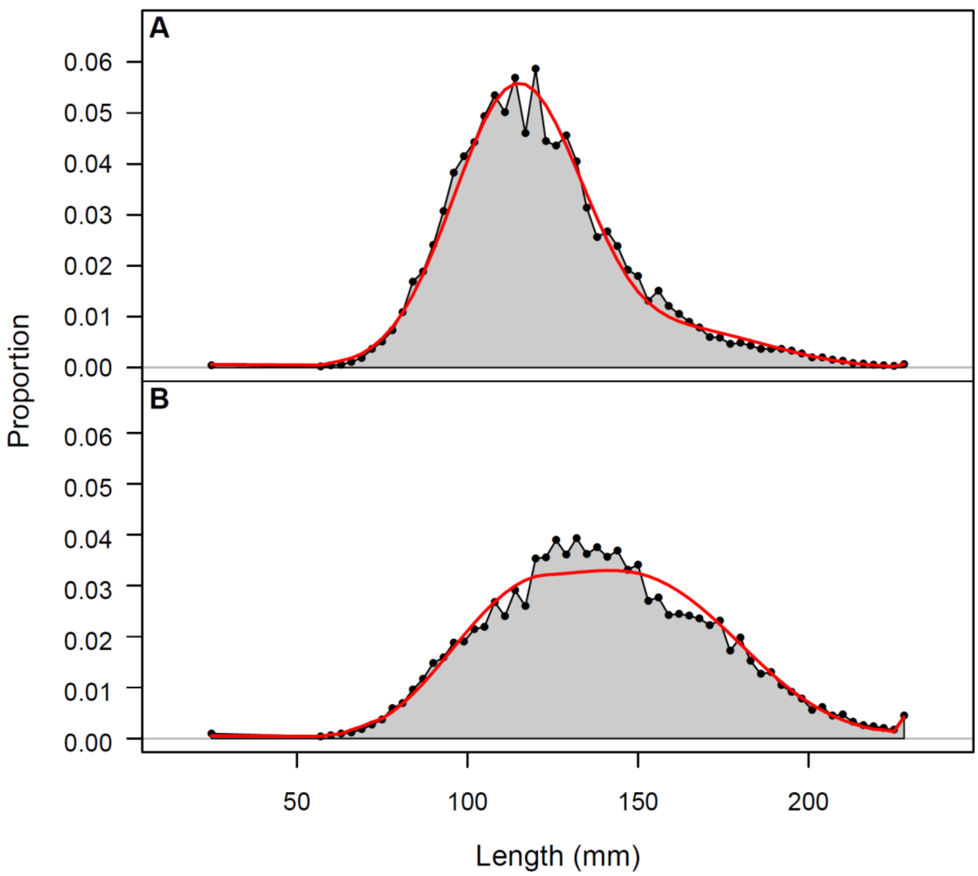


Figure 4.5.2. Brown shrimp size composition fits for the SEAMAP surveys. Panel a is Inshore and Panel b is Offshore survey fits.

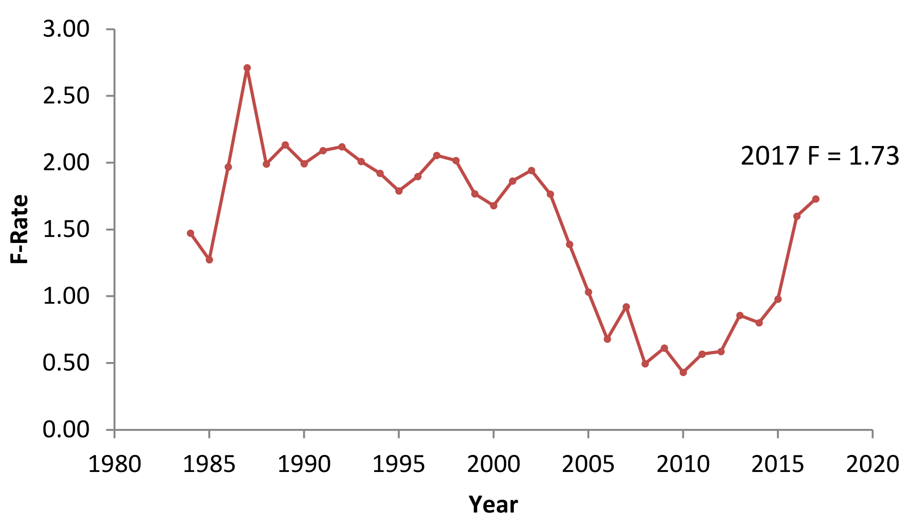


Figure 4.6.1. Brown shrimp annual F value.

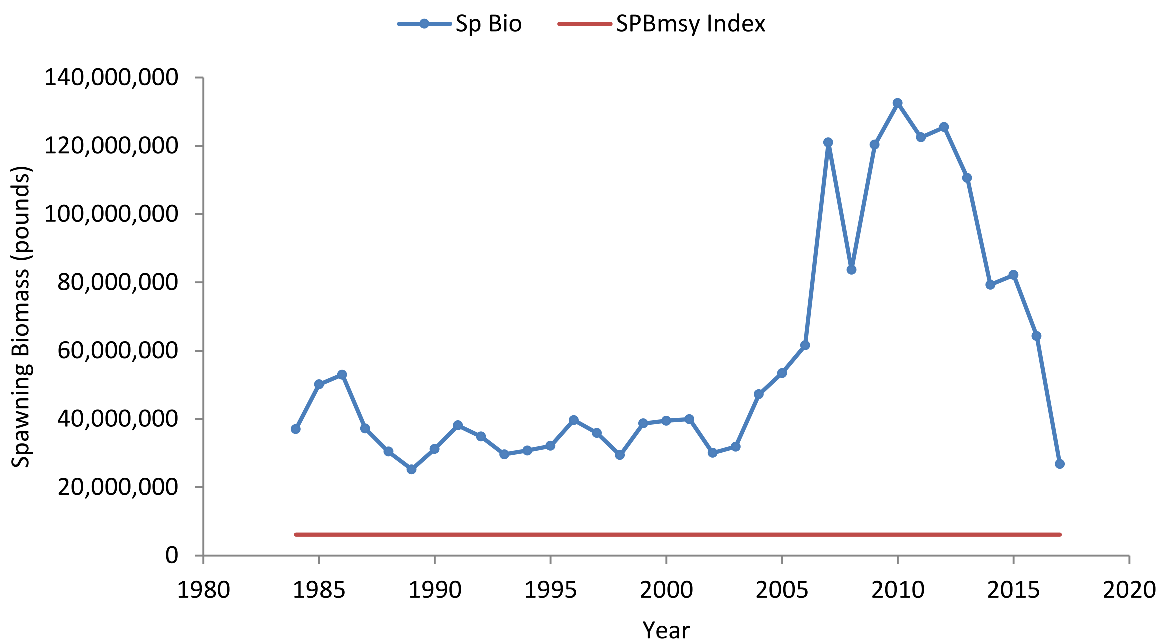


Figure 4.7.1. Brown shrimp spawning biomass estimates.

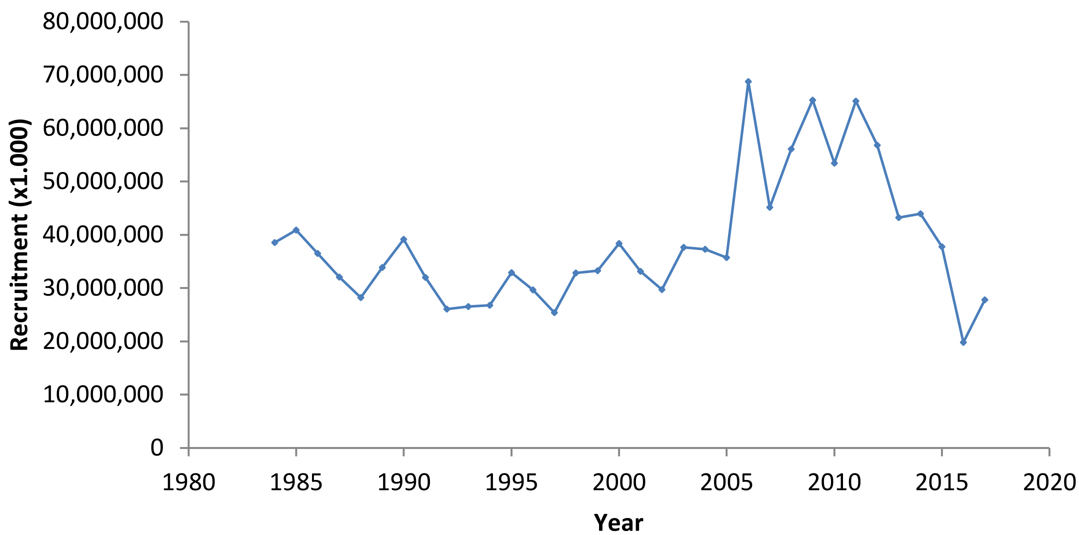


Figure 4.7.2. Brown shrimp recruitment model estimates.