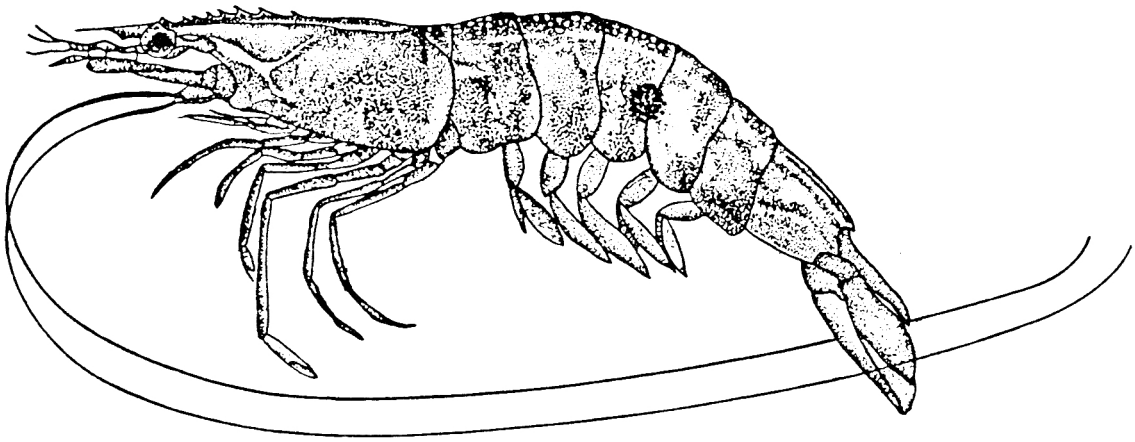
Stock Assessment Update for Pink Shrimp (*Farfantepenaeus duorarum*) in the U.S. Gulf of Mexico for 2014



Rick A. Hart

March 2015

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 30 years of commercial pink shrimp data from 1984 - 2013. 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.

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 biological year, monthly weighted apical F of 0.03 being estimated for the 2013 fishing season. Spawning biomass and recruitment for the 2013 biological year fishing season were 13,955 metric tons and 2.54 billion individuals respectively. Note that the 2013 biological year only includes 6 months of data, so the biological year 2012 should be considered as well. Spawning biomass and recruitment for the 2012 season were 38,526 metric tons and 2.8 billion individuals respectively.

2. INTRODUCTION

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 1984-2013.

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 2013. 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 (1984-2013; statistical zones 1-11)

and 2 indices of abundance:

1) SEAMAP Summer Groundfish Trawls (Fisheries-independent; 1987-2013)
2) SEAMAP Fall Groundfish Trawls (Fisheries-independent; 1987- 2013)

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 2013.

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 (360 "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 2008-2013 and nominal CPUE data from 1987-2013 were model inputs. Size compositions for pink shrimp collected and measured in 1987-2013 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 30 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 1987-2013 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 2013 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 apical weighted monthly F for biological year 2013 equaling 0.025 (Figure 4.6.1).

4.7. Spawning Biomass and Recruitment

Spawning biomass and recruitment for the 2013 biological year fishing season were 13,955 metric tons and 2.54 billion individuals respectively (Figures 4.7.1 and 4.7.2). Note the 2013 biological year only includes 6 months of data, therefore, biological year 2012 (July 2011-June 2013) should be considered as well. Steepness for the spawner-recruit curve was estimated at 0.87. Spawning biomass and recruitment for biological year 2012 were 38,526 metric tons and 2.8 billion individuals respectively.

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 an increasing trend in spawning biomass and recruitment in recent years, and a decreasing trend in fishing mortality, F. No indications of overfishing or of the fishery being in an overfished condition are evident.

6. REFERENCES

Berry, R. J. 1967. Dynamics of the Tortugas (Florida) pink shrimp population. Ph.D. dissertation, University Microfilms, Ann Arbor, MI. 177 p.

Gallaway, B. J., J. G. Cole L. M. Martin, J. M. Nance, and M. Longnecker. 2003a. An evaluation of an electronic logbook as a more accurate method of estimating spatial patterns of trawling effort and bycatch in the Gulf of Mexico shrimp fishery. North American Journal of Fisheries Management 23:787–809.

Gallaway, B. J., J. G. Cole, L. R. Martin, J. M. Nance, and M. Longnecker. 2003b. Description of a simple electronic logbook designed to measure effort in the Gulf of Mexico shrimp fishery. North American Journal of Fisheries Management 23:581–589.

Hart, R. A., and J. M. Nance. 2010. Gulf of Mexico Pink shrimp assessment modeling update from a static VPA to an integrated assessment model Stock Synthesis. NOAA Technical Memorandum NMFS-SEFSC-604, 32 p.

Methot, R.D. 2009. Stock Assessment: Operational Models in Support of Fisheries Management. In Beamish and Rothschild (ed) Future of Fishery Science. Proceedings of the 50th Anniversary Symposium of the American Institute of Fishery Research Biologists, Seattle, WA. Springer. Fish & Fisheries Series, Vol. 31: Pg. 137-165.

Methot, R.D. and C. Wetzel. 2013. Stock Synthesis: a biological and statistical framework for fish stock assessment and fishery management. Fisheries Research 142:86-99.

Nance, J., W. Keithly Jr., C. Caillouet Jr., J. Cole, W. Gaidry, B. Gallaway, W. Griffin, R. Hart, and M. Travis. 2008. Estimation of effort, maximum sustainable yield, and maximum economic yield in the shrimp fishery of the Gulf of Mexico. NOAA Technical Memorandum NMFS-SEFSC-570, 71 p.

Phares, P.L. 1981. Paper presented to the Workshop on the Scientific Basis for Management of Penaeid Shrimp. Key West, FL.

Schirripa, M. J., C. P. Goodyear, and R. D. Methot. 2009. Testing different methods of incorporating climate data into the assessment of US West Coast sablefish. ICES Journal of Marine Science: Journal du Conseil 2009 66(7):1605-1613.

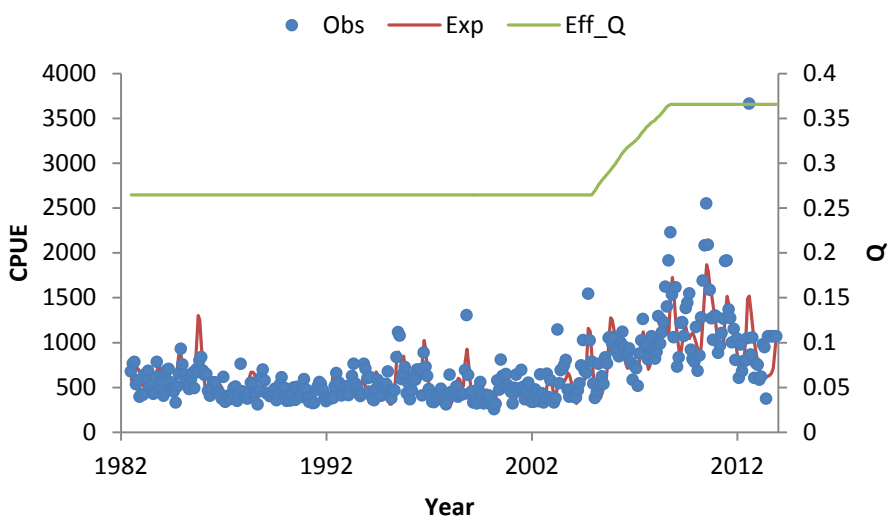


Figure 4.2.1. Pink shrimp CPUE and Q model fits, 1984-2013.

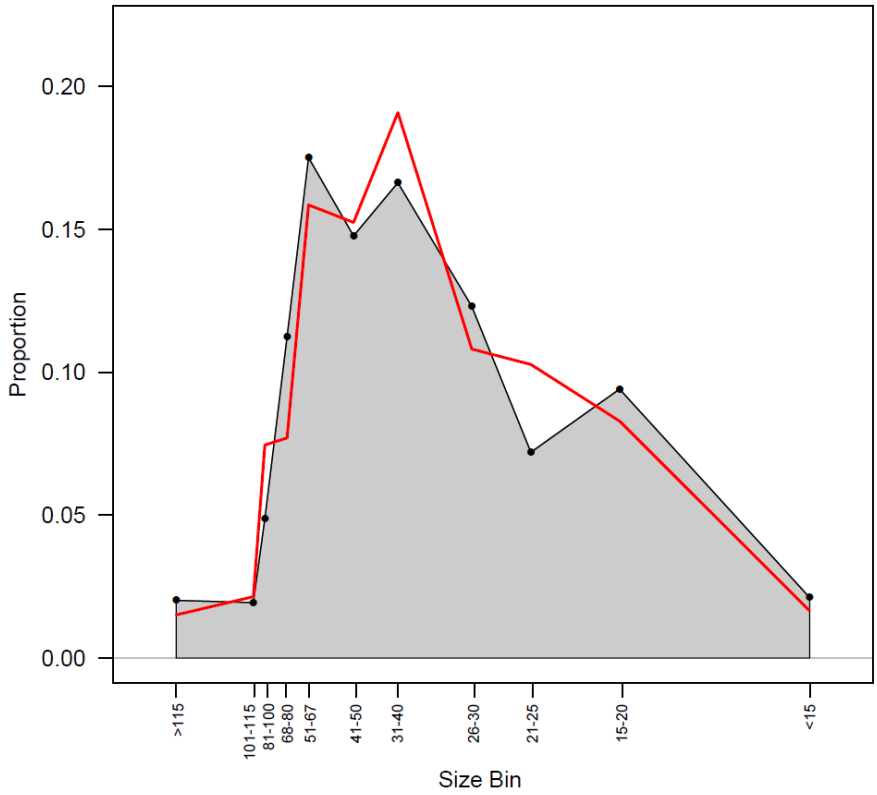


Figure 4.3.1. Pink shrimp size composition fits for the commercial fleet, 1984-2013.

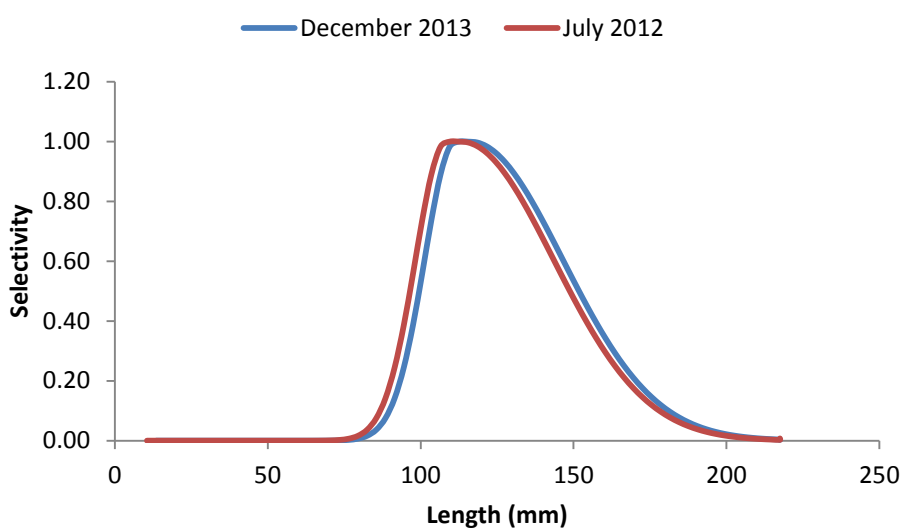
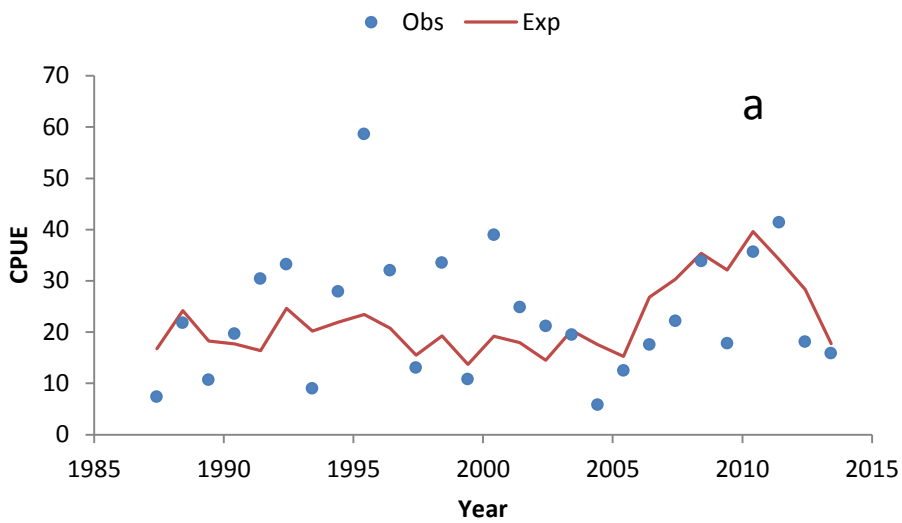


Figure 4.4.1. Pink shrimp commercial fleet size selectivity. Example months depicting the block setup.



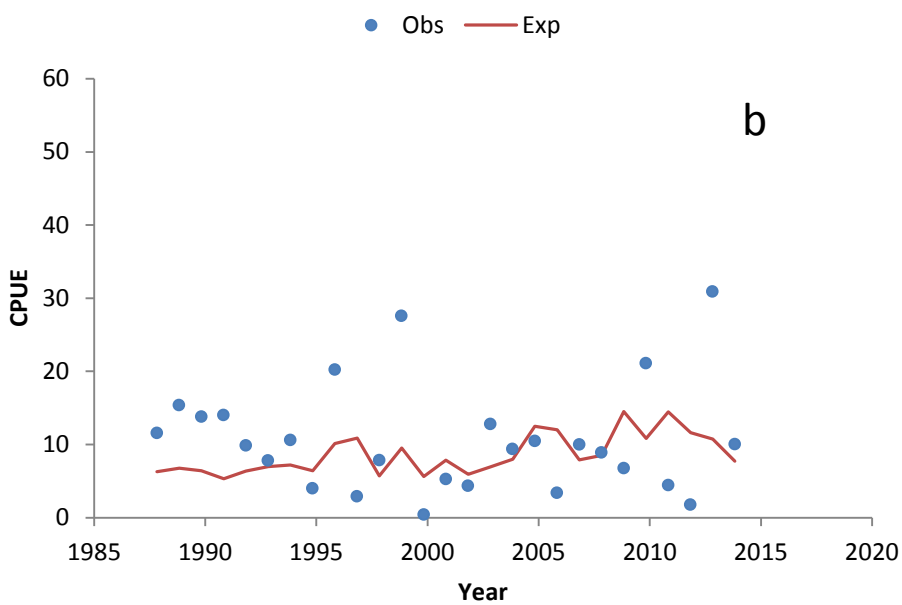


Figure 4.5.1. Pink shrimp survey fits for the Summer and Fall SEAMAP surveys, 1987-2013. Plot a is summer and plot b is fall survey.

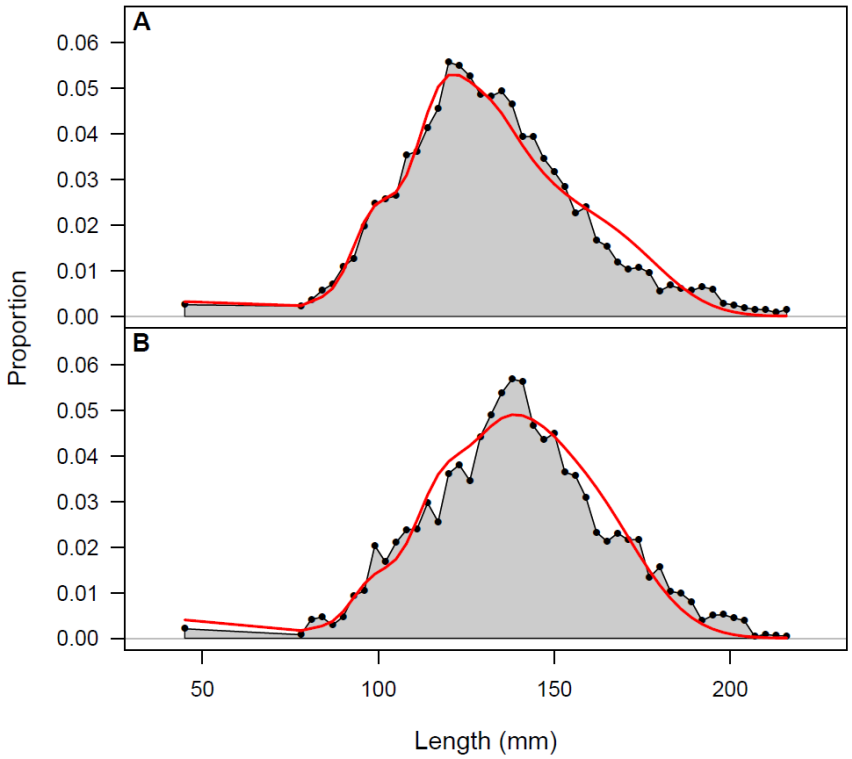


Figure 4.5.2. Pink shrimp size composition fits for the Summer panel A and Fall panel B SEAMAP surveys, 1987-2013.

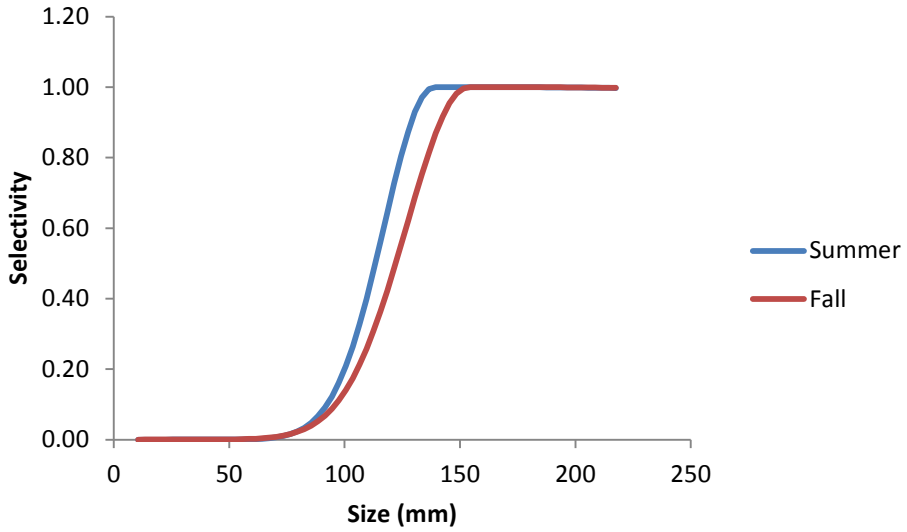


Figure 4.5.3. Pink shrimp size selectivity for the Summer and Fall SEAMAP surveys, 1987-2013.

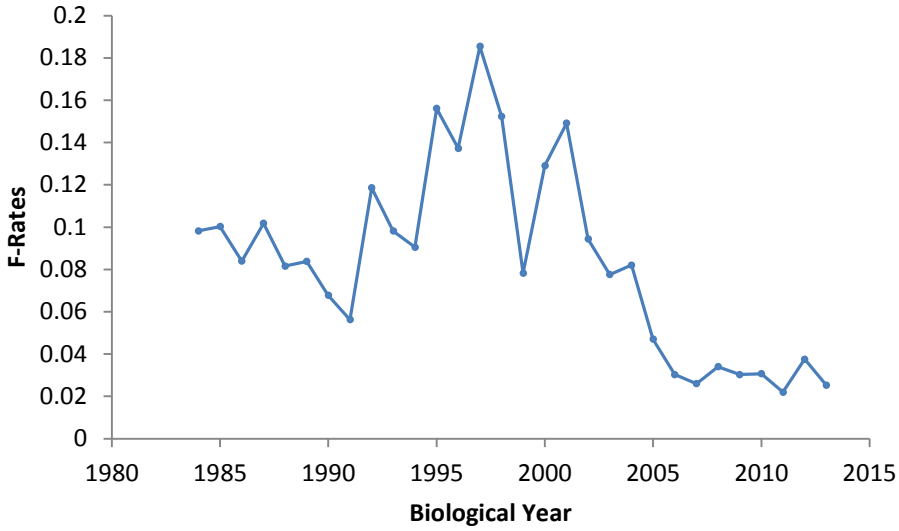


Figure 4.6.1. Pink shrimp weighted monthly apical F-values across ages 1-19 for 1984-2013.

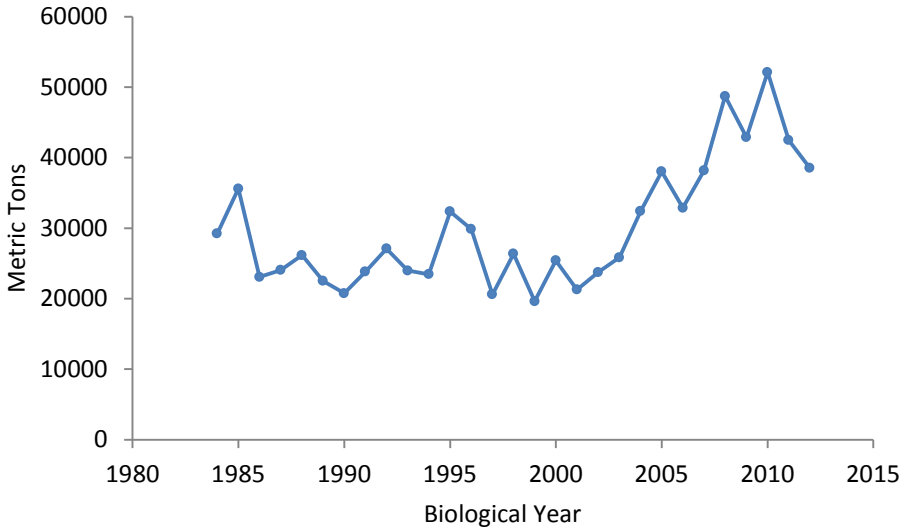


Figure 4.7.1. Biological year pink shrimp spawning biomass estimates, 1984-2013.

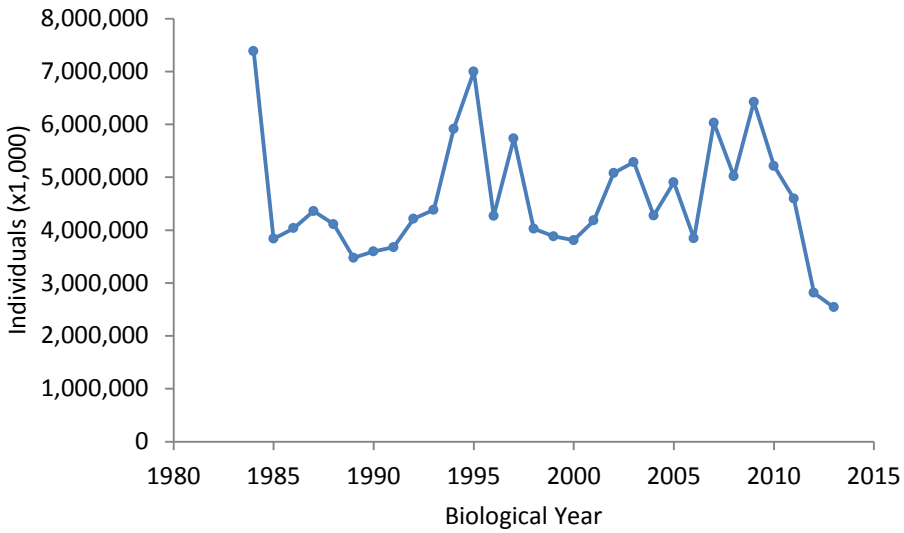


Figure 4.7.2. Pink shrimp biological year recruitment estimates, 1984-2013.