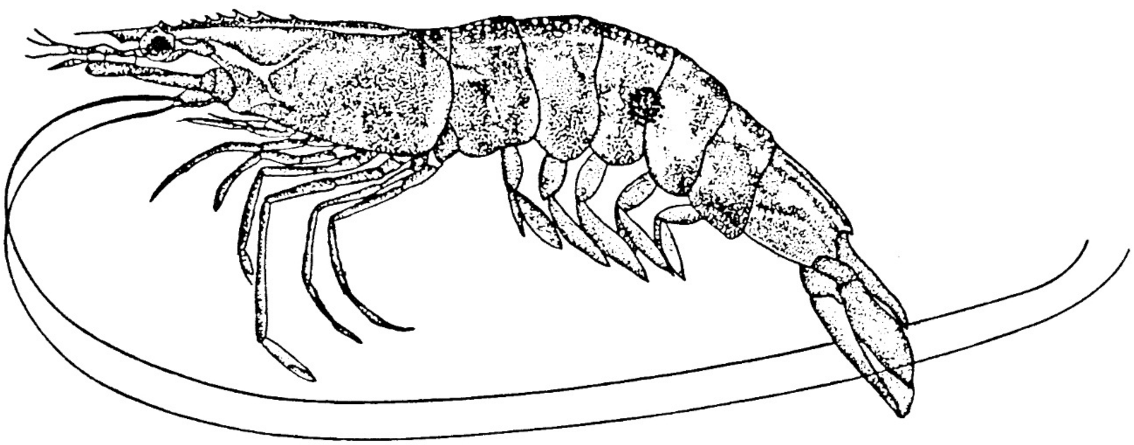
Tab D, No. 5(c)

Stock Assessment Update for Pink Shrimp (*Farfantepenaeus duorarum*) in the U.S. Gulf of Mexico for 2014



Rick A. Hart

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NOAA Fisheries
Southeast Fisheries Science Center
Galveston Laboratory
Galveston, TX 77551
Rick.Hart@noaa.gov

1. ABSTRACT

This assessment examined the pink shrimp (*Farfantepenaeus duorarum*) population behavior when parameterized with 31 years of commercial pink shrimp data from 1984 - 2014. In the model runs, CPUE estimates, size selectivity, spawning biomass, and numbers of recruits were generated. In addition, the incorporation of direct fishery independent surveys of shrimp abundance into the model greatly improves the precision (i.e., tuning) of this and future assessments.

Amendment 15 of the Gulf of Mexico Fisheries Management Plan (FMP) set new overfishing and overfished levels generated from the 2012 bench mark stock assessment. These criteria are based on SSBmsy and Fmsy and are 23.7 million pounds of tails and 1.34 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 update generates fishing mortality (F) values, spawning stock biomass outputs in terms of pounds of spawning biomass, and numbers of recruits. Fishing mortality has been decreasing in recent years, with the biological year 2013 F equaling 0.25. Biological year 2013 spawning biomass and recruitment were 55.4 million pounds and 5.55 billion individuals respectively.

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 have been reviewed by these SSCs during several workshops. During the March 10, 2014 GMFMC special shrimp SSC meeting the group was again presented with the benchmark brown, pink, and white shrimp stock assessments. The group discussed that MSY based reference points be developed for the shrimp stocks. They also recommended that a shrimp MSY workshop be held to develop MSY based reference points for inclusion in Shrimp Amendment 15 of the GMFMC Shrimp Fishery Management Plan (FMP).

A SSC webinar workshop was held on August 2014 to discuss the Gulf of Mexico (GOM) penaeid shrimp MSY and ABC control rule based benchmarks. The group was presented the most recent shrimp stock assessment and the calculation of MSY for these stocks. In addition the group "discussed that MSY needs to be in terms of what the annual harvest- essentially a sum of yields- and it should be calculated from the monthly inputs and the monthly Fs, rather than the summaries and apical Fs that are currently reported from the model."

The group also discussed the tasks and logistics of an in-person MSY workshop to determine MSY based reference points. The GMFMC SSC shrimp MSY workshop was held on October 7, 2014. During this workshop MSY based reference points were presented and accepted by the SSC. These reference points were then presented to members of the Special Shrimp SSC during their March 2015 meeting. Discussions regarding the MSY estimates and the MSY based reference points centered on the differences within reference points between stocks. As excerpted from the meeting minutes, "…it was explained that the exploitation rates, i.e., F, could be similar because of harvesting many more small individuals, but yield does not increase due to harvesting smaller animals. Additionally, the models were parameterized differently for each of the shrimp species to account for differences in life history and differences in the way each fishery is prosecuted. Pink shrimp has primarily an offshore fishery, while white shrimp has primarily an inshore fishery and brown shrimp has both an inshore and offshore fishery. It was also explained that each state manages its shrimp fishery differently…" Members of the SSC voted unanimously to accept the MSY based reference points as the best available science and found them suitable for management advice.

Following the MSY workshop, the results were presented at the April 2015 GMFMC Shrimp Committee. Outside of, and before this meeting convened, the Standing SSC Chairman noted that using MSY for an overfished reference point would be incorrect as it is a rate, and hence an overfishing metric. He stated that SSBmsy would be appropriate and recommended that this be used for the overfished reference point. This information was discussed with NMFS shrimp stock assessment scientists and the Shrimp Committee Chairman. Therefore, the SSC Chair did not present the MSY estimates. Instead the committee discussed the use of SSBmsy for the overfished reference point. Using the SSBmsy would be appropriate and follows the spirit of the SSC charge of using MSY based values for the overfished and overfishing indices. Therefore, the Shrimp Committee and the Full Council granted Council staff editorial license to refine Alternative 1.3 to reflect that the overfished reference point is SSBmsy.

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 overfished and overfishing is occurring 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. For the pink and white shrimp assessments the model is parameterized with months as years so the terminal SSBmsy value is for the terminal month and is multiplied by 12 to arrive at an annual SSBmsy index. This index value is then compared against the sum of the 12 monthly SSB estimates for the terminal assessment year. If the assessment year sum of SSB is greater than the index SSBmsy than the stock is not overfished. Conversely, if the assessment year sum of SSB is less than the index SSBmsy than the stock is overfished. Similar to the overfished reference point, the overfishing reference point F by month estimates are summed to an annual F estimate and are compared to the calculated annual Fmsy estimates 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 the updated stock assessment for Gulf of Mexico pink shrimp (*Farfantepenaeus duorarum*) using a generalized stock assessment model, Stock Synthesis (SS-3) (Methot 2009). The assessment model update is parameterized with fishery data from 1984-2014. Model outputs span the biological year, i.e., July through June, versus calendar year. Therefore the model estimates for the terminal year of this assessment span July 2013 to June 2014.

3. METHODS

3.1. Model Overview

This Stock Synthesis (SS-3) (Methot 2009, Schirripa et al, 2009) stock assessment model update was parameterized with time varying selectivity with a block approach, and a random walk of the Q parameter during select time periods of the fishery's history. These model data and settings are noted in subsequent sections below.

3.2. Data Sources

This model was parameterized in biological years, with the models starting in July 1984 and continuing through December 2014. Two years of dummy landings data were entered before July 1984 for a model burn-in period. This burn in period allowed for recruitment deviations or cycles to begin before the actual starting year data were called into the model.

The model structure included 1 fleet:

1) Commercial Shrimp Inshore and Offshore Catch Combined (1984-2014; statistical zones 1-11)

and 2 indices of abundance:

1) SEAMAP Summer Groundfish Trawls (Fisheries-independent; 1987-2014)
2) SEAMAP Fall Groundfish Trawls (Fisheries-independent; 1987- 2014)

3.2.1. Commercial Catch Statistics – The Stock Synthesis assessment model was parameterized with pink 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 pink shrimp, used to calculate monthly CPUE; total catch; and catch by size, i.e., size composition data consisting of count of numbers of shrimp per pound; for statistical zones 1-11 from January 1984 through December 2014.

To calculate catch and CPUE 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 are used to supplement the effort and location data collected by NMFS port agents and state trip tickets.

Total catch in pounds of shrimp tails by month was a primary input. In addition, catch is entered into the model as monthly catch in pounds in each of eleven size bins. These count categories are; <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).

3.2.2. Growth curve and other population level rates – The model was parameterized with growth parameters k and linf derived and reported by Phares (1981), with a coefficient of variation (CV) equal to 0.07 (Berry 1967). Data inputs included a growth curve for each gender; natural mortality rate (0.3 per month as previously used in the historical VPA); and conversion factors to go from total length to the poundage breaks between the catch count categories. Stock Synthesis estimated steepness in the spawner-recruit function and linf., with a starting size of 10 mm at age 1 month through age 20 months.

3.2.3. Size Selectivity - A dome shaped (double normal) selectivity pattern with 4 estimated parameters was used, providing a good fit to the data. In addition, since SS-3 is an annual model; individual months were modeled as years (372 "years"). Selectivity was modeled to fluctuate in 12 "1-year" blocks beginning in July. This approach is equivalent to an annual model with July through June biological year fluctuations.

3.2.4. Catchability Q – Catchability was set as a random walk in the model, with Q allowed to randomly vary during January 2005 through October 2008. These select years correspond to those years when a large increase in CPUE is evident in the time series.

3.2.5. SEAMAP Data – SEAMAP data collected by NOAA Fisheries research vessels and State Fisheries agencies were used in the Stock Synthesis model. These SEAMAP sampling data were collected primarily from statistical zones 7-11. SEAMAP shrimp abundance indices using the delta log normal index from 2008-2014 and nominal CPUE data from 1987-2014 were model inputs. Size compositions for pink shrimp collected and measured in 1987-2014 during summer and fall cruises were also data inputs.

3.3. Model Configuration and Population Dynamics

3.3.1. Selectivity, Fishing Mortality, and Natural Mortality – For the commercial fishing fleet selectivity we used a double normal setup with selectivity modeled to fluctuate in 12 "1-year" blocks beginning in July. We used a constant natural mortality (M) setup (M=0.30) for the model. 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 – The Stock Synthesis modeling framework allows time varying fleet-specific selectivity and catchability parameters. A blocking technique was employed to allow time varying selectivity in blocks of 12 months so changes in selectivity can occur each year (or block). As noted previously, Q was also allowed to vary through a random walk technique in the model. Similarly, R_0 (unfished recruitment) was allowed to be estimated while recruitment was modeled with monthly deviations.

4. RESULTS

4.1. Parameter Estimates and Model Setups

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 (F deviations, recruitment deviations, selectivity deviations, etc.).

4.2. Fishery Catch Rates (CPUE)

The fit showing observed and expected catch rates show how Stock Synthesis models the changes in catch rates over time. Catch rates have shown an increasing trend over the last several years. Fluctuations both within and between years were revealed, with a close fit of expected to observed catch rates in all of the modeling scenarios. The model fits to the fishery CPUEs are illustrated in figure 4.2.1. The model allowed a random walk of Q beginning in January 2005 through October 2008. The increase in Q occurred during those years when CPUE was showing an increasing trend towards record high levels. This is due in part because the model is compensating for the high catch rates by increasing catchability. Allowing Q to increase this way accounted for some of the uncertainty in the signal in the increasing CPUE versus the model compensating by only increasing biomass. This increase in Q during this time period is also supported by the trend in CPUE measured in the fishery independent SEAMAP data.

4.3. Generalized Size Comps

The model was fit to the size composition of the catch in the model. Because the pink shrimp stock is modeled with months as “years” each month for the 31 year time period has a fit to the size composition data. Figure 4.3.1 illustrates the overall good fit of the size composition data aggregated across years.

4.4. Fishery Selectivity

The Stock Synthesis model results indicate that fishery selectivity tends to decline as shrimp get larger. This selectivity pattern matches the observed low occurrence of shrimp in the smallest count category, i.e., the largest sized shrimp. Figure 4.4.1 illustrates the size selectivity using the blocking approach.

4.5. SEAMAP CPUE, Size Composition, and Selectivity

The use of these fishery independent data has provided added information on some of the trends we see in the shrimp fishery, thus allowing us to better tune the models recruitment parameters. The summer and fall SEAMAP cruises reveal an increase in CPUE similar to the commercial fishery (Figures 4.5.1). Figure 4.5.2 shows the fit to the size composition data for 1987-2014 for summer and fall survey data with size composition data fits aggregated across all years. Size selectivity curves for the SEAMAP surveys are shown in figure 4.5.3.

4.6. Fishing Mortality

Stock Synthesis reports fishing mortality rates by age and month. While Stock Synthesis reports annual Fs by age, the pink shrimp model is parameterized with monthly data which SS-3 treats as years. Consequently Stock Synthesis outputs F values by age and month, e.g., for 2014 the number of F values is 12 months x 19 ages = 228 F values.

To deal with this large number of F's per year, the consensus of the 2012 SSC working group was to calculate the F rates in the following manner:

$$\text{Weighted Average Monthly F} = \frac{\sum[Numbers\ by\ Age\ Matrix\ by\ Month]\times[F\ by\ Age\ Matrix\ by\ Month]}{\sum Numbers\ at\ Age\ by\ Month} \qquad \text{(Eq.1)}$$

Equation 1 resulted in the calculation of one weighted, i.e., numbers of shrimp at age, F-value per month; the weighted average monthly F across all ages. Fishing mortality rates have been decreasing, with the weighted monthly F for biological year 2013 equaling 0.25 per year (Figure 4.6.1).

4.7. Spawning Biomass and Recruitment

Spawning biomass and recruitment for the 2013 biological year fishing season were 55.4 million pounds of tails and 5.54 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 pink shrimp fishery. The stock has been showing a slight decrease in spawning biomass over the last few years, increases in recruitment in recent years, and a decreasing trend in fishing mortality, F. No indications of overfishing of the fishery being in an overfished or overfishing conditions are evident.

6. REFERENCES

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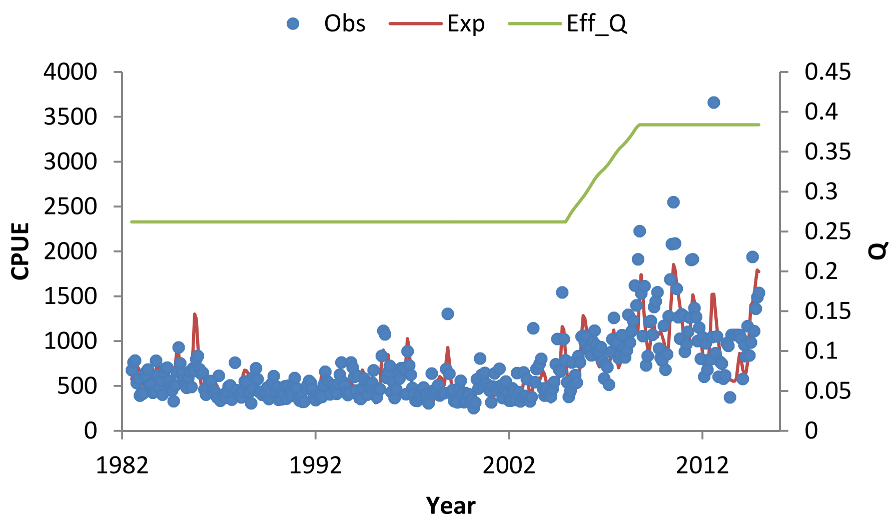

Figure 4.2.1. Pink shrimp CPUE and Q model fits, 1984-2014.

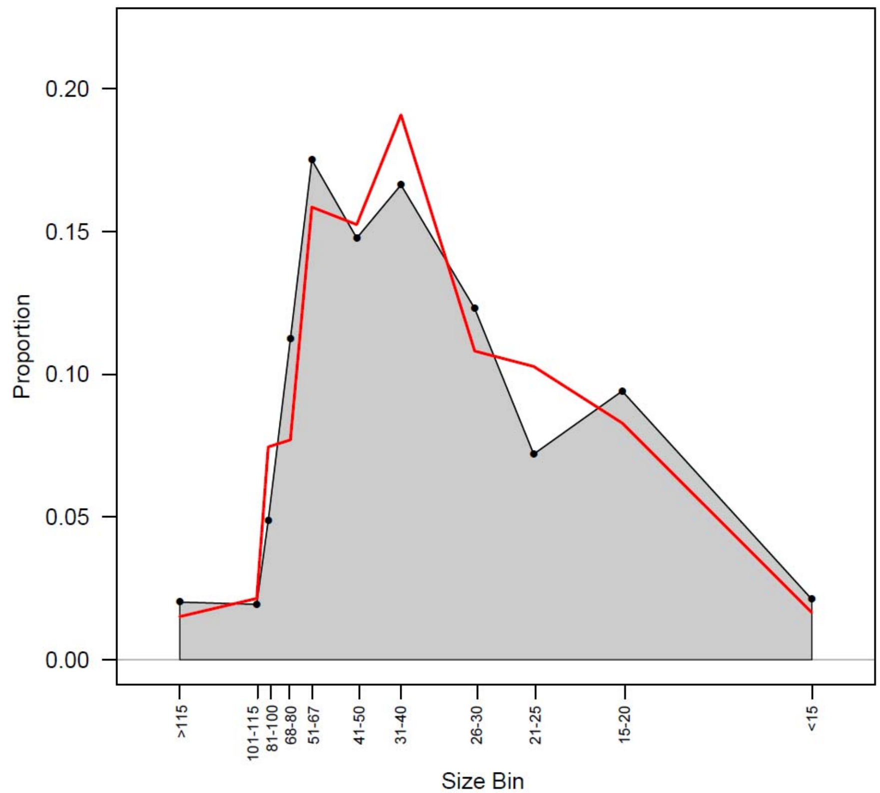

Figure 4.3.1. Pink shrimp size composition fits for the commercial fleet, 1984-2014.

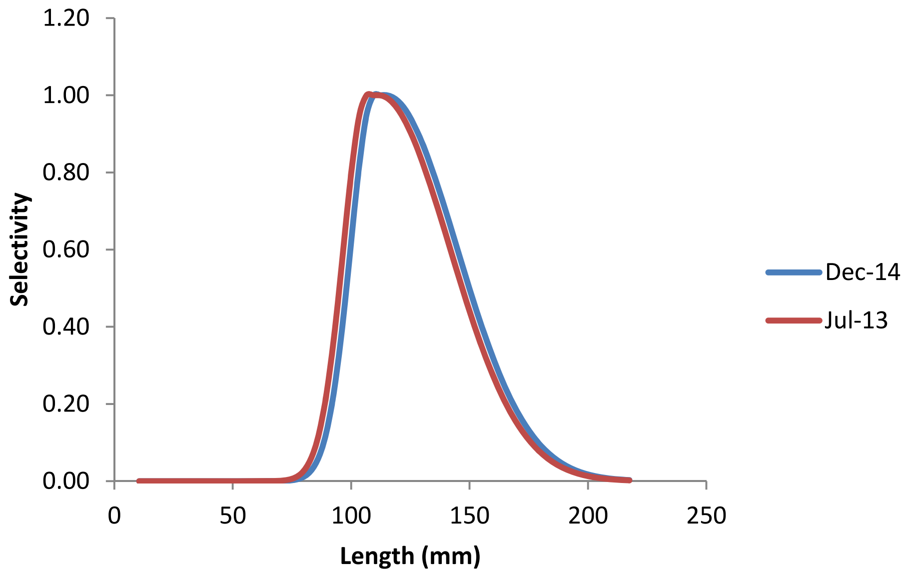

Figure 4.4.1. Pink shrimp commercial fleet size selectivity, 2014. Example months depicting the block setup.

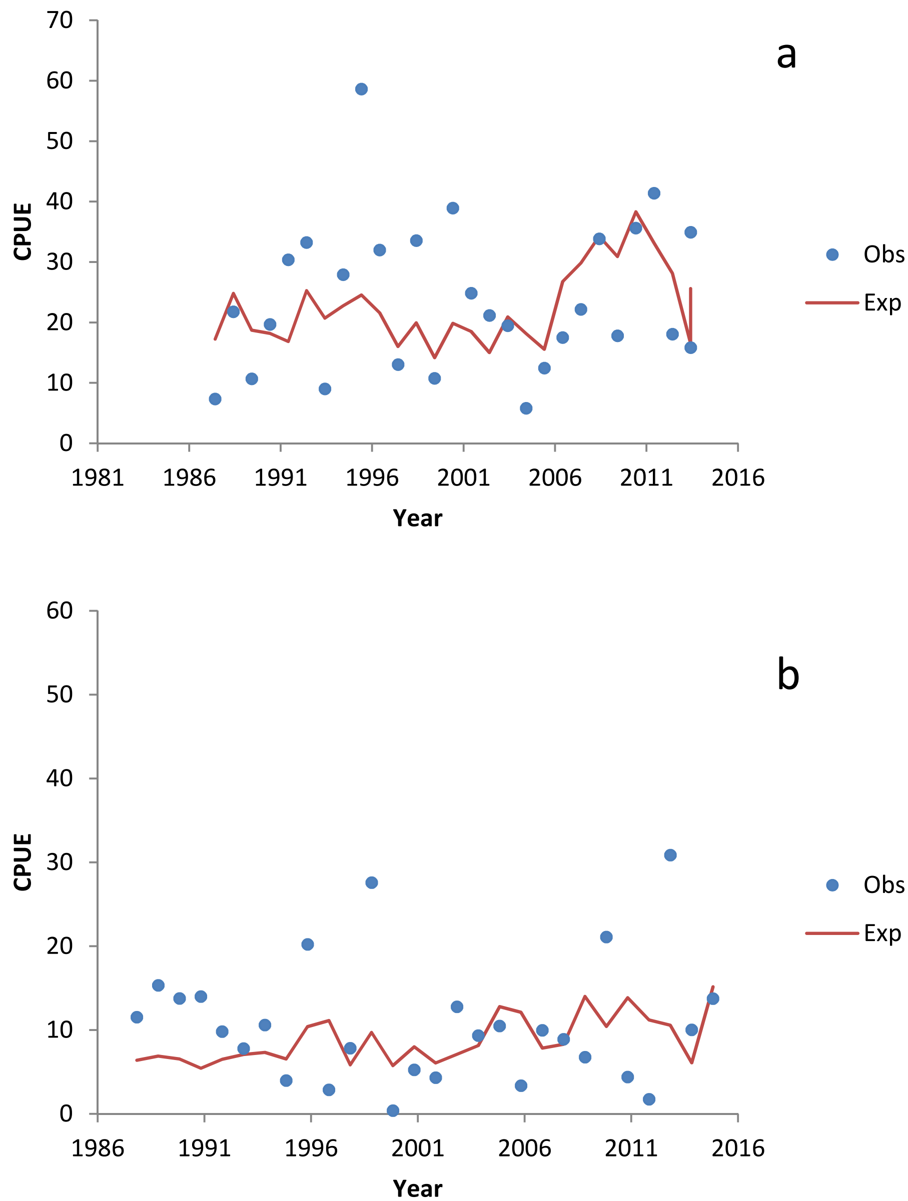

Figure 4.5.1. Pink shrimp survey fits for the Summer and Fall SEAMAP surveys, 1987-2014. Plot a is summer and plot b is fall survey.

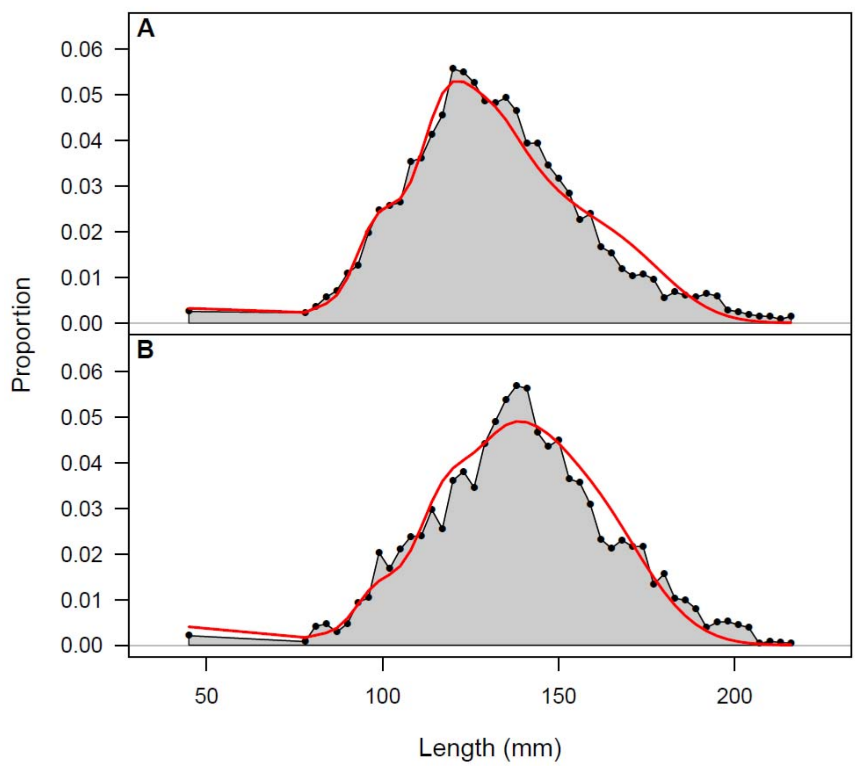

Figure 4.5.2. Pink shrimp size composition fits for the Summer panel A and Fall panel B SEAMAP surveys, 1987-2014.

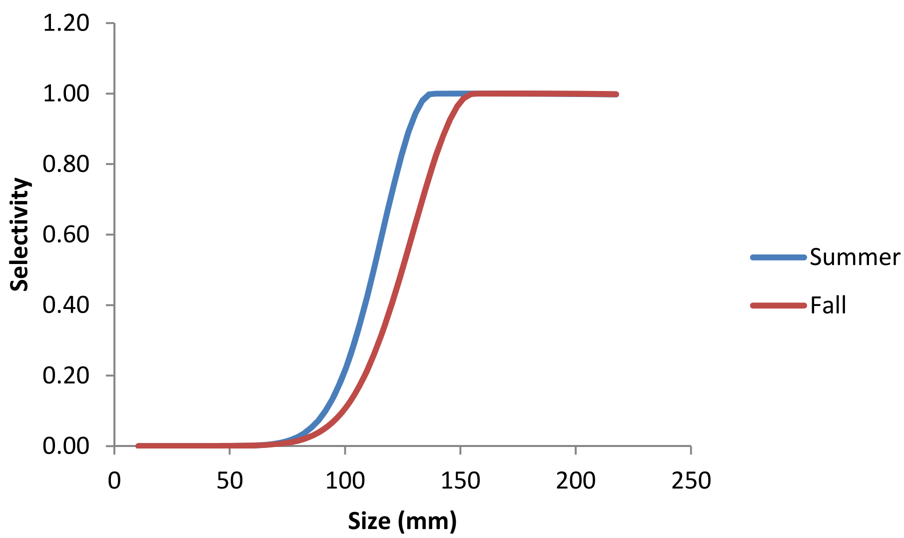

Figure 4.5.3. Pink shrimp size selectivity for the Summer and Fall SEAMAP surveys, 1987-2014.

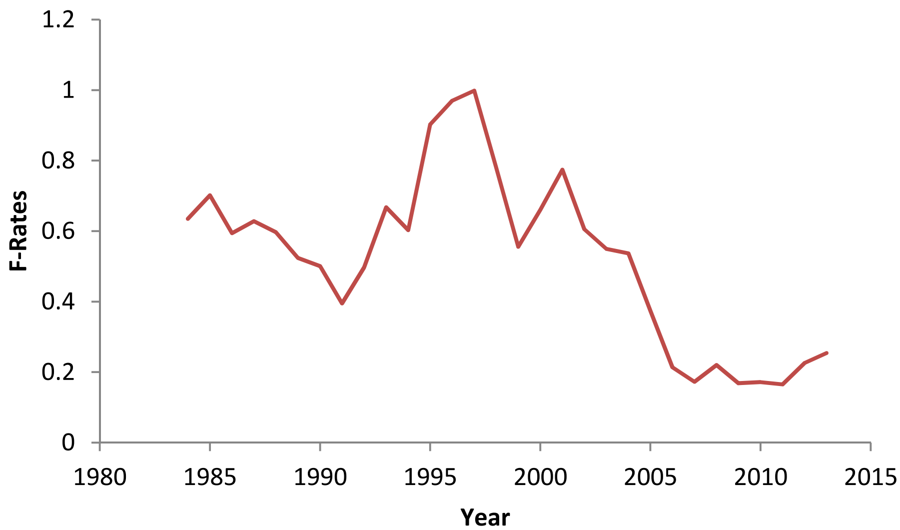

Figure 4.6.1. Pink shrimp weighted annual F-values across ages 1-19 for 1984-2014.

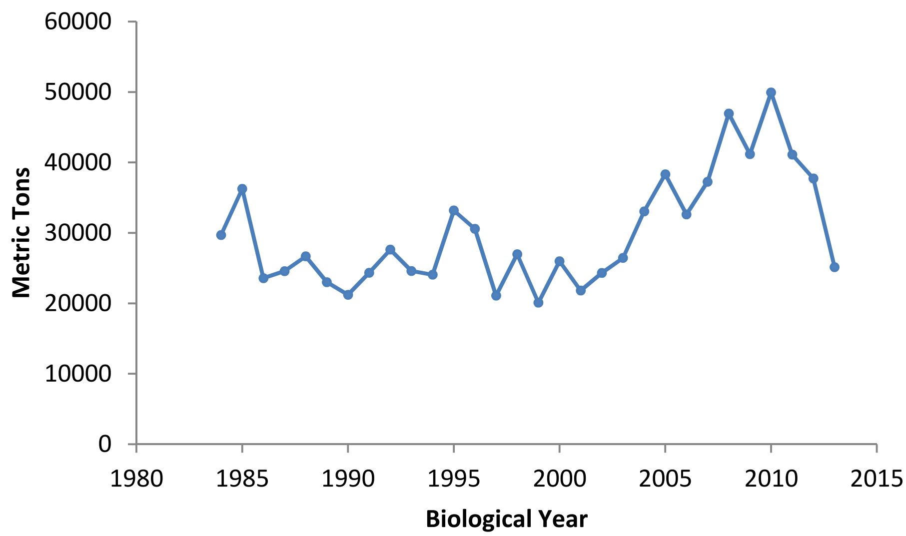

Figure 4.7.1. Biological year pink shrimp spawning biomass estimates, 1984-2014.

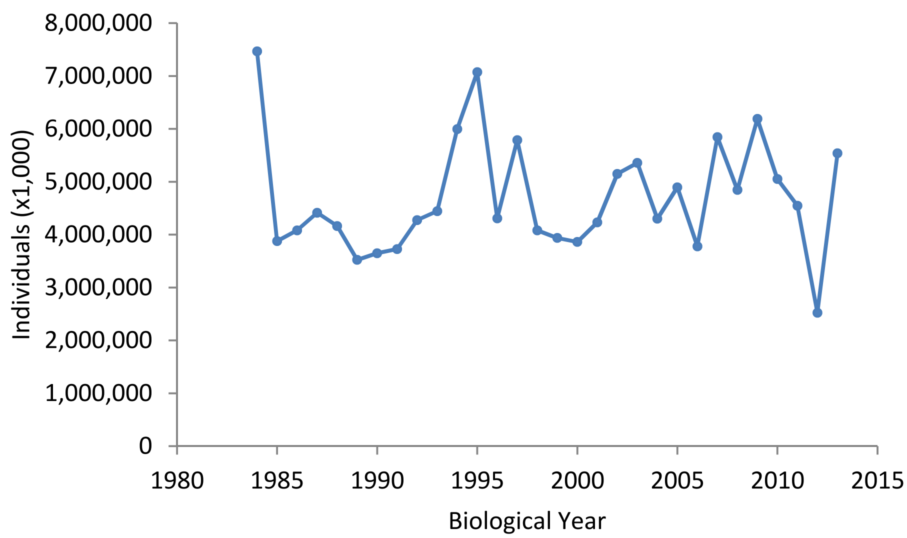

Figure 4.7.2. Pink shrimp biological year recruitment estimates, 1984-2014.