SPECIES COMPOSITION AND ANNUAL, SEASONAL, AND SPATIAL VARIABILITY OF VERTEBRATE AND INVERTEBRATE ASSEMBLAGES IN THE TEXAS SURF ZONE

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

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ABSTRACT

From 1988 through 1995, the Texas Parks and Wildlife Department (TPWD) collected beach seine and bag seine samples during the period from May through November from seven Gulf beach areas along the Texas coast. A total of 36,107 vertebrate organisms and 4,941 invertebrate organisms were collected in beach seines, and a total of 203,249 vertebrate organisms and 28,876 invertebrate organisms were collected in bag seines. The composition, annual variability, seasonal variability, and spatial distribution of the catch were examined with respect to mean values for dissolved oxygen, salinity, water temperature, and turbidity.

The composition of the catch in both sampling gears was found to have been dominated numerically by only a few species. Species abundance varied by as much as a factor of seven from year to year. Annual variability, seasonal variability, and spatial distribution did not appear to be directly related to dissolved oxygen, salinity, water temperature, or turbidity. It was hypothesized that seasonal variability in the abundance of surf-zone organisms was driven by variability in primary productivity in response to water temperature and wave energy.

Beach seines and bag seines are potentially useful tools for providing long-term population trend information for several recreationally and commercially important surf-zone species such as Florida pompano, *Trachinotus carolinus*, spotted seatrout, *Cynoscion nebulosus*, black drum, *Pogonias cromis*, striped mullet, *Mugil cephalus*, blue crabs, *Callinectes sapidus*, and white shrimp, *Litopenaeus setiferus*. However, the TPWD's current fishery-independent sampling program already provides adequate population trend information for these species without the use of beach seines and bag seines in the Texas surf zone.

INTRODUCTION

While the importance of inshore estuarine habitat in the life cycles of numerous marine organisms has been confirmed, less attention has been paid to the role that surf zones of sandy beaches may play in this regard (Anderson et al. 1977, Modde 1980, Ruple 1984). Surf zones are dynamic, high-energy environments characterized by harsh physical conditions (Britton and Morton 1989) which have often been perceived as having depauperate fish assemblages (Brown and McLachlan 1990). However, some studies have shown that these environments are capable of supporting fish and invertebrate assemblages comparable in diversity and biomass to inshore habitats (Pitts 1985, Guillen and Landry 1986, Bennett 1989, Ross et al. 1987). In addition, the presence of large numbers of juveniles associated with surf zones indicates that these habitats might be important nursery areas for a number of species (Modde 1980, Modde and Ross 1981, Ruple 1984, Guillen and Landry 1986, Bennett 1989).

Several studies have been conducted in the surf zone of Gulf of Mexico beaches to assess the importance of the surf-zone habitat in the life history of finfishes and shellfishes (Gunter 1958; Springer and Woodburn 1960; McFarland 1963; Naughton and Saloman 1978; Modde 1980; Modde and Ross 1981, 1983; Ruple 1984; Kittrel et al. 1985; Pitts 1985; Guillen and Landry 1986; Ross et al. 1987). These studies revealed abundant populations of fish and invertebrates associated with the surf zone that are numerically dominated by a few species. Organisms present in the surf zone tended to be small-bodied species or juvenile stages of larger-bodied species. Though the exact composition of the dominant species complex varied from study to study, this general pattern was consistent. Differences in results detected between studies may have been an artifact of differences in collection methods (e.g. mesh size, gear size, method of gear deployment) (McFarland 1963, Modde and Ross 1981). Studies of surf zones on the East Coast of the United States revealed similar patterns where species were the same or cognates of those commonly found on the Gulf Coast (Gunter 1958). While collection areas typically spanned relatively small geographical areas, the similarities between studies along the East and Gulf Coasts imply that patterns are consistent over large geographical areas.

Biomass and abundance of marine organisms in the surf zone were found to vary seasonally, with both peaking in the warmer months and reaching lows in the colder months (Gunter 1958, McFarland 1963, Modde and Ross 1981, Ross et al. 1987). Annual variability could not be determined because previous studies rarely exceeded one annual cycle; however, Gunter (1958) noted differences in species composition in collections made from Mustang Island, TX in different years. Wilber et al. (2003) found that abundance varied between years by as much as an order of magnitude for some of the most abundant taxa in the surf zone of the New Jersey coast.

The Texas Parks and Wildlife Department (TPWD) has monitored the relative abundance of organisms in its inshore bays since 1975 and in the Texas Territorial Sea (TTS) since 1985 (Hensley et al. 2000) using a standardized, fishery-independent sampling program. Long-term trend data based on these types of sampling programs are necessary to effectively manage marine resources (Hensley et al. 2000). In October 1987, TPWD began a long-term sampling program in the surf zone of the Texas Gulf Coast using bag seines and large beach seines.

The purpose of the study was to develop a more comprehensive understanding of seasonal, annual, and spatial variation in Texas' surf-zone vertebrate and invertebrate assemblages, to augment existing knowledge of the life histories of organisms using the surf zone, to determine if the abundance or distribution of these organisms are correlated with certain environmental variables, and to determine any management implications. A summary of the data is presented here.

MATERIALS AND METHODS

From October 1987 through November 1995, beach seine and bag seine samples were collected from seven Gulf beach areas along the Texas coast: 1) Bolivar Peninsula area from Sabine Pass to the Galveston north jetty; 2) Galveston Island area from the Galveston south jetty to the Freeport north jetty; 3) Matagorda Peninsula area from Caney Creek to the Colorado River; 4) Matagorda Island area from Pass Cavallo to Cedar Bayou; 5) San Jose Island area from Cedar Bayou to the Port Aransas north jetty; 6) Padre Island area from the Port Aransas south jetty to Yarborough Pass; and 7) South Padre Island area from the Port Mansfield south jetty to the Rio Grande River (Figure 1).

Six samples were collected monthly with each gear type in each Gulf beach area. Half of the samples in each area were collected between the 1st and the 15th of each sampling month, and the other half between the 16th and 31st of each month. Catches were very low in the winter months from 1987-1989, so beginning in 1990, sampling became seasonal, and samples were collected from May-November only. In 1992, sampling on San Jose Island ceased because of difficulty accessing the beach. Data presented in this report were collected during May-November from 1988-1995. During this period of time, a total of 2,772 samples were collected with each gear type.

Sampling areas were divided into one-minute longitude by one-minute latitude grids that contained at least 15.2 m of sampleable shoreline. Each grid was then subdivided into 144 five-second "gridlets." Sample grids were randomly chosen, and sample sites were randomly chosen from among all "gridlets" that contained sampleable shoreline within the sample grid. No grid was sampled more than once during a month.

Beach seines were 60.9 m long by 1.8 m deep and were constructed of 76 mm stretched #12 monofilament mesh. Bag seines were 18.3 m long by 1.8 m deep, with 8.3 m long wings and a 1.8 m wide bag. The wings were constructed of 19 mm stretched #5 multifilament nylon mesh, and the bag of 13 mm stretched #5 multifilament nylon mesh.

Immediately prior to the collection of each sample, salinity (‰) was measured with a refractometer, dissolved oxygen (mg/l) was measured with a portable hand-held dissolved oxygen meter, and water temperature (^{0}C) was measured with a hand-held thermometer. A water sample was then collected for transport to the lab for turbidity (NTU) analysis.

Both gears were deployed in the direction of the longshore current, parallel to the shore (for details on gear deployment, see Appendix A). The amount of surface area sampled was calculated to the nearest 0.01 ha by multiplying the distance the gear was pulled by the length of extension of the seine. After gear recovery, captured organisms were counted, and up to 19 individuals of each species were measured in each sample. Catch rates were calculated by dividing the number of each species captured by the surface area sampled. Due to the difficulties inherent in counting organisms belonging to certain phylogenetic groups, they were assigned a density code in lieu of counting. These organisms included all members of Phylums Porifera, Ctenophora, and Bryozoa; all members of Classes Hydrozoa, Scyphozoa (except *Stomolophus meleagris*), and Ascidiacea; and all members of Order Gorgonacea. These density-coded organisms have been excluded from the results presented in this report.

Mean values for hydrological parameters, and catch rates and body size of organisms caught were calculated using Microsoft Access. Results are reported by Gulf beach area, year, and month. No estimates of variability were calculated, and no hypotheses were tested.

RESULTS

Hydrological Data

A cursory examination of hydrological data values and trends for bag seine and beach seine samples revealed that they were nearly identical for the two gears, so data for both gears were pooled and reported here as a mean of the values for each gear.

Mean water temperatures ranged from 26.0 to 26.8 C across Gulf beach sampling areas (Figure 2). Mean temperatures were slightly lower along the upper (northeastern) part of the Texas coast than on the lower (southern) part of the Texas coast. Mean annual temperatures ranged from 25.8 to 26.9 C (Figure 3). Mean monthly temperatures from May-November ranged from 20.3 to 29.6 C (Figure 4). Temperatures were lowest in November and highest in August.

Mean salinities increased from the upper to the lower Texas coast (Figure 2). They ranged from 25.3 ‰ in the Bolivar Peninsula area to 33.9 ‰ in the South Padre Island area. Mean annual salinity ranged from 28.7 to 32.9 ‰ (Figure 3). Mean monthly salinities from May-November ranged from 26.4 to 33.0 ‰ (Figure 4). Salinities were lowest in May, peaked in August, and decreased through November.

Mean dissolved oxygen (DO) ranged from 5.8 to 7.0 mg/l across Gulf beach sampling areas (Figure 2). Mean DO was highest in the Matagorda Island area and lowest in the South Padre Island area. Mean annual DO ranged from 6.2 to 6.7 mg/l (Figure 3). Mean monthly DO from May-November ranged from 6.1 to 7.5 mg/l (Figure 4). DO was lowest in August and highest in November.

Mean turbidities were highest on the upper Texas coast and lowest on the lower Texas coast (Figure 2). Mean turbidity ranged from 61 NTU in the Bolivar Peninsula area to 11 NTU in the San Jose Island area. Mean annual turbidity ranged from 22 NTU to 35 NTU (Figure 3). Mean monthly turbidities from May-November ranged from 18 to 35 NTU (Figure 4). Turbidities were lowest in September and highest in July.

Species Composition

A total of 36,107 vertebrate organisms and 4,941 invertebrate organisms were collected in beach seines (Tables 1 and 2). Of those, 36,100 individual vertebrate organisms were identified to the species level, and 93 species were identified. Eighty-two percent of the total vertebrate catch was comprised of six species: striped mullet, *Mugil cephalus*; striped anchovy, *Anchoa hepsetus*; Florida pompano, *Trachinotus carolinus*; hardhead catfish, *Arius felis*; black drum, *Pogonias cromis*; and spotted seatrout, *Cynoscion nebulosus* (Figure 5). Mean annual and monthly catch rates and size of the most abundant vertebrate species sampled with beach seines are reported by Gulf beach area in Tables 3 and 4, respectively.

Of the invertebrates sampled with beach seines, 4,763 individual organisms were identified to the species level, and 22 species were identified. Ninety-one percent of the total invertebrate catch was comprised of four species: blue crab, *Callinectes sapidus*; speckled swimming crab, *Arenaeus cribrarius*; cabbagehead jellyfish, *Stomolophus meleagris*; and brown grass-shrimp, *Leander tenuicornis* (Figure 5). Blue crabs and speckled swimming crabs made up 85% of the catch. Of the 178 invertebrate organisms not identified to the species level, 166 of them were members of Order Actiniaria. Mean annual and monthly catch rates and size of the most abundant invertebrate species sampled with beach seines are reported by Gulf beach area in Tables 5 and 6, respectively.

A total of 203,249 vertebrate organisms and 28,876 invertebrate organisms were collected in bag seines (Tables 7 and 8). Of those, 192,444 individual vertebrate organisms were identified to the species level, and 109 species were identified. Eighty percent of the total vertebrate catch was comprised of six species: Florida pompano, *Trachinotus carolinus*; Atlantic threadfin, *Polydactylus octonemus*; scaled sardine, *Harengula jaguana*; Gulf kingfish, *Menticirrhus littoralis*; bay anchovy, *Anchoa mitchilli*; and striped anchovy, *Anchoa hepsetus* (Figure 6). An additional 10,108 organisms (5% of the total catch) were unidentified anchovies (Family Engraulidae). Mean annual and monthly catch rates and size of the most abundant vertebrate species sampled with bag seines are reported by Gulf beach area in Tables 9 and 10, respectively.

Of the invertebrates sampled with bag seines, 28,851 individual organisms were identified to the species level, and 51 species were identified. Ninety-one percent of the total invertebrate catch was comprised of four species: seabobs, *Xiphopenaeus kroyeri*; speckled swimming crab, *Arenaeus cribrarius*; white shrimp, *Litopenaeus setiferus*; and blue crab, *Callinectes sapidus* (Figure 6). Mean annual and monthly catch rates and size of the most abundant invertebrate species sampled with bag seines are reported by Gulf beach area in Tables 11 and 12, respectively.

Annual Variability

Mean annual catch rates for vertebrates and invertebrates collected in both gears were highly variable from year to year. The mean annual catch rate for vertebrates sampled with beach seines ranged from 55.5/ha in 1994 to 24.7/ha in 1993 (Figure 7). The mean annual catch rate of invertebrates sampled with beach seines ranged from 9.6/ha in 1991 to 2.5/ha in 1993 (Figure 7). The mean annual catch rate of vertebrates sampled with bag seines ranged from 4,622.5/ha in 1995 to 1,307.1/ha in 1992 (Figure 8). The mean annual catch rate of invertebrates sampled with bag seines ranged from 1,305.5/ha in 1991 to 185.7/ha in 1993 (Figure 8).

The trends in annual abundance exhibited by invertebrates and vertebrates sampled with both gears showed some similarities. In each case, catch rates were high in 1991. Catch rates were also relatively high in 1988, 1994, and 1995. Catch rates in 1993 were the lowest recorded for invertebrates sampled with both gears and for vertebrates sampled with beach seines, but not for vertebrates sampled with bag seines. Catch rates for vertebrates and invertebrates sampled with both gears were relatively low in 1990.

Blue crabs, speckled swimming crabs, and striped mullet were consistently dominant in beach seines, and annual variability in overall catch rates was driven by variability in the catch rates of these species (Figure 7). In contrast, in bag seine samples, Florida pompano were the dominant vertebrate species overall and were caught in relatively consistent numbers throughout the study but were not consistently the dominant vertebrate species from year to year (Figure 8). From year to year, the dominant vertebrate species changed. For example, in 1988 and 1991, Atlantic threadfin were dominant, and in 1989, scaled sardines were dominant. Annual variability in overall abundance was driven by the abundance of these ephemeral fish species. Similarly, speckled swimming crabs were caught in relatively consistent numbers in bag seines and were typically the dominant invertebrate species, except in 1988 and 1991, when large numbers of seabobs were caught and drove the overall catch rates to the second-highest and highest levels recorded, respectively (Figure 8).

Seasonal Variability

The mean monthly catch rate for vertebrates sampled from May-November with beach seines was highest in May, June, and July, peaking in June at 67.9/ha (Figure 9). The mean catch rate then fell to 33.0/ha in August and continued to decline to a low of 19.0/ha in November. The mean catch rate of invertebrates sampled from May-November with beach seines peaked in July at 8.7/ha then fell to 4.3/ha in August and continued to decline to a low of 2.6/ha in November (Figure 9). The mean monthly catch rate for vertebrates sampled from May-November with bag seines was high in May (4,990.5/ha) and declined through August to 2,393.8/ha (Figure 10). In September, the mean monthly catch rate peaked at 5,882.1/ha then fell to 1,158.2/ ha in October and reached a low of 401.7/ha in November. The mean monthly catch rate for invertebrates sampled from May-November with bag seines exhibited a minor peak in June (412.0/ha) followed by a low of 165.3/ha in August, another minor peak in September (382.5/ha), and a high of 1,116.7/ha in November (Figure 10).

The seasonal trends in abundance of vertebrates and invertebrates sampled with beach seines were similar. Overall catch rates were highest in late spring and early summer, and decreased through the fall. The decline in the overall catch rate of invertebrates was a result of fewer blue crabs in the samples in late summer and fall (Figure 9). Numbers of speckled swimming crabs sampled in beach seines remained relatively consistent from May-November.

The seasonal trend in abundance of vertebrates was driven largely by the presence of striped mullet (Figure 9). The catch rate for striped mullet peaked in July, reached a low in September, and increased slightly through November. Striped anchovies comprised about 8% of the catch in May and about 33% of the catch in June but did not make up a significant portion of the catch in other months. Florida pompano were present from May-November but were slightly more abundant in July and August.

The seasonal trend in abundance of vertebrates sampled with bag seines was similar to those for beach seines, except that the overall catch rate peaked in September as a result of a dramatic increase in the number of scaled sardines and "other" species sampled (Figure 10). The dominant species, Florida Pompano, was most abundant May-June, decreasing in abundance steadily through November. Atlantic threadfin were the dominant species in May but were virtually absent from samples by July.

The seasonal trend in abundance of invertebrates sampled with bag seines was almost the reverse of that for beach seines. Samples in the fall were dominated by seabobs, which peaked in abundance in November, driving the overall catch rate in November to almost three times that of the next highest month, June (Figure 10). Excluding seabobs, the seasonal trend in abundance of invertebrates sampled with bag seines was similar to that for invertebrates and vertebrates sampled with beach seines. Speckled swimming crabs were present in samples from May-November but were most abundant in late spring and summer.

Spatial Distribution

The mean catch rate for vertebrates sampled with beach seines was highest in the Galveston Island area and lowest in the South Padre Island area (Figure 11). The mean catch rate ranged from 60.0/ha to 15.7/ha. The mean catch rate for invertebrates sampled with beach seines was also highest in the Galveston Island area and lowest in the South Padre island area (Figure 11). The mean catch rate ranged from 12.5/ha to 2.2/ha. The mean catch rate for vertebrates sampled with bag seines was highest in the North Padre Island area and lowest in the Matagorda Peninsula area (Figure 12). The mean catch rate ranged from 6,677.7/ha to 1,729.2/ha. The mean catch rate for invertebrates sampled with bag seines was highest in the Matagorda Peninsula area and lowest in the South Padre Island area (Figure 12). The mean catch rate ranged from 1,020.2/ha to 26.8/ha.

Invertebrates sampled in both gears tended to be more abundant on the upper Texas coast than on the lower Texas coast. Seabobs, speckled swimming crabs, and blue crabs were all more abundant on the upper Texas coast than on the lower Texas coast (Figures 11 and 12). Seabobs, which were the most abundant invertebrate sampled in bag seines, were completely absent from samples collected on the lower Texas coast.

This pattern did not hold up for vertebrates sampled in either gear when the collective catch rate was examined. However, striped mullet, the dominant vertebrate species sampled with beach seines, were more abundant on the upper Texas coast (Figure 11). Scaled sardines sampled with bag seines and striped anchovies sampled with beach seines, on the other hand, were both much more abundant on the lower Texas coast (Figures 11 and 12).

DISCUSSION

Species Composition

The numerical dominance of the Texas surf zone by a relative handful of vertebrate and invertebrate species is typical of surf-zone communities (Gunter 1958, McFarland 1963, Anderson et al. 1977, Ross et al. 1987, Santos and Nash 1995, Wilber et al. 2003). The composition of the invertebrate and vertebrate communities reported here were very similar to those reported elsewhere for the Gulf surf zone (Gunter 1958, McFarland 1963, Modde and Ross 1981, Kittrel et al. 1985, Ross et al. 1987). Gunter (1958), McFarland (1963), and Kittrel et al. (1985) all reported the same dominant species respective to the sampling gear. Ross et al. (1987) reported the same species but with different relative abundance.

Differences in dominant species complexes reported in the literature may have been the result of a failure of short-term studies to capture annual variability rather than actual differences in the spatial distribution of dominant species. Wilber et al. (2003) found that surf-zone community composition and species abundance along a New Jersey shore varied over both temporal and spatial scales, and the dominant species changed from year to year.

Annual Variability

Annual variability in the abundance of vertebrates and invertebrates sampled with both gears in this study was substantial, with the highest catch rates exceeding the lowest catch rates by as much as a factor of seven. There were some similarities in the trends in annual abundance between invertebrate and vertebrate organisms across both gear types, but no consistent pattern existed. The trends in annual abundance of invertebrate organisms sampled with both gears were similar to each other but were unlike the trends in annual abundance for vertebrate organisms sampled in either gear. In addition, the trend in annual abundance of vertebrate organisms sampled with beach seines was different than that of vertebrate organisms sampled with bag seines.

Using bag seines in a New Jersey surf zone, Wilber et al. (2003) found that the dominant species changed from year to year and that dominants varied in abundance by an order of magnitude among years. Similarly, from 1988-1995 along the Texas coast, the dominant vertebrate and invertebrate species sampled with bag seines changed from year to year. However, during the same time period, the dominant vertebrate and invertebrate species sampled with beach seines remained constant. The ability of the bag seines to capture small-bodied organisms may explain the differences between beach seine and bag seine samples in both the overall trends in annual vertebrate abundance and patterns of species dominance. Small-bodied organisms may typically be characterized as R-selected species, which by definition are more ephemeral in nature than larger K-selected species (Pianka 1994).

Annual trends in catch rate for vertebrate and invertebrate organisms sampled with both gear types were seemingly unrelated to trends in water temperature, salinity, dissolved oxygen, and turbidity. Ross et al. (1987) proposed a hierarchical structure of factors influencing species occurrence and abundance in surf zones in which the primary factor affecting year-class strength and recruitment processes, and therefore annual variability, was large-scale climatic events rather than short-term physicochemical factors such as temperature and salinity.

Seasonal Variability

Low catch rates in the winters of 1987-89 prompted TPWD to abandon year-round sampling in favor of seasonal sampling from May-November; therefore seasonal trends discussed here are limited to the period from late spring through late fall. However, the low catch rates in the winter months of 1987-89 are consistent with what has been previously reported for Texas Gulf beaches (Gunter 1958, McFarland 1963).

The late spring and early summer peaks in abundance that occurred for invertebrates and vertebrates sampled with both gear types are also consistent with what has been reported in the literature (Gunter 1958, McFarland 1963, Modde and Ross 1981). A second peak in abundance of vertebrate organisms sampled with bag seines occurred in September. Using similar gear, Modde and Ross (1981) reported peaks in abundance of fishes in August 1975-76, and in September 1977. Also using bag seines, Gunter (1958) reported a peak of scaled sardines *(H. jaguana)* in September. In the present study about 40% of the September vertebrate catch in bag seines was comprised of scaled sardines.

Scaled sardines are among the species that most readily utilize the Gulf surf zone as a nursery area (Ruple 1984). They spawn offshore (Houde 1977), and larvae begin appearing on Gulf beaches at a length of about 20 mm in spring, followed by a second wave of recruitment in early summer (Modde 1980, Ruple 1984). Modal length of juvenile scaled sardines captured in the surf zone of Horn Island Mississippi was 31-35 mm in June (Modde 1980). Scaled sardines first became susceptible to capture in our bag seines at about 30 mm TL, and the mean size of fish captured was 45 mm TL. Assuming the timing of onshore movements and growth of scaled sardines along Texas beaches is similar to movement patterns and growth in Mississippi, scaled sardines would begin recruiting to the bag seines in June or July with peak catch rates occurring in August or September, as observed. Therefore, while the catch rate of scaled sardines was high in September, the actual abundance of this species was probably much higher in late spring and early summer. In the surf zone of Horn Island almost 90% of larvae and post larval fishes collected were collected during spring and summer (Ruple 1984).

It is well known that physicochemical parameters such as temperature and salinity are important factors influencing the distribution and abundance of inshore estuarine fishes. However, factors affecting the spatial and temporal distribution and abundance of surf-zone fishes have not been studied extensively. None of the four physicochemical parameters measured in this study appeared to correlate well with the overall seasonal trend in abundance of organisms in the surf from May-November, but temperature seems to play a role in influencing seasonal abundance if the entire annual cycle is considered. Anderson et al. (1977) found temperature to be a significant factor in determining seasonal abundance of surf-zone fishes on a South Carolina beach. Modde and Ross (1981) also found temperature to be a significant factor in determining seasonal abundance of surf-zone fishes in the Gulf. The low catch rates of organisms on Texas beaches in the winters of 1987-89 support their findings.

Some studies have implicated turbidity as a potential factor influencing species abundance in surf zones. On King's Beach in South Africa, wind speed was found to be the primary determinant of fluctuations in abundance, but it was suggested that unmeasured variables related to wind speed such as turbidity or wave action might actually be driving variability in abundance (Lasiak 1984). Blaber and Blaber (1980) found that distribution patterns of estuarine fish were correlated with turbidity and Ross et al. (1987) noted that fish abundance in the surf was low during times of clear water which occurred in conjunction with diminished wave activity. One possible mechanism by which turbidity might influence the abundance of surf-zone organisms is by affecting predator/prey dynamics. It has been suggested that the surf zone serves as a refuge from predators for juveniles of larger species, and adults of many small-bodied species. Any aspect of the environment that affects its ability to function in this respect is potentially important in shaping the community (Modde 1980, Modde and Ross 1981, Ruple 1984, Guillen and Landry 1986, Bennett 1989). An increase in turbidity could provide more protection from predators. However, when the increase in turbidity is generated by turbulence, this could also disorient prey species and render them more vulnerable to capture by predators (Moyle and Cech 1988).

From May-August there appeared to be a positive relationship between the abundance of organisms captured in beach and bag seines and turbidity, but from September-November, there appeared to be no correlation. This inconsistency suggests the absence of a direct causal relationship between turbidity and abundance; however, it is possible that turbidity and one or more other factors such as temperature interact to influence the seasonal abundance of surf-zone organisms.

The seasonal pattern of turbidity in the surf is largely a product of wave energy. Wave energy plays a significant role in controlling primary productivity (Brown and McLachlan 1990). An increase in wave energy can translate to an increase in primary productivity, resulting in greater food availability for fish and invertebrates in the surf (Brown and McLachlan 1990). Thus in theory, the surf zone has the potential to support more organisms when turbidity (i.e. wave energy) is high. Shelton and Robertson (1981) found that intertidal macrofauna on a high-energy beach in Texas was three times more abundant than on a lower-energy beach. This may be particularly true if the increased wave energy is coupled with an increase in water temperature and a resultant increase in the overall rate of metabolic activity in the surf zone.

Brown and McLachlan (1990) categorized sandy-shore beaches into two major types: (1) beaches with little or no surf zone, which are dependent on food imports from the sea and; (2) beaches with extensive surf zones sustaining sufficient primary productivity to be self-supporting. The fundamental difference between these two beach systems revolves primarily around incident wave energy and surf circulation patterns.

Texas Gulf beaches fall into the latter category of "self-supporting." Characteristic features of this type of beach include high primary productivity and high biomass. Measurements of phytoplankton productivity in the surf zone of Mustang Island, Texas and rough estimates of fish metabolism and carbon requirements indicated that plankton productivity in the surf zone was sufficient to support the fish populations during the summer (McFarland 1963).

Phytoplankton respiration on Mustang Island was lowest in winter and peaked in spring before leveling off at a rate four times greater than in winter (McFarland 1963). Increased phytoplankton productivity coincided with increased biomass of fishes. Because surf-zone food webs tend to be dependent on primary productivity and suspended organic detritus, and they are less buffered against seasonal changes in food availability than inshore estuarine food webs, low abundance of organisms in winter months may be the result of food limitation as primary productivity declines (McLachlan 1980, Ross et al. 1987). In summary, evidence suggests that the Texas surf zone is a self-supporting system in which water temperature and wave energy drive seasonal fluctuations in primary productivity, which in turn drives seasonal trends in abundance of surf-zone organisms.

Spatial Distribution

A careful review of the literature revealed few studies that have attempted to evaluate factors influencing spatial distribution of surf-zone organisms and none that have examined spatial variation on a scale equivalent to the present study. Romer (1990) found that wave energy influenced spatial distribution of surf-zone organisms, and Ayvazian and Hyndes (1995) found that near shore currents influenced surf-zone community composition on a spatial scale. Ross et al. (1987) theorized that point abundance of surf-zone organisms is governed by short-term physicochemical factors such as wave height, salinity, temperature, and wind speed.

Mean overall catch rates of surf-zone organism along the Texas coast were highly variable from one sampling area to the next. Catch rates of vertebrates in both gears were relatively low at South Padre Island and Matagorda Peninsula, but there did not appear to be any relationship between the spatial distribution of vertebrate organisms and the four measured variables. No other patterns in the spatial distribution of vertebrates were discernable. Perhaps this is not surprising given the similarities in surf-zone fish assemblages across the Gulf. However, when the distributions of catch rates of the most abundant species were examined, a gradient in the distribution of striped mullet, scaled sardines, and striped anchovies from the upper coast to the lower coast became apparent. The gradient was also apparent in the distribution of invertebrates sampled with both gears. Invertebrates as a whole were more abundant on the upper coast largely as a result of inequities in the distribution of the two most abundant invertebrates sampled. Blue crabs and seabobs were both much more abundant on the upper coast. In fact, seabobs were completely absent from lower coast samples. The differences between the upper coast to the lower coast in the distribution of organisms appeared to be more pronounced with invertebrate organisms than with vertebrates. Perhaps the relative lack of mobility of invertebrates compared to fishes makes them more sensitive to local conditions.

A number of physical differences are manifest between the upper and lower Texas coast. Rainfall varies from an average of 140 cm annually around Sabine Pass to less than 74 cm annually in the Brownsville area (Britton and Morton 1989). Consequently, upper coast bay systems receive more freshwater inflow than lower coast bay systems. The continental shelf is wider (200 km) on the upper coast than on the lower coast (110 km) and not as steep on the upper coast as it is on the lower coast (TPWD 2001). For example, the maximum depth within the TTS is 15 m on the upper coast and 28 m on the lower coast (TPWD 2001). Current circulation patterns on the upper coast also differ from those on the lower coast. In the summertime, the prevailing southwesterly longshore current on the upper coast collides with the northbound longshore current of the lower coast at a point known as Big Shell on Padre Island (Britton and Morton 1989). As a result of these differences in current circulation patterns as well as rainfall patterns, water clarity, salinity, and sediment composition all differ from the upper coast to the lower coast (Britton and Morton 1989). Each of these factors is among those known to influence nearshore faunal assemblages (TPWD 2001). With so many variables potentially influencing the spatial distribution of surf-zone organisms, it is difficult to identify the specific factors that are most influential. It is likely that the whole suite of factors work in concert to govern the spatial distribution of organisms in the surf zone of Texas.

MANAGEMENT IMPLICATIONS

Eight years of data collection along the Gulf beaches of Texas resulted in what is likely the largest collection of data on surf-zone organisms in the world. This dataset contains a wealth of information pertaining to the life histories of organisms utilizing the Gulf surf-zone habitat. A number of these species have recreational and/or commercial value. The information gathered on these species will be valuable when making informed management decisions regarding these species in the future.

Based on the relative abundance of organisms in the samples, beach seine sampling has the potential to be a useful tool for providing long-term population trend information for striped mullet, Florida pompano, black drum, spotted seatrout, and blue crabs. Bag seine sampling has the potential to provide useful trend information on populations of Florida pompano, Gulf kingfish, seabobs, and white shrimp. Long-term monitoring programs are expensive, however, and the inherent difficulties associated with sampling the surf zone add to the cost. Adequate population trend information for striped mullet, black drum, spotted seatrout, blue crabs, and white shrimp is already provided by the current TPWD fishery-independent monitoring program (Hensley et al. 2000). TPWD's ability to monitor trends in the populations of Florida pompano, Gulf kingfish, and seabobs could be improved by the use of beach and bag seine sampling in the surf zone, but given the relatively low level of interest by commercial and sport fishermen in these species, and the additional cost incurred to monitor them, surf-zone sampling was terminated in 1995.

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TABLE 1. Coastwide abundance, catch rates, and mean size of vertebrate species sampled with beach seines (1988-1995).

Scientific Name	Abundance	Catch Rate (#/ha)	Mean Size (TL mm)
Mugil cephalus	21,252	324.81	343
Anchoa hepsetus	2,247	34.34	42
Trachinotus carolinus	2,074	31.70	130
Arius felis	1,653	25.26	333
Pogonias cromis	1,453	22.21	271
Cynoscion nebulosus	1,109	16.95	424
Anchoa nasuta	609	9.31	33
Leiostomus xanthurus	579	8.85	234
Harengula jaguana	539	8.24	37
Polydactylus octonemus	521	7.96	134
Menticirrhus littoralis	470	7.18	257
Mugil curema	422	6.45	69
Sciaenops ocellatus	370	5.65	376
Dasyatis sabina	320	4.89	162
Chaetodipterus faber	320	4.89	129
Brevoortia patronus	308	4.71	175
Micropogonias undulatus	226	3.45	259
Paralichthys lethostigma	211	3.22	273
Elops saurus	192	2.93	423
Chloroscombrus chrysurus	129	1.97	190
Trachinotus goodei	127	1.94	235
Menticirrhus americanus	116	1.77	262
Astroscopus y-graecum	106	1.62	255
Selene vomer	86	1.31	138
Cynoscion arenarius	67	1.02	301
Archosargus probatocephalus	57	0.87	340
Larimus fasciatus	43	0.66	57
Lagodon rhomboides	43	0.66	152
Trachinotus falcatus	41	0.63	185
Anchoa mitchilli	36	0.55	45
Scomberomorus maculatus	35	0.53	373
Caranx hippos	34	0.52	169
Opisthonema oglinum	33	0.50	75
Carcharhinus limbatus	32	0.49	567
Menidia beryllina	28	0.43	60

Table 1. Cont.

Scientific Name	**Abundance**	**Catch Rate (#/ha)**	**Mean Size (TL mm)**
Pomatomus saltatrix	26	0.40	344
Hemicaranx amblyrhynchus	19	0.29	51
Stellifer lanceolatus	15	0.23	94
Centropomus undecimalis	12	0.18	408
Dasyatis americana	10	0.15	493
Selene setapinnis	10	0.15	152
Membras martinica	9	0.14	45
Dorosoma cepedianum	6	0.09	280
Strongylura marina	6	0.09	382
Bagre marinus	5	0.08	325
Orthopristis chrysoptera	5	0.08	241
Rhinoptera bonasus	5	0.08	413
Abudefduf saxatilis	5	0.08	36
Paralichthys albigutta	5	0.08	228
Citharichthys spilopterus	4	0.06	168
Peprilus alepidotus	4	0.06	179
Umbrina coroides	4	0.06	189
Chelonia mydas	3	0.05	180
Family *Clupeidae*	3	0.05	N/A
Narcine brasiliensis	3	0.05	249
Sphyrna tiburo	3	0.05	521
Carcharhinus isodon	3	0.05	800
Peprilus burti	3	0.05	138
Fundulus grandis	2	0.03	65
Histrio histrio	2	0.03	55
Lutjanus griseus	2	0.03	373
Cynoscion nothus	2	0.03	73
Rhinobatos lentiginosus	2	0.03	741
Rhizoprionodon terraenovae	2	0.03	655
Family *Mugilidae*	2	0.03	25
Scomberomorus cavalla	2	0.03	40
Family *Carangidae*	2	0.03	42
Negaprion brevirostris	2	0.03	660
Synodus foetens	2	0.03	N/A
Balistes capriscus	2	0.03	40

Table 1. Cont.

Scientific Name	Abundance	Catch Rate (#/ha)	Mean Size (TL mm)
Oligoplites saurus	2	0.03	130
Pomadasys crocro	1	0.02	47
Gymnura micrura	1	0.02	390
Agonostomus monticola	1	0.02	40
Eucinostomus argenteus	1	0.02	66
Mustelus canis	1	0.02	825
Menidia peninsulae	1	0.02	50
Centropomus parallelus	1	0.02	357
Sphyrna lewini	1	0.02	555
Menticirrhus saxatilis	1	0.02	290
Aetobatis narinari	1	0.02	555
Dorosoma petenense	1	0.02	276
Monacanthus hispidus	1	0.02	40
Cyprinodon variegatus	1	0.02	31
Trichiurus lepturus	1	0.02	405
Eucinostomus gula	1	0.02	46
Kyphosus incisor	1	0.02	212
Dasyatis say	1	0.02	195
Sardinella aurita	1	0.02	100
Bairdiella chrysoura	1	0.02	220
Conodon nobilis	1	0.02	69
Trinectes maculatus	1	0.02	120
Syacium gunteri	1	0.02	145
Paralichthys squamilentus	1	0.02	234
Lepidochelys kempi	1	0.02	332
Diapterus auratus	1	0.02	195

TABLE 2. Coastwide abundance, catch rates, and mean size of invertebrate species sampled with beach seines (1988-1995).

Scientific Name	Abundance	Catch Rate (#/ha)	Mean Size (TL mm)
Callinectes sapidus	2,251	34.4	137
Arenaeus cribrarius	1,943	29.7	89
Order Actiniaria	166	2.54	21
Stomolophus meleagris	164	2.51	N/A
Leander tenuicornis	151	2.31	25
Scyllaea pelagica	117	1.79	N/A
Pagurus pollicaris	26	0.40	N/A
Portunus sayi	19	0.29	25
Callinectes similis	13	0.20	96
Latreutes parvulus	11	0.17	27
Xiphopenaeus kroyeri	11	0.17	81
Beroe ovata	10	0.15	N/A
Penaeus setiferus	10	0.15	136
Neverita duplicata	9	0.14	83
Simnialena marferula	7	0.11	2
Alpheus estuariensis	6	0.09	29
Class Asteroidea	6	0.09	115
Luidia clathrata	5	0.08	150
Order Nudibranchia	5	0.08	N/A
Libinia dubia	4	0.06	15
Libinia emarginata	2	0.03	112
Phylum Mollusca	1	0.02	N/A
Loligo pealeii	1	0.02	19
Penaeus aztecus	1	0.02	47
Pagurus longicarpus	1	0.02	N/A
Ocypode quadrata	1	0.02	44

TABLE 3. Annual catch rates (CPUE) and mean size (MS) of the most abundant vertebrates sampled with beach seines by Gulf beach area (May-November).

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Anchoa hepsetus																
1988	0.00		0.00		0.00		88.78	39	0.00		0.00		0.00		12.68	39
1989	0.00		0.23	33	0.12	57	0.00		7.33	34	0.00		0.00		1.10	41
1990	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
1991	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
1992	0.00		0.00		0.00				0.00		0.00		0.00			
1993	0.00		0.00		0.00				0.34	36	0.00		0.00		0.06	36
1994	0.00		0.00		0.00				31.04	53	0.00		0.00		5.17	53
1995	0.00		0.00		0.00				0.00		0.00		0.00			
Mean	**0.00**		**0.03**	**33**	**0.02**	**57**	**22.19**	**39**	**4.84**	**41**	**0.00**		**0.00**		**2.38**	**42**
Arius felis																
1988	11.96	336	0.74	291	1.87	323	1.47	330	0.00		0.00		1.25	321	2.47	320
1989	2.21	326	0.91	270	3.24	337	1.30	347	0.23	356	0.06	326	1.65	326	1.37	327
1990	4.99	323	0.96	342	2.83	344	2.32	351	0.06	282	0.06	532	4.52	336	2.25	359
1991	7.54	324	0.91	331	1.36	316	1.36	347	0.11	330	0.06	365	0.98	385	1.76	343
1992	0.74	346	0.45	319	4.20	352			0.34	301	0.00		1.68	344	1.23	333
1993	2.04	327	0.00		0.68	353			0.34	292	0.06	290	0.57	349	0.61	322
1994	16.33	323	0.57	307	1.47	334			0.17	307	0.11	328	0.51	327	3.19	321
1995	5.73	347	1.47	318	1.25	345			0.11	304	0.00		1.76	339	1.72	330
Mean	**6.44**	**332**	**0.75**	**311**	**2.11**	**338**	**1.62**	**344**	**0.17**	**310**	**0.04**	**368**	**1.61**	**341**	**1.83**	**332**
Cynoscion nebulosus																
1988	3.40	417	2.04	442	0.74	408	0.28	425	0.11	460	0.46	476	2.36	384	1.34	430
1989	1.02	443	4.25	452	0.61	384	0.68	426	0.97	458	0.34	438	0.79	451	1.24	436
1990	1.76	438	2.04	448	0.17	412	0.23	408	0.74	457	0.74	485	1.31	433	1.00	440
1991	3.23	414	1.42	478	0.40	335	0.79	396	0.40	394	0.23	414	1.69	426	1.16	408
1992	1.30	423	1.47	442	0.51	388			0.74	468	0.06	489	3.12	434	1.20	441
1993	1.19	420	1.25	490	0.79	414			0.85	412	0.34	491	1.36	468	0.96	449
1994	1.08	433	1.30	436	1.76	416			3.44	410	0.40	493	0.68	419	1.44	434
1995	2.21	407	1.36	402	0.57	439			2.05	463	0.68	478	2.61	414	1.58	434
Mean	**1.90**	**424**	**1.89**	**449**	**0.69**	**399**	**0.50**	**413**	**1.16**	**440**	**0.40**	**470**	**1.74**	**429**	**1.24**	**434**

Table 3. Cont.

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Mugil cephalus																
1988	25.06	365	29.82	359	9.18	361	1.87	359	20.80	357	4.72	345	6.46	337	13.99	355
1989	31.80	368	31.69	343	3.24	344	0.45	351	2.35	351	8.19	355	4.64	338	11.77	350
1988	25.06	365	29.82	359	9.18	361	1.87	359	20.80	357	4.72	345	6.46	337	13.99	355
1989	31.80	368	31.69	343	3.24	344	0.45	351	2.35	351	8.19	355	4.64	338	11.77	350
1990	43.37	353	54.59	340	5.84	344	5.16	346	5.10	337	6.01	375	5.04	331	17.87	347
1991	29.76	349	74.43	318	18.76	335	52.15	338	15.93	325	13.10	346	34.18	329	34.05	334
1992	27.66	345	62.70	345	71.15	348			24.77	367	9.64	340	9.23	335	34.19	347
1993	19.50	355	26.02	342	17.01	349			9.73	354	12.53	356	11.11	330	15.98	348
1994	25.34	359	30.73	338	42.63	349			36.83	366	6.18	368	14.00	355	25.95	356
1995	36.11	354	55.61	350	42.52	338			14.34	383	8.11	365	59.01	336	35.95	354
Mean	**29.83**	**356**	**45.70**	**342**	**26.29**	**346**	**14.91**	**348**	**16.23**	**355**	**8.56**	**356**	**17.96**	**336**	**23.72**	**349**
Other																
1988	15.02	267	3.63	239	2.72	267	3.97	208	10.15	240	5.76	355	2.92	295	6.31	267
1989	5.50	231	6.75	185	15.57	168	11.17	189	27.66	218	4.70	261	4.17	210	10.79	209
1990	3.00	207	6.58	206	4.93	303	9.75	215	4.31	260	3.91	272	2.03	279	4.93	249
1991	7.03	260	9.13	207	5.84	209	5.61	256	5.78	220	5.27	299	4.29	285	6.14	248
1992	3.63	333	6.46	267	7.48	287			3.12	279	2.83	307	2.34	306	4.31	297
1993	3.29	264	3.23	234	2.83	291			5.58	183	7.77	271	1.81	307	4.09	259
1994	5.05	246	4.93	253	2.32	357			57.54	189	7.31	224	1.76	351	13.15	270
1995	9.30	284	10.37	208	1.98	318			7.92	224	4.76	349	3.12	289	6.24	279
Mean	**6.48**	**262**	**6.38**	**225**	**5.46**	**275**	**7.62**	**217**	**15.26**	**227**	**5.29**	**292**	**2.80**	**290**	**6.99**	**260**
Pogonias cromis																
1988	1.02	231	0.96	233	0.79	300	0.11	287	0.28	334	0.00		0.69	249	0.55	272
1989	1.87	259	3.46	263	1.65	259	1.13	241	2.00	229	0.34	216	0.86	228	1.62	242
1990	1.76	300	1.76	258	1.30	313	2.83	298	1.47	287	0.91	355	1.57	264	1.66	296
1991	2.15	295	3.80	235	0.96	293	2.04	255	16.38	252	0.68	217	1.27	235	3.90	254
1992	0.45	252	3.68	248	3.85	324			2.32	273	0.23	362	0.72	249	1.88	285
1993	1.13	284	1.70	289	2.27	353			1.31	345	0.68	350	0.06	525	1.19	358
1994	1.13	239	0.85	246	1.13	428			0.63	384	0.00		0.06	302	0.63	320
1995	2.15	283	2.55	254	0.34	299			0.55	389	0.62	326	0.85	271	1.18	303
Mean	**1.46**	**268**	**2.35**	**253**	**1.54**	**321**	**1.53**	**270**	**3.12**	**312**	**0.43**	**304**	**0.76**	**290**	**1.58**	**291**

Table 3. Cont.

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Trachinotus carolinus																
1988	0.34	200	0.23	161	1.08	180	0.96	135	1.47	133	0.52	117	0.28	195	0.70	160
1989	0.51	157	7.94	135	0.92	142	3.06	118	15.86	93	1.15	229	0.39	132	4.26	144
1990	0.62	183	1.76	217	2.15	171	0.34	154	1.47	151	1.42	179	0.65	188	1.20	178
1991	0.23	240	2.04	113	4.25	120	1.19	156	4.48	163	1.19	182	1.13	180	2.07	165
1992	0.68	169	1.98	175	1.87	162			4.20	180	0.06	211	1.38	181	1.69	180
1993	0.17	196	2.27	153	2.55	169			4.21	173	1.64	186	0.23	173	1.85	175
1994	0.23	176	6.46	161	2.55	144			25.36	151	0.57	127	0.40	153	5.93	152
1995	0.28	213	0.74	119	0.51	144			1.33	169	1.30	149	0.11	206	0.71	167
Mean	**0.38**	**192**	**2.93**	**154**	**1.99**	**154**	**1.39**	**141**	**7.30**	**152**	**0.98**	**172**	**0.57**	**176**	**2.30**	**16**

[1] Sampling ceased on San Jose Island following 1991.

TABLE 4. Monthly catch rates (CPUE) and mean size (MS) of the most abundant vertebrates sampled with beach seines by Gulf beach area (1988-1995).

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Anchoa hepsetus																
May	0.00		0.20	33	0.00		0.00		27.23	44	0.00		0.00		3.92	39
June	0.00		0.00		0.00		155.36	39	0.00		0.00		0.00		22.19	39
July	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
August	0.00		0.00		0.10	57	0.00		0.45	35	0.00		0.00		0.08	46
September	0.00		0.00		0.00		0.00		5.90	33	0.00		0.00		0.84	33
October	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
November	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
Mean	**0.00**		**0.03**	**33**	**0.01**	**57**	**22.19**	**39**	**4.80**	**38**	**0.00**		**0.00**		**3.86**	**39**
Arius felis																
May	11.76	329	0.74	306	5.29	320	1.39	335	0.60	321	0.00		2.58	330	3.19	324
June	12.85	314	1.39	287	4.32	340	3.08	354	0.05	322	0.05	343	3.73	353	3.64	330
July	6.45	336	1.74	319	2.08	334	1.88	354	0.20	315	0.10	301	1.86	335	2.04	328
August	8.93	330	0.94	328	1.04	354	2.28	339	0.20	313	0.15	408	0.81	329	2.05	343
September	3.82	338	0.40	346	1.69	340	2.28	319	0.05	334	0.00		1.68	354	1.42	339
October	1.29	348	0.05	158	0.40	358	0.40	370	0.10	304	0.00		0.52	338	0.39	313
November	0.00		0.00		0.10	339	0.00		0.00		0.00		0.06	365	0.02	352
Mean	**6.44**	**333**	**0.75**	**291**	**2.13**	**341**	**1.62**	**345**	**0.17**	**318**	**0.04**	**351**	**1.61**	**343**	**1.82**	**333**
Cynoscion nebulosus																
May	3.03	406	1.59	449	0.95	418	0.20	504	0.05	538	0.20	404	2.28	450	1.19	453
June	3.27	431	2.68	431	0.84	323	0.00		1.52	431	0.20	445	1.81	447	1.48	418
July	2.58	419	3.67	448	0.74	402	0.30	396	4.02	412	0.86	461	0.77	422	1.85	423
August	1.98	443	2.43	470	0.69	422	0.79	407	1.09	392	0.65	507	2.65	424	1.47	438
September	1.19	411	1.74	457	0.45	392	0.20	481	1.19	438	0.69	466	3.57	407	1.29	436
October	0.99	435	0.74	455	0.30	439	0.30	397	0.05	445	0.20	486	0.58	399	0.45	437
November	0.25	456	0.40	440	0.89	448	1.69	393	0.20	561	0.00		0.55	410	0.57	451
Mean	**1.90**	**429**	**1.89**	**450**	**0.70**	**406**	**0.50**	**430**	**1.16**	**460**	**0.40**	**461**	**1.74**	**423**	**1.18**	**436**
Mugil cephalus																
May	37.15	358	60.37	326	26.19	346	6.15	353	15.43	341	14.80	349	21.38	342	25.92	345
June	33.33	361	64.09	353	45.04	342	23.61	341	21.47	334	7.12	342	30.11	328	32.11	343
July	34.52	347	57.39	334	77.13	332	51.79	328	35.42	351	10.68	354	55.17	330	46.01	340
August	38.84	351	28.87	332	11.06	346	14.78	351	8.23	370	7.04	358	10.33	322	17.02	347
September	17.51	357	35.17	346	2.13	348	3.27	348	7.09	357	5.41	363	5.68	330	10.89	350

Table 4. Cont.

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Mugil cephalus cont.																
October	25.05	361	39.98	342	7.69	341	2.58	347	14.19	374	1.97	367	6.64	351	14.01	355
November	22.37	357	34.03	360	16.22	363	2.18	362	11.61	367	13.48	365	1.82	361	14.53	362
Mean	**29.83**	**356**	**45.70**	**342**	**26.50**	**346**	**14.91**	**347**	**16.21**	**356**	**8.64**	**357**	**18.73**	**338**	**22.93**	**349**
Other																
May	2.43	251	3.82	205	8.57	272	2.28	228	52.51	179	2.45	288	1.26	298	10.48	246
June	10.57	227	4.32	200	5.75	262	12.30	168	2.25	265	2.54	309	2.03	335	5.68	252
July	4.12	249	5.46	212	2.28	229	3.97	172	6.35	245	5.60	311	1.92	239	4.24	237
August	9.52	212	9.28	213	6.94	276	6.35	209	10.42	227	4.02	302	3.00	270	7.08	244
September	9.28	260	12.90	208	6.40	248	12.30	217	29.41	223	5.11	303	5.25	281	11.52	249
October	8.13	302	5.31	262	6.25	279	14.58	230	2.56	203	10.30	252	4.04	280	7.31	258
November	1.29	346	3.62	283	1.59	354	1.59	298	2.78	243	6.92	281	1.43	354	2.74	308
Mean	**6.48**	**264**	**6.38**	**226**	**5.40**	**274**	**7.62**	**217**	**15.18**	**226**	**5.28**	**292**	**2.70**	**294**	**7.01**	**256**
Pogonias cromis																
May	1.34	276	1.24	313	2.01	394	0.20	321	1.29	295	0.15	439	0.36	236	0.94	325
June	0.99	291	2.38	287	1.69	314	0.60	353	3.33	387	0.61	379	0.51	302	1.44	330
July	1.19	284	2.73	258	1.04	332	0.89	256	1.84	362	0.36	238	1.26	244	1.33	282
August	1.88	249	4.76	245	1.44	299	0.89	263	1.64	284	0.15	252	1.02	238	1.68	261
September	2.18	261	2.53	230	2.48	278	3.17	266	11.90	254	1.14	268	1.35	276	3.54	262
October	1.44	241	2.08	230	1.04	322	4.17	254	1.25	284	0.56	214	0.40	268	1.56	259
November	1.19	302	0.69	228	1.09	335	0.79	276	0.55	248	0.10	472	0.11	243	0.65	300
Mean	**1.46**	**272**	**2.35**	**256**	**1.54**	**325**	**1.53**	**284**	**3.11**	**302**	**0.44**	**323**	**0.72**	**258**	**1.59**	**289**
Trachinotus carolinus																
May	0.20	191	6.25	171	1.27	129	0.40	223	10.50	152	0.51	186	0.12	155	2.75	172
June	0.15	65	3.03	96	3.72	94	0.40	68	1.47	134	0.51	124	0.00		1.32	97
July	0.50	169	3.72	134	1.14	162	4.56	99	14.04	171	0.41	161	0.60	174	3.57	153
August	0.50	204	3.27	174	1.98	159	1.19	108	16.37	143	0.50	175	1.68	162	3.64	161
September	0.79	181	2.23	169	3.72	185	1.98	141	5.85	159	0.55	170	0.92	188	2.29	170
October	0.55	195	1.88	200	1.98	157	0.69	189	1.95	143	2.02	191	0.46	191	1.36	181
November	0.00		0.10	193	0.10	206	0.50	184	0.55	196	2.42	205	0.00		0.52	197
Mean	**0.38**	**168**	**2.93**	**162**	**1.99**	**156**	**1.39**	**144**	**7.25**	**157**	**0.99**	**173**	**0.54**	**174**	**2.21**	**16**

[1] Sampling ceased on San Jose Island following 1991.

TABLE 5. Annual catch rates (CPUE) and mean size (MS) of the most abundant invertebrates sampled with beach seines by Gulf beach area (May-November).

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Arenaeus cribrarius																
1988	4.59	84	10.26	93	1.30	91	6.63	94	1.42	104	1.77	102	7.22	94	4.74	95
1989	1.98	83	7.43	84	1.89	92	3.46	96	1.26	101	0.74	108	2.04	87	2.69	93
1990	3.74	79	6.46	80	0.17	88	1.87	91	1.08	87	1.53	106	0.59	93	2.21	89
1991	0.45	91	3.63	87	0.85	82	0.74	93	1.25	76	0.79	102	1.62	88	1.33	88
1992	1.30	88	2.61	84	0.96	97			2.72	91	1.87	111	1.20	73	1.78	91
1993	0.51	89	2.27	85	0.62	95			0.51	108	1.76	113	0.74	86	1.07	96
1994	2.72	88	3.91	87	0.34	96			1.09	99	1.47	105	1.70	91	1.87	94
1995	0.96	87	1.36	92	0.11	95			4.10	98	0.85	105	0.34	103	1.29	97
Mean	**2.03**	**86**	**4.74**	**86**	**0.78**	**92**	**3.17**	**93**	**1.68**	**95**	**1.35**	**107**	**1.93**	**89**	**2.12**	**93**
Callinectes sapidus																
1988	1.47	139	0.51	134	0.40	132	0.68	109	0.06	156	0.26	133	0.49	174	0.55	139
1989	2.72	139	1.70	135	0.00		0.17	126	0.00		0.11	153	0.31	151	0.72	141
1990	4.31	127	8.73	129	0.06	117	0.96	128	0.00		0.34	128	0.65	131	2.15	127
1991	6.07	137	25.45	132	1.25	123	3.40	130	0.17	105	1.19	130	8.51	122	6.58	126
1992	3.63	139	2.21	128	2.66	159			0.40	105	0.51	136	1.14	130	1.76	133
1993	2.89	128	1.87	117	2.04	131			0.23	136	0.34	117	0.23	113	1.27	124
1994	6.97	153	15.65	148	4.20	148			0.69	143	0.11	129	1.47	136	4.85	143
1995	4.93	127	5.50	132	0.96	134			0.11	156	0.06	151	0.85	124	2.07	137
Mean	**4.12**	**136**	**7.70**	**132**	**1.45**	**135**	**1.30**	**123**	**0.21**	**133**	**0.37**	**134**	**1.71**	**135**	**2.49**	**134**
Leander tenuicornis																
1988	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
1989	0.00		0.00		0.18	30	0.17	30	0.17	20	0.00		0.00		0.08	27
1990	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
1991	0.00		0.00		0.00		0.00		4.25	25	0.00		0.00		0.61	25
1992	0.00		0.00		0.00				0.06	22	0.00		0.00		0.01	22
1993	0.00		0.00		0.00				0.00		0.00		0.00		0.00	
1994	0.00		0.00		0.00				1.32	26	2.44	24	0.00		0.63	25
1995	0.00		0.00		0.00				0.00		0.00		0.00		0.00	
Mean	**0.00**		**0.00**		**0.02**	**30**	**0.04**	**30**	**0.72**	**23**	**0.30**	**24**	**0.00**		**0.16**	**25**

Table 5. Cont.

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Other																
1988	1.64	61	0.00		0.17	113	0.00		0.06		0.00		0.00		0.27	87
1989	0.11	79	0.23	40	0.12	13	0.23	94	0.06	22	0.00		0.00		0.11	50
1990	0.23		0.00		0.11	140	0.11	93	0.17	30	0.00		0.00		0.09	88
1991	0.00		0.17	59	0.06	19	0.74	100	5.90	1	0.11	112	0.00		1.00	58
1992	0.00		0.17	141	0.40	118			0.11	3	0.00		0.00		0.11	87
1993	0.57	78	0.06	30	0.00				0.00		0.00		0.00		0.10	54
1994	0.00		0.00		0.23	39			1.26	77	1.64	17	0.00		0.52	44
1995	0.06	151	0.00		9.41	21			0.39	73	0.00		0.00		1.64	82
Mean	**0.33**	**92**	**0.08**	**67**	**1.31**	**66**	**0.27**	**95**	**0.99**	**34**	**0.22**	**64**	**0.00**		**0.48**	**69**
Stomolophus meleagris																
1988	0.06		0.00		0.00		0.00		0.00		0.00		0.00		0.01	
1989	0.06		0.00		0.00		0.00		0.00		0.00		0.08		0.02	
1990	0.79		0.06		0.06		0.17		0.00		0.00		0.13		0.17	
1991	0.00		0.06		0.00		0.11		0.00		0.00		0.14		0.04	
1992	0.00		0.00		0.00				0.00		0.00		0.00		0.00	
1993	0.00		0.00		0.00				0.17		0.00		0.00		0.03	
1994	0.74		0.06		0.00				0.29		0.00		0.00		0.18	
1995	3.85		0.00		0.45				2.05		0.00		0.00		1.06	
Mean	**0.69**		**0.02**		**0.06**		**0.07**		**0.31**		**0.00**		**0.04**		**0.19**	

[1] Sampling ceased on San Jose Island following 1991.

TABLE 6. Monthly catch rates (CPUE) and mean size (MS) of the most abundant invertebrates sampled with beach seines by Gulf beach area (1988-1995).

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Arenaeus cribrarius																
May	0.25	83	4.02	94	0.79	97	5.85	101	4.28	74	2.50	101	2.22	94	2.85	92
June	0.74	78	2.53	86	1.14	77	4.96	88	0.98	105	1.22	112	1.19	98	1.82	92
July	1.19	83	2.48	81	0.64	97	4.76	90	1.14	101	2.14	107	2.52	81	2.12	91
August	2.43	83	6.89	86	0.50	95	1.79	89	0.84	100	0.96	98	0.97	86	2.05	91
September	3.82	85	5.46	86	1.09	93	2.58	91	1.24	100	1.54	113	2.81	89	2.65	94
October	3.92	94	6.35	88	0.35	90	0.30	99	1.10	102	0.35	116	2.42	85	2.11	96
November	1.88	92	5.46	85	0.89	90	1.98	96	2.23	94	0.71	105	0.77	92	1.99	94
Mean	**2.03**	**85**	**4.74**	**87**	**0.77**	**91**	**3.17**	**93**	**1.69**	**97**	**1.34**	**107**	**1.84**	**89**	**2.23**	**93**
Callinectes sapidus																
May	5.95	122	6.99	111	2.43	133	3.17	112	0.30	99	0.15	111	0.48	125	2.78	116
June	8.68	135	23.02	131	6.25	124	3.47	124	0.10	145	0.56	130	1.30	153	6.20	135
July	8.38	147	15.67	128	0.84	151	1.39	143	0.79	132	0.92	142	8.37	137	5.20	140
August	1.64	146	7.14	141	0.64	142	0.50	127	0.25	145	0.80	132	0.76	144	1.68	139
September	1.84	131	0.79	146	0.05	132	0.50	124	0.00		0.05	159	0.16	93	0.48	131
October	1.34	138	0.20	146	0.05	132	0.10	100	0.00		0.10	108	0.23	145	0.29	128
November	1.04	137	0.10	151	0.00		0.00		0.00		0.00		0.00		0.16	144
Mean	**4.12**	**137**	**7.70**	**136**	**1.47**	**136**	**1.30**	**122**	**0.21**	**130**	**0.37**	**130**	**1.62**	**133**	**2.40**	**133**
Leander tenuicornis																
May	0.00		0.00		0.16	30	0.00		4.93	24	0.00		0.00		0.73	27
June	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
July	0.00		0.00		0.00		0.30	30	0.00		0.00		0.00		0.04	30
August	0.00		0.00		0.00		0.00		0.05	17	0.00		0.00		0.01	17
September	0.00		0.00		0.00		0.00		0.10	23	0.00		0.00		0.01	23
October	0.00		0.00		0.00		0.00		0.00		2.17	24	0.00		0.31	24
November	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
Mean	**0.00**		**0.00**		**0.02**	**30**	**0.04**	**30**	**0.73**	**21**	**0.31**	**24**	**0.00**		**0.16**	**24**

Table 6. Cont.

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Other																
May	0.00		0.10	27	0.53	90	0.10	124	6.37	3	0.61	15	0.00		1.10	52
June	0.45	54	0.10	30	0.35	72	1.39	81	0.10	12	0.10	112	0.00		0.35	60
July	0.55	114	0.10	35	8.28	32	0.20	34	0.00		0.00		0.00		1.30	54
August	0.05	111	0.05	45	0.00		0.00		0.00		0.00		0.00		0.01	78
September	0.20		0.00		0.05	135	0.00		0.05	22	0.00		0.00		0.04	79
October	0.00		0.15	141	0.00		0.00		0.35	49	0.86	19	0.00		0.19	69
November	1.04		0.05	90	0.00		0.20	154	0.10	111	0.00		0.00		0.20	118
Mean	**0.33**	**93**	**0.08**	**61**	**1.32**	**83**	**0.27**	**98**	**1.00**	**39**	**0.22**	**48**	**0.00**		**0.46**	**73**
Stomolophus meleagris																
May	0.05		0.05		0.00		0.00		0.00		0.00		0.00		0.01	
June	0.35		0.00		0.10		0.10		0.15		0.00		0.06		0.11	
July	0.05		0.00		0.00		0.00		0.00		0.00		0.00		0.01	
August	3.08		0.00		0.30		0.00		0.00		0.00		0.10		0.50	
September	0.64		0.05		0.00		0.00		0.05		0.00		0.00		0.11	
October	0.00		0.00		0.05		0.40		0.85		0.00		0.06		0.19	
November	0.64		0.05		0.00		0.00		1.19		0.00		0.06		0.28	
Mean	**0.69**		**0.02**		**0.06**		**0.07**		**0.32**		**0.00**		**0.04**		**0.17**	

[1] Sampling ceased on San Jose Island following 1991.

TABLE 7. Coastwide abundance, catch rates, and mean size of vertebrate species sampled with bag seines (1988-1995).

Scientific Name	Abundance	Catch Rate (#/ha)	Mean Size (TL mm)
Trachinotus carolinus	61,019	932.58	53
Polydactylus octonemus	36,375	555.94	79
Harengula jaguana	30,738	469.78	45
Menticirrhus littoralis	16,450	251.41	58
Anchoa mitchilli	10,270	156.96	51
Family Engraulidae	10,108	154.49	40
Anchoa hepsetus	7,061	107.92	40
Chaetodipterus faber	5,123	78.30	21
Mugil curema	3,941	60.23	78
Membras martinica	2,929	44.77	52
Menticirrhus americanus	2,720	41.57	83
Anchoa nasuta	2,420	36.99	47
Mugil cephalus	2,193	33.52	193
Sardinella aurita	1,571	24.01	51
Stellifer lanceolatus	1,270	19.41	57
Arius felis	837	12.79	125
Caranx hippos	803	12.27	45
Etrumeus teres	778	11.89	42
Menidia beryllina	728	11.13	60
Brevoortia patronus	596	9.11	48
Family Carangidae	391	5.98	37
Alosa chrysochloris	366	5.59	60
Cynoscion arenarius	310	4.74	46
Hemicaranx amblyrhynchus	304	4.65	40
Lagodon rhomboides	303	4.63	89
Fundulus similis	293	4.48	71
Chloroscombrus chrysurus	292	4.46	42
Trachinotus falcatus	248	3.79	38
Larimus fasciatus	199	3.04	41
Leiostomus xanthurus	163	2.49	90
Micropogonias undulatus	155	2.37	73
Oligoplites saurus	155	2.37	76
Family Clupeidae	148	2.26	31
Scomberomorus maculatus	140	2.14	56
Dorosoma petenense	139	2.12	110
Paralichthys lethostigma	122	1.86	129

Table 7. Cont.

Scientific Name	Abundance	Catch Rate (#/ha)	Mean Size (TL mm)
Family Mugilidae	113	1.73	34
Cyprinodon variegatus	112	1.71	34
Menidia peninsulae	98	1.50	59
Eucinostomus argenteus	96	1.47	65
Strongylura marina	84	1.28	262
Elops saurus	81	1.24	299
Astroscopus y-graecum	76	1.16	130
Pogonias cromis	73	1.12	155
Trachinotus goodei	62	0.95	95
Brevoortia gunteri	62	0.95	62
Citharichthys spilopterus	61	0.93	68
Selene vomer	49	0.75	48
Abudefduf saxatilis	41	0.63	33
Eucinostomus gula	38	0.58	58
Histrio histrio	35	0.53	28
Hyporhamphus unifasciatus	34	0.52	101
Conodon nobilis	33	0.50	54
Cynoscion nothus	30	0.46	65
Caranx latus	24	0.37	41
Fundulus grandis	22	0.34	72
Scomberomorus cavalla	21	0.32	53
Cynoscion nebulosus	19	0.29	369
Sciaenops ocellatus	19	0.29	327
Sphoeroides parvus	19	0.29	22
Monacanthus hispidus	17	0.26	28
Paralichthys albigutta	17	0.26	116
Lobotes surinamensis	16	0.24	36
Family Scombridae	15	0.23	39
Dasyatis sabina	13	0.20	196
Pomadasys crocro	11	0.17	39
Syngnathus louisianae	11	0.17	91
Opisthonema oglinum	11	0.17	61
Pomatomus saltatrix	10	0.15	57
Eucinostomus melanopterus	10	0.15	52
Symphurus plagiusa	10	0.15	86
Umbrina coroides	10	0.15	73
Jenkinsia lamprotaenia	9	0.14	64

Table 7. Cont.

Scientific Name	**Abundance**	**Catch Rate (#/ha)**	**Mean Size (TL mm)**
Family Haemulidae	9	0.14	20
Family Sciaenidae	7	0.11	28
Bairdiella chrysoura	7	0.11	192
Trinectes maculatus	6	0.09	33
Archosargus	5	0.08	123
Trachurus lathami	5	0.08	57
Class Osteichthyes	4	0.06	32
Urophycis floridana	4	0.06	41
Agonostomus monticola	4	0.06	38
Genus *Scomberomorus*	4	0.06	35
Carcharhinus limbatus	4	0.06	540
Bagre marinus	4	0.06	108
Orthopristis chrysoptera	4	0.06	109
Lagocephalus laevigatus	3	0.05	18
Trichiurus lepturus	3	0.05	288
Eucinostomus lefroyi	3	0.05	57
Synodus foetens	3	0.05	43
Syngnathus pelagicus	3	0.05	79
Monacanthus setifer	3	0.05	38
Citharichthys macrops	3	0.05	123
Family Atherinidae	3	0.05	22
Hemiramphus brasiliensis	2	0.03	90
Aluterus schoepfi	2	0.03	23
Negaprion brevirostris	2	0.03	653
Gobiesox strumosus	2	0.03	51
Xanthichthys ringens	2	0.03	23
Hippocampus erectus	2	0.03	82
Antennarius striatus	2	0.03	54
Lutjanus griseus	2	0.03	77
Sphyraena barracuda	2	0.03	26
Balistes capriscus	2	0.03	57
Hemiramphus balao	1	0.02	145
Morone americana	1	0.02	46
Selene setapinnis	1	0.02	58
Rhinoptera bonasus	1	0.02	419
Seriola dumerili	1	0.02	36
Narcine brasiliensis	1	0.02	132

Table 7. Cont.

Scientific Name	**Abundance**	**Catch Rate (#/ha)**	**Mean Size (TL mm)**
Family Balistidae	1	0.02	44
Peprilus alepidotus	1	0.02	22
Family Elopidae	1	0.02	38
Syngnathus scovelli	1	0.02	133
Family Syngnathidae	1	0.02	74
Prionotus tribulus	1	0.02	31
Paralichthys squamilentus	1	0.02	170
Ancylopsetta quadrocellata	1	0.02	50
Kyphosus sectatrix	1	0.02	244
Syacium gunteri	1	0.02	140
Bathygobius soporator	1	0.02	46
Diplectrum bivittatum	1	0.02	54

TABLE 8. Coastwide abundance, catch rates and mean size of invertebrate species sampled with bag seines (1988-1995).

Scientific Name	Abundance	Catch Rate (#/ha)	Mean Size (TL mm)
Xiphopenaeus kroyeri	13,731	209.86	70
Arenaeus cribrarius	9,999	152.82	33
Penaeus setiferus	1,679	25.66	62
Callinectes sapidus	889	13.59	87
Donax variabilis	455	6.95	14
Pagurus pollicaris	388	5.93	N/A
Emerita portoricensis	271	4.14	21
Penaeus aztecus	201	3.07	65
Isocheles wurdemanni	176	2.69	N/A
Pagurus brevidactylus	163	2.49	N/A
Latreutes parvulus	122	1.86	27
Portunus sayi	111	1.70	21
Leander tenuicornis	106	1.62	23
Callinectes similis	60	0.92	26
Astropecten duplicatus	51	0.78	85
Scyllaea pelagica	51	0.78	2
Pagurus longicarpus	49	0.75	N/A
Beroe ovata	40	0.61	N/A
Crassostrea virginica	40	0.61	18
Dromidia antillensis	37	0.57	12
Palaemonetes sp.	34	0.52	27
Albunea paretii	30	0.46	19
Clibanarius vittatus	25	0.38	N/A
Libinia dubia	19	0.29	13
Lepidopa benedicti	19	0.29	18
Latreutes fucorum	18	0.28	22
Mellita quinquiesperforata	17	0.26	32
Luidia clathrata	13	0.20	119
Family Paguridae	9	0.14	N/A
Neverita duplicata	9	0.14	19
Order Actiniaria	7	0.11	19
Lolliguncula brevis	7	0.11	28
Portunus gibbesii	6	0.09	18
Albunea gibbesii	5	0.08	23
Family Portunidae	4	0.06	18
Ovalipes floridanus	3	0.05	44
Family Pinnotheridae	3	0.05	15

Table 8. Cont.

Scientific Name	**Abundance**	**Catch Rate (#/ha)**	**Mean Size (TL mm)**
Renilla mulleri	3	0.05	7
Callianassa louisianensis	3	0.05	32
Menippe adina	2	0.03	11
Class Asteroidea	2	0.03	74
Libinia emarginata	2	0.03	68
Euceramus praelongus	2	0.03	15
Macrobrachium ohione	2	0.03	54
Cantharus cancellarius	2	0.03	27
Dyspanopeus texana	1	0.02	17
Dosinia discus	1	0.02	46
Penaeus duorarum	1	0.02	85
Aplysia brasiliana	1	0.02	N/A
Acetes americanus	1	0.02	23
Oliva sayana	1	0.02	37
Persephona mediterranea	1	0.02	20
Thais haemastoma	1	0.02	36
Busycon sinistrum	1	0.02	29
Pagurus impressus	1	0.02	N/A
Palaemonetes pugio	1	0.02	26

TABLE 9. Annual catch rates (CPUE) and mean size (MS) of the most abundant vertebrates sampled with bag seines by Gulf beach area (May-November).

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Anchoa hepsetus																
1988	2.38	124	2.38	61	141.27	58	942.06	43	0.79	39	289.68	53	0.00		196.94	63
1989	0.00		0.00		25.64	48	15.87	35	1,095.24	44	6.35	50	0.00		163.30	44
1990	0.00		0.79	105	4.76	60	0.79	49	0.79	61	48.41	74	3.17	71	8.39	70
1991	0.00		0.00		0.00		91.27	36	4.76	38	11.11	56	0.00		15.31	43
1992	0.00		0.79	49	0.00				15.87	51	11.90	61	0.00		4.76	53
1993	0.00		0.00		2.38	40			27.78	62	3.17	60	1.59	51	5.82	53
1994	0.00		20.63	38	0.00				895.24	43	73.81	55	0.00		164.95	46
1995	0.00		0.00		0.00				1,792.86	41	72.22	60	0.00		310.85	51
Mean	**0.30**	**124**	**3.08**	**63**	**21.76**	**51**	**262.50**	**41**	**479.17**	**47**	**64.58**	**59**	**0.60**	**61**	**108.79**	**53**
Anchoa mitchilli																
1988	2,569.05	65	0.79	36	1,500.79	47	4.76	49	60.32	32	12.70	56	34.92	59	597.62	49
1989	1,012.70	50	8.73	45	49.57	37	3.97	44	1.59	54	0.00		7.14	55	154.81	48
1990	0.00	9.52	48.00	1.59	45.00		0.00		328.57	49	0.00		0.79	67	48.64	52
1991	11.11	55	3.97	53	2.38	33	22.22	43	0.00		0.00		12.70	55	7.48	48
1992	12.70	57	0.00		7.14	50			0.00		3.17	67	9.52	60	5.42	58
1993	118.25	58	11.90	53	0.79	39			0.79	27	46.03	31	2.38	64	30.03	45
1994	5.56	58	934.13	50	0.00				0.00		49.21	53	7.14	33	166.01	48
1995	15.87	58	1,115.87	49	15.08	49			3.17	50	3.17	35	132.54	28	214.29	45
Mean	**468.15**	**57**	**260.62**	**48**	**197.17**	**43**	**7.74**	**45**	**49.31**	**42**	**14.29**	**48**	**25.89**	**52**	**153.04**	**49**
Harengula jaguana																
1988	0.00		0.00		191.27	40	41.27	45	19.05	43	400.00	56	21.43	58	96.15	48
1989	0.00		0.79	93	296.58	49	411.11	35	10,453.17	39	224.60	56	15.08	67	1,628.76	56
1990	0.00		5.56	57	118.25	51	30.16	35	483.33	47	10.32	49	0.00		92.52	48
1991	0.00		0.00		27.78	43	263.49	42	450.00	29	369.84	63	9.52	62	160.09	48
1992	0.00		3.17	55	5.56	57			17.46	37	225.40	58	3.97	47	42.59	51
1993	4.76	48	81.75	46	1,603.17	65			2,834.13	31	11.90	66	60.32	75	766.01	55
1994	0.00		104.76	42	0.79	49			3,475.40	58	875.40	58	0.00		742.72	52
1995	0.00		97.62	49	65.08	38			812.70	38	270.63	53	19.84	53	210.98	46
Mean	**0.60**	**48**	**36.71**	**57**	**288.56**	**49**	**186.51**	**39**	**2,318.15**	**40**	**298.51**	**57**	**16.27**	**60**	**467.48**	**51**

Table 9. Cont.

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Menticirrhus littoralis																
1988	25.40	73	123.81	53	297.62	61	226.19	64	192.86	59	60.32	117	7.94	67	133.45	71
1989	73.81	69	105.56	63	334.19	50	377.78	51	462.70	47	44.44	66	13.49	82	201.71	61
1990	53.97	105	173.02	67	274.60	69	592.86	60	515.87	53	120.63	93	17.46	65	249.77	73
1991	15.87	71	106.35	80	317.46	74	600.79	55	895.24	54	170.63	72	35.71	89	306.01	71
1992	46.83	67	176.19	78	190.48	53			767.46	54	77.78	73	31.75	80	215.08	67
1993	11.90	107	462.70	63	251.59	58			688.89	50	226.19	64	43.65	87	280.82	72
1994	45.24	75	192.86	56	293.65	53			1,102.38	65	280.95	63	146.03	78	343.52	65
1995	66.67	61	138.89	64	152.38	51			1,098.41	53	301.59	78	48.41	56	301.06	60
Mean	**42.46**	**78**	**184.92**	**66**	**264.00**	**59**	**449.40**	**57**	**715.48**	**54**	**160.32**	**78**	**43.06**	**76**	**253.93**	**68**
Other																
1988	208.73	86	169.84	90	119.05	90	386.51	75	640.48	49	959.52	94	138.89	96	374.72	83
1989	1,076.98	182	521.43	109	153.85	63	192.86	43	202.38	48	153.97	91	183.33	128	354.97	95
1990	484.92	117	271.43	98	88.10	73	146.83	52	697.62	78	428.57	126	53.17	157	310.09	100
1991	501.59	124	283.33	92	663.49	54	235.71	62	438.89	52	554.76	111	1,091.27	123	538.44	88
1992	242.06	121	109.52	101	138.89	76			407.14	39	138.10	100	126.98	161	193.78	100
1993	801.59	122	3,613.49	82	1,176.98	60			122.22	37	111.11	76	184.13	133	1,001.59	85
1994	686.51	83	291.27	67	114.29	91			170.63	65	452.38	86	342.06	90	342.86	80
1995	511.90	75	8,098.41	68	276.98	84			838.10	39	720.63	74	2,094.44	76	2,090.08	70
Mean	**564.29**	**114**	**1,669.84**	**89**	**341.45**	**74**	**240.48**	**58**	**439.68**	**51**	**439.88**	**95**	**526.79**	**120**	**650.82**	**88**
Polydactylus octonemus																
1988	4,791.27	102	7.94	126	231.75	105	44.44	82	0.00		1,172.22	112	192.86	118	920.07	108
1989	27.78	82	102.38	94	2,162.39	81	321.43	64	1,449.21	67	413.49	89	2,315.87	120	970.36	85
1990	3.17	142	2.38	183	10.32	146	0.00		6.35	106	65.08	122	1.59	131	12.70	138
1991	169.05	115	24.60	83	2,833.33	77	550.79	80	7,915.08	89	65.87	80	1,743.65	112	1,900.34	91
1992	0.79	61	1.59	63	1.59	80			0.00		1.59	67	7.94	142	2.25	82
1993	18.25	81	0.00		15.87	103			57.94	128	270.63	87	33.33	148	66.01	109
1994	0.00		0.00		1.59	134			19.84	92	2.38	92	16.67	110	6.75	107
1995	2.38	170	0.79	153	5.56	132			15.87	89	1,923.02	128	1.59	126	324.87	133
Mean	**626.59**	**108**	**17.46**	**117**	**657.80**	**107**	**229.17**	**75**	**1,183.04**	**95**	**489.29**	**97**	**539.19**	**126**	**525.42**	**107**

Table 9. Cont.

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Trachinotus carolinus																
1988	430.16	55	727.78	50	695.24	50	649.21	51	1,088.10	47	269.05	67	500.00	53	622.79	53
1989	843.65	66	1,523.02	56	1,383.76	58	1,262.70	49	1,341.27	53	315.87	62	346.03	60	1,002.33	58
1990	608.73	62	666.67	51	1,211.11	52	1,070.63	41	1,934.92	45	407.94	59	544.44	59	920.63	53
1991	840.48	55	993.65	54	1,092.86	53	830.16	49	1,369.84	49	967.46	60	450.79	66	935.03	55
1992	871.43	61	760.32	53	1,017.46	54			1,305.56	48	465.08	55	639.68	64	843.25	56
1993	684.13	61	851.59	49	783.33	57			938.89	48	488.89	62	374.60	65	686.90	57
1994	1,105.56	57	2,753.17	50	969.84	49			1,580.16	53	526.19	57	1,023.02	57	1,326.32	54
1995	976.98	56	822.22	53	1,057.94	48			2,393.65	50	1,030.95	56	740.48	56	1,170.37	53
Mean	**795.14**	**59**	**1,137.30**	**52**	**1,026.44**	**53**	**953.17**	**47**	**1,494.05**	**49**	**558.93**	**60**	**577.38**	**60**	**938.45**	**55**

[1] Sampling ceased on San Jose Island following 1991.

TABLE 10. Monthly catch rates (CPUE) and mean size (MS) of the most abundant vertebrates sampled with bag seines by Gulf beach area (1988-1995).

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Anchoa hepsetus																
May	0.00		0.00		0.00		1.39	49	2.08	35	74.3	43	0.00		11.11	43
June	2.08	124	0.00		3.47	54	0.00		11.81	37	1.39	87	1.39	75	2.88	75
July	0.00		2.08	61	126.39	60	22.22	38	100.00	51	39.58	83	0.00		41.47	59
August	0.00		0.69	105	18.75	25	16.67	34	2,156.25	51	281.25	54	1.39	67	353.57	56
September	0.00		18.06	38	0.00		1,797.22	40	1,081.25	39	9.03	47	1.39	51	415.28	43
October	0.00		0.69	49	2.08	63	0.00		2.78	59	45.83	66	0.00		7.34	59
November	0.00		0.00		0.00		0.00		0.00		0.69	61	0.00		0.10	61
Mean	**0.30**	**124**	**3.08**	**63**	**21.53**	**51**	**262.50**	**40**	**479.17**	**45**	**64.58**	**63**	**0.60**	**64**	**118.82**	**56**
Anchoa mitchilli																
May	12.50	59	1,254.17	43	2.22	46	0.00		0.69	70	0.00		12.50	56	183.15	55
June	2,254.17	59	3.47	49	18.06	40	0.00		53.47	35	7.64	54	130.56	52	352.48	48
July	11.81	65	3.47	48	13.19	49	6.94	44	0.00		52.78	50	0.69	82	12.70	56
August	11.81	50	15.97	51	26.39	39	5.56	45	288.89	49	27.78	34	0.69	70	53.87	48
September	975.00	48	544.44	52	1,311.11	49	8.33	49	0.00		2.78	59	9.72	40	407.34	49
October	8.33	60	1.39	43	6.25	44	33.33	41	0.69	27	0.00		21.53	63	10.22	46
November	3.47	64	1.39	49	0.00		0.00		1.39	51	9.03	53	5.56	50	2.98	53
Mean	**468.15**	**58**	**260.62**	**48**	**196.75**	**44**	**7.74**	**44**	**49.31**	**46**	**14.29**	**50**	**25.89**	**59**	**146.11**	**51**
Harengula jaguana																
May	0.00		0.00		0.00		0.00		0.00		0.69	108	0.00		0.10	108
June	0.00		0.69	93	41.67	44	0.00		134.72	36	22.92	53	3.47	47	29.07	55
July	0.00		0.69	45	181.25	49	56.94	34	783.33	36	518.06	53	13.89	79	222.02	49
August	0.00		58.33	49	190.28	35	493.06	41	1,459.03	37	179.17	57	4.17	59	340.58	46
September	4.17	48	195.83	46	1,502.08	47	691.67	38	13,787.50	42	324.31	55	70.14	55	2,367.96	47
October	0.00		1.39	58	81.94	60	63.89	42	56.25	41	1,002.08	53	18.06	58	174.80	52
November	0.00		0.00		4.17	68		0	6.25	87	42.36	67	4.17	62	8.13	71
Mean	**0.60**	**48**	**36.71**	**58**	**285.91**	**51**	**186.51**	**39**	**2,318.15**	**47**	**298.51**	**64**	**16.27**	**60**	**448.95**	**61**

Table 10. Cont.

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Menticirrhus littoralis																
May	25.00	122	25.00	107	29.63	72	23.61	83	236.81	65	128.47	99	6.94	120	67.92	96
June	7.64	103	41.67	64	254.86	55	194.44	42	620.14	45	93.75	91	15.97	84	175.50	69
July	16.67	50	95.14	57	389.58	53	480.56	49	755.56	55	68.75	72	18.75	58	260.71	56
August	44.44	53	370.83	55	401.39	56	798.61	64	899.31	53	85.42	80	113.19	65	387.60	61
September	50.69	60	463.19	61	320.83	54	683.33	62	1,412.50	61	222.22	67	82.64	69	462.20	62
October	84.03	71	208.33	58	338.19	57	723.61	49	865.97	48	447.92	73	33.33	83	385.91	63
November	68.75	72	90.28	61	94.44	66	241.67	55	218.06	55	75.69	68	30.56	72	117.06	64
Mean	**42.46**	**76**	**184.92**	**66**	**261.28**	**59**	**449.40**	**58**	**715.48**	**55**	**160.32**	**79**	**43.06**	**79**	**265.27**	**67**
Other																
May	295.14	138	333.33	94	264.44	83	93.06	90	461.81	34	313.19	114	179.17	123	277.16	97
June	671.53	100	3,379.17	87	608.33	86	431.94	54	829.86	35	233.33	84	405.56	142	937.10	84
July	375.69	117	263.89	103	175.00	100	95.83	53	761.11	44	195.14	97	659.03	128	360.81	92
August	1,000.69	91	239.58	79	388.19	56	106.94	43	743.06	49	678.47	76	114.58	119	467.36	73
September	777.08	89	7,359.03	92	821.53	59	851.39	71	157.64	62	476.39	94	1,853.47	129	1,756.65	85
October	510.42	127	81.25	96	127.78	57	59.72	47	70.83	78	1,052.08	94	81.25	82	283.33	83
November	319.44	133	32.64	69	11.81	72	44.44	47	53.47	56	130.56	104	394.44	115	140.97	85
Mean	**564.29**	**114**	**1,669.84**	**89**	**342.44**	**73**	**240.48**	**58**	**439.68**	**51**	**439.88**	**95**	**526.79**	**120**	**603.34**	**86**
Polydactylus octonemus																
May	392.36	86	81.25	75	3,985.93	92	579.17	68	7,152.08	79	2,938.19	91	3,343.06	89	2,638.86	83
June	3,988.19	101	12.50	91	547.22	98	976.39	62	965.97	95	215.97	96	343.75	101	1,007.14	92
July	4.17	158	26.39	127	156.25	111	47.22	75	145.14	100	61.11	95	70.83	122	73.02	113
August	0.69	154	1.39	140	0.00		1.39	111	7.64	80	15.97	95	7.64	156	4.96	123
September	0.69	143	0.69	270	28.47	131	0.00		10.42	113	185.42	139	5.56	182	33.04	163
October	0.00		0.00		0.69	192	0.00		0.00		7.64	183	3.47	203	1.69	193
November	0.00		0.00		0.00		0.00		0.00		0.69	53	0.00		0.10	53
Mean	**626.59**	**129**	**17.46**	**141**	**674.08**	**125**	**229.17**	**79**	**1,183.04**	**94**	**489.29**	**107**	**539.19**	**142**	**536.97**	**117**

Table 10. Cont.

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Trachinotus carolinus																
May	1,772.22	48	3,275.00	45	1,845.93	48	1,798.61	38	2,548.61	37	694.44	49	750.69	50	1,812.22	45
June	1,543.75	58	1,906.94	53	2,097.22	56	1,455.56	51	2,620.83	48	1,338.89	62	1,018.06	60	1,711.61	56
July	1,091.67	62	1,127.78	57	1,497.22	56	2,004.17	46	2,107.64	56	798.61	66	963.19	65	1,370.04	58
August	647.22	67	850.69	53	809.72	49	709.72	44	1,557.64	51	309.03	61	616.67	61	785.81	55
September	167.36	61	357.64	58	652.08	52	487.50	45	954.17	51	172.22	55	286.11	67	439.58	56
October	228.47	57	281.25	47	196.53	48	152.78	53	490.97	49	461.11	54	253.47	55	294.94	52
November	115.28	60	161.81	53	115.28	59	63.89	56	178.47	53	138.19	69	153.47	62	132.34	59
Mean	**795.14**	**59**	**1,137.30**	**52**	**1,030.57**	**53**	**953.17**	**47**	**1,494.05**	**49**	**558.93**	**60**	**577.38**	**60**	**935.22**	**54**

[1] Sampling ceased on San Jose Island following 1991.

TABLE 11. Annual catch rates (CPUE) and mean size (MS) of the most abundant invertebrates sampled with bag seines by Gulf beach area (May-November).

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Arenaeus cribrarius																
1988	140.48	50	379.37	41	70.63	60	30.95	44	38.10	30	8.73	88	41.27	62	101.36	53
1989	209.52	38	794.44	47	11.97	56	209.52	28	123.02	31	3.97	61	45.24	64	199.67	46
1990	303.17	50	611.11	31	11.11	55	207.94	36	80.95	35	17.46	83	30.95	48	180.39	48
1991	105.56	39	142.06	35	72.22	32	88.89	26	311.90	20	7.14	38	29.37	54	108.16	35
1992	139.68	48	334.92	41	58.73	47			360.32	23	11.11	55	27.78	47	155.42	43
1993	221.43	35	191.27	33	35.71	75			228.57	18	3.97	41	27.78	61	118.12	44
1994	288.10	49	314.29	27	155.56	36			738.89	23	7.94	45	142.86	35	274.60	36
1995	213.49	43	123.02	36	4.76	47			135.71	22	11.90	67	31.75	38	86.77	42
Mean	**202.68**	**44**	**361.31**	**36**	**52.59**	**51**	**134.33**	**34**	**252.18**	**25**	**9.03**	**60**	**47.12**	**51**	**153.06**	**44**
Callinectes sapidus																
1988	9.52	108	1.59	25	7.14	58	0.79	103	0.00		0.00		1.59	79	2.95	75
1989	93.65	87	15.08	88	0.85	126	0.00		0.00		0.00		3.17	105	16.11	101
1990	26.19	81	49.21	106	0.00		1.59	25	0.00		0.00		2.38	121	11.34	83
1991	93.65	106	32.54	100	17.46	59	4.76	57	0.00		0.00		35.71	83	26.30	81
1992	39.68	92	44.44	73	9.52	108			1.59	21	0.79	174	7.94	98	17.33	94
1993	30.95	99	16.67	83	6.35	121			0.79	157	0.00		0.79	77	9.26	107
1994	20.63	126	26.98	86	28.57	91			1.59	74	0.00		5.56	84	13.89	92
1995	48.41	86	13.49	118	1.59	120			0.79	33	0.00		1.59	60	10.98	83
Mean	**45.34**	**98**	**25.00**	**85**	**8.94**	**98**	**1.79**	**62**	**0.60**	**71**	**0.10**	**174**	**7.34**	**88**	**13.52**	**90**
Other																
1988	152.38	14	26.98	8	10.32	16	1.59	23	15.87	18	0.79	46	18.25	20	32.31	21
1989	46.03	17	101.59	35	19.66	13	39.68	19	12.70	20	0.00		6.35	22	32.29	21
1990	65.87	26	76.19	25	107.94	29	22.22	42	26.98	17	4.76	21	3.17	7	43.88	24
1991	11.90	39	4.76	8	23.02	26	57.94	32	128.57	16	1.59	61	7.14	31	33.56	30
1992	68.25	30	57.14	10	25.40	13			42.06	18	4.76	31	26.98	14	37.43	19
1993	28.57	26	12.70	14	44.44	19			36.51	12	80.95	17	0.79	20	33.99	18
1994	37.30	31	47.62	31	24.60	19			269.84	15	44.44	23	26.98	25	75.13	24
1995	26.98	16	39.68	9	24.60	9			69.84	13	2.38	17	15.08	31	29.76	16
Mean	**54.66**	**25**	**45.83**	**18**	**35.00**	**18**	**30.36**	**29**	**75.30**	**16**	**17.46**	**31**	**13.10**	**21**	**39.80**	**22**

Table 11. Cont.

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Penaeus setiferus																
1988	26.19	67	4.76	78	0.79	50	0.79	45	0.00		0.79	69	3.17	64	5.22	62
1989	30.16	59	1.59	76	0.85		3.17	52	0.00		0.00		42.06	65	11.12	63
1990	8.73	61	7.94	79	0.00		0.79	59	0.00		0.00		0.00		2.49	66
1991	415.08	82	1.59	77	0.00		0.00		0.00		0.00		2.38	69	59.86	76
1992	188.89	83	10.32	83	1.59	84			0.00		0.00		3.17	80	33.99	83
1993	38.10	57	3.17	78	0.00				0.00		0.79	38	0.79	60	7.14	58
1994	30.95	65	0.00		0.79	88			0.00		0.00		2.38	65	5.69	73
1995	462.70	69	0.00		3.17	62			13.49	50	0.00		21.43	54	83.47	59
Mean	**150.10**	**68**	**3.67**	**78**	**0.90**	**71**	**1.19**	**52**	**1.69**	**50**	**0.20**	**54**	**9.42**	**65**	**26.12**	**67**
Xiphopenaeus kroyeri																
1988	2,096.83	77	257.94	36	0.00		2.38	51	0.00		0.00		3.17	86	337.19	63
1989	340.48	83	0.00		0.00		0.00		0.00		0.00		0.00		48.64	83
1990	0.00		10.32	63	0.00		0.00		0.00		0.00		0.00		1.47	63
1991	0.79	41	0.00		0.00		0.00		0.00		0.00		7,542.86	70	1,077.66	55
1992	478.57	68	0.00		0.00				0.00		0.00		0.00		79.76	68
1993	103.17	84	0.00		0.00				0.00		0.00		0.00		17.20	84
1994	10.32	51	0.00		0.00				0.00		0.00		0.00		1.72	51
1995	50.79	57	0.00		0.00				0.00		0.00		0.00		8.47	57
Mean	**385.12**	**66**	**33.53**	**49**	**0.00**		**0.60**	**51**	**0.00**		**0.00**		**943.25**	**78**	**196.51**	**66**

[1] Sampling ceased on San Jose Island following 1991.

TABLE 12. Monthly catch rates (CPUE) and mean size (MS) of the most abundant invertebrates sampled with bag seines by Gulf beach area (1988-1995).

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Arenaeus cribrarius																
May	55.56	37	708.33	31	42.96	68	181.94	37	234.72	18	24.31	60	37.50	61	183.62	45
June	322.92	31	808.33	30	215.97	26	177.78	29	696.53	22	8.33	71	40.97	46	324.40	36
July	425.69	40	334.72	31	31.94	33	51.39	24	622.22	25	4.86	79	159.72	44	232.94	40
August	192.36	47	363.89	32	6.94	42	48.61	51	100.00	22	5.56	73	35.42	42	107.54	44
September	172.92	43	112.50	30	43.75	26	19.44	54	22.92	25	2.08	52	25.69	69	57.04	43
October	222.92	47	125.00	48	19.44	78	34.72	21	50.69	30	6.94	22	24.31	46	69.15	42
November	26.39	61	76.39	54	9.03	66	426.39	26	38.19	38	11.11	57	6.25	50	84.82	50
Mean	**202.68**	**44**	**361.31**	**37**	**52.86**	**49**	**134.33**	**35**	**252.18**	**26**	**9.03**	**59**	**47.12**	**51**	**151.36**	**43**
Callinectes sapidus																
May	190.97	83	100.69	81	22.96	96	8.33	57	0.00		0.00		4.86	63	46.83	76
June	40.97	100	46.53	84	35.42	105	0.00		0.69	19	0.00		7.64	116	18.75	85
July	29.17	100	16.67	81	4.86	102	1.39	31	0.69	131	0.00		36.81	113	12.80	93
August	16.67	91	5.56	130	0.00		0.00		2.08	71	0.69	174	1.39	21	3.77	97
September	17.36	107	4.17	91	0.00		1.39	103	0.00		0.00		0.00		3.27	101
October	18.06	107	0.69	103	0.00		0.00		0.00		0.00		0.69	109	2.78	106
November	4.17	105	0.69	86	0.69	26	1.39	18	0.69	16	0.00		0.00		1.09	50
Mean	**45.34**	**99**	**25.00**	**94**	**9.13**	**82**	**1.79**	**52**	**0.60**	**59**	**0.10**	**174**	**7.34**	**84**	**12.76**	**87**
Other																
May	52.78	28	27.78	29	27.41	36	41.67	42	125.00	16	27.08	24	20.83	28	46.08	29
June	59.03	40	126.39	41	23.61	20	81.94	41	84.03	16	67.36	48	31.94	26	67.76	33
July	46.53	20	40.28	11	60.42	15	22.22	25	120.83	16	3.47	24	13.19	19	43.85	19
August	38.19	29	58.33	11	9.72	16	1.39	29	69.44	17	0.69	20	12.50	3	27.18	18
September	20.83	11	18.75	22	10.42	10	4.17	30	5.56	16	4.17	21	9.72	21	10.52	19
October	39.58	12	40.97	19	102.78	11	20.83	23	76.39	12	13.89	33	0.69	18	42.16	18
November	125.69	19	8.33	9	11.11	10	40.28	14	45.83	17	5.56	27	2.78	20	34.23	16
Mean	**54.66**	**23**	**45.83**	**20**	**35.07**	**17**	**30.36**	**29**	**75.30**	**16**	**17.46**	**28**	**13.10**	**19**	**38.82**	**22**

Table 12. Cont.

	Bolivar P.		Galveston I.		Matagorda I.		San Jose I.[1]		Padre I.		S. Padre I.		Matagorda P.		Coastwide	
	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS	CPUE	MS
Penaeus setiferus																
May	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
June	5.56	106	0.00		0.69		0.00		0.00		0.00		0.00		0.89	106
July	15.28	66	0.69	72	0.69	50	1.39	45	0.00		0.00		2.78	64	2.98	59
August	24.31	77	10.42	74	0.00		0.00		0.00		0.00		45.14	59	11.41	70
September	102.08	59	4.17	78	0.00		0.00		0.00		0.00		2.08	79	15.48	72
October	553.47	62	7.64	75	2.08	86	0.00		0.69	34	0.69	38	14.58	64	82.74	60
November	350.00	63	2.78	94	2.78	62	6.94	55	11.11	66	0.69	69	1.39	45	53.67	65
Mean	**150.10**	**72**	**3.67**	**79**	**0.89**	**66**	**1.19**	**50**	**1.69**	**50**	**0.20**	**54**	**9.42**	**62**	**23.88**	**72**
Xiphopenaeus kroyeri																
May	12.50	101	0.00		0.00		0.00		0.00		0.00		0.00		1.79	101
June	0.00		0.69	78	0.00		0.00		0.00		0.00		0.69	119	0.20	99
July	69.44	72	0.00		0.00		0.00		0.00		0.00		0.00		9.92	72
August	98.61	74	8.33	48	0.00		0.00		0.00		0.00		0.69	69	15.38	64
September	1,843.75	53	225.69	36	0.00		4.17	51	0.00		0.00		0.00		296.23	47
October	670.83	75	0.00		0.00		0.00		0.00		0.00		2.08	53	96.13	64
November	0.69	71	0.00		0.00		0.00		0.00		0.00		6,599.31	71	942.86	71
Mean	**385.12**	**74**	**33.53**	**54**	**0.00**		**0.60**	**51**	**0.00**		**0.00**		**943.25**	**78**	**194.64**	**74**

[1] Sampling ceased on San Jose Island following 1991.

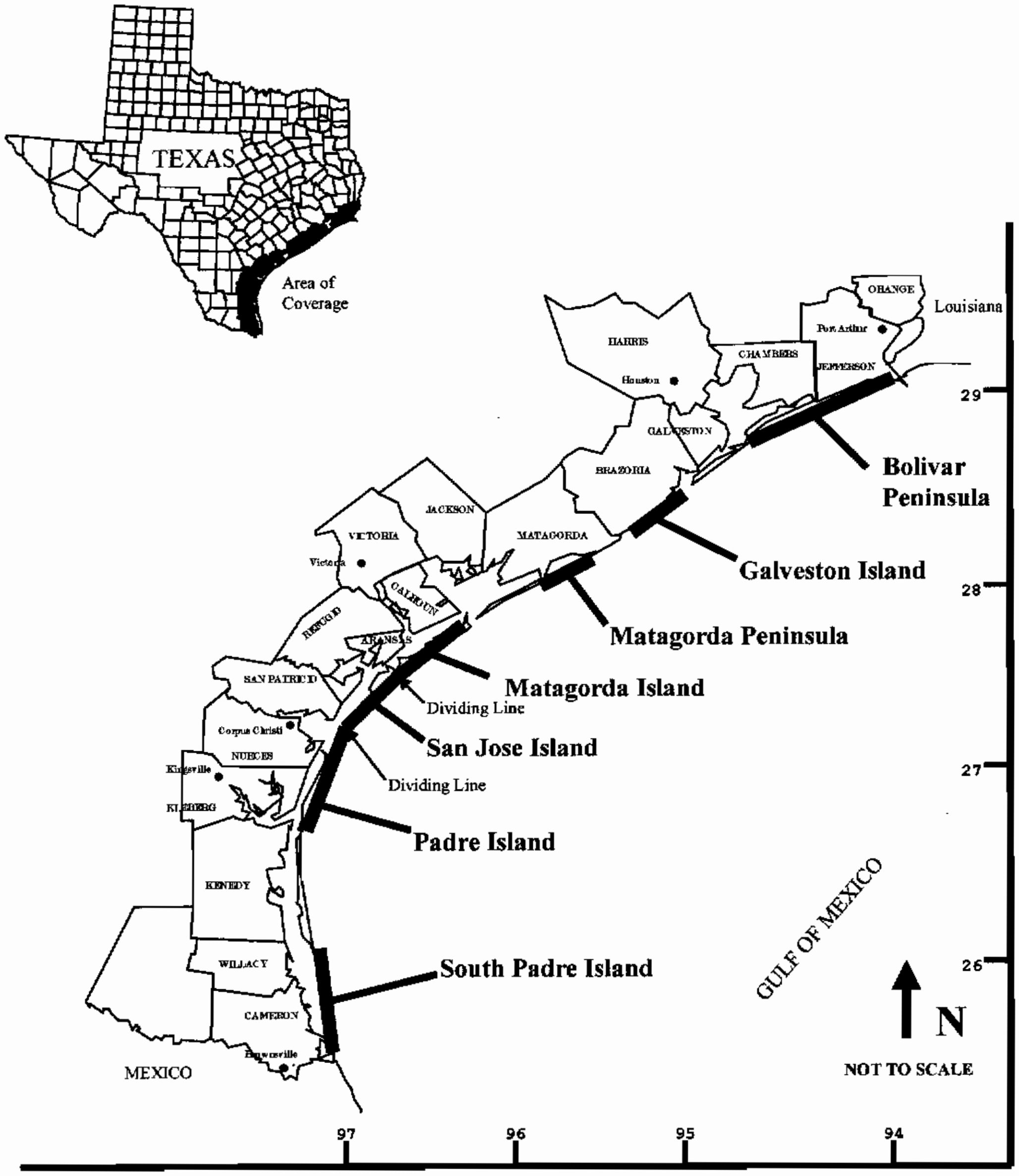


Figure 1. Texas Gulf beach sampling areas.

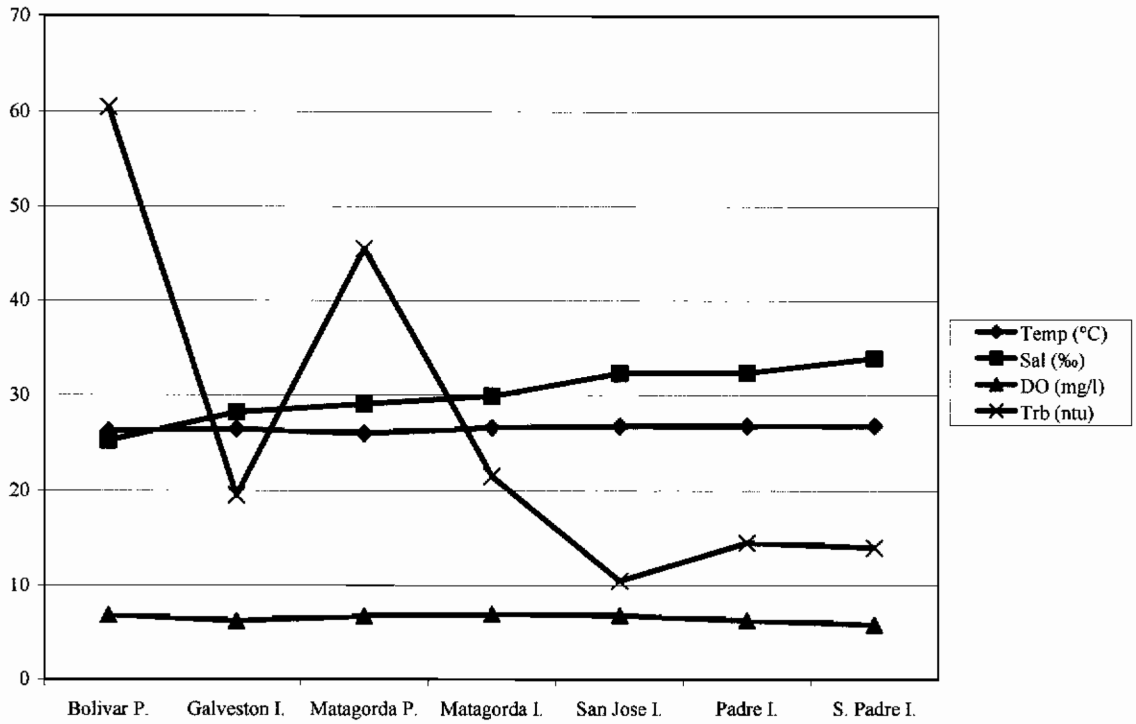


Figure 2. Mean coastwide hydrological data values for beach seine and bag seine samples collected May through November from 1998 to 1995 along Texas Gulf beaches by Gulf beach area.

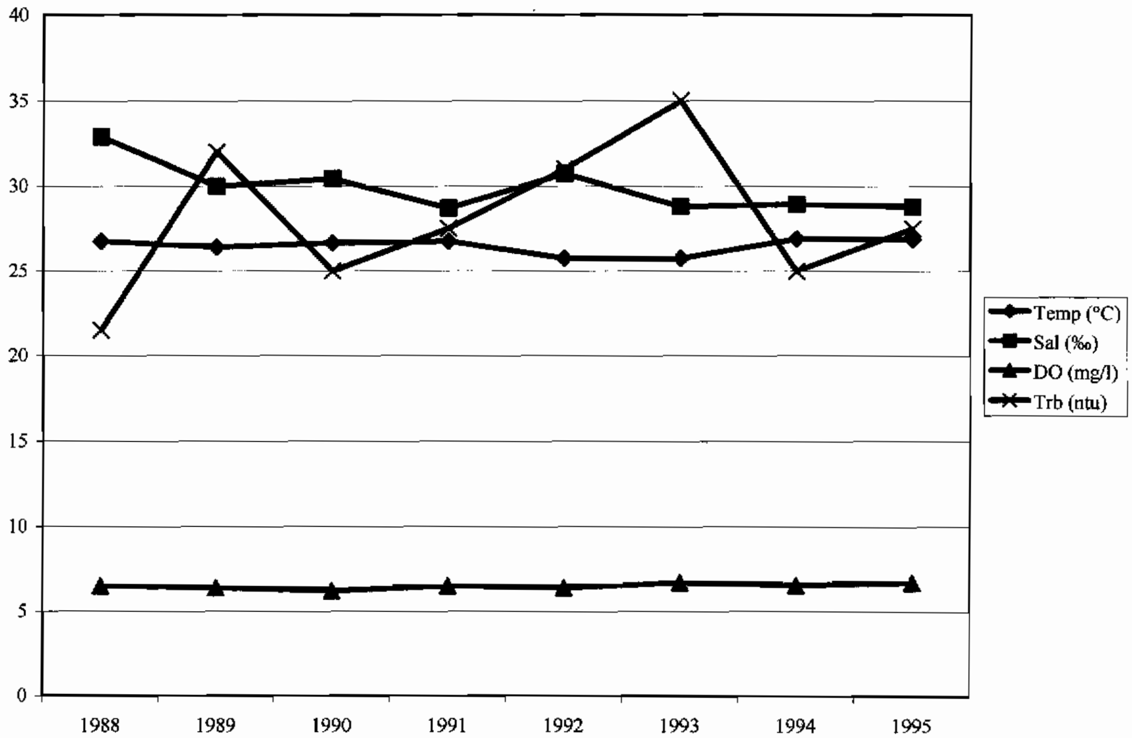


Figure 3. Mean coastwide hydrological data values for beach seine and bag seine samples collected May through November from 1998 to 1995 along Texas Gulf beaches by year.

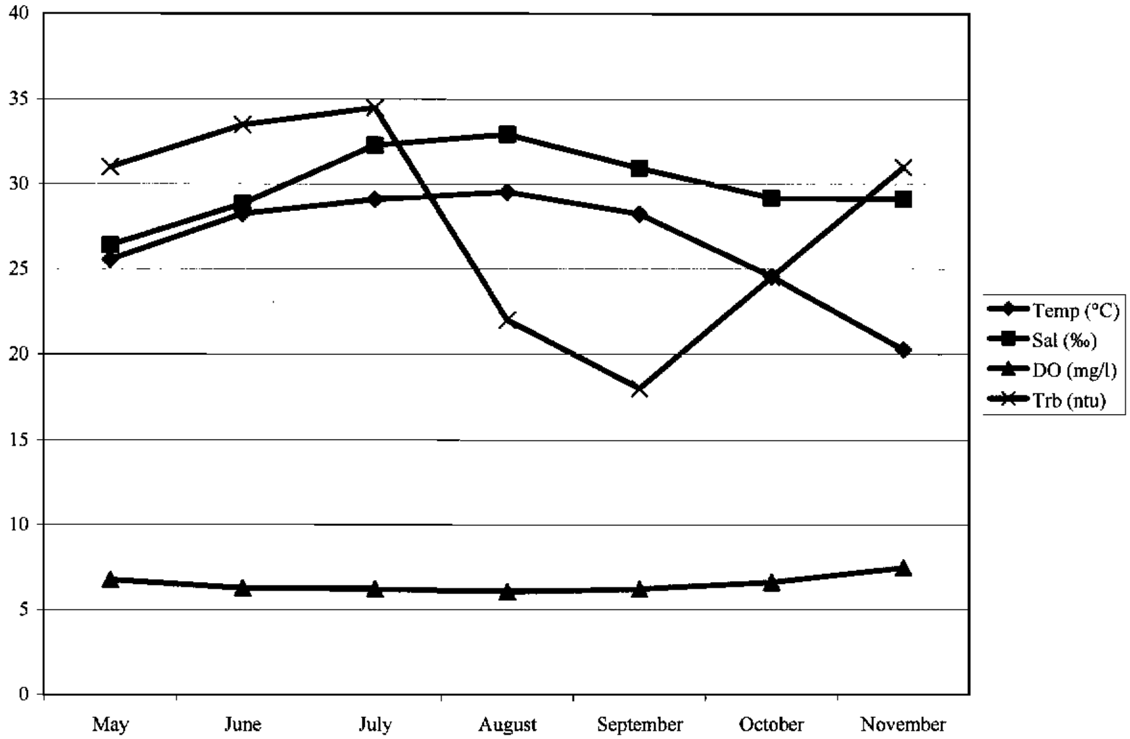
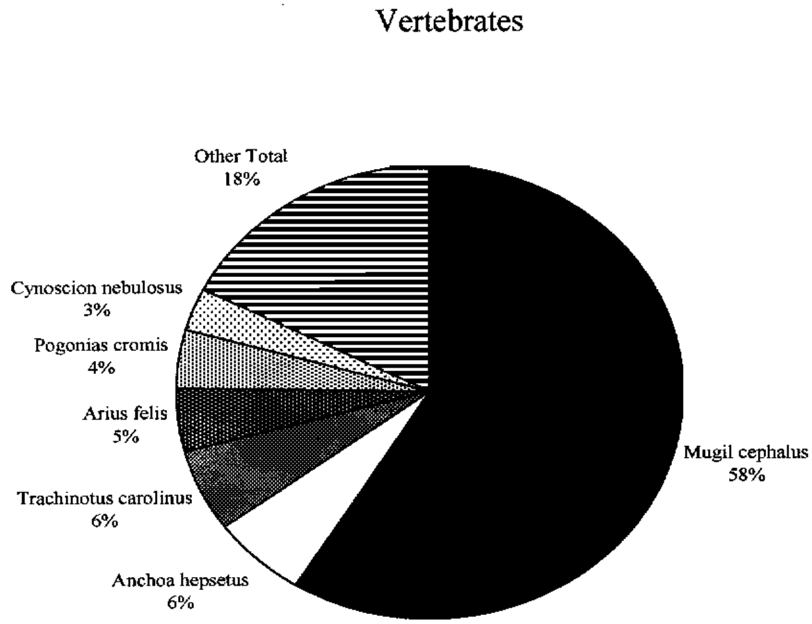


Figure 4. Mean coastwide hydrological data values for beach seine and bag seine samples collected May through November from 1998 to 1995 along Texas Gulf beaches by month.



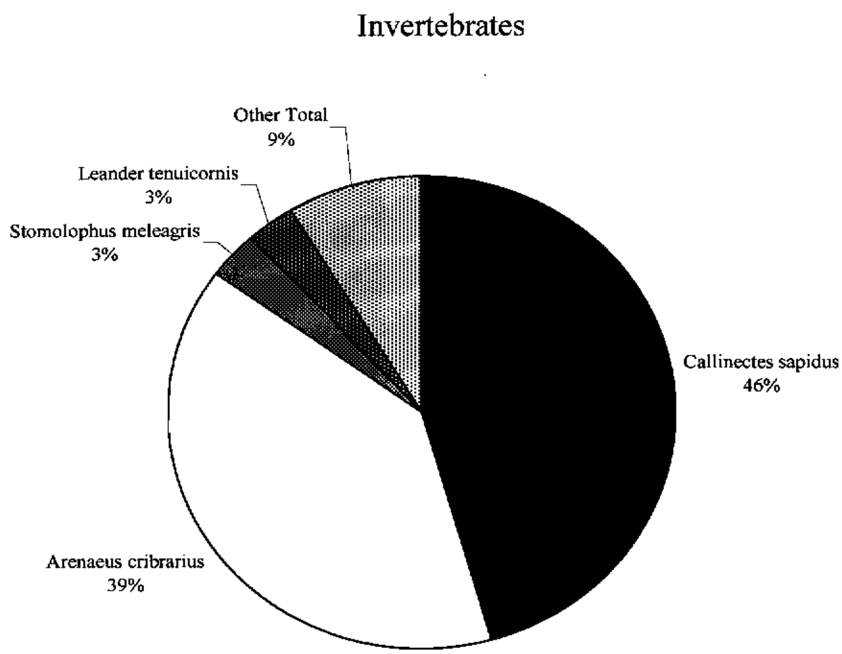
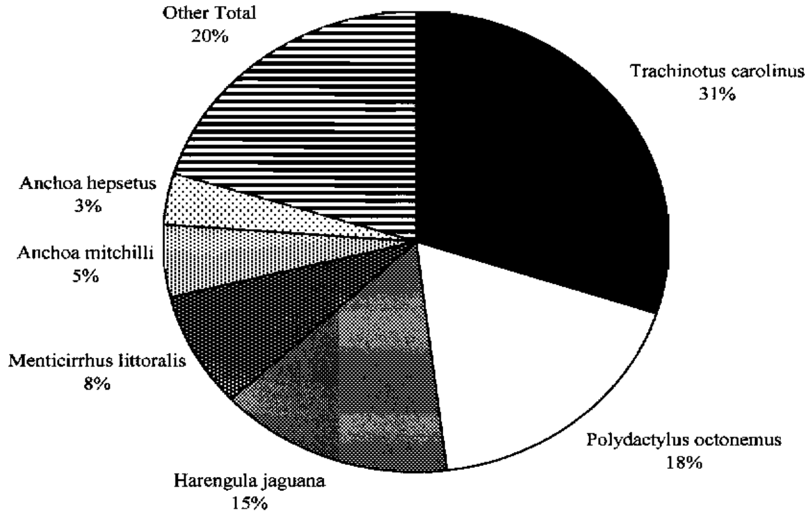


Figure 5. Percent abundance of vertebrate and invertebrate organisms sampled with beach seines.

Vertebrates



Invertebrates

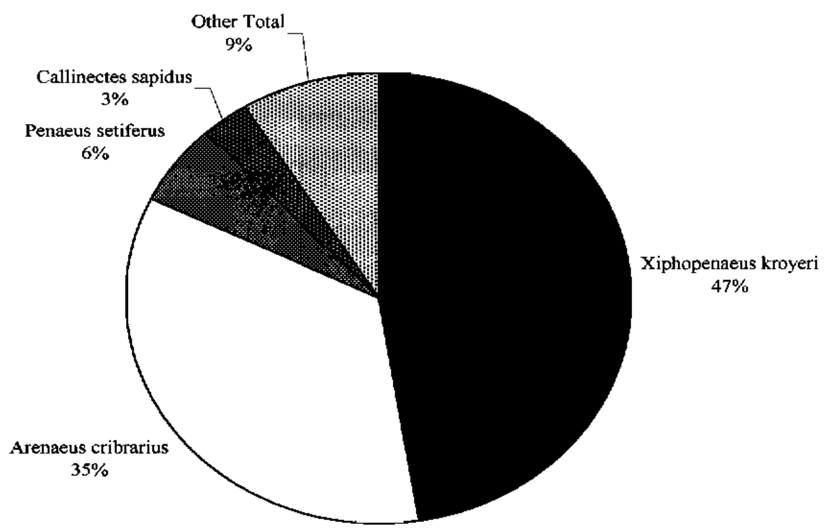
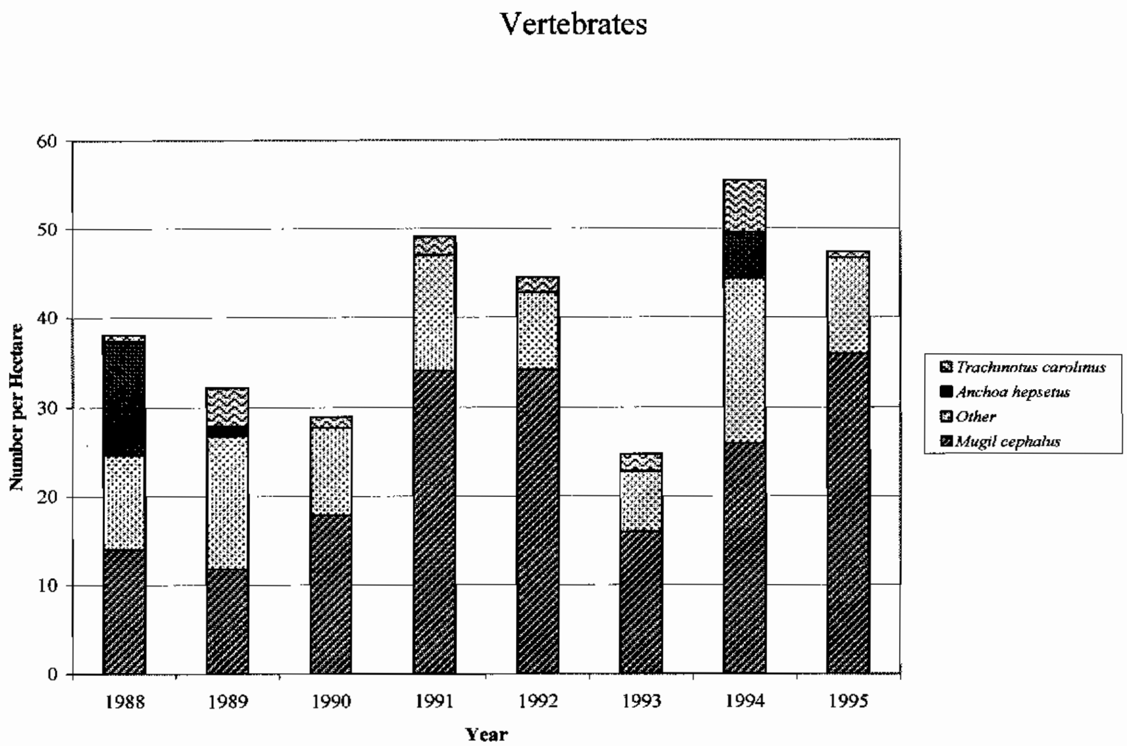


Figure 6. Percent abundance of vertebrate and invertebrate organisms sampled with bag seines.



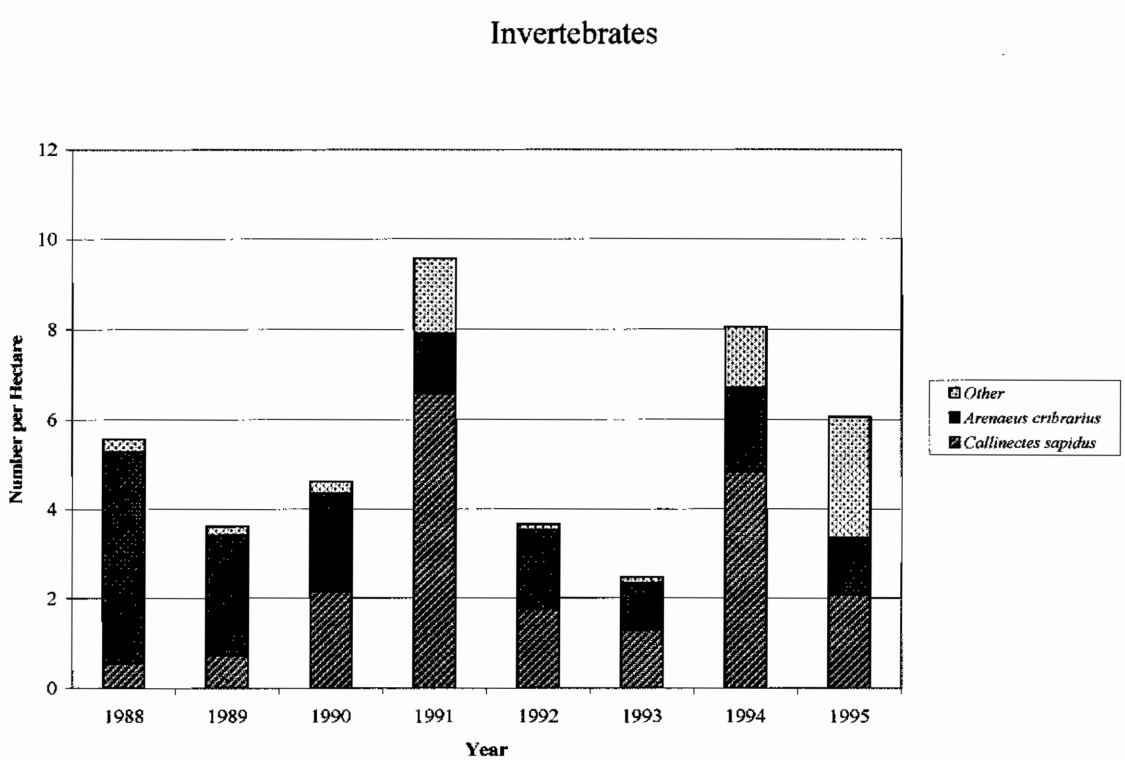
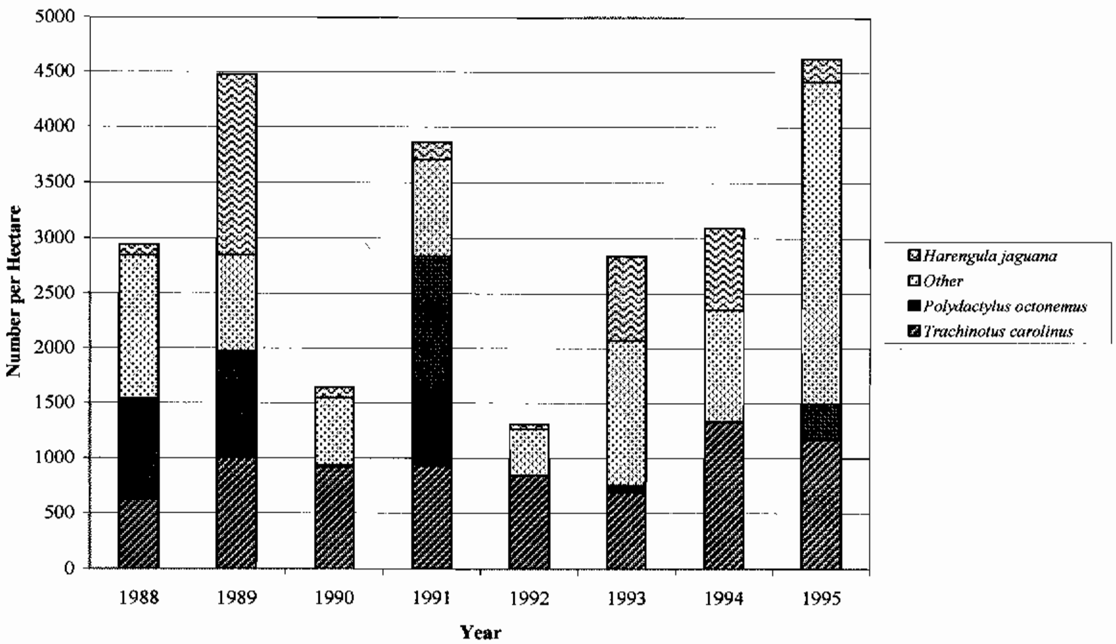


Figure 7. Catch rates of vertebrate and invertebrate organisms sampled with beach seines by year.

Vertebrates



Invertebrates

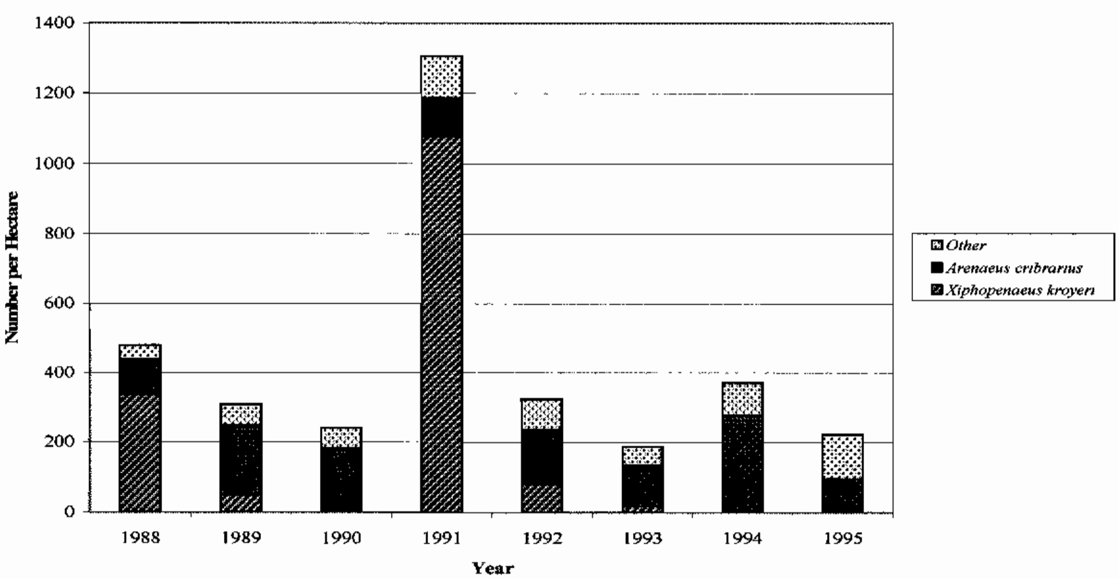
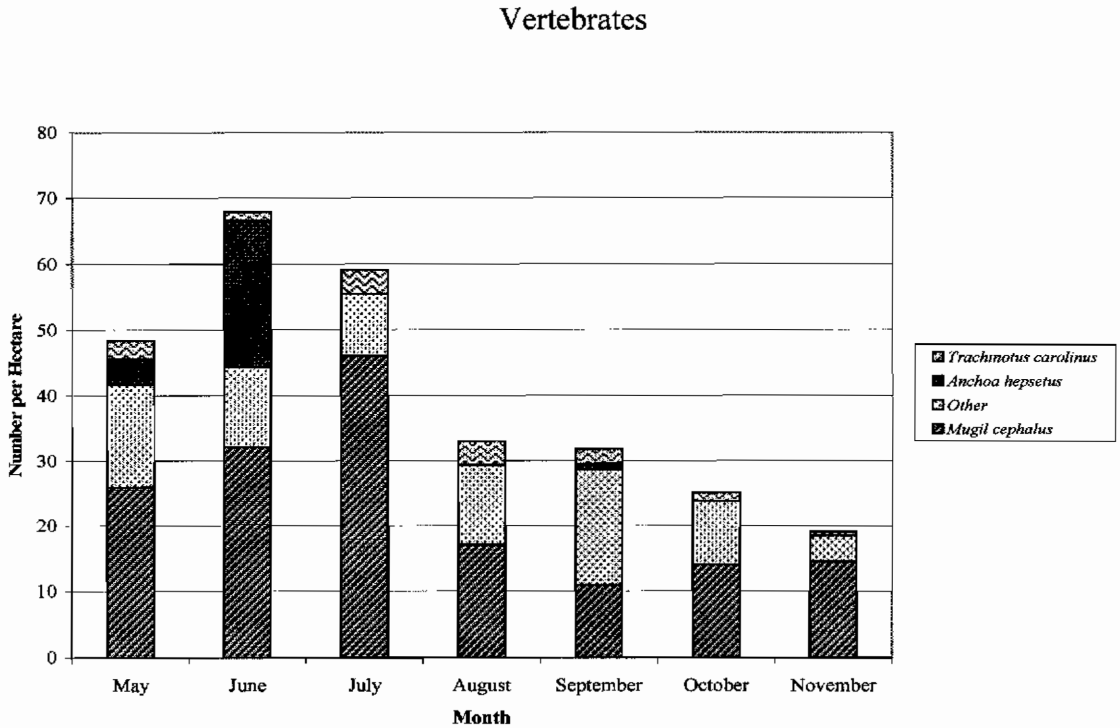


Figure 8. Catch rates of vertebrate and invertebrate organisms sampled with bag seines by year.



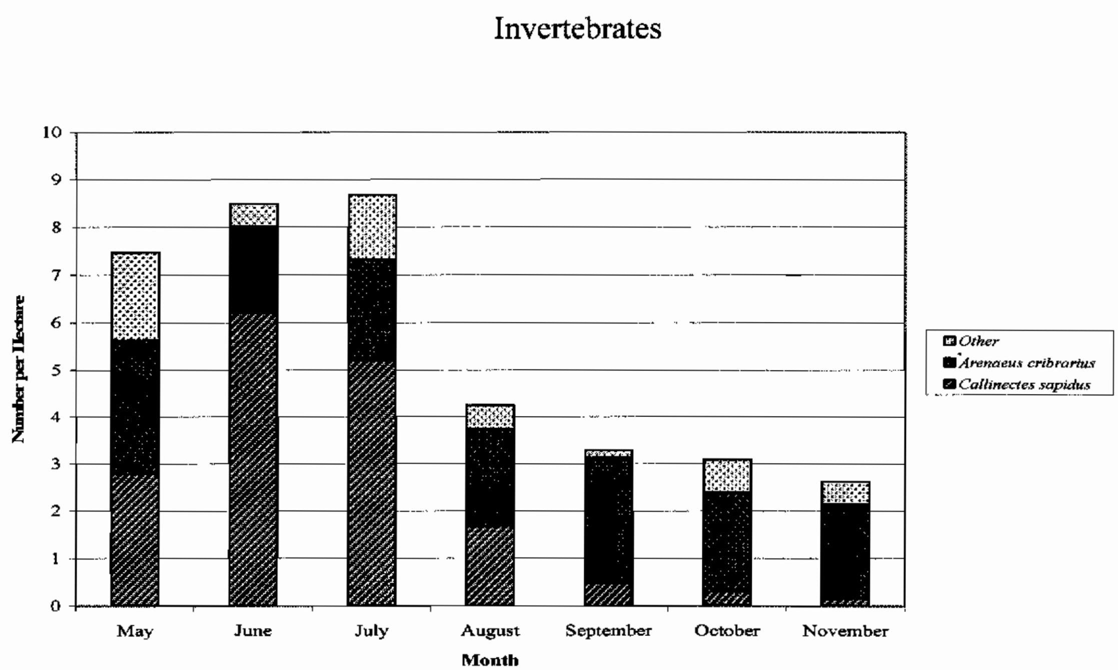
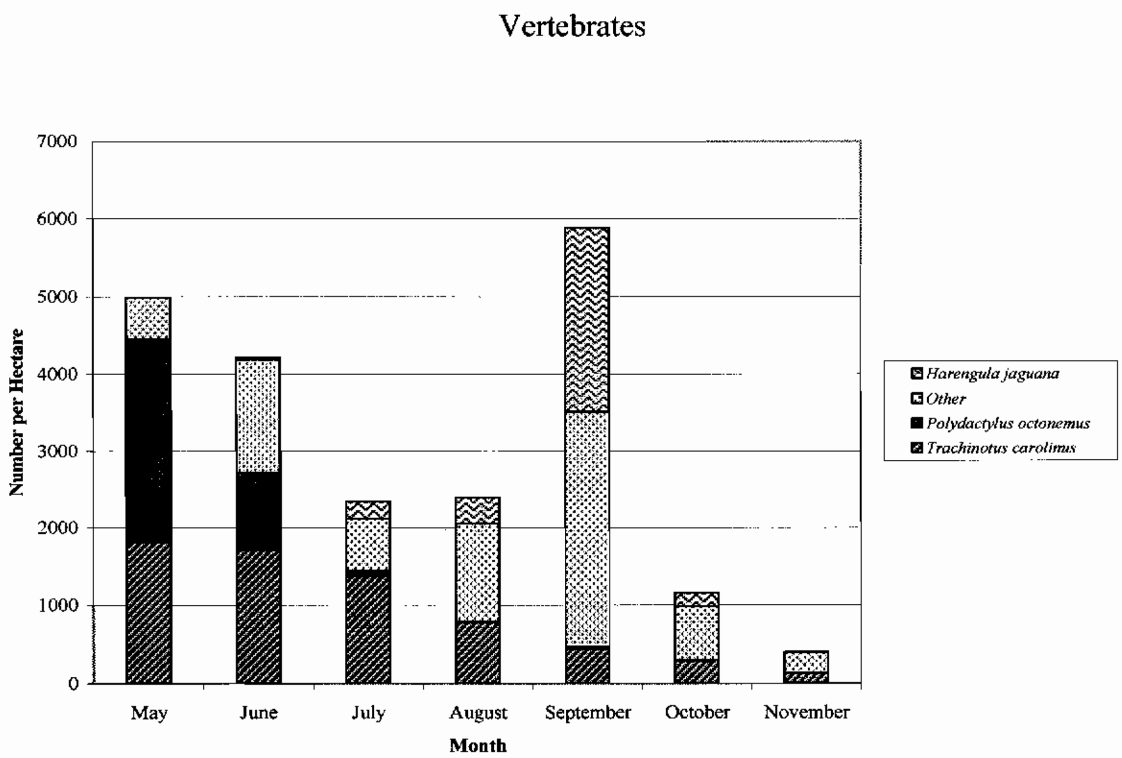


Figure 9. Catch rates of vertebrate and invertebrate organisms sampled with beach seines by month.



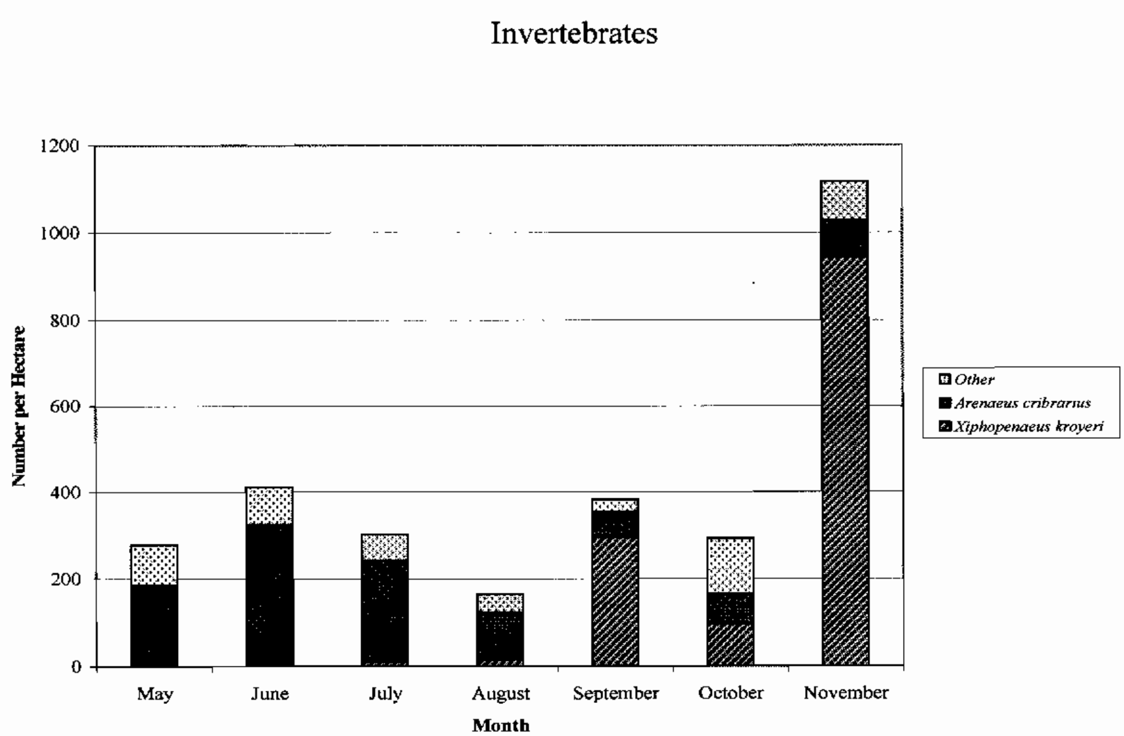
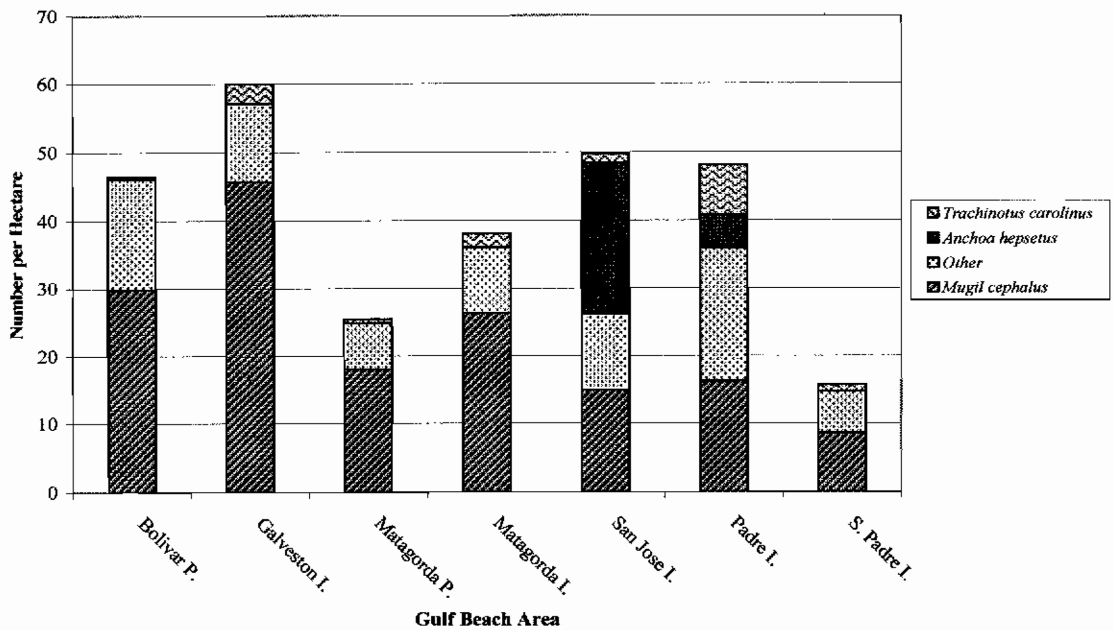


Figure 10. Catch rates of vertebrate and invertebrate organisms sampled with bag seines by month.

Vertebrates



Invertebrates

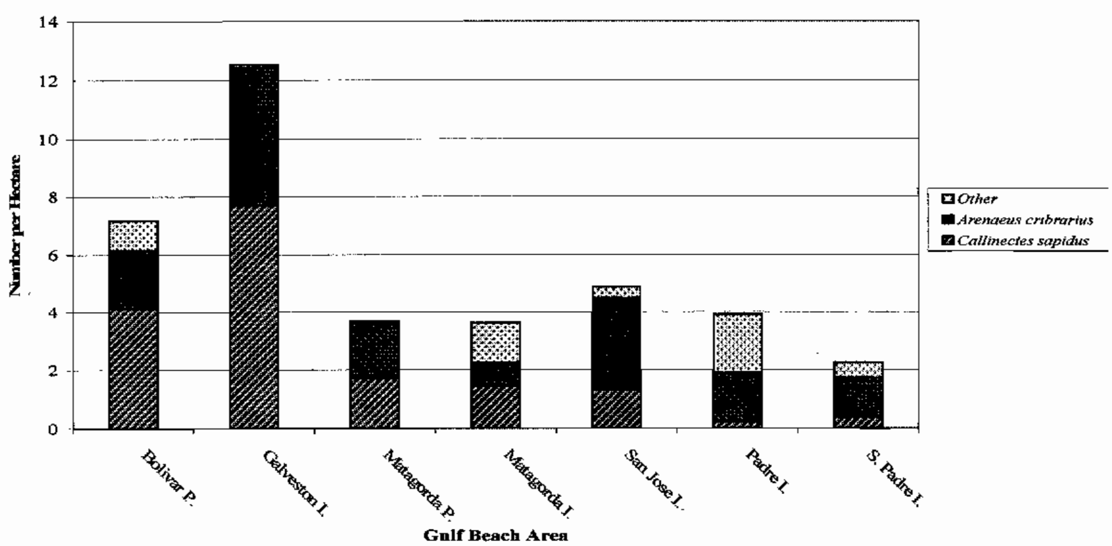
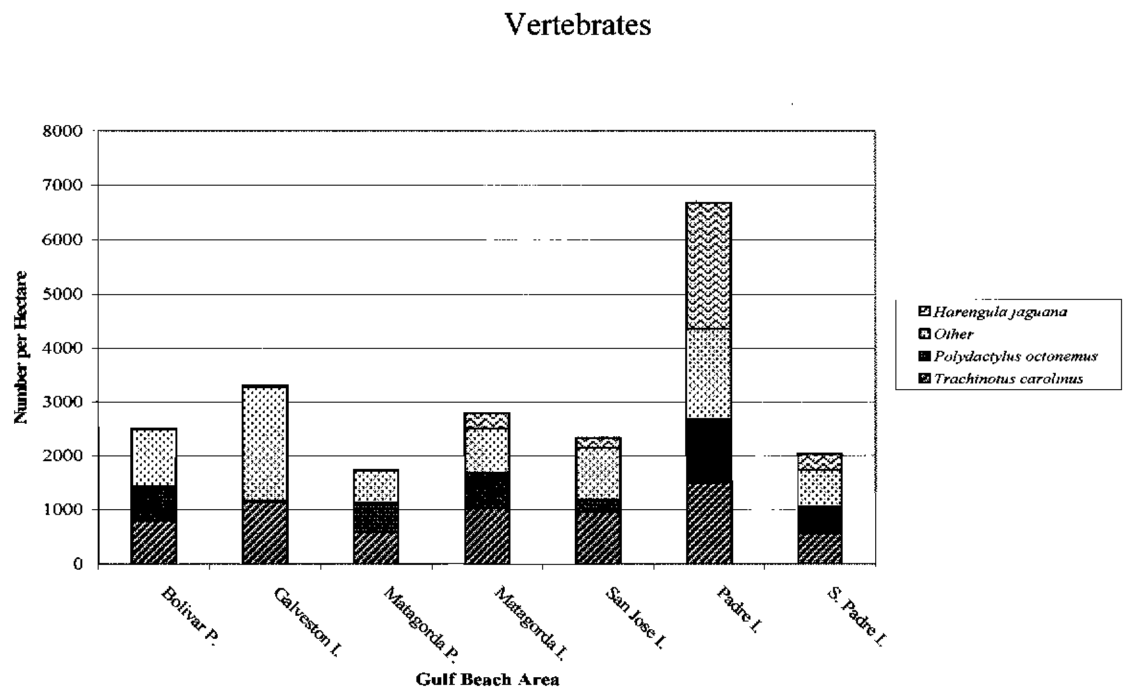


Figure 11. Catch rates of vertebrate and invertebrate organisms sampled with beach seines by area.



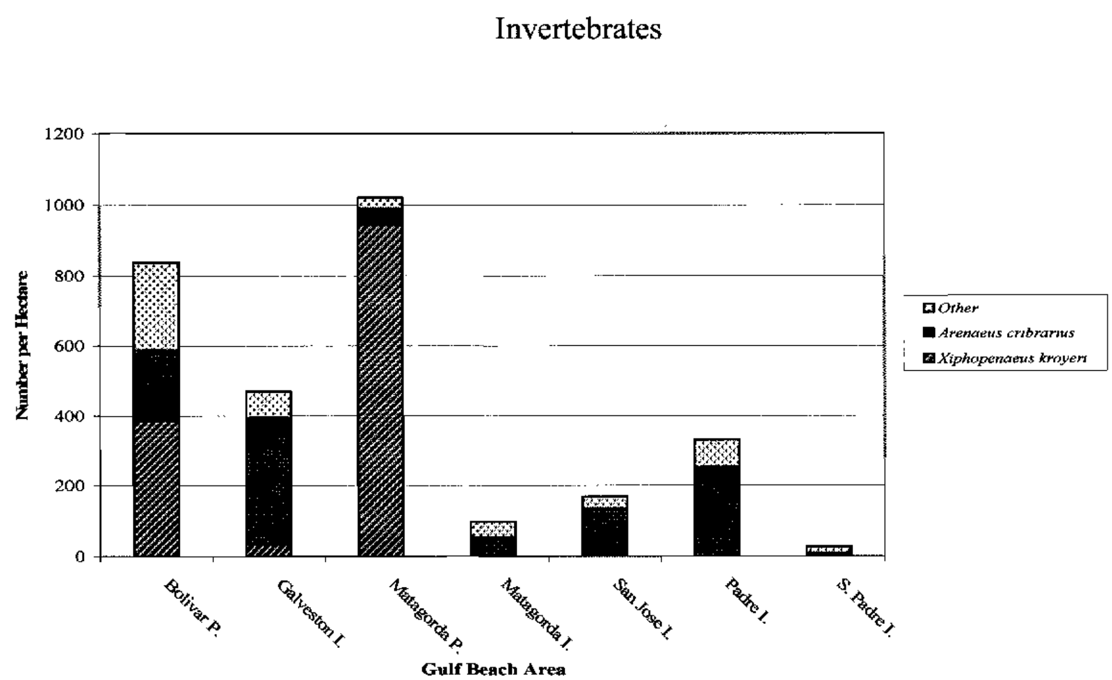


Figure 12. Catch rates of vertebrate and invertebrate organisms sampled with bag seines by area.

Appendix A. Gear deployment procedures (taken from 1992 Texas Parks and Wildlife Department, Coastal Fisheries Division, Marine Resource Monitoring Operations Manual).

Beach Seine Deployment Procedure

Step	Action
1	Lay a pre-measured rope, 30.5 m (100 ft) long, parallel to surfline. Attach a pre-measured 42.7 m (140 ft) rope between the net poles.
2	One person maintains end of beach seine at beginning of 30.5 m mark.
3	Personnel (preferably two people) proceed with beach seine, including an extra 18.3 m (60 ft) of beach seine, down the beach 42.7 m in the opposite direction of the longshore current.
4	Once the beach seine is extended, personnel (preferably two people) pull it out into the water with the prevailing current. The person onshore remains stationary, while the extended net is pulled offshore and pivots around the stationary person.
5	Once persons offshore and onshore are in a line perpendicular to the beach, proceed with both ends of the net 30.5 m down the beach in the direction of the longshore current. The person onshore should stay about 3.0 m behind persons offshore.
6	At 30.5 m, the person onshore should remain stationary while persons offshore proceed to shore with seine extended pivoting around the stationary, onshore person.
7	Persons at both ends of the net pull the beach seine onto shore.

Beach Bag Seine Deployment Procedure

Step	Action
1	Lay a pre-measured rope, 15.2 m (50 ft) long, parallel to surfline. Attach a 12.2 m (40 ft) line between the net poles.
2	Persons proceed 6.1 m (20 ft) offshore of waterline with bag seine in a folded condition.

Appendix A Cont.

Step	Action
3	At 6.1 m offshore, one person pulls one end of the bag seine offshore and one person pull the other end onshore. The third person holds the bag to keep it from rolling.
4	Once the bag seine is extended, proceed with both ends of the net 15.2 m down the beach in the direction of the longshore current, with the person onshore about 3.0 m behind the person offshore.
5	At 15.2 m, the person onshore remains stationary while the person offshore proceeds to shore with the seine extended, pivoting around the stationary, onshore person.
6	Both persons pull the bag seine to shore.

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