4.5 Fisheries Abundance

4.5.1 Trends in Fisheries Populations Sampled by Bag Seine

The Texas Parks and Wildlife Department (TPWD) maintains the database on fisheries resources for Galveston Bay. This database is separate from the commercial and recreational fisheries database held by the agency. The fisheries resource database contains 607,039 records sampled in the GBEP study area and dates back to 1975. It includes information on a host of aquatic plants and animals sampled by the agency using a wide variety of sampling techniques. This database was used to analyze species abundances in East Bay, Upper and Lower Galveston Bay, Trinity Bay and West Bay.

The data from bag seine collections should describe the variation in abundance of the smaller species and younger individuals of large species. Those species that only occur in bag seine collections are of little commercial interest and are not described in this section, e.g. sheepshead minnow and long-nosed killifish. They are discussed in the section on multivariate results and their trend graphs are found in Appendix Y.

Atlantic Croaker

Atlantic croaker is a common component of the catch in bag seine collections. The annual CPUE is quite variable. In Galveston Bay, there is an apparent decline in the bag seine CPUE for this species shown in Figure 4.5.1. The trends for the other three major sub-bays are less convincing because the trend lines explain less than 10 percent of the variation in annual CPUE. The validity of this trend is not supported by the trend expressed by this species in the shrimp trawl data. Figure 4.5.2 shows the annual CPUE for Atlantic croaker in shrimp trawl collections made in Galveston Bay. The conflicting trends exhibited for this species in the same area of the Bay using gear catching different age classes suggests caution is necessary in interpreting the data obtained. In general the negative trends for bag seine data collected in different sub-bays are weaker than the positive trends for the same species in the same area using shrimp trawl.

Figure 4.5.1. Average Annual CPUE of Atlantic Croaker Captured in Bag Seine in Upper and Lower Galveston Bay

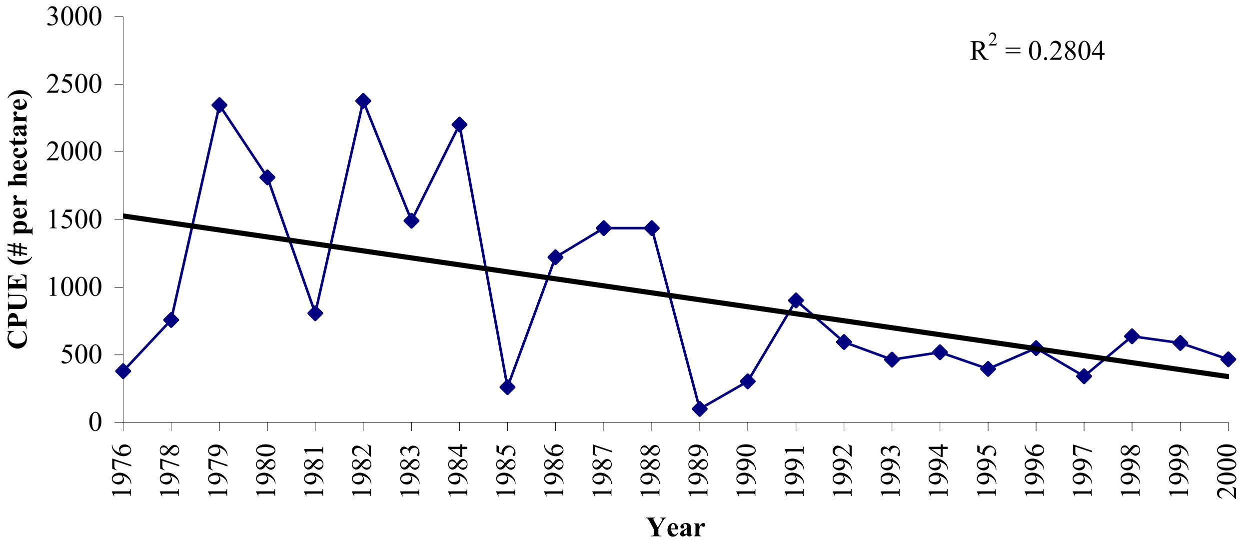
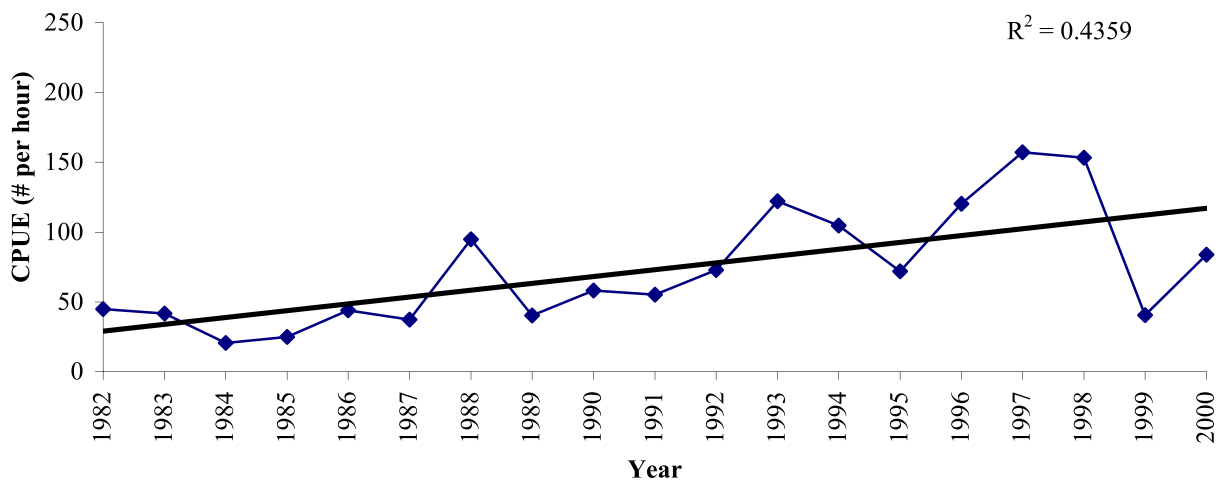


Figure 4.5.2. Average Annual CPUE of Atlantic Croaker Captured in Shrimp Trawl in Upper and Lower Galveston Bay



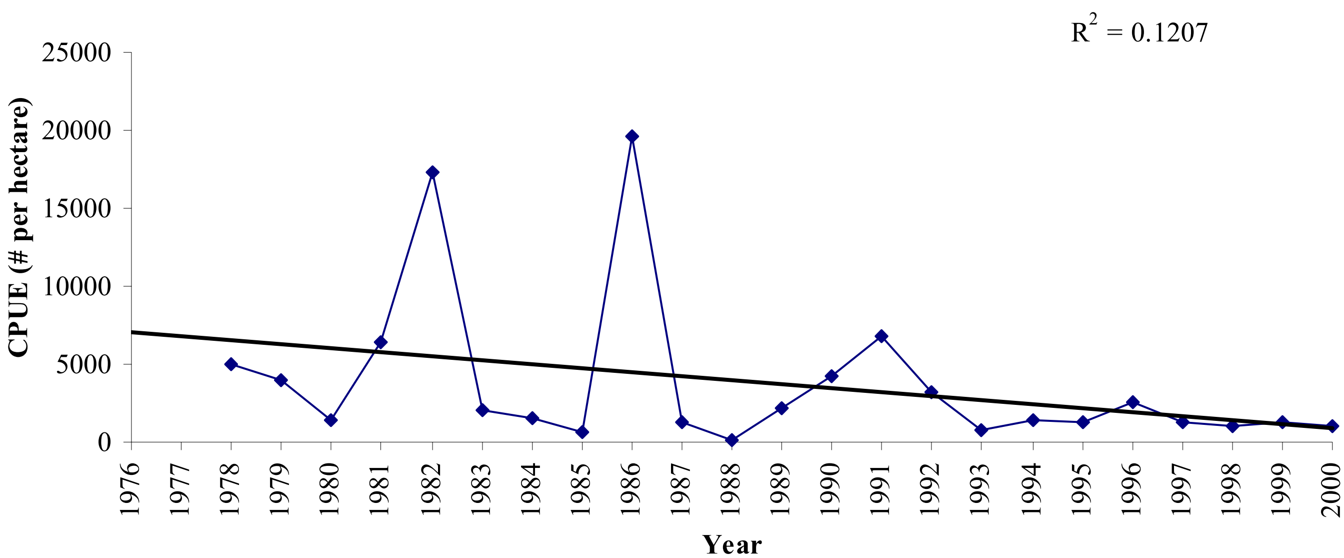
Bay Anchovy
Annual CPUE of bay anchovy for bag seine collections do not show a trend in abundance in any of the major sub-bays (see Appendix D).

Striped Mullet
Annual CPUE of striped mullet for bag seine collections do not show a trend in abundance in any of the major sub-bays (see Appendix D).

Brown Shrimp
Annual CPUE of brown shrimp for bag seine collections do not show a trend in abundance in any of the major sub-bays (see Appendix D).

White Shrimp
Annual CPUE of white shrimp for bag seine collections do not show a trend in abundance in any of the major sub-bays. The CPUE values are highly variable and, although the trend lines for East and West Bay data decline, the regressions explain very little of the variation across years. Figure 4.5.3 shows the pattern for white shrimp in bag seines collections in East Bay. Exceedingly high CPUE values in 1982 and 1986 result in a declining trend line that has little explanatory value.

Figure 4.5.3. Annual CPUE of White Shrimp Captured in Bag Seine in East Bay



4.5.2 Trends in Fisheries Populations Sampled by Shrimp Trawl

Brown Shrimp

There are no trends in brown shrimp CPUE for shrimp trawl data in any sub-bay. The fluctuation from year to year is large and is not explained to any significant degree by linear trend lines. Figure 4.5.4 shows a graph of the CPUE data for shrimp trawl collections in Trinity Bay from 1982 to 2000. The linear trend line appears to increase, but actually explains less than 5% of the variance in the CPUE values. In Figure 4.5.5, the CPUE data from shrimp trawl collections of brown shrimp in West Bay are plotted. The trend line in this case has a slight positive slope, but explains so little of the variation in annual CPUE that the best explanation for the data is no significant trend over time.

Figure 4.5.4. Average Annual CPUE of Brown Shrimp Captured in Shrimp Trawl in Trinity Bay

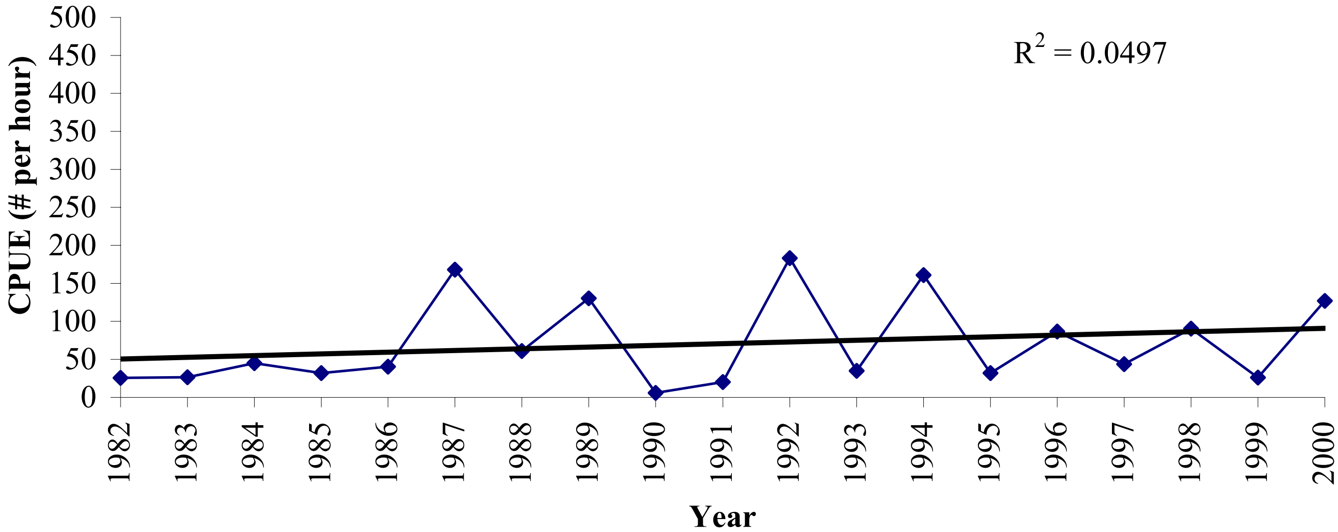
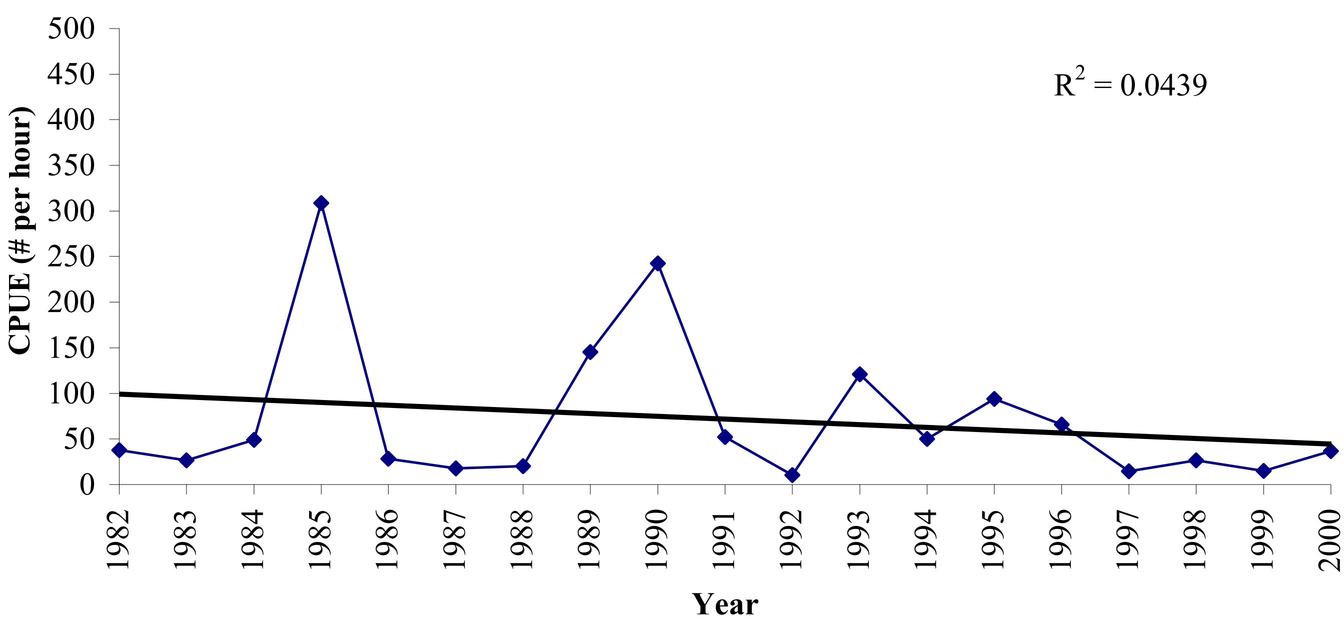
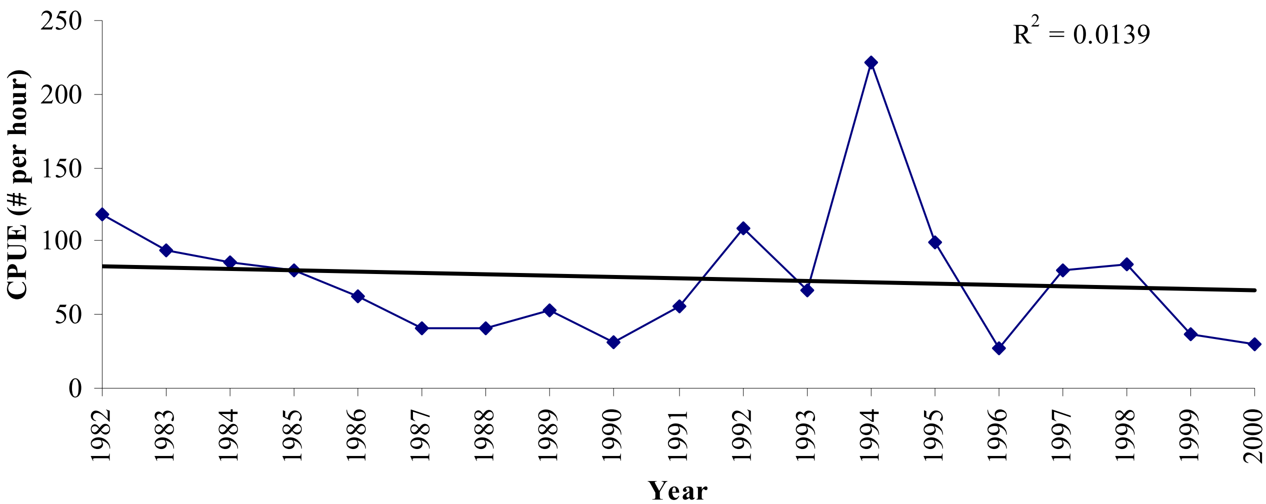


Figure 4.5.5. Average Annual CPUE of Brown Shrimp Captured in Shrimp Trawl in West Bay



White Shrimp
Between 1982 and 2000 the CPUE of white shrimp captured by TPWD shrimp trawl shows no consistent trend in any of the four major sub-bays of the Galveston Bay system. East Bay has the greatest appearance of a pattern. In 1982 the CPUE for this species in shrimp trawl was 167 per hour and in 2000 it was around 32 per hour. However, there is high variation in the annual CPUE and the trend line explains only 11 percent of the variation. The graph in Figure 4.5.6 is representative of the changes in annual abundance that can occur for species with high reproductive potential. This graph for CPUE in Galveston Bay shows a relatively steady decline in the 80's followed by an increase in the 90's. The resultant pattern is one of no trend. Trinity Bay shows high variation in annual CPUE throughout the period of record, but a high CPUE of around 85 per hour. West Bay has a lower density of white shrimp than East, Galveston or Trinity Bays. It also shows no trend in CPUE.

Figure 4.5.6. Annual CPUE of White Shrimp Captured in Shrimp Trawl in Upper and Lower Galveston Bay



Blue Crab

The abundance of blue crabs in shrimp trawls exhibits two patterns. In Trinity and West Bays there is a negative trend that explains over 30% of the variation in annual CPUE. Figure 4.5.7 shows the annual CPUEs for Trinity Bay and the resultant trend line. In Galveston and East Bays there is no trend in annual CPUE for blue crab captured in shrimp trawls. Figure 4.5.8 shows the plot of annual CPUE and the flat trend line computed for those CPUE values. Trinity and West Bay share a trend despite the large difference in annual CPUE. Trinity and Galveston Bays have the highest CPUE values, East and West Bays the lowest.

Figure 4.5.7. Annual CPUE of Blue Crab
Captured in Shrimp Trawl in Trinity Bay

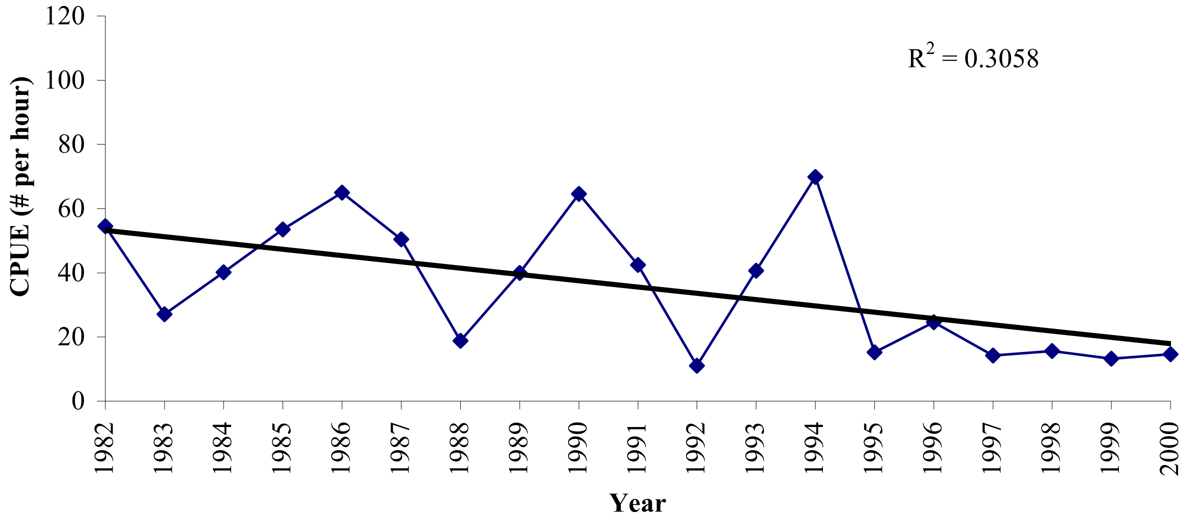
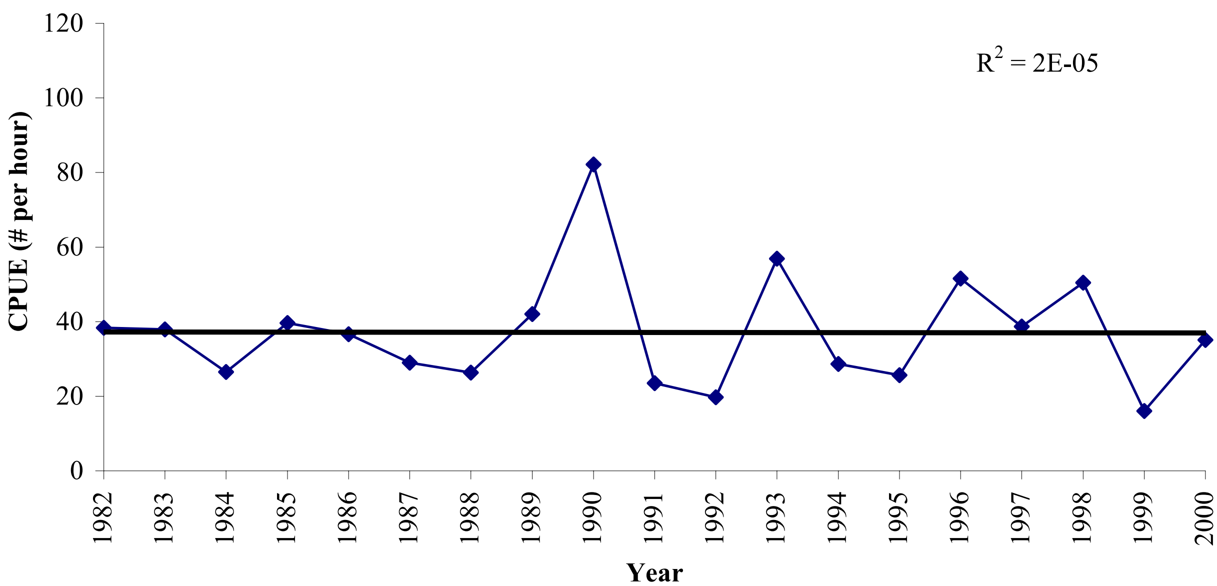


Figure 4.5.8. Annual CPUE of Blue Crab
Captured in Shrimp Trawl in Upper and Lower Galveston Bay



Gulf Menhaden

Shrimp trawl collections of Gulf menhaden show different patterns across the Galveston Bay system. In East Bay (Figure 4.5.9) and West Bay, there are some years with very high CPUEs, but no discernable trend in abundance. In Galveston Bay the variation is less, but there is still no trend in CPUE. However, the shrimp trawl collections of Gulf menhaden in Trinity Bay (Figure 4.5.10) show less variation than East and West Bay and a positive slope that explains 22% of the variation in annual CPUE.

Figure 4.5.9. Annual CPUE of Gulf Menhaden Captured in Shrimp Trawl in East Bay

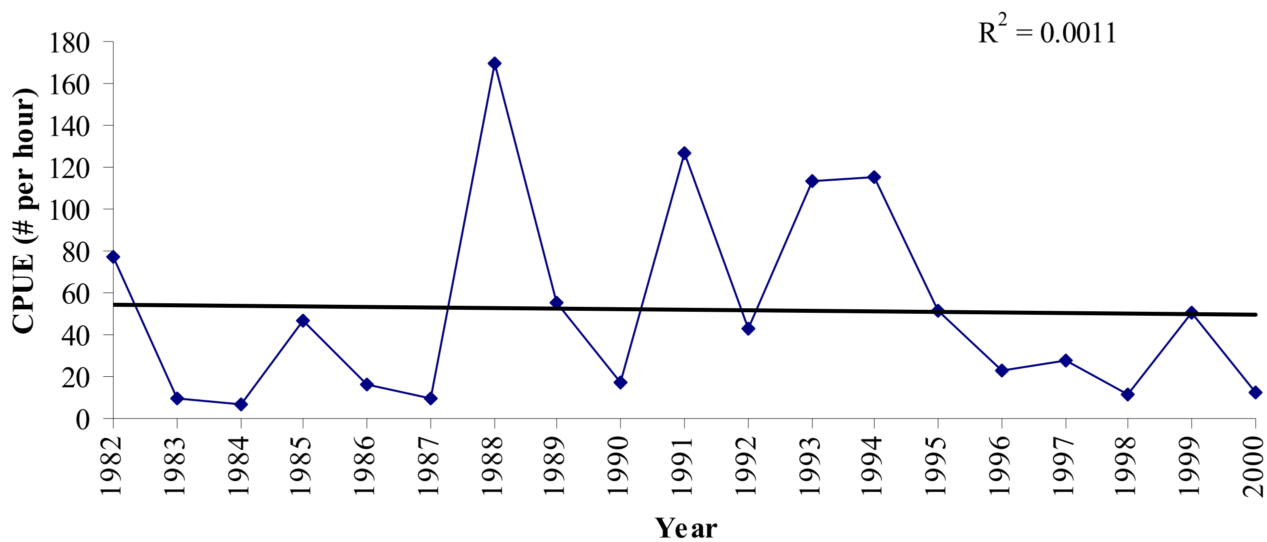
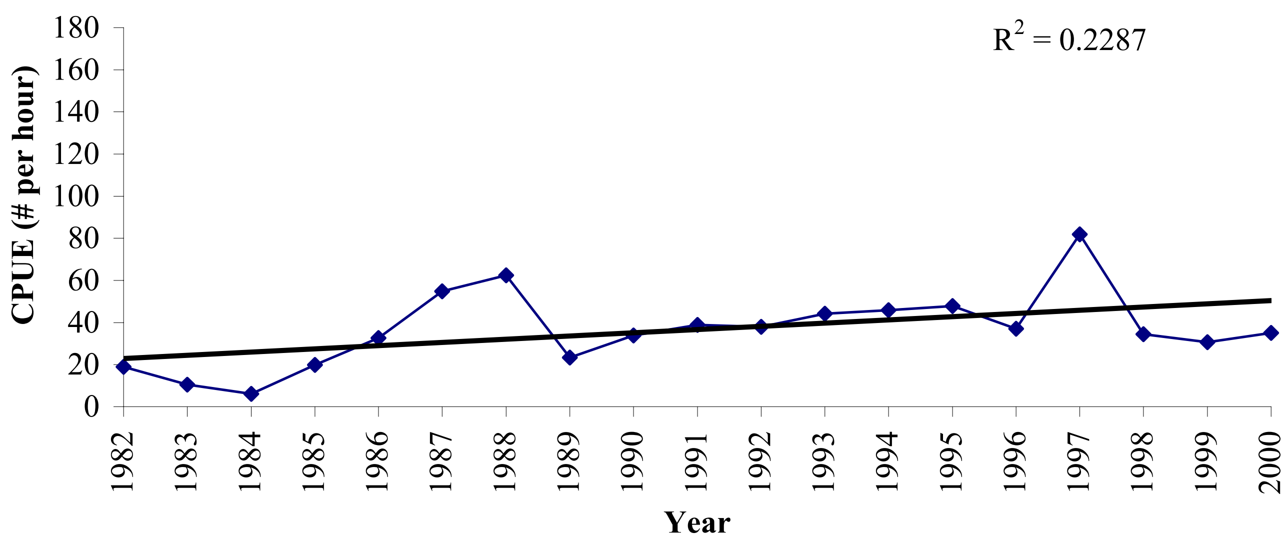


Figure 4.5.10. Annual CPUE of Gulf Menhaden Captured in Shrimp Trawl in Trinity Bay



4.5.3 Trends in Fisheries Populations Sampled by Gill Net

Gill nets capture large individuals of nektonic species reliably. This gear is not suitable for collecting benthic crustaceans and small nektonic species. Four common species that are readily captured for which gill net CPUE is an appropriate measure of abundance are black drum, red drum, Southern flounder, and spotted seatrout.

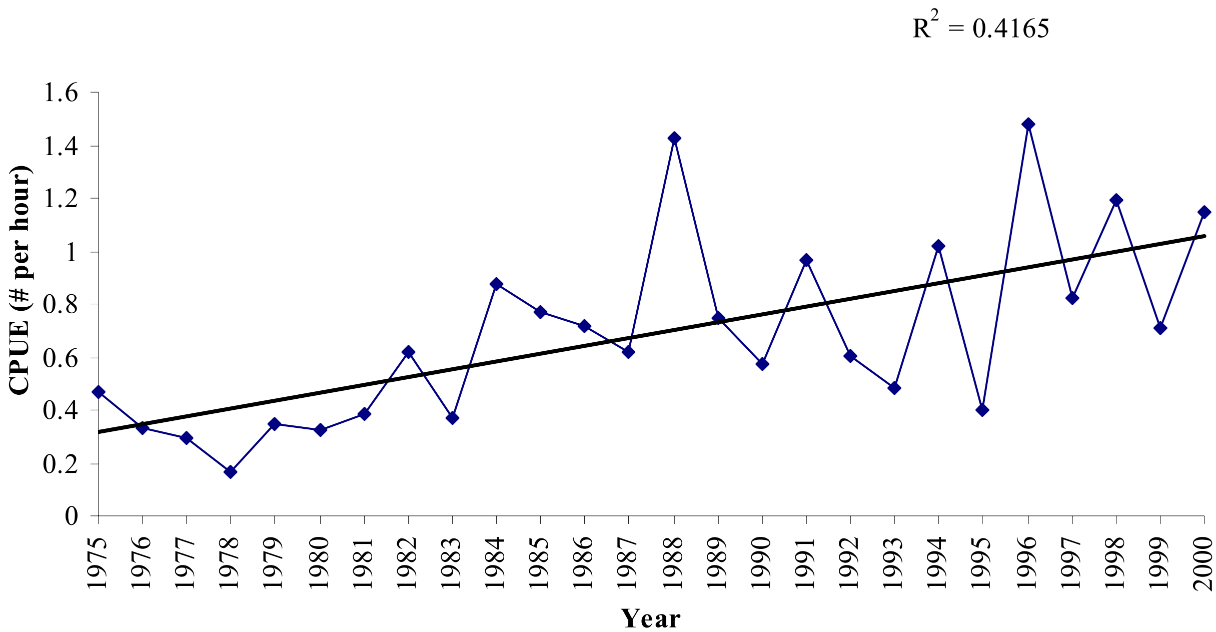
Black Drum
Annual CPUE for gill net captures of black drum in East, Galveston, Trinity and West Bays show no trend in any sub-bay. CPUE values range for greater than one per hour to fewer than one per two hours. Trend graphs for gill net capture rates of this species are included in Appendix D.

Red Drum
Annual CPUE for gill net captures of red drum in East, Galveston, Trinity and West Bays show no significant trend in any sub-bay. CPUE values fluctuate from greater than three per hour to zero per hour, but are more commonly between 1.5 and 0.5. Trend graphs for gill net capture rates of this species are included in Appendix D.

Southern Flounder
CPUE values for Southern flounder captured in gill nets have been relatively stable since 1980. High values in the late 1970's in Trinity and West Bays give the trend lines for those sub-bays a weak negative slope. Poor catches in the late 1970's in East and Galveston Bay give the trend lines for flounder gill net CPUE in those sub-bay a weak positive slope. Over the last 20 years there is no apparent trend in gill net CPUE for flounder. The graphs of CPUE for this species with this gear are included in Appendix D.

Spotted Seatrout
Unlike the other three species described in this section, the gill net capture rate of spotted seatrout has shown a significant increase over the period of record. The trend lines for annual CPUE of spotted seatrout in gill net explains between 27% and 50% of the variation in the data points. The most dramatic increase has occurred in East Bay where the CPUE has risen from 0.3 per hour to 1.0 per hour from 1975 to 2000. Figure 4.5.11 shows the plot of East Bay data for this gear and species.

Figure 4.5.11. Annual CPUE of Spotted Seatrout Captured in Gill Net in East Bay



4.5.4 Trends in Fisheries Populations Sampled by Oyster Dredge

Oyster dredges capture individuals of the benthic community, primary oysters and associated species. One common species that is readily captured for which oyster dredge CPUE is an appropriate measure of abundance is the Eastern oyster. TPWD monitors oyster abundance through the timed deployment of oyster dredges. CPUE trends for Eastern oysters in the four sub-bays of Galveston Bay can be viewed in Appendix D.

4.5.5 Multivariate Analysis of Aquatic Living Resources in Galveston Bay

The TPWD data has been analyzed according to sub-bays and gear type using selected species. The gear types are bag seine, shrimp trawl and gill net. Bag seine collections are made near shore and contain small species and juveniles of many large commercial species. Shrimp trawl data is made at random locations around the Bay system with sufficient water depth to deploy a small trawl behind a trawler. Trawl samples contain benthic species and nektonic species, but are deficient for fast swimming nektonic species. Gill nets are deployed at random sites around the Bay away from shipping lanes and channels. Gill nets capture larger individuals of nektonic species. In this report we provide analyses of 18 species in bag seine collections, 15 species from shrimp trawl collections and six species from gill net collections. The analyses are conducted for samples obtained in Trinity Bay, Upper and Lower Galveston Bay and West Bay.

Bag Seine

The analyses of bag seine catch per unit effort (CPUE: number captured per hectare) are based on the capture data for 19 species of fish and crustaceans. The CPUEs of the six most common species in the three largest sub-bays are shown in Table 4.5.1. These collections are made in nursery areas near the shoreline and the data is restricted to individuals smaller than 204 mm in length. It appears that West Bay maintains the highest densities of small shrimp and some small shoreline fishes, while Trinity Bay has higher densities of juvenile Atlantic croaker and striped mullet.

Table 4.5.1. Number per hectare of six common species captured by bag seine in three large sub-bays of the Galveston Bay system obtained by TPWD between 1976 and 2000. N is the number of bag seine catches documented in the data set.

Species	**Trinity Bay** (N=197)	**Upper and Lower Galveston Bay** (N=251)	**West Bay** (N=275)
Atlantic Croaker	616	518	398
Bay Anchovy	215	409	520
Sheepshead Minnow	224	51	749
Striped Mullet	218	204	181
Brown Shrimp	498	268	911
White Shrimp	949	476	1557

A correlation matrix was generated from the bag seine sampling data in each of the large sub-bays. Correlations between species may be indicative of ecological relationships that would permit one species to be an indicator for another. Tables of significant correlations are provided for the reader to examine the relationships and decide for himself whether any are indicative of strong ecological relationships. For example, the highest correlations between species in bag seines from Galveston Bay are those between striped mullet and Atlantic croaker (0.49) and between spot and pinfish (0.39). The ecological roles of croaker and mullet are quite distinct and provide no obvious clues to the causation of the correlation. In addition, these two species do not show significant correlations in the analyses of Trinity and West Bays. We conclude that the correlation is a function of their response to environmental forces and not the result of ecological causation. On the other hand, there is one correlation that is expressed in all three of the data sets, blue crab and flounder. In the bag seine data for Galveston Bay, the CPUEs of the two species have a correlation of 0.21, in Trinity Bay 0.32, and in West Bay 0.31. This sort of consistent relationship between species sharing a habitat suggests an ecological relationship.

Table 4.5.2. Correlations of CPUEs of 19 species in Bag Seine Samples from Galveston Bay obtained by TPWD between 1976 and 2000 (N=251 bag seine samples).

Species	Brown shrimp	Red drum	Southern flounder	Spot	Striped mullet
Brown shrimp					
White shrimp					
Blue crab			0.21**	0.33***	
Atlantic brief squid		0.28***			
Bay anchovy	0.22**				
Gulf menhaden	0.22**				
Striped mullet					
Threadfin shad		0.37***			
Spot					
Longnosed killifish			0.28**		
Sheepshead minnow					
Southern flounder					
Atlantic croaker		0.26***			0.49***
Sand seatrout	0.29***				
Hardhead catfish					
Pinfish			0.24**	0.39***	
Red drum					
Black drum					
Spotted seatrout					0.22**

**= p<0.001
**= p<0.001
***= p<0.0001

The correlations in Table 4.5.3 that appear to represent known ecological relationships are spotted seatrout to white shrimp and sheepshead minnow, Atlantic croaker and sand seatrout to brown shrimp, and black drum to killifish. All of these could represent predator-prey associations, which would explain the timing of juveniles in the same habitat space.

Table 4.5.3. Correlations of CPUEs of 19 species in Bag Seine Samples from Trinity Bay obtained by TPWD between 1976 and 2000 (N=197 bag seine samples).

Species	**Brown shrimp**	**Bay anchovy**	**Spot**	**Southern flounder**	**Longnosed killifish**	**Spotted seatrout**
Brown shrimp						
White shrimp						0.36***
Blue crab				0.32***		
Atlantic brief squid						
Bay anchovy						
Gulf menhaden	0.20*					
Striped mullet			0.22*			
Threadfin shad						
Spot						
Longnosed killifish		0.41***				
Sheepshead minnow						0.30**
Southern flounder			0.21*			
Atlantic croaker	0.44***		0.23*			
Sand seatrout	0.24**	0.64***			0.29**	
Hardhead catfish						
Pinfish						
Red drum						
Black drum					0.22*	
Spotted seatrout						

**= p<0.001
**= p<0.001
***= p<0.0001

The same types of correlations noted above in Table 4.5.3 can be found in Table 4.5.4 for the bag seine data from West Bay. The correlations between the following pairs could be the result of known or suspected predator-prey relationships: spotted seatrout to white shrimp and Gulf menhaden, red drum to killifish and sheepshead minnow, croaker to blue crab, flounder to blue crab, and pinfish to brown shrimp. However, most of these correlations are not consistent across the entire Bay system, which makes interpretation difficult.

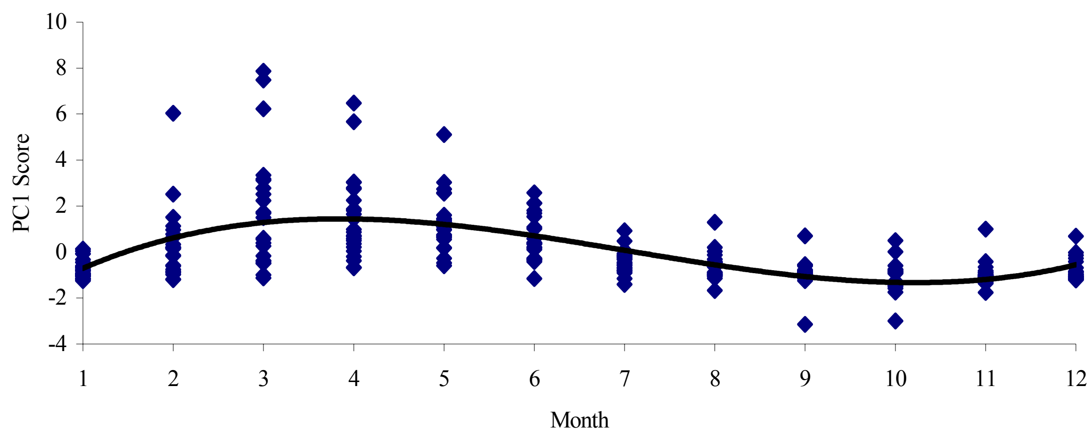
Table 4.5.4. Correlations of CPUEs of 19 species in bag seine samples from West Bay obtained by TPWD between 1976 and 2000 (N=275 bag seine samples).

Species	Blue crab	Gulf menhaden	Atlantic croaker	Spot	Pinfish	Red drum	Spotted seatrout
Brown shrimp	0.21**			0.23**	0.31***		
White shrimp							0.58***
Blue crab							
Atlantic brief squid					0.22**		
Bay anchovy							
Gulf menhaden							0.22**
Striped mullet				0.23**			
Threadfin shad							
Spot			0.35***				
Longnosed killifish						0.30***	
Sheepshead minnow						0.29***	
Southern flounder	0.31***		0.51***				
Atlantic croaker	0.32***						
Sand seatrout							
Hardhead catfish							
Pinfish	0.33***						
Red drum							
Black drum		0.46***					0.29***
Spotted seatrout							

**= p<0.001
**= p<0.001
***= p<0.0001

Principal component analysis of West Bay bag seine data indicates a species association represented by croaker, flounder, blue crab and spot that is abundant in the spring, decreases over summer months and is at its lowest abundance in late fall and winter. This pattern is shown in Figure 4.5.12 in which PC1 scores are plotted against months. For the Galveston Bay bag seine data, the first PC is representative of spot, blue crab, pinfish and flounder. It also shows a seasonal pattern with highest values in March and April and a decline to lowest values in late fall and winter from October to January. The same analysis of Trinity Bay has a similar association of species loading on the second PC: spot, croaker and brown shrimp. The high values for this variable occur in March through May, corresponding to the time of peak abundance of small brown shrimp in nursery areas.

Figure 4.5.12. Seasonal Pattern of PC1 Scores from Bag Seine Data for West Bay. (PC1 represents croaker, flounder, blue crab and spot.)



Shrimp Trawl

Shrimp trawl collections capture larger individuals of some species that were captured as juveniles in bag seine collections. Trawling also captures species that prefer the open bay bottom habitat and the water column above it. However, trawl collections are deficient in individuals of species that can swim rapidly and avoid nets. A sample of species commonly captured in shrimp trawl samples was employed in multivariate analysis. Those species are listed in the first column of Table 4.5.5 below.

Unlike the correlation analysis of bag seine samples, the shrimp trawl data showed some consistent associations and the potential of using some common species as indicator organisms. In both Trinity and Galveston Bay, Atlantic croaker and sand seatrout exhibit high numbers of correlations with other species captured in this gear. These species show relationships with each other and with shrimp, crab and spot. Other species, such as hardhead catfish and Gulf menhaden, also have significant correlations with croaker or sand seatrout in different bays. The consistent correlations of Atlantic croaker to the other species that are captured by this gear make it a strong candidate as an indicator species for the benthic community represented most often in shrimp trawl samples.

Table 4.5.5. Significant correlations between monthly CPUE of aquatic species captured in shrimp trawl samples by TPWD from Trinity Bay between 1982 and 2000. (n=225)

Species	Atlantic croaker	Blue crab	Pinfish	Sand seatrout	Striped mullet	Threadfin shad
Atlantic Croaker						
Bay Anchovy						0.19*
Black drum					0.24**	
Blue crab	0.24**			0.22**		
Brown shrimp	0.31***			0.36***		
Gulf menhaden						0.22**
Hardhead catfish				0.45***		
Pinfish						
Sand seatrout	0.25**					
Southern flounder	0.24**	0.30***				
Spot				0.20*		0.20*
Atlantic brief Squid			0.30***			
Striped mullet						
Threadfin shad						
White shrimp				0.22**		

*= p<0.01
** = p<0.001
*** = p<0.0001

Table 4.5.6. Significant correlations between monthly catch per unit effort of aquatic species captured in shrimp trawl samples by TPWD from Galveston Bay between 1982 and 2000. (n=225)

Species	Atlantic croaker	Blue crab	Sand seatrout	Menhaden	Striped mullet	Threadfin shad
Croaker						
Anchovy			0.17*	0.26***		0.24**
Black drum					0.35***	
Blue crab	0.39***		0.22**			
Brown shrimp	0.22**	0.21**	0.40***			
Gulf menhaden			0.20*		0.19*	0.34***
Hardhead catfish						0.20*
Pinfish						
Sandtrout	0.19*					
Southern flounder						
Spot	0.19*					
Spotted seatrout					0.43***	
Squid						
Striped mullet						
Threadfin shad						
White shrimp						

* = p<0.01
** = p<0.001
*** = p<0.0001

Table 4.5.7. Significant correlations between monthly catch per unit effort of aquatic species captured in shrimp trawl samples by TPWD from West Bay between 1982 and 2000 (n=277). All species included in the analysis are shown in the first column.

Species	Atlantic croaker	Blue crab	White shrimp	Sandtrout	Striped mullet	Threadfin shad
Croaker						
Anchovy						
Black drum						
Blue crab	0.21*					
Brown shrimp	0.21*	0.34***				
Gulf menhaden						
Hardhead catfish	0.19*			0.30***		
Pinfish			0.25**			
Sandtrout	0.43***					
Southern flounder			0.18*			
Spot	0.18*				0.40***	0.18*
Squid						
Striped mullet						
Threadfin shad						
White shrimp						

* = p<0.01
** = p<0.001
*** = p<0.0001

Gill Net

The species selected for analysis are Atlantic croaker, black drum, red drum, southern flounder, spotted seatrout, and striped mullet captured in gill net sets in Trinity, Galveston and West Bays. The abundance of these species in gill net data appears to be relatively independent. The only correlations of note are between croaker and flounder in Galveston Bay (0.49 p<0.0001) and between red drum and spotted seatrout in West Bay (0.35 p<0.0001). In the principal component analyses, there is a consistent relationship between croaker and flounder in all three sub-bays shown by their high loading on the same principal component. In each bay, the principal component representing croaker and flounder accounts for 20% to 25% of the variation in the data set. This is the only general relationships among the species detected by this analysis, but the relationship is not sufficient to employ either of these species as indicators of a guild or ecosystem.

Spotted seatrout and red drum vary in their association with other species across the sub-bays. In Trinity Bay, spotted seatrout loads highly on the first PC with croaker and flounder. In West Bay, spotted seatrout has a high loading on PC1 with red drum and black drum. However, in Galveston Bay, spotted seatrout is uncorrelated with the other species and has its own factor, PC3. Red drum also loads strongly on principal components with black drum and mullet.