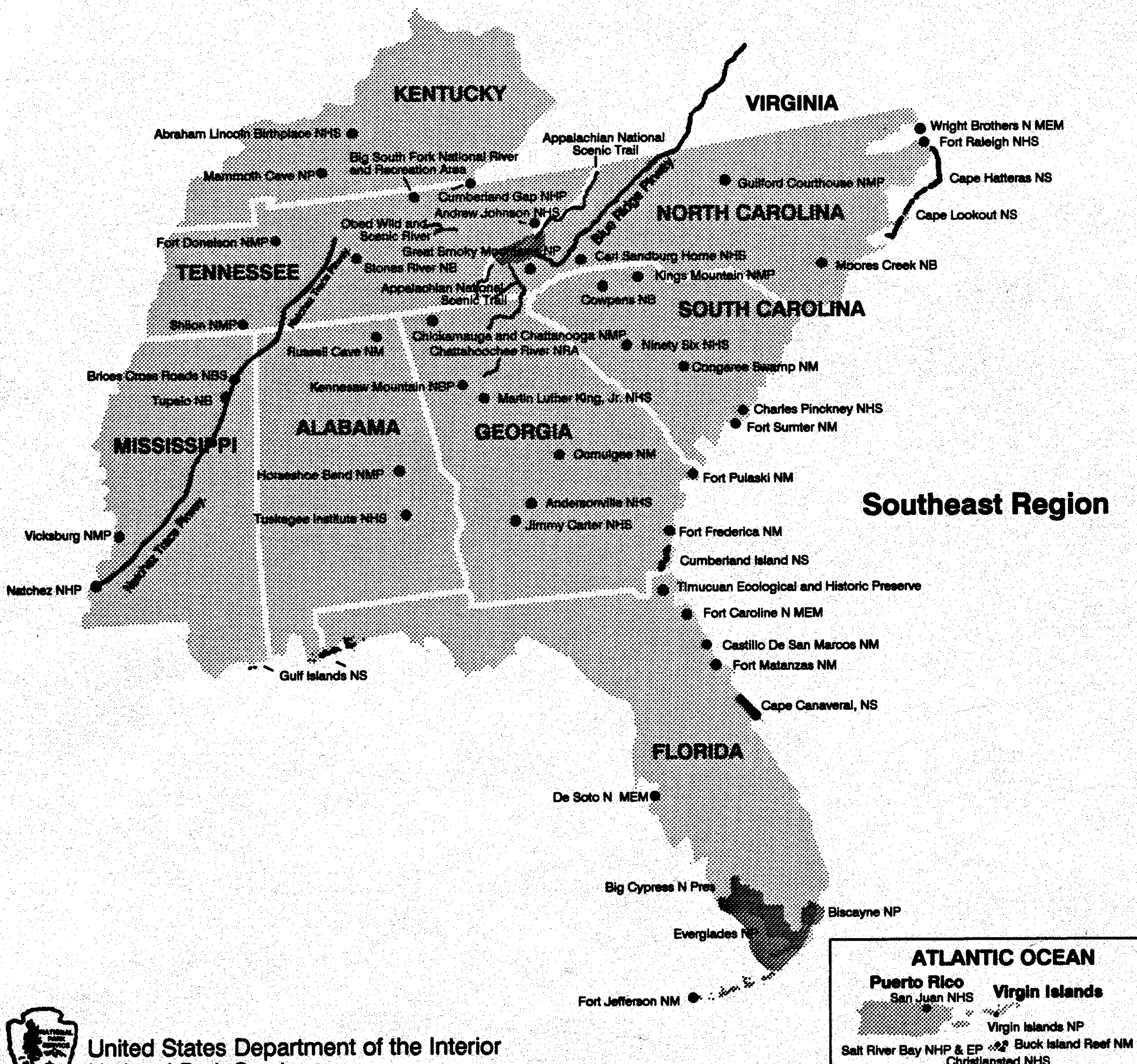
**COMMUNITY CHARACTERISTICS OF DOMINANT**

**FORAGE FISHES AND DECAPODS**

**IN THE WHITEWATER BAY -**

**SHARK RIVER ESTUARY, EVERGLADES NATIONAL PARK**

**Technical Report NPS/SEREVER/NRTR-93/12**




United States Department of the Interior
National Park Service

# COMMUNITY CHARACTERISTICS OF DOMINANT FORAGE FISHES AND DECAPODS IN THE WHITEWATER BAY - SHARK RIVER ESTUARY, EVERGLADES NATIONAL PARK

**Technical Report NPS/SEREVER/NRTR-93/12**


T. W. Schmidt
Everglades National Park
South Florida Research Center
Post Office Box 279
Homestead, Florida 33030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NATIONAL PARK SERVICE - Southeast Region
South Florida Research Center

U.S. Department of the Interior
National Park Service
Southeast Regional Office
Office of Science and Natural Resources Management
75 Spring Street, S.W.
Atlanta, Georgia 30303

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## ABSTRACT

This report presents the results of studies on the community characteristics (relative abundance, seasonal occurrence, size, reproductive activity, and food habitats) of the following dominant epibenthic forage fish and decapod crustacean species: pink shrimp (*Penaeus duronarum*), blue crab (*Callinectes sapidus*), pinfish (*Lagodon rhomboides*), silver jenny (*Eucinostomus gula*), pigfish (*Orthopristis chrysoptera*), and silver perch (*Bairdiella chrysura*). Juveniles and adults were collected with trawl and gill nets from five sites among open water bay habitats in the Whitewater Bay-Shark River system, March 1979 through May 1980. Macrobenthos sampling was usually conducted at each site on the day fish collections were made (Brook 1982).

Silver jenny, silver perch, and blue crab were classified as residents in the estuary while pink shrimp, pinfish, and pigfish were seasonal visitors which spawn offshore. Juvenile pink shrimp, the most abundant animal studied, occurred year-around, most abundantly during summer, fall, and winter, while pigfish showed abundance maxima in spring-summer. Blue crab and silver perch occurred most often in winter-spring while nearly equal numbers of silver jenny and pinfish occurred year-around. All species, except for silver jenny, occurred in greatest numbers at the Clearwater Pass site in mid-Whitewater Bay. This site, reflecting potential food sources for these species, had: (1) the greatest macrobenthic diversity, and abundance maximas of crustaceans (amphipoda), polychaetes, and mollusks (bivalves), and (2) the most dense vegetative cover of all sites sampled. Spatial and temporal variations in abundance of the dominant epibenthic species were explained, in part, by spatial and temporal patterns of food availability and habitat quality (i.e, sediment, vegetative cover). Salinity and temperature may only be autocorrelates with spawning activities and recruitment, and were not shown to be important limiting factors for these species.

In this study, catches of small juveniles of pink shrimp and pigfish suggests post-larval settlement at Clearwater Pass, whereas catches of young silver jenny and pinfish indicates post-larval settlement in eastern Whitewater Bay for these species. Except for blue crab, catches of larger specimens of all species studied occurred at the deep water, high salinity Oyster Bay site.

Diets of seasonal visitors (pink shrimp, pinfish and pigfish) suggested omnivory, with feeding primarily on crustaceans (amphipods and isopods) and vegetation (marine alga/seagrasses), whereas resident species exhibited carnivorous feeding habits, consuming mainly crustaceans (amphipods and shrimp), polychaetes, and mollusks (bivalves). Spatial, temporal, and ontogenetic variations in foods habits were found among the species sampled. Shrimp exhibited dramatic differences in diet with predator size, site, and season; highest feeding activity was found in the fall-winter period while feeding diversity was lowest at the inner-most sampling site (Tarpon Bay). Silver jenny diet varied with season and site, while pinfish varied by season and size and pigfish by predator size. Variations in diet with site and season were attributed to food availability and habitat structure while trophic ontogeny was related to fish/shrimp morphogenesis. These species were sufficiently opportunistic in their food habits to take advantage of the availability of major prey groups found at the sampled sites.

In summary, variations in abundance of the dominant species among sites were related to feeding habits as a reflection of prey availability and vegetative cover, while recruitment and reproductive activity were associated with season effects. It may be that patterns of estuarine abundance, as reported in this study, are influenced by long-term evolutionary adaption than by short-term ecological or behavioral response to environmental parameters.

## INTRODUCTION

Everglades National Park estuaries have experienced considerable alterations in their historical watersheds and fishery harvests not only from human disturbance (i.e., coastal development, drainage, and boating activity), but from climatic events such as hurricanes, droughts, and long-term cycles in temperature and rainfall. During the 1970's, much attention was focused on the Whitewater Bay-Shark River region where alterations by man (manipulation of freshwater inflow to this estuarine system and plugging of the Buttonwood Canal) may have a significant impact on Coot Bay, Whitewater Bay, and Florida Bay (Davis and Hilsenbeck 1974, Tabb and Roessler 1989).

In addition to these physical threats to the estuaries, a growing concern was noted over the decline of the total park fish harvest and the removal of fishery resources by extensive park commercial and recreational fisheries (Tilmant et al. 1990). The commercial and recreational net fisheries concentrated on herbivorous and omnivorous species at the base of the food web, such as mullet, spiny lobster, and pink shrimp, while the trap fisheries removed large percentages of middle and higher level carnivores such as blue crabs and stone crabs. The recreational fisheries also concentrated on high level food web fish such as snook, spotted seatrout, red and black drum, grouper, and snapper (Tilmant et al. 1990) which consume mostly small forage fish and crustaceans (Stewart 1961, Fore and Schmidt 1973b, Hettler 1989, and many others). The selective removal of these higher carnivores may be causing changes in the ecosystem far beyond the mere removal of their biomass (May et al. 1979). Since that time, and because of these concerns, the park has gradually phased out commercial fishing (Tilmant et al. 1990).

It was felt in 1978, that studies should be made on major non-game forage fish and commercially important decapod crustaceans at the mid and lower levels of the food web inhabiting the Whitewater Bay-Shark River estuary. Information obtained on these species would provide insight into the condition of the park's coastal fishery resources and the ecological state in which park estuarine and marine resources exist at present.

The objectives of this report are twofold: (1) to review previous work on epibenthic forage fish and commercially important decapod crustaceans of Whitewater Bay-Shark River estuary, and (2) to present data on the community characteristics (relative abundance, seasonal occurrence, size, reproductive activity and food habits) of the selected dominant fish and decapods at five sites from open water bay habitats in the Whitewater Bay-Shark River estuary. (Fig. 1).

### Previous Work

In other Gulf and Atlantic areas, studies on epibenthic forage fish have documented distribution, growth, and reproduction (Welsh and Breder 1923; Hildebrand and Schroeder 1928; Hildebrand and Cable 1930, 1934, 1938; Gunter 1945) and food (Hildebrand and Schroeder 1928; Hildebrand and Cable 1930, 1938; Darnell 1961). A voluminous literature exists on the biology and ecology of blue crab in the Atlantic region and has been documented thoroughly by Cronin et al. (1957). The pink shrimp and blue crab found along the Atlantic and Gulf coasts of the United States support two of the largest U.S. fisheries (Cronin et al. 1957, Bielsa et al. 1983). Due to their great economic value and extensive range, these estuarine dependent species have become the subject of a tremendous number of fishery-oriented investigations. Even though most forage species (i.e., pinfish, silver jenny, pigfish, and silver perch) do not reach sufficient size to become commercially or recreationally important, they are widespread and are among the most abundant epibenthic non-game fish species found in the rivers, bays, and estuaries bordering the Gulf and south Atlantic coasts of the United States (Stoner 1980, Livingston 1984, Sogard et al. 1989a, 1989b, 1989c and many others).

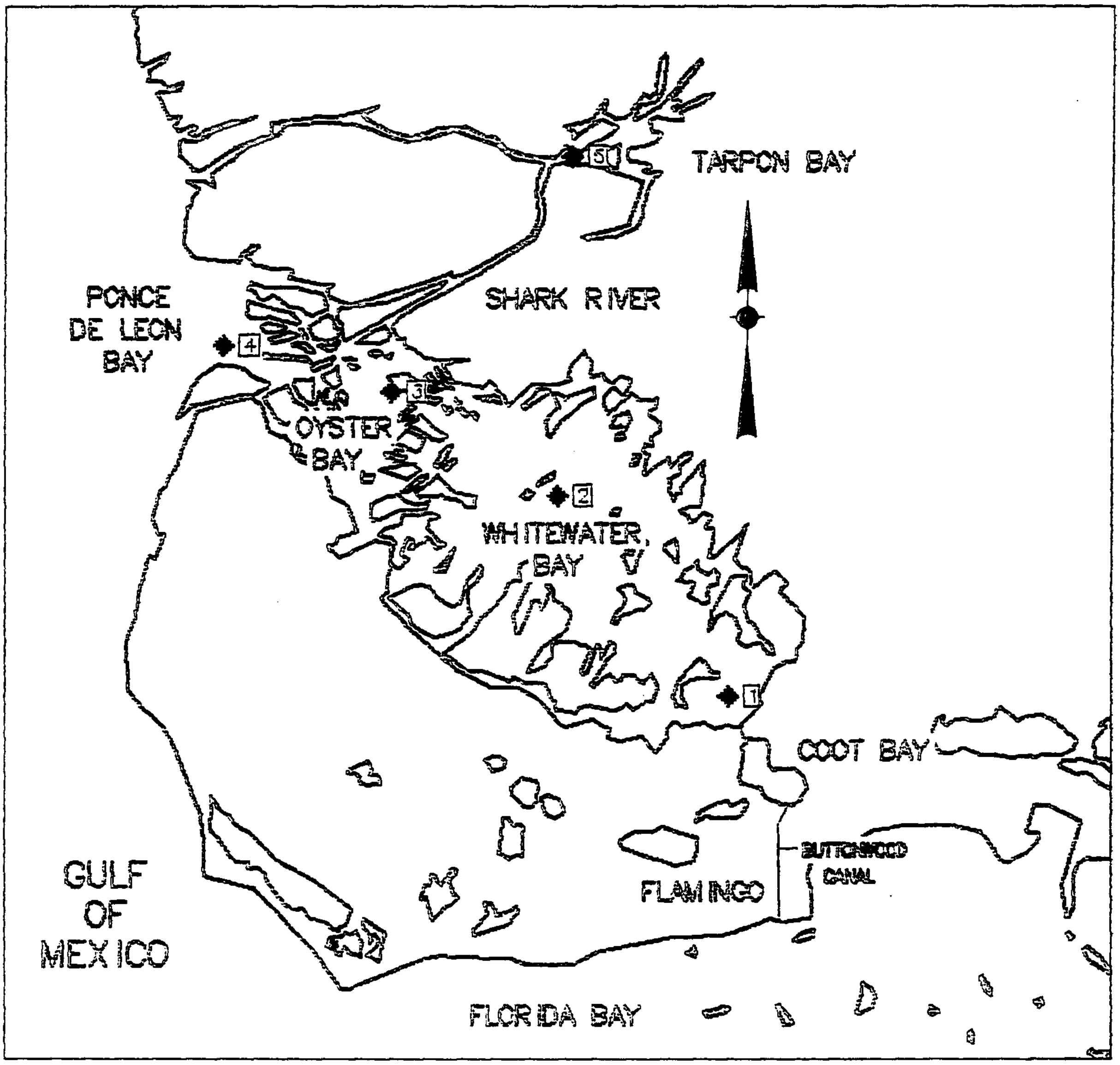


Figure 1. Map of Whitewater Bay-Shark River estuary showing sampling sites, 1979-1980. Site descriptions are in Table 1.

Considerable information has been collected elsewhere in Florida on epibenthic forage fish habitat and distribution (Reid 1954, Kilby 1955, Caldwell 1957, Springer and Woodburn 1960, Gunter and Hall 1965, Wang and Raney 1971, Fore and Schmidt 1973a, Yokel 1975, Gilmore 1977, Weinstein et al. 1977, Colby et al. 1985, Browder et al. 1986), food (Reid 1954, Caldwell 1957, Springer and Woodburn 1960, Hansen 1969, Carr and Adams 1973, Adams et al. 1974, Charles 1975, Brook 1977, Stoner 1980, Leber 1983, 1985, Kerschner et al. 1985), growth (Caldwell 1957, Springer and Woodburn 1960, Hansen 1969, Charles 1975), relative abundance (Springer and Woodburn 1960, Yokel 1975, Gilmore 1977, Weinstein et al. 1977), reproduction (Caldwell 1957, Charles 1975), and blue crab biology (Tagatz 1968, Norse 1975, Oesterling 1976). Fore and Schmidt (1973a) and Yokel (1975) found that densities of juvenile pink shrimp and forage fishes are highest in seagrass beds of open water habitats and mangrove-lined bays near the park's western boundary. Reviews of pink shrimp biology and ecology can be found in Costello and Allen (1970) and Bielsa et al (1983).

In park estuaries the seasonal abundance, size, reproductive activity, and food habits of epibenthic forage fish species and commercially important decapod crustaceans are only minimally understood. At the time of this study, knowledge available was largely confined to: (1) checklists of existing species (Tabb and Manning 1961, Hudson et al. 1970, Rouse 1970), (2) broad-scope ecological surveys (Springer and McErlean 1962, Tabb et al. 1962, Lindall et al. 1973, Davis and Hilsenbeck 1974, Schmidt 1979), and (3) specific studies addressing the ecology of fishes, i.e., relative abundance and relationships with environmental parameters (Waldinger 1968, Roessler 1970, Clark 1971, Roessler and Rehr 1971, Allen et al. 1980, Costello et al. 1986) and food (Odum 1971, Sastrakusumah 1971).

Based on the numerical dominance of fish and crustacean species collected in faunal and abundance studies from the Whitewater Bay area (as noted above), and from preliminary biological surveys (see below), the following decapods and epibenthic forage fish were selected for study: pink shrimp (*Penaeus duorarum*), blue crab (*Callinectes sapidus*), pinfish (*Lagodon rhomboides*), silver jenny (*Eucinostomus gula*), pigfish (*Orthopristis chrysoptera*), and silver perch (*Bairdiella chrysura*). Gamefish food studies in and adjacent to park estuaries often cite the importance of these select species as forage; e.g., Stewart (1961), Rutherford et al. (1982), Hettler (1989) in spotted seatrout; Rutherford et al. (1983), Harrigan et al. (1989), Hettler (1989) in gray snapper; Yokel (1966) in red drum; and Marshal (1958) and Fore and Schmidt (1973b) in snook.

Thayer et al. (1987), Powell et al. (1987), Robblee and Tilmant (1989), Robblee et al. (in prep.), Sogard et al. (1987), (1989a) (1989b) (1989c), Holmquist et al. (1989a) (1989b), and Thayer and Chester (1989) provide the most recent information on habitat and distribution of these species in park estuaries. For a comprehensive listing of papers pertinent to forage fishes and decapod crustaceans in park estuaries, the reader is referred to Schmidt and Kayar (1979), and most recently, Schmidt (1991).

## DESCRIPTION OF STUDY AREA

The Whitewater Bay-Shark River estuary covers approximately 1,000 $km^2$ at the southwest tip of Florida and historically received the bulk of the drainage from the Everglades drainage basin (Schmidt and Davis 1978). Shark Slough, largest of the park's drainage basins, is underlain by Pleistocene bedrock (Gleason 1974) and drains slowly to the southwest exiting to the Gulf of Mexico via the Shark River and five smaller rivers that flow into a large embayment, Whitewater Bay. A more detailed description of the upland environment can be found in Gleason (1974).

The Whitewater Bay-Shark River estuary is characterized by shallow water depths averaging about 1 m in eastern Whitewater Bay to about 2-5 m in Oyster Bay and the Shark River (Tabb et al. 1962). The bays and coastal shorelines are fringed by mangroves (Craighead 1971). Algal genera predominate the benthic flora of the nearshore bays, while seagrasses become dominant in outer bays and seaward. Salinities are highly variable over the long-term, depending on rainfall, runoff, and evaporation; salinity has ranged from 0 to 44 ppt. Water temperature varies seasonally and spatially, but is generally from 16 to 32 °C. Water quality characteristics have been summarized in Schmidt and Davis (1978).

## SAMPLING METHODS

The target species were sampled monthly from March 1979 to June 1980 (Table 1). A brief description of the sites, and the gear and techniques used to obtain samples follows.

### Stations

Past studies have identified five distinct substrate/salinity regimes in the Whitewater Bay-Shark River estuarine system (Tabb et al. 1962, Clark 1971). One sampling site only (due to time constraints) was selected in each distinct type after underwater (mask and snorkel) and water sampling surveys were conducted in Whitewater, Oyster, Ponce de Leon, and Tarpon Bays to reaffirm differences in substrate types and salinity. Two sampling sites were located in Whitewater Bay and one site each in Oyster, Ponce de Leon, and Tarpon Bays. The Whitewater and Oyster Bay sites were nearly identical in location to those used in earlier investigations (Tabb et al. 1962, Idyll and Yokel 1970, Clark 1971, Davis and Hilsenbeck 1974). As described below, each site was marked by two large styrofoam buoys placed 160 m apart.

### Site Descriptions

Except as noted, each of the following site descriptions are based on: (1) monthly salinities taken at the time of sampling (Table 2) over the 14-month study period, (2) vegetation (or lack thereof) noted in trawl samples, and (3) vegetation and sediment samples collected during a concurrent macrobenthos study by Brook (1982). Each station represents an area of about 30 x 160 m where trawling was conducted.

Sampling sites were as follows: Site 1 (25°13' N, 80°56'W), located in the shallow southeast portion of Whitewater Bay, had a bottom composed of sand and coarse shell fragments with very low vegetation density consisting of green calcareous algae (mostly *Batophora oerstedi*) and shoalgrass (*Halodule wrightii*) (Fig. 1). Salinities ranged from 10.7 to 25.7 ppt with a mean of 16.7 ppt. Site 2 (25°17' N, 81°00 W), located in the shallow western portion of Whitewater Bay known at Clearwater Pass, had a substrate comprised of shell-sand and gumbo marl and the densest vegetative cover of all sites sampled. Bottom vegetation included *H. wrightii*, *Sargassum fillipendula*, and *Udotea* sp., while unattached red algae occurred occasionally in the samples. Salinities ranged from 13.1 to 32.1 ppt with a mean of 20.1 ppt. Site 3 (25°20' N, 81°04' W), a rocky, deepwater (2 m) channel in Oyster Bay, had a substrate composed of old oyster reef outcrops which were devoid of benthic vegetation. Salinities at this site ranged from 20.3 to 35.3 ppt with a mean of 27.1 ppt. Site 4 (25°21' N, 81°08'W), situated in the shallow waters of Ponce de Leon Bay, was subject to strong river and tidal fluctuations (Tabb et al. 1982, Davis and Hilsenbeck 1974). The bottom was composed of fine-grained, soft, muddy sediments which support scattered growths of *H. wrightii*. Salinities ranged from 18.6 to 35.3 ppt with a mean of 26.9 ppt. Site 5 (25°25' N, 80°59' W), located at the shallow headwaters of the Shark River in Tarpon Bay, exhibited strong currents (estimated between 2 and 3 km/h) from upland surface runoff during spring-summer. The rock outcrop substrate devoid of benthic vegetation contained depressions with varying amounts of mangrove detritus, peat, and debris. Salinities at this site ranged from 1 to 22.5 ppt with a mean of 5.6 ppt.

Table 1. Sampling dates, number of samples, and gear used at each site. Except where noted, each gear used at a sampling site represents one sample. Sampling sites are as follows: Site 1=Eastern Whitewater Bay (EWB)*; Site 2=Western Whitewater Bay (WWB); Site 3=Oyster Bay (OYB); Site 4=Ponce de Leon Bay (PDB); and Site 5=Tarpon Bay (TPB).

| DATE | SAMPLES | GEAR** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SITE 1 | | | SITE 2 | | | SITE 3 | | | SITE 4 | | | SITE 5 | | |
| March 1979 | 4 | 1 | - | - | 1 | - | - | 1 | - | - | 1 | - | - | - | - | - |
| April | 5 | 1 | - | - | 1 | - | - | 1 | - | - | 1 | - | - | 1 | - | - |
| May | 11 | 1*** | 2*** | - | 1*** | 2*** | - | 1 | - | - | 1 | - | - | 1 | - | - |
| June | 8 | 1 | - | - | 1 | 2 | - | 1 | 2 | - | 1 | 2 | - | 1 | - | - |
| July | 5 | 1 | - | - | 1 | - | - | 1 | - | - | 1 | - | - | 1 | - | - |
| September | 6 | 1 | - | - | 1 | - | 3 | 1 | - | - | 1 | - | - | 1 | - | - |
| October | 11 | 1*** | - | - | 1*** | - | - | 1*** | - | 3 | 1*** | - | 3 | 1 | - | - |
| November | 5 | 1 | - | - | 1 | - | - | 1 | - | - | 1 | - | - | 1 | - | - |
| December | 5 | 1 | - | - | 1 | - | - | 1 | - | - | - | 2 | - | - | 2 | - |
| January 1980 | 5 | 1 | - | - | 1 | - | - | 1 | - | - | - | 2 | - | - | 2 | - |
| February | 7 | 1 | - | 3 | 1 | - | - | 1 | - | - | - | 2 | 3 | - | 2 | - |
| March | 8 | 1 | - | 3 | 1 | - | 3 | 1 | - | 3 | - | 2 | - | - | 2 | - |
| April | 10 | 1 | - | 3 | 1 | - | 3 | 1 | - | 3 | - | 2 | 3 | - | 2 | 3 |
| May | 8 | 1 | - | 3 | 1 | - | - | 1 | - | 3 | - | 2 | - | - | 2 | 3 |
| TOTALS | 98 | 16 | 2 | 4 | 16 | 3 | 3 | 15 | 1 | 4 | 9 | 7 | 3 | 7 | 6 | 2 |

*Acronyms (in parentheses) are as used in Figures

***Two samples collected by each gear

**1=Roller Frame Trawl
2=Otter Trawl
3=Gill Net

Gear and Techniques

Preliminary sampling in Whitewater Bay, studies in Biscayne Bay (Roessler 1965), and previous experience in park estuaries (Yokel, pers. comm.) indicate that catches of fish and crustaceans increase following sunset. Therefore, sampling was conducted between the hours of 1900 and 0200 hrs and during a two-night period, ± 3 days of the new moon to avoid variations in catches influenced by moonlight. At each station, trawling and netting were conducted on alternate nights. Due to mechanical boat difficulties, no sampling was conducted in August 1979, thus, a total of 14 sampling periods were made at each of the five sites.

To insure adequate sample representation of the entire size range of the target species in the population, epibenthic collections were made with a paired roller frame trawl and an otter trawl and pelagic collections were made with gill nets. Although the sampling limitations of trawls are well established (e.g., Taylor 1953, Roessler 1965, Clark 1971), they are used to describe various aspects of estuarine fish communities (Guillory et al. 1982 and numerous references therein). Roller frame trawling allows comparison with other studies in the area (Idyll and Yokel 1970, Clark 1971). All sampling was carried out from a 20-foot fiberglass boat equipped with a 150 hp outboard motor. The boat was modified by the addition of an outrigger-boom winching assembly placed amidship to facilitate handling of the epibenthic sampling gear. The specially constructed one-meter wide roller trawls consisted of 1.27 cm bar mesh net on the body and 0.95 cm bar mesh webbing on the cod-end. The strainer bars were removed to allow for the capture of adult blue crabs. The trawls were deployed by paying out and retrieving the nets simultaneously from each side of the boat by a two-man crew. The trawls were released when the boat was on site adjacent to a marker buoy and headed against the direction of the current. At each site, parallel, non-overlapping replicate tows were made.

Because of known variability in trawl sampling, preliminary sampling was conducted to determine the effects of tow length on variability and catch rates. As recommended in Schramm and Pennington (1982), samples collected from opposite sides of a boat were considered replicates for species diversity, but not for numbers of taxa. During May 1979 at site 2, nine 2-min, ten 4-min, and eight 6-min samples were made. Unequal sample effort for 2-min tows was due to equipment malfunction. A greater ($t = 3.75$, $V = 17$, $P<0.01$) cumulative mean number of target species were taken during 4-min tows (mean=3) than during 2-min tows (mean=1). There was no significant difference in number of species between 4- and 6-min tows. The 4-min tows had the lowest coefficient of variation for species (.4), as opposed to .9 and .7 for the 2- and 6-min tows, respectively. This preliminary sampling procedure was also used to determine the number of replicate trawls needed to achieve 83% accumulation of target species (5 of 6 target species) on a sampling date. Eight 4-min replicate trawls indicated that six replicates were sufficient to collect 5 of the 6 selected species found. Thus, catch data from three paired replicates at each site were grouped to form one sample and used to determine abundance (number of fishes per species). During this procedure, the average distance covered for 4-min tows was 160 m. The calculated ($S = D/T$) boat speed was 1.4 km/h (about 850 RPMs on the engine tachometer) for 4 min. Consequently, all roller trawl collections analyzed for abundance were made for 4-min over distances of 160 m using three paired replicates at each of the three sites in Whitewater and Oyster Bays.

The 4.2-m wide semiballon otter trawl consisted of 2.54 cm bar mesh webbing fitted with a .64-cm bar mesh liner in the cod end. The trawl was deployed by paying the net over the stern of the boat while maintaining slight headway. The trawl boards were deployed upon reaching a marker buoy and headed against the direction of the current. When the tow ropes were taut, a timed haul of 2 min at approximately 2 km/h was performed. Three non-overlapping parallel tows were made over a distance of 160 m; the time necessary to trawl this distance was 2 min. Three replicate hauls formed one sample. Both of these gear types were deployed to catch juveniles and smaller adults of the target species.

Gill net sampling consisted of two 30 m long variable-mesh nets; each net was comprised of 3-10 m long monofilament panels with bar mesh sizes of 25 mm, 51 mm, and 76 mm. They were set by boat and fished for 2 1/2 hours across current, adjacent to each trawl site. Each gill net sample consisted of two net-sets. The gill nets were deployed to catch the larger (adult), faster moving specimens of the target species.

At each site, prior to obtaining biological samples, subsurface salinity and temperature were measured insitu with a Beckman RS-5 salinometer.

After each sampling, all specimens were placed in labelled buckets for each site and gear type and preserved in 10% formalin. The preserved samples were sorted in the laboratory and fixed in 95% ethanol. All specimens were measured and weighed. Standard lengths (SL) from the tip of the snout with the mouth closed to the tip of the vertebrate column (or hypural plate) were taken on all finfish while crustacean measurements were carapace width (CW), defined as distance between the ends of the lateral spines for crabs and carapace length (CL) defined as distance between the rear orbital margin and the posterior carapace margin at the dorsal midline for shrimp. Weights were recorded to the nearest 0.1 gm using a dial-type Ohaus balance. Lengths and widths were recorded to the nearest 0.1 mm.

## DATA ANALYSIS

The data were evaluated based on the sites and the period of time over which the samples were collected. Except where noted, all analyses (i.e., size, reproductive activity, food habitats) were based over the 14-month sampling period.

### Abundance/Size

Estimates of abundance were made using 33 monthly (one sample/month) roller trawl samples collected from May 1979-June 1980 at sites 1-3 (Appendix I). Species abundances (numbers per sample and tow) were transformed ($\log_e [x+1]$). When assumptions of normality (Kolmogorov-Smirnov test) and homogeneity (Bartlett Box F test/Hartley $F_{max}$ test) were met, a parametric one-way ANOVA was used to test site and date effects. After significance was determined (0.05 level), a Student-Newman-Kuels (SNK) test was used to identify particular differences. If conditions of normality and homogeneity were not met after transformations, a non-parametric Kruskal-Wallis one way analysis of variance (KW-1-way ANOVA) was used to test for significance (0.05 level). Difference in mean fish length was accomplished using one-way ANOVA or *t*-test. A SNK test was used to locate specific differences. Correlations with site for size, abundance, salinity and temperature were computed. The product-moment correlation is a robust statistic and is insensitive to data which is non-normal in distribution (Horton 1978). Differences were considered significant at the 0.05 probability level. Relationships among sites for salinity and temperature were compared using a one-way analysis of variance (ANOVA) ($P<0.05$). A SNK test was used to detect specific differences.

Length-weight relationships were calculated for selected species according to the formula:

$$W = aL^b$$

when W = weight (0.1 gm), L = length (mm SL for fish, CL for shrimp), and a, b are empirically determined constants. $Log_{10}$ transformations of individual weights and lengths were plotted and a regression line was calculated by the methods of least squares.

Reproductive Activity

Four aspects of reproductive activity: seasonality, fecundity, size at maturity and sex ratios were examined. In the laboratory, body cavities of the selected species were opened and their gonads were examined macroscopically. Finfish were graded on a seven-stage maturity scale by sex following procedures published by Bagenal (1971). Blue crabs were classified using scales developed by Tagatz (1968). Female shrimp were assigned a stage of development: undeveloped, developing, and nearly ripe (Cummings 1961). Male shrimp maturity was based on extruding spermatophores (Eldred et al. 1961). The occurrence and size of the selected species at different gonadal stages of maturity were noted and used as indicators of size at first maturity and seasonality. Fecundity was determined by the gravimetric method described by Bagenal (1971). All female crabs were examined for the presence of an egg mass (sponge) attached to the abdomen. Three replicate sub-samples of preserved eggs were used to count a known weight of eggs and in estimating total fecundity by proportion. To determine differences in fecundity, the mean relative fecundity index (the number of eggs per unit weight of the fish) was calculated. For silver perch, the relationship between fecundity and length was determined using the formulae $\text{Log } F = \log a + b \text{ Log } L$ where a was a constant and b an exponent derived from the data (Bagenal 1971). The Chi-square test was applied to the total number of male and female individuals of each species to determine any significant departure from unity.

Food

For the food studies, stomachs were carefully removed from all specimens and prey identification was made microscopically to the lowest possible taxon and detritus and/or sediment were noted. The percent volume of each food item was measured by water displacement to 0.001 mL using a Kimax-McNaught graduated cylinder. Prey identifications were based on pertinent literature from local species descriptions and identification keys which were compiled in a bibliographic project report (Schmidt and Kayar 1979) and the use of invertebrate reference specimens supplied by a concurrent NPS/University of Miami macrobenthos study. This study, undertaken to provide information for the analysis of feeding habits of the selected species, was conducted monthly during 1979, January and May 1980 on each day fish collections were made. Invertebrate identifications were made by Julio Garcia-Gomez of the University of Miami. Laboratory annelid identifications were made by Dr. S. Kayar, a coastal marine polychaete specialist and research assistant on this study.

Two methods were used to determine the contribution of different prey items to the predator's diet: (1) the percentage volume of a prey category for all individuals sampled to the total volume of the stomachs contents of all specimens, and (2) the percentage of total stomachs containing food in which a prey category occurred. For these analyses, the stomach contents of all specimens were pooled without regard to season, site, or predator size.

## RESULTS

### Environmental Conditions

#### Salinity

The highest recorded salinity, (35.3°/oo at sites 3 and 4) occurred during April 1979, just prior to the start of the rainy season, while the lowest salinity occurred at site 5 (0.9°/oo) in October; the average salinity over sites and times was 19.3°/oo (Table 2). Salinity differed significantly (1-way ANOVA; Table 2) among sites. Site 5, which receives freshwater runoff from the Shark River Slough, had significantly lower salinities than other sites. In Whitewater Bay, salinities at both sites were similar to each other (3/79-5/80) but lower than those at sites 3 and 4 near the estuary mouth, and higher than those at site 5, further inland. At sites 1 to 3 and 5, lowest salinities were observed in fall (Oct-Dec) followed by a gradual increase over the next five months.

Table 2. Monthly salinities and descriptive statistics with significant differences among sites indicated.[1,2] Site designations are in Table 1.

| | | SITE | | | | |
|---|---|---|---|---|---|---|
| YEAR | MONTH | 1 | 2 | 3 | 4 | 5 |
| 1979 | Mar | 22.5 | 30.5 | 33.7 | 33.7 | 18.5 |
| | Apr | 25.7 | 32.1 | 35.3 | 35.3 | 22.5 |
| | May | 21.7 | 22.7 | 28.9 | 31.3 | 41.7 |
| | Jun | 18.3 | 23.5 | 29.1 | 29.0 | 7.9 |
| | Jul | 17.4 | 17.2 | 25.2 | 26.0 | 3.7 |
| | Sep | 16.5 | 14.6 | 26.6 | 18.6 | 2.7 |
| | Oct | 11.7 | 13.1 | 23.0 | 26.7 | 0.9 |
| | Nov | 11.8 | 14.1 | 21.7 | 22.9 | 2.3 |
| | Dec | 10.7 | 13.1 | 23.3 | 23.8 | 2.4 |
| 1980 | Jan | 14.7 | 18.8 | 28.5 | 28.2 | 3.5 |
| | Feb | 13.0 | 16.1 | 27.3 | 26.0 | 2.2 |
| | Mar | 14.2 | 15.8 | 24.2 | 23.4 | 2.1 |
| | Apr | 18.0 | 26.2 | 30.4 | 29.8 | 5.0 |
| | May | 17.3 | 24.2 | 25.7 | 24.2 | 3.4 |
| Mar 79-May 80 | | | | | | |
| Mean | | 16.7 | 20.1 | 27.1 | 26.9 | 5.6 |
| Std. Dev. | | 4.42 | 6.41 | 4.27 | 4.76 | 56.57 |
| Variance | | 19.5 | 41.02 | 18.26 | 22.61 | 43.16 |
| Maximum | | 25.7 | 32.1 | 35.3 | 35.3 | 22.58 |
| Minimum | | 10.7 | 13.1 | 20.3 | 18.6 | 0.9 |
| Sample Size | | 14 | 14 | 14 | 14 | 14 |
| Jun 79-May 80 | | | | | | |
| Mean | | 14.8 | 17.8 | 25.6 | 25.1 | 3.28 |
| Std. Dev. | | 2.78 | 4.69 | 3.16 | 3.47 | 1.87 |
| Variance | | 7.7 | 22.02 | 9.98 | 12.03 | 3.48 |
| Maximum | | 18.3 | 26.2 | 30.4 | 39.8 | 7.9 |
| Minimum | | 10.7 | 13.1 | 20.3 | 18.6 | 0.9 |
| Sample Size | | 11 | 11 | 11 | 11 | 11 |

[1]Significant according to both one-way Anova ($P \leq 0.05$) and SNK ($P \leq 0.05$).
[2]Underlined mean site values are not significantly different from each other according to SNK test ($P \leq 0.05$).

Temperature

The range of temperature was 14.5 °C with the maximum of 30.5 °C and the minimum 16.0 °C (Table 3). Temperatures across sites revealed that January was the coldest and June was the warmest. There were no significant differences in temperatures among sites (1-way ANOVA; Table 3).

Table 3. Monthly temperatures and descriptive statistics with significant differences among sites indicated.[1] Site designations are in Table 1.

| | | SITE | | | | |
|---|---|---|---|---|---|---|
| YEAR | MONTH | 1 | 2 | 3 | 4 | 5 |
| 1979 | Mar | 21.1 | 21.0 | 21.5 | 21.5 | 23.5 |
| | Apr | 25.0 | 25.5 | 25.4 | 26.0 | 26.0 |
| | May | 27.8 | 28.4 | 28.1 | 28.5 | 29.0 |
| | Jun | 30.1 | 29.7 | 301.5 | 30.4 | 30.5 |
| | Jul | 29.6 | 29.7 | 30.1 | 29.5 | 29.8 |
| | Sep | 28.9 | 29.4 | 29.6 | 29.5 | 29.8 |
| | Oct | 25.6 | 25.8 | 26.5 | 26.9 | 26.1 |
| | Nov | 22.1 | 21.9 | 24.0 | 23.5 | 23.6 |
| | Dec | 20.0 | 19.0 | 22.0 | 19.0 | 19.0 |
| 1980 | Jan | 17.3 | 17.4 | 17.5 | 17.2 | 16.0 |
| | Feb | 18.0 | 19.0 | 20.0 | 20.0 | 19.0 |
| | Mar | 25.4 | 25.0 | 25.6 | 23.8 | 24.8 |
| | Apr | 23.0 | 22.4 | 23.7 | 24.0 | 24.4 |
| | May | 28.9 | 29.1 | 27.7 | 27.9 | 27.5 |
| Mar 79-May 80 | | | | | | |
| Mean | | 24.5 | 24.5 | 25.16 | 24.89 | 24.9 |
| Std. Dev. | | 4.32 | 4.4 | 3.94 | 4.236 | 4.425 |
| Variance | | 18.7 | 19.36 | 15.53 | 17.95 | 19.58 |
| Maximum | | 30.1 | 29.7 | 30.5 | 30.4 | 30.5 |
| Minimum | | 17.3 | 17.4 | 17.5 | 17.2 | 16.0 |
| Sample Size | | 14 | 14 | 14 | 14 | 14 |
| Jun 79-May 80 | | | | | | |
| Mean | | 24.4 | 24.4 | 25.2 | 24.7 | 24.5 |
| Std. Dev. | | 4.695 | 4.72 | 4.241 | 4.55 | 4.83 |
| Variance | | 22.04 | 22.316 | 17.98 | 20.72 | 23.33 |
| Maximum | | 30.1 | 29.7 | 30.5 | 30.4 | 30.5 |
| Minimum | | 17.3 | 17.4 | 17.5 | 17.2 | 16.0 |
| Sample Size | | 11 | 11 | 11 | 11 | 11 |

[1]Underlined mean site values are not significantly different from each other according to SNK test ($P \leq 0.05$).

Species Comparison

During the 14-month survey, a total of 60 species of fish and 31 species of non-molluscan macroinvertebrates representing 1,524 and 4,233 individuals, respectively were taken in 98 trawl and net collections (Appendices I-IV). Of the 666 target and 858 secondary fish collected, 83% were benthic/epibenthic species. Numerically, by decreasing order of abundance, silver jenny (268), pinfish (203), pigfish (131), and silver perch (64) were the most abundant epibenthic fish, collectively representing 75% of the total epibenthic fish collected. Numerically, pink shrimp (3,172) and blue crab (105) were the dominate decapods, together representing 78% of the total invertebrate catch.

The dominant species were classified as either full-time resident species or cyclical/seasonal visitors as categorized in Yanez-Arancibia et al. (1980). As opposed to the species that reside in the estuarine habitat on a year-round basis (residents), others spawn offshore and enter the estuary only as a nursery habitat or for certain portions of their lives. Silver jenny, silver perch, and blue crab were designated residents; pink shrimp, pinfish, and pigfish were seasonal visitors to the estuary. For each species, the community characteristics (seasonal abundance and occurrence, size, reproductive activity and food habits) is discussed throughout the text.

Pink Shrimp

*Occurrence/Abundance*

Shrimp occurred year round at all sites (Appendicies I,II). Shrimp were found in greater numbers at Whitewater Bay sites 1 (1,139) and 2 (1,309) than at the Oyster Bay site (155) (1-way ANOVA). The KW-1-way ANOVA yielded identical results. At sites 1 and 2, shrimp were most abundant during summer, fall and winter. Spring catches were significantly lower. However, at site 3 catches were highest from winter through summer, with lowest abundance during fall (one-way ANOVA). Salinity and water temperature and shrimp catch were significantly correlated, negatively at site 1 ($r = -.762, -.662$, $df = 9$) and site 2 ($r = -.664, -.702$, $df = 9$). No such correlation was found at site 3. Salinities for collections in which pink shrimp were caught ranged from 1 to 35°/oo; water temperature ranged from 16 to 32°C (Appendix V).

*Size*

Shrimp lengths ranged from 5.1 to 29.6 mm CL (mean = 14.5 $\pm$ .3 mm CL, N = 3102) over the 14-month period. Size distribution of shrimp (mm CL) captured followed a normal distribution curve (Fig. 2).

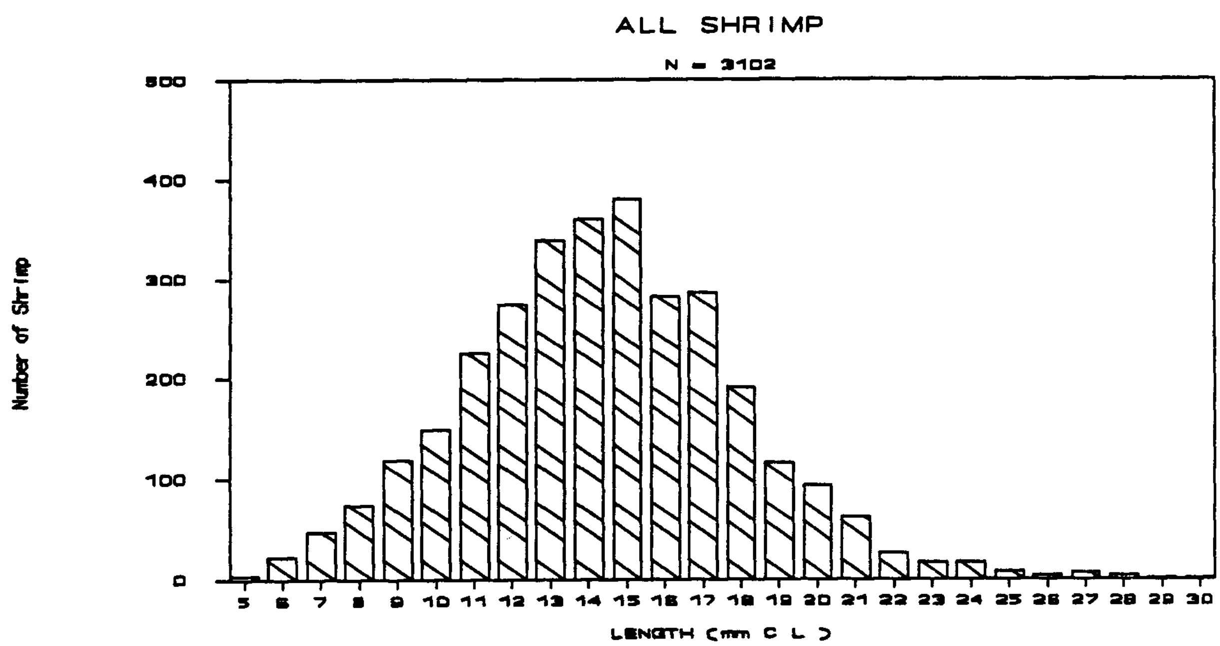


Figure 2. Length frequency of pink shrimp, 1979-1980.

Size composition varied spatially and over time. Mean lengths differed significantly (P<0.001) by site being smaller (mean = 11.8 mm) at site 5 and larger (mean = 15.7 mm) at site 3. Mean size at sites 1 (14.8 mm), 2 (14.1 mm) and 4 (14.0 mm) were statistically similar (according to SNK range tests). There was no distinct pattern in mean size with increase of distance from the coast. At site 1, shrimp length was significantly (P<0.001) smallest, and statistically similar in June and July, probably reflecting the peak of the offshore spawning season (Fig. 3 A). Although groups of statistically similar sizes were not as clearly defined at site 2, both sites showed an abrupt decrease in mean size from May to June (1979) followed by a steady increase in mean size from summer (June-July) to early fall when a small mid-fall reduction in size occurred from November to December/January after which mean size increased steadily from February to April, reaching a maximum in May (1980) (Fig. 3 A & B). Mean size of females was larger than that of males at sizes greater than 18 mm. Females also out numbered males in the larger size classes. Significant relations were found between mean size and salinity at sites 2 and 3.

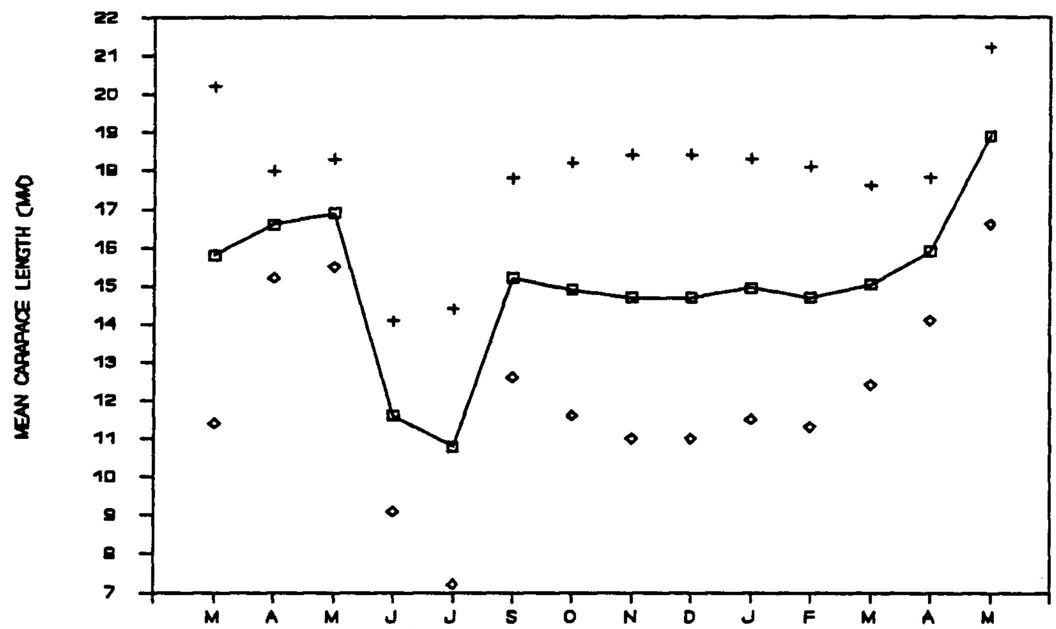


Figure 3 A. Mean carapace length of pink shrimp at site 1, March 1979-May 1980. Mean values have ± 1 SD.

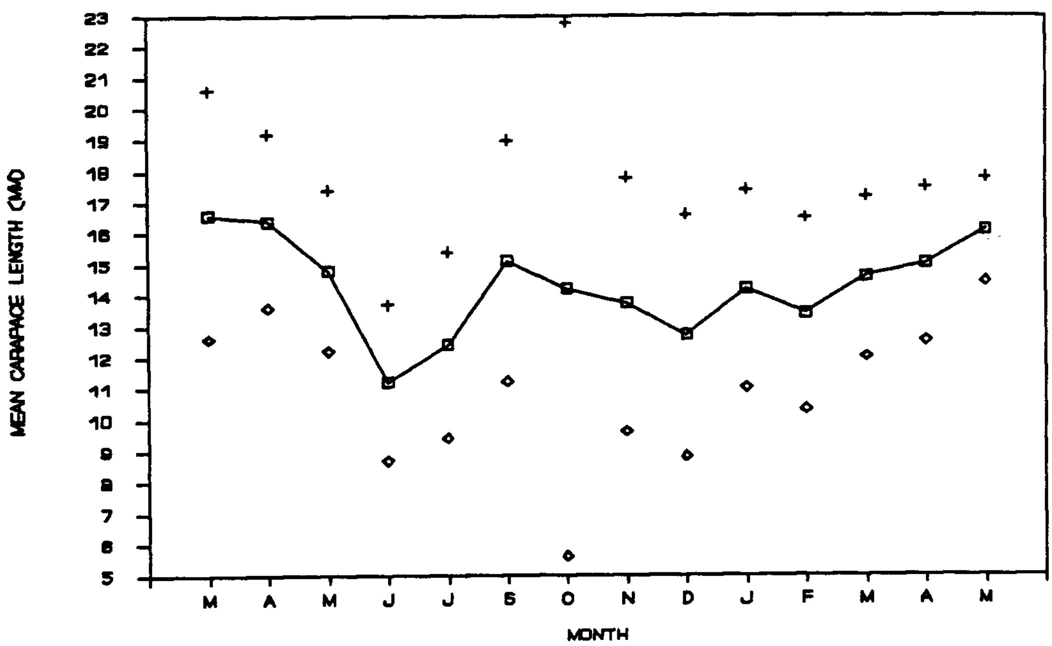


Figure 3 B. Mean carapace length of pink shrimp at site 2, March 1979-May 1980. Mean values have ±1 SD.

Shrimp length-weight relationships were obtained using 2270 shrimp (5-20 mm CL) (Table 4). This relationship can be adequately represented by the equation ($W = aL^b$) for combined sexes, but not for shrimp > 20 mm as they are sexually dimorphic (Kutkuhn 1966). The combined length-weight regression equation in the log (base 10) form was Log W = -3.5534 + 3.2890 (log L). Shrimp tended to be heavier at a given length in fall (October-December) and winter (January-February). Also, when comparing regression equations based on data from individual months, differences in slope were found among all combinations of months except those for shrimp in July versus those in September (t >.05, 1.83). The linear slopes of the other cited comparisons differed (t = 6.78-373.95 < $T_{05}$ = 1.96).

Table 4. Carapace length-weight relationships for 2270 individuals of pink shrimp, collected from June 1979 to February 1980, by month. (N = number of shrimp examined; Log a = Log W (or log CL) axis intercept; b = slope; and r = correlation coefficient.)

| Month | Carapace range in mm | N | Log a | Log b | 95% Confidence interval of b | r |
|---|---|---|---|---|---|---|
| Jun | 5.2-19.6 | 96 | -2.7526 | 2.5414 | 1.7548-2.3279 | .92 |
| Jul | 6.1-19.1 | 103 | --- | 3.0673 | 3.2470-2.8876 | .96 |
| Sep | 8.0-20.0 | 338 | -3.2013 | 3.0018 | 3.1092-2.8944 | .95 |
| Oct | 6.7-20.0 | 311 | -3.8503 | 3.5301 | 3.6500-3.4100 | .96 |
| Nov | 6.7-10.1 | 310 | -3.6032 | 3.3283 | 3.4067-3.2499 | .98 |
| Dec | 6.3-20.2 | 519 | -3.7195 | 3.4349 | 3.5210-3.3490 | .96 |
| Jan | 6.6-20.0 | 353 | -3.4370 | 3.1881 | 3.2750-3.1007 | .97 |
| Feb | 7.2-20.1 | 240 | -3.6454 | 3.3718 | 3.4933-3.2497 | .96 |
| Combined | | 2270 | -3.5534 | 3.2890 | 3.3283-3.2497 | .96 |

### *Reproductive Activity*

Of 3,124 shrimp examined for maturity, only 13 were found in pre-spawning condition. They occurred at sites 1-4 from September to March, ranging in size from 20 to 27 mm for both sexes. Of 3124 shrimp sexed, 1609 were females and 1514 were males, giving an overall F:M sex ratio of 1.1:1. There was no significant departure from unity.

### *Food*

Of the 3,144 shrimp stomachs, 2,748 (87%) contained food items. Of the 52 prey types taken by all size classes (Appendix VI), most belonged to five major groups: Crustacea, Polychaeta, Mollusca (bivalvia, and gastropod), Echinodermata (Ophiuroidea) , and plant material. Crustacea, the predominant prey group, occurred in 57% of the specimens and accounted for 42% of the total food volume (Fig. 4).

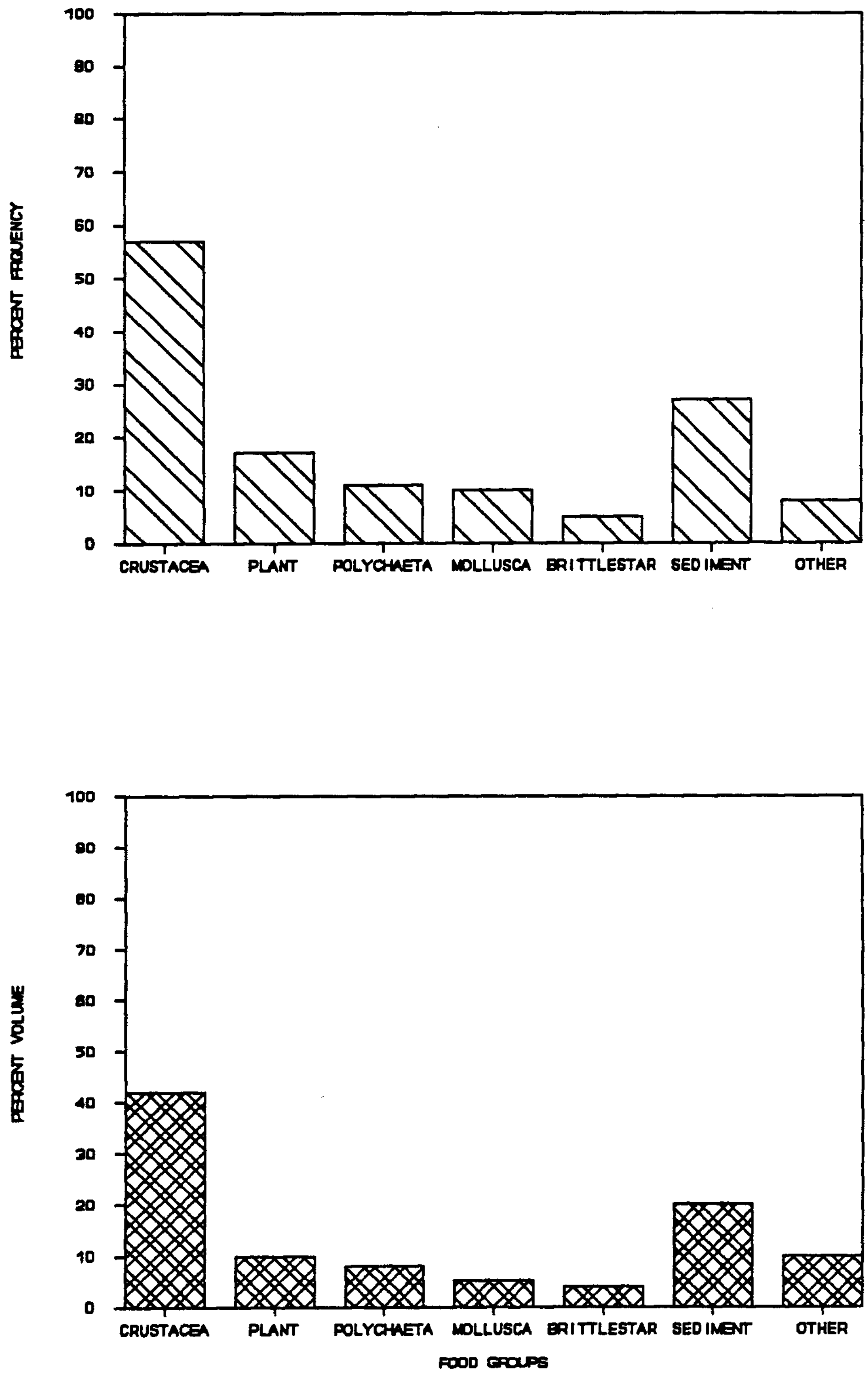


Figure 4. Percent frequency and volume of prey consumed by all pink shrimp.

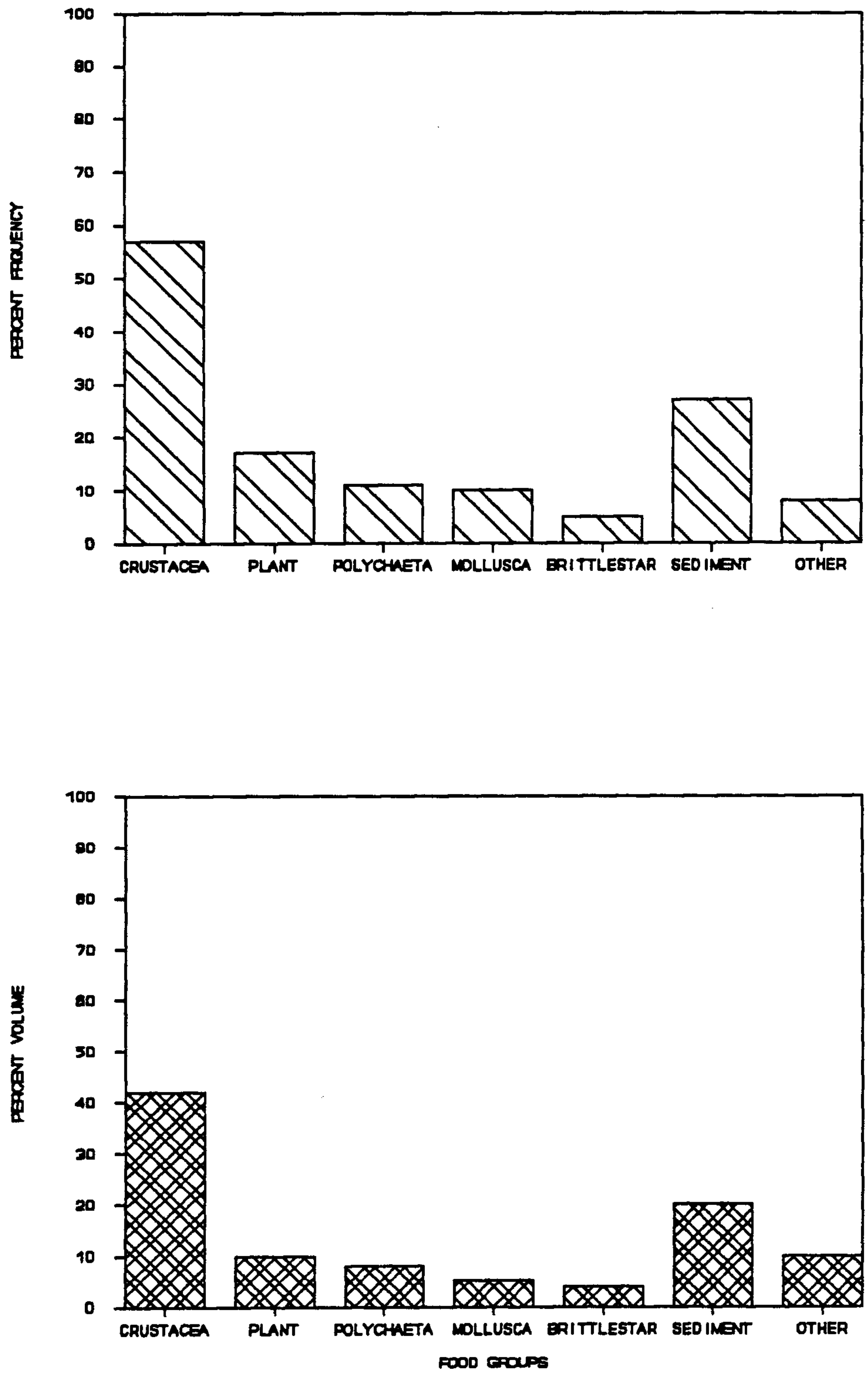


Figure 4. Percent frequency and volume of prey consumed by all pink shrimp.

These included gammarid amphipods, isopods, tanaids, penaeid shrimp, and unidentified crustaceans. Plants ranked second in frequency (17%) and volume (10%). Of those, a green alga, *Batophora oerstedi*, was the principal species by occurrences (6%) and volume (4%). Polychaetes ranked third in occurrences (11%) and volume (8%). Mollusks, primarily bivalves and gastropods, ranked fourth by frequency (10%) and volume (5%). Bivalves contributed the largest percentage of molluscan volume and the scorched mussel *Brachidontes exustus*, was the predominant species. Invertebrates of lesser importance were sipunculids, nemerteans, nematodes, porifereans, hydroids, and foraminiferans and together with animal remains (8% frequency, 9.1% volume) formed the "other" category. Sediment occurred in 27% of all shrimp examined and comprised 20% of the total volume. All five food groups were found over all predator size class ranges while sediment was common in all four size classes examined (Appendix VI).

Differences in food consumption varied significantly by site, size, and season. The frequency of prey consumed by shrimp at different sites varied significantly ($P<0.05$) (Fig. 5). Shrimp at site 1 ate vegetation proportionately more often than other food groups while crustaceans and plants were eaten proportionately more often at site 2. Crustaceans and brittlestars occurred proportionately more often in the diet than other food groups for shrimp taken at site 3. Whereas, crustaceans and bivalves were consumed proportionately more often in the diet of shrimp from sites 4 and 5. When all food groups were considered separately, highly significant differences ($P<0.01$) occurred among sites in prey frequencies of crustaceans ($x^2$ = 30.5), bivalves ($x^2$ = 29.1), brittlestars ($x^2$ = 38.3), and plants ($x^2$ = 25.8). Polychaete and gastropod differences were non-significant. Shrimp taken at Tarpon Bay consumed proportionately more crustaceans than shrimp from other sites, while shrimp taken at site 1 ate more vegetation than shrimp obtained from other sites. Prey frequencies of brittlestars were proportionately higher from shrimp taken at Oyster Bay then from shrimp taken elsewhere. Bivalves proportionately comprised a greater part of the diet at site 4 than at other sites.

Food consumption varied significantly by size class ($P < 0.001$). Crustaceans were consumed proportionately more often than all other groups in the smallest size group (6-10 mm) (Fig. 6 A & B). In size group 10-15 mm, crustaceans and plants were consumed proportionately more often than other food groups while 15-20 mm sized shrimp ate crustaceans, polychaetes, and plants more frequently than mollusks and brittlestar. Differences in the largest size group (20-27 mm) were non-significant. When the food groups were analyzed individually, very highly significant ($P<0.001$) differences were found among size groups in prey frequencies of polychaetes ($x^2$ = 36.7), bivalves ($x^2$ = 52.7), gastropods ($x^2$ = 54.5), brittlestars ($x^2$ = 39.1), and plants ($x^2$ = 17.2; $P<0.01$). Crustacean differences were non-significant. Larger shrimp (>21 mm) consumed plants, polychaetes, mollusks, and brittlestars more often proportionately than other shrimp. Polychaetes, bivalves, and brittlestars represented a progressively larger percentage of the diet (by frequency) with growth.

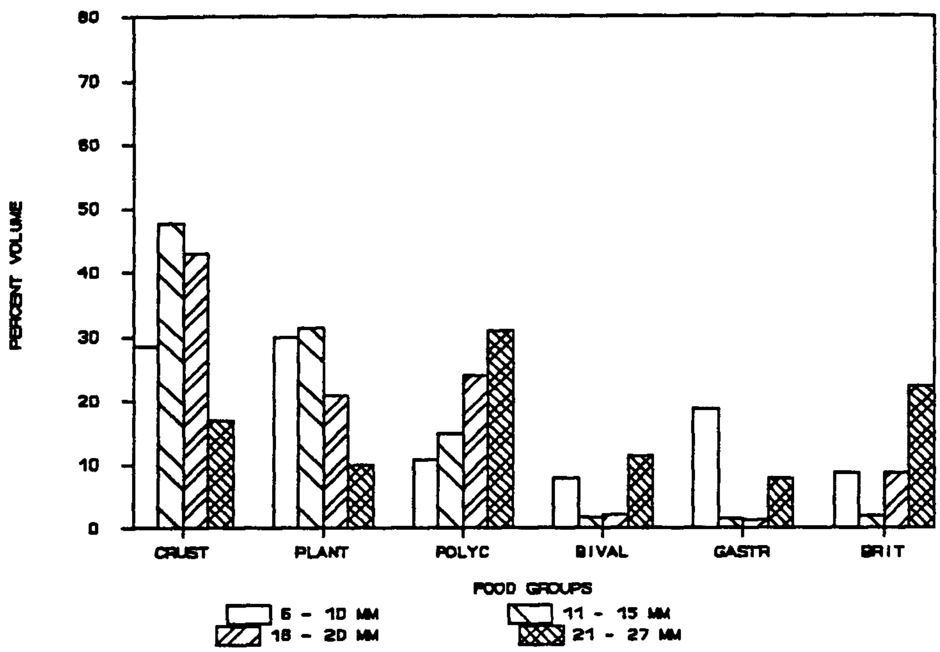


Figure 6 A. Percent volume of prey consumed by pink shrimp by size class.

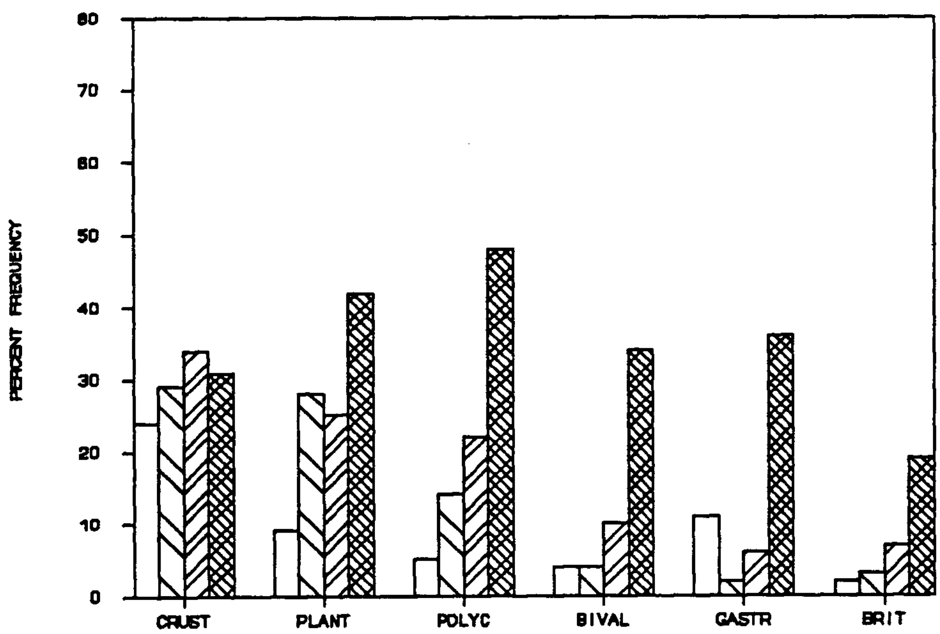


Figure 6 B. Percent frequency of prey consumed by pink shrimp by size class. Legends are as in Figure 6A.

Food consumption varied significantly by season (P<0.001). Shrimp taken in spring consumed crustaceans more often than other groups, while shrimp taken in summer ate crustaceans and polychaetes more often (Fig. 7). Crustaceans and plants were consumed more often than other groups for shrimp taken in fall and winter. When all food groups were evaluated separately, differences among seasons (P<0.01) were found. Shrimp consumed crustaceans ($x^2$ = 166.9) proportionately more often in winter and spring than in other seasons. Polychaetes ($x^2$ = 23.5) were found more often in the diet during summer than shrimp taken in other seasons, while shrimp consumed vegetation ($x^2$ = 48.5) proportionately more often in fall than in other seasons.

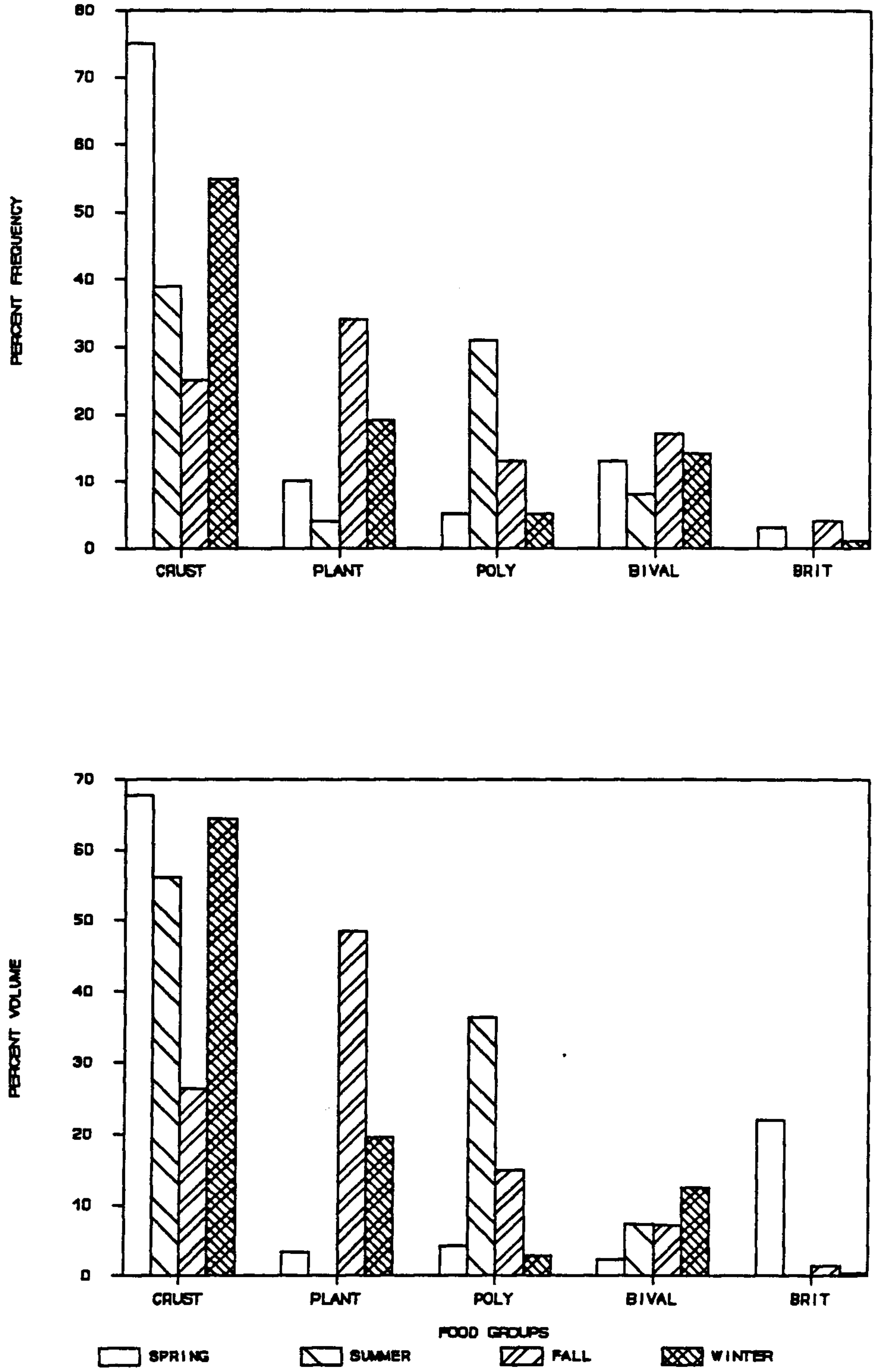


Figure 7. Percent frequency and volume of prey consumed by season.

Feeding activity varied significantly ($x^2$ = 129.7, P<0.001) over time (Fig. 8). During the warmest months (June-July), only relatively moderate proportions of feeding activity occurred, however, with decreasing temperatures from September to January (Table 3), feeding abruptly changed to very high proportions. Length-weight relationships reflected these changes (Table 4). The log-transformed relationship for June had an exponent (slope) of 2.541. A significant increase in slope values (b) occurred from July (3.067) to December (3.435) during which time those months showed an abrupt increase in feeding, thus indicating that the weight per unit length of pink shrimp fluctuated with feeding activity. Within the size interval of shrimp examined (5-20 mm), differences in feeding activity were minimal (Table 5).

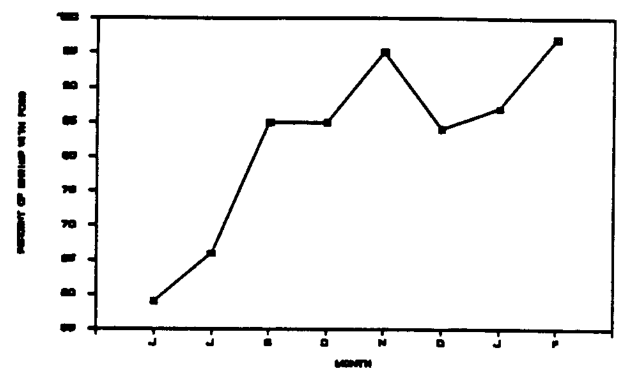

Figure 8. Percentage of pink shrimp containing food, 1979-1980.

Table 5. Number of pink shrimp with food by three size classes.

| | | Size Classes (mm CL) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 6-10 | | 11-15 | | 16-20 | |
| Month | N | No. examined | No. w/food | No. examined | No. w/food | No. examined | No. w/food |
| Jun | 95 | 20 | 8 | 68 | 41 | 7 | 7 |
| Jul | 99 | 37 | 21 | 47 | 35 | 15 | 12 |
| Sep | 331 | 26 | 17 | 187 | 156 | 118 | 107 |
| Oct | 300 | 49 | 44 | 157 | 132 | 94 | 76 |
| Nov | 310 | 54 | 52 | 167 | 157 | 89 | 85 |
| Dec | 518 | 122 | 96 | 255 | 219 | 141 | 121 |
| Jan | 353 | 30 | 23 | 179 | 159 | 143 | 126 |
| Feb | 240 | 32 | 31 | 161 | 157 | 47 | 44 |

Diet diversity varied by size of shrimp, seasonality and site (Table 6). Shrimp taken at site 5 showed the lowest diversity because one food group, crustacea, overwhelmed the importance of other foods. Dietary diversity was highest at site 1 because, in addition to crustacea, polychaetes, and bivalves, brittlestars and plant material made important contributions to the diet. H' values from other sites were nearly identical. Shrimp between 21 and 27 mm showed the greatest breadth in diet. Diet diversity in these shrimp reflected the degree at which large quantities of various animal foods in addition to plant material contributed to the diet. Lower dietary diversities in shrimp <16 mm occurred because 40% of their diets were composed of sediment. Dietary breadth appeared to increase with growth. Diet diversity by season was lowest in spring-winter because over 73% of the diet was composed of crustaceans. Highest diversity breadth occurred in fall, when crustacea were consumed in smaller quantities and other food groups such as polychaetes and vegetation made important contributions to the diet.

## Blue Crab

### *Occurrence/Abundance*

The greatest numbers of crabs (61%) came from the Clearwater Pass site where 23% of the effort was made (Appendix I). Crabs occurred year round in proportion to sampling effort (Appendix II). Sample sizes were inadequate to warrant further evaluation. Crabs occurred over a wide range of salinities (1-32.2%) and temperatures (16-32 °C) (Appendix V). There was no significant correlation between catch and salinity or temperature.

### *Size*

A total of 105 blue crabs 12 to 194 mm C.W. (mean = 80.2 $\pm$ 41 mm) were collected (Appendix I). Trawl-caught crabs <120 mm wide (mean = 63.4 $\pm$ 23.4 mm, r = 12-194 mm, n = 85) were collected year round with greatest concentrations occurring March-May. Mean width differed significantly ($F_{1,73}$ = 5.5) by sites sampled. Size was greater at site 1 (mean = 73 mm, n = 14) than at Clearwater Pass (mean = 59 mm, n = 59). Twenty crabs ranging in size from 124-194 mm C.W. (mean = 151.8 $\pm$ 22 mm) were caught in gill nets (n = 11) and trawls (n = 9) at all sites, April-June and November. All crabs <40 mm were caught from December to June indicating a seasonal pattern of reproductive activity. There was no significant correlation between crabs (<120 mm) and salinity or temperature.

Table 6. Percentages of total volume of major food groups and H' values for each pink shrimp locality - size class - seasonal sample. (Size Class I=6-10 mm CL; II=11-15 mm CL; III=16-20 mm CL; IV=≥21 mm CL.) Site descriptions are in Table 1.

| | FOOD GROUP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Crustaceans | Polychaetes | Bivavles | Gastropods | Ophiuroids | Plant Material | UID Animal Material | Sediment | H' |
| Site | | | | | | | | | |
| 1 - Fal - II | 16.0 | 9.0 | 4.3 | - | 0.9 | 30.2 | 5.8 | 33.8 | 1.756 |
| 2 - Fal - II | 27.0 | 8.5 | 1.1 | 1.0 | 1.2 | 17.8 | 4.0 | 39.6 | 1.513 |
| 3 - Fal - II | 14.7 | 15.5 | 1.0 | - | 37.0 | 1.0 | 6.2 | 10.7 | 1.618 |
| 4 - Fal - II | 29.9 | 1.6 | 9.2 | 1.6 | 6.5 | 1.0 | 10.9 | 39.1 | 1.546 |
| 5 - Fal - II | 79.7 | - | 5.1 | 8.5 | - | - | 6.7 | - | 0.723 |
| Size Class | | | | | | | | | |
| I - Fal - 2 | 13.6 | 5.2 | 3.8 | 9.1 | 4.1 | 14.3 | 9.8 | 40.0 | 1.770 |
| II - Fal - 2 | 27.0 | 8.5 | 1.1 | 1.0 | 1.1 | 17.8 | 4.0 | 39.6 | 1.511 |
| III - Fal - 2 | 22.6 | 12.7 | 1.1 | 0.8 | 4.5 | 11.0 | 24.2 | 23.1 | 1.912 |
| IV - Fal - 2 | 10.1 | 18.4 | 6.7 | 4.9 | 13.2 | 5.9 | 20.3 | 20.5 | 1.953 |
| Season | | | | | | | | | |
| SPR - 2 - II | 73.7 | 1.5 | 1.6 | 1.3 | 10.2 | 1.6 | 2.0 | 9.5 | 1.011 |
| SUM - 2 - II | 50.0 | 7.6 | 3.8 | - | 1.5 | - | 33.0 | 3.8 | 1.221 |
| FAL - 2 - II | 27.0 | 8.5 | 1.1 | 1.0 | 1.1 | 17.8 | 4.0 | 39.6 | 1.513 |
| WIN - 2 - II | 73.1 | 2.2 | 1.0 | 1.0 | 2.2 | 3.7 | 7.0 | 9.6 | 1.021 |

*Reproductive Activity*

The greatest number (n = 20) of mature male and female blue crabs occurred in spring (April-June). The smallest mature female and male identified was 77 mm (stage II) and 104 mm (stage III), respectively. One crab (130 mm) collected in March ripe enough to count its eggs had 101,106 with a relative fecundity of 692 eggs/gm body weight. Of 99 crabs sexed, 46 females and 53 males yielded a F:M ratio of .87:1. There was no significant departure from unity.

*Food*

Of 105 stomachs, 84 (80%) contained food. Forty-eight prey types were taken by all sizes (Appendix VII). Mollusks (78% occurrence, 50% volume) and Crustacea (23% occurrence, 43% volume) were the predominant food groups (Fig. 9 A & B).

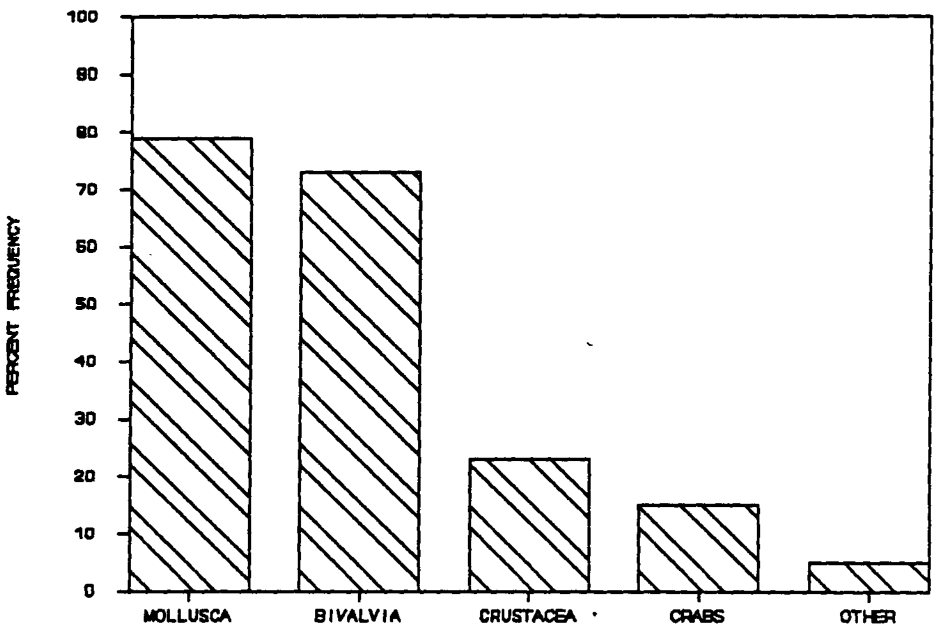


Figure 9 A. Percent frequency of prey consumed by all blue crabs.

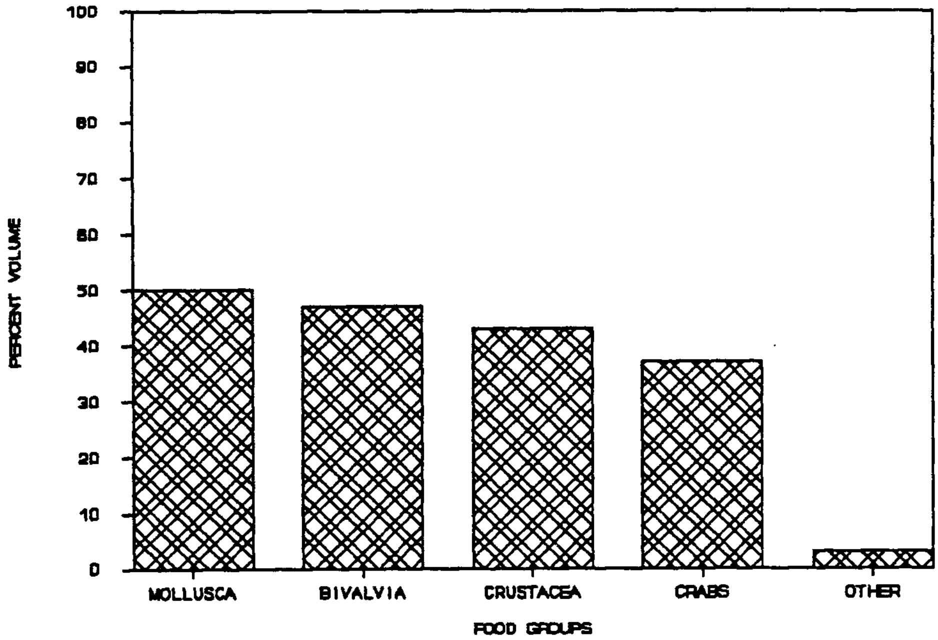


Figure 9 B. Percent volume of prey consumed by all blue crabs.

The dominant molluscan prey by occurrences (46%) and volume (28%) were bivalvia, principally *B. exustus*. The most frequently eaten crustacea were unidentified xanthid and portunid crab remains. Plant material, unidentified (UID) animal remains, and sediment comprised only 4% of the food volume and formed the "other" category.

In general, all sizes of crabs consumed similar types of food. The number of sample specimens was too low and variable to consider further analysis by site or month.

Silver Jenny

*Occurrence/Abundance*

Nearly half (45%) of the catch came from the Ponce de Leon Bay site where 18% of the effort was made (Appendix I). Silver jenny were collected year round in proportion to sampling effort (Appendix II). No significant differences in abundance were found among sites (1-3) or months. Salinities for samples containing silver jenny ranged from 2 to 30 °/oo; water temperatures ranged between 16 and 31 °C (Appendix V). No significant relationships were found between salinity or temperature and abundance.

*Size*

Of the 268 specimens, lengths ranged from 22 to 96 mm (mean = 64.5 $\pm$ 2.7 mm) (Appendix I). Mean size of silver jenny varied greatly ($P<0.001$; $F_{2,254} = 300.5$) among sites sampled, but not over time. Stations 1, 2, and 4 were statistically different from each other. Mean standard lengths were smaller at site 1 (mean = 43 $\pm$ 2.8 mm, n = 83) than at Clearwater Pass (mean = 57 $\pm$ 4.9 mm, n = 51) or site 4 (mean = 84 $\pm$ 1.4 mm, n = 123). Mean size decreased with distance and with salinity from the opening to the Gulf (site 4) to the middle reaches of the estuary (sites 2 and 1). There was no significant difference in length by month at site 4. The length-weight relationship of 250 fish (28-117 mm SL) was Log W = -4.74497 + 3.1001 (Log L); r = 0.995. The 95% confidence interval about a b (slope) value of 3.1001 ranged from 3.0454 to 3.1546.

*Reproductive Activity*

Fish with gonads of stage III or above were considered mature. Nine females 60-96 mm collected in March-June had mature gonads. Two gravid specimens (93-96 mm) were collected in March and April. Five males (73-94 mm) with mature gonads were caught October-November, January, and March. The smallest maturing (stage III) female and male specimens were 60 and 73 mm, respectively. The overall F:M sex ratio 1.07:1 was not significantly different from unity. The estimated fecundities and relative fecundities of two fish 93 and 96 mm were 23,334 and 63,675 eggs, and 920 and 2460 ova per gram body weight, respectively.

*Food*

Of 264 stomachs, 215 (81%) contained food. Fifty prey types taken by all sizes were identified and summarized in Appendix IX; most prey items belonged to three groups : Crustacea, Polychaeta, and Mollusca. Polychaetes ranked first in frequency (44%) and volume (43%) (Fig. 10 A & B).

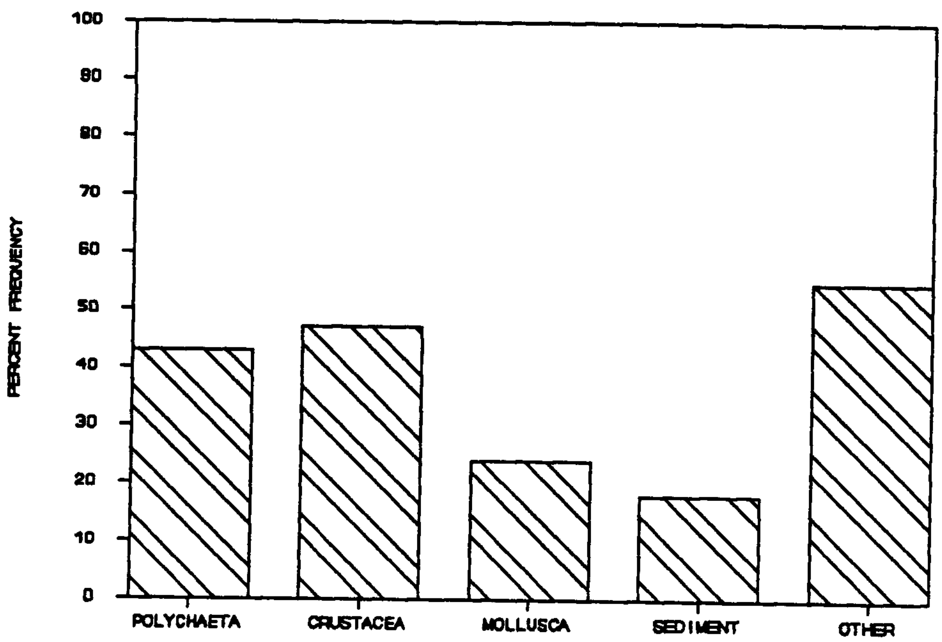


Figure 10 A. Percent frequency of prey consumed by all silver jenny.

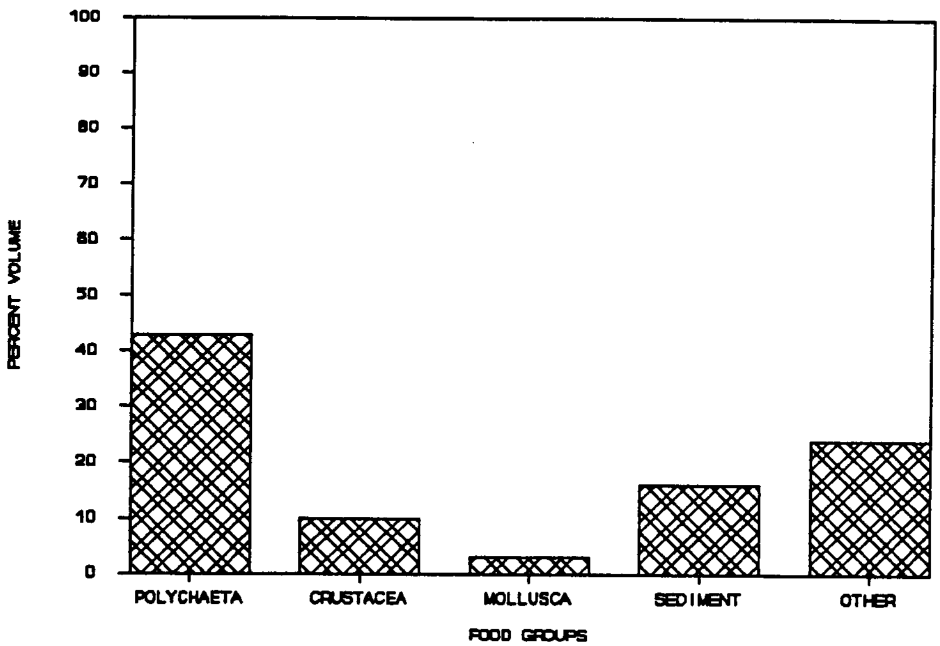


Figure 10 B. Percent volume of prey consumed by all silver jenny.

Nerids, the "crawling" groups of worms, were more important by frequency and volume than "burrowing" or "tubiculous" forms, such as Pectinariidae. Crustaceans (47% occurrences, 10% volume) were second in importance. This group was dominated by isopods (*Cymodoce faxoni*), amphipods (Gammaridea), and tanaids. Mollusks ranked third in frequency (24%) and volume (3%). The most frequently consumed species were: *Bulla striata* and *Acteocina canaliculata*. Vegetation, (< 2% by volume), together with fish, porifera, nematodes, foraminifera, and UID animal remains (27% by volume) formed the "other" category (Fig. 10 A & B). Sediment contributed 8% of the occurrences and comprised 16% of the volume. During this study, crustaceans were found over all size classes (10 mm size classes) while polychaetes were consumed in all but one size class (20-29 mm) and mollusks in all but two size groups (Fig. 12). Fish <29 mm consumed mostly Hydroids and copepods (80% and 10% by volume), respectively. All fish >29 mm fed heavily upon polychaetes.

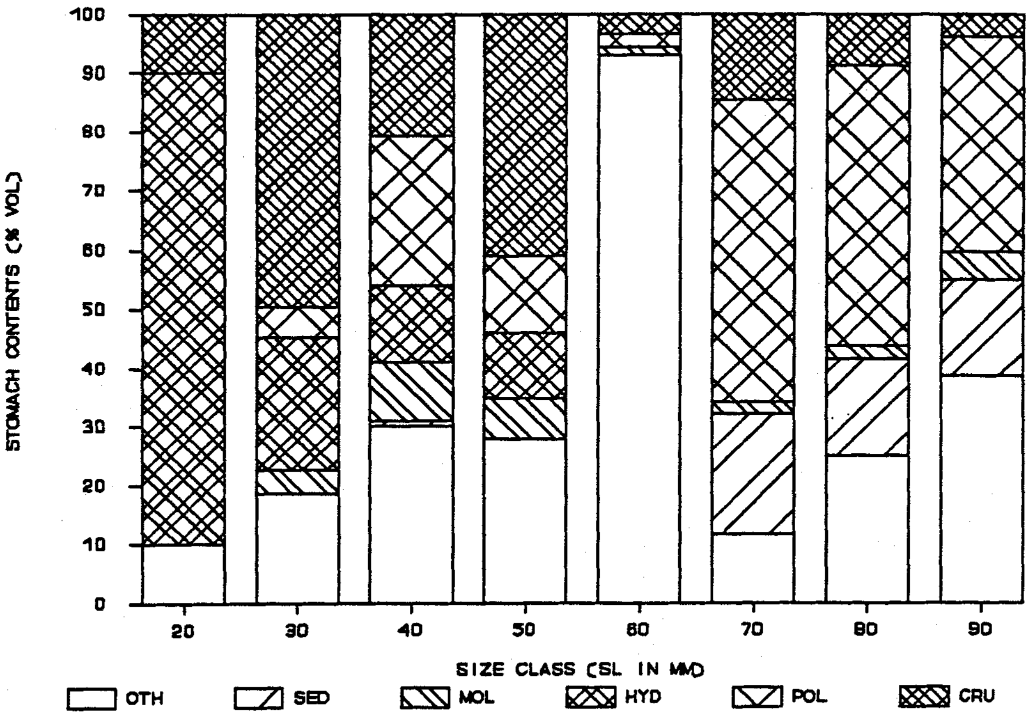


Figure 11. Percent volume of prey consumed for silver jenny by 10 mm size classes. Prey acronyms are as follows: OTH=other; SED=sediment; MOL=mollusca; HYD=hydroidea; POL=polychaeta; CRU=crustacea.

Differences in food consumption varied significantly by site and season. There were highly significant ($P<0.001$) differences in prey frequency of crustaceans ($x^2$ = 15.4) and polychaetes ($x^2$ = 8.7) in diet from site to site (Fig. 12).

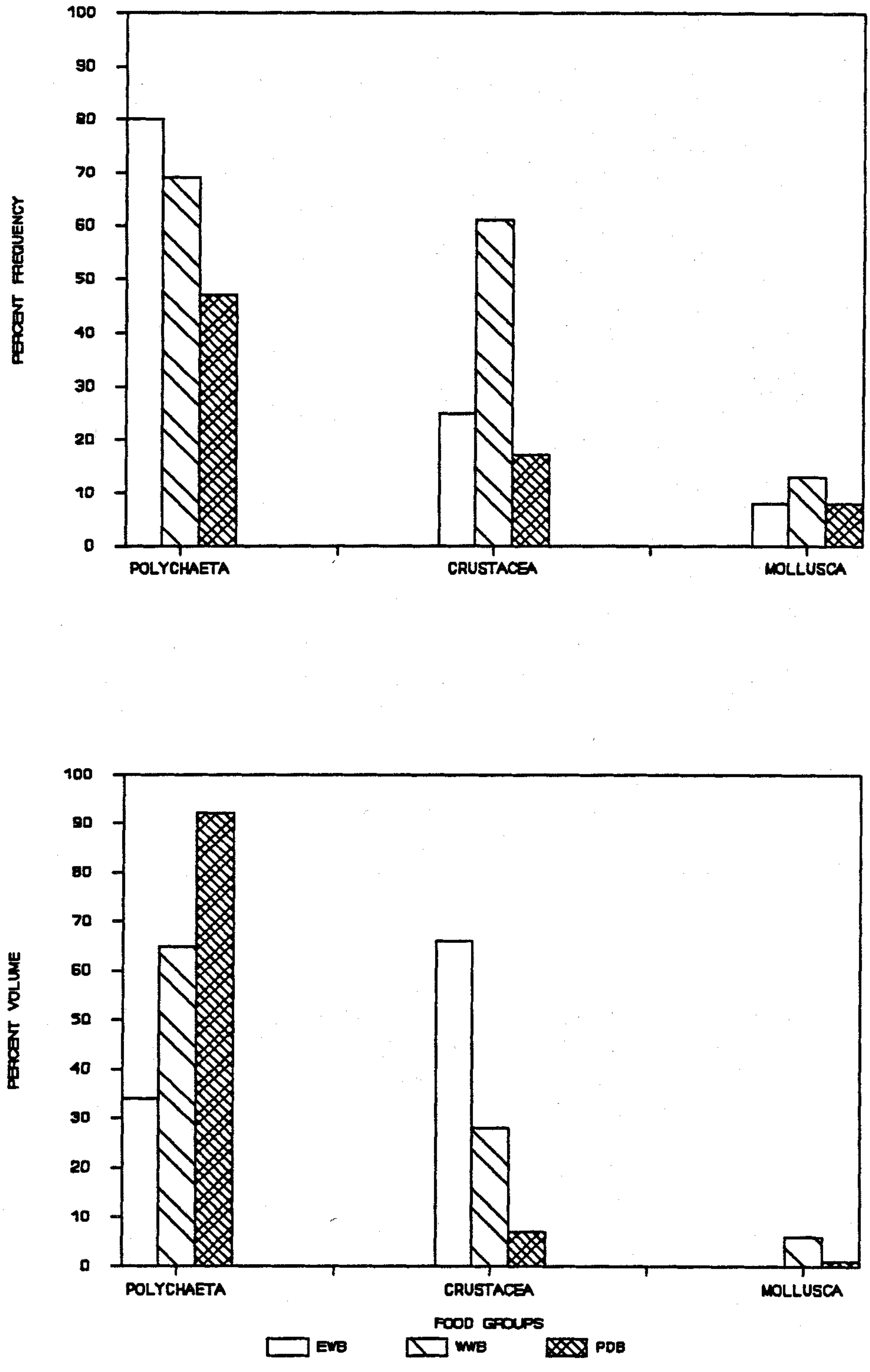


Figure 12. Percent frequency and volume of prey consumed by silver jenny among sites. Site descriptions are in Table 1.

Fish caught at sites 1 and 2 consumed proportionately more polychaetes by occurrence than silver jenny from site 4. Fish from Clearwater Pass consumed crustaceans proportionately more often than fish from sites 1 and 4. Mollusc differences were nonsignificant. Frequencies of crustaceans ($x^2 = 24.5$; $P<0.001$) and mollusks ($x^2 = 15.97$; $P<0.001$) demonstrate highly significant seasonal change (Fig. 13) while polychaete differences were non-significant.

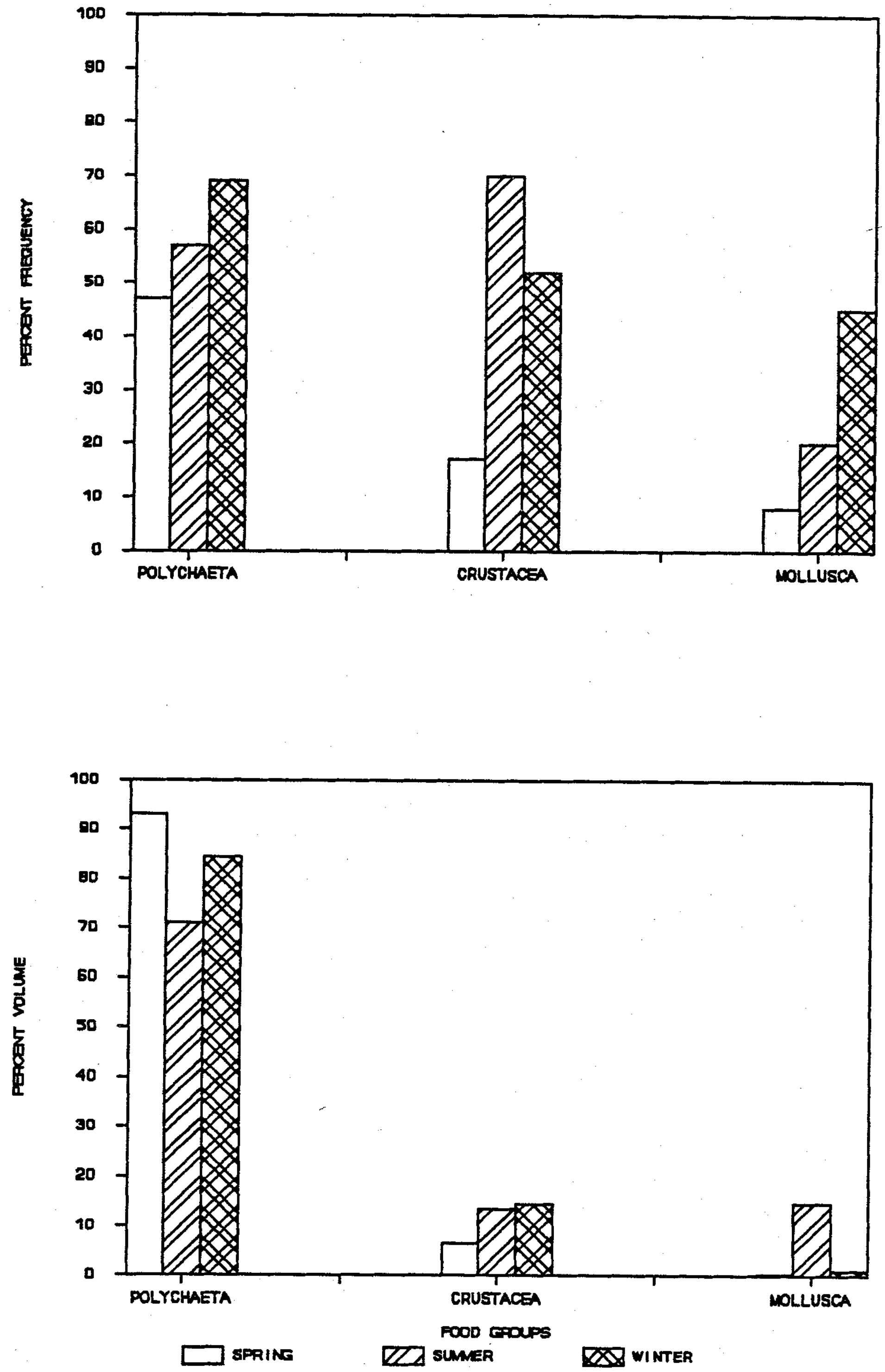


Figure 13. Percent frequency and volume of prey consumed by silver jenny by season.

Silver jenny consumed crustaceans proportionately more often in summer than in other seasons. Proportionately more mollusks (bivalves and gastropods) were eaten in winter than in spring or summer. Specimen samples were too low and variable to analyze differences by site among predator size groups.

### Pinfish

#### *Occurrence/Abundance*

Most (71%) pinfish came from the Clearwater Pass site where 23% of the samples were collected (Appendix I). Pinfish were collected year round in proportion to sampling effort made (Appendix II). There was no significant difference in fish abundance at Clearwater Pass by month. Pinfish occurred over a relatively wide range of salinity (11-30 °/oo) and temperature (17-33 °C) (Appendix V). Salinity showed a significant ($P<0.05$) negative relationship with catch ($r = -.65$) at site 2.

#### *Size*

Of 203 pinfish, lengths ranged from 25 to 122 mm (mean = 64 ± 3.1 mm). Mean fish size varied among sites. Mean lengths of trawl-caught pinfish were significantly ($P<0.001$; $F_{1,197}$ = 104.2) smaller at site 1 (mean = 36 ± 3.2 mm, n = 52) than at site 2 (mean = 67 + 3.3 mm, n = 146). There was no significant ($P<0.05$) difference in fish length by month at site 2. The length-weight relationship of 192 fish (25-123 mm) (combined sexes and unsexed fish < 40 mm) was Log W = -4.71684 + 3.08891 (Log L); r = 0.99. The 95% confidence interval around slope (b) value of 3.08891 ranged from 3.0229 to 3.15565.

#### *Reproductive Activity*

No ripe pinfish were collected during the course of this study. Of 127 sexually distinguishable fish (at ~80 mm), only three showed early signs of maturing gonads (stage III). The sex ratio of .63:1 was significantly ($P<0.05$) different from unity.

#### *Food*

Of 203 stomachs, 197 (97%) contained food items. Of 61 prey types identified (Appendix VIII), most belonged to four groups: Crustacea, Polychaeta, Mollusks (bivalves), and vegetation (Fig. 15). Crustacea predominated by frequency (72%) and volume (16%) (Fig. 14).

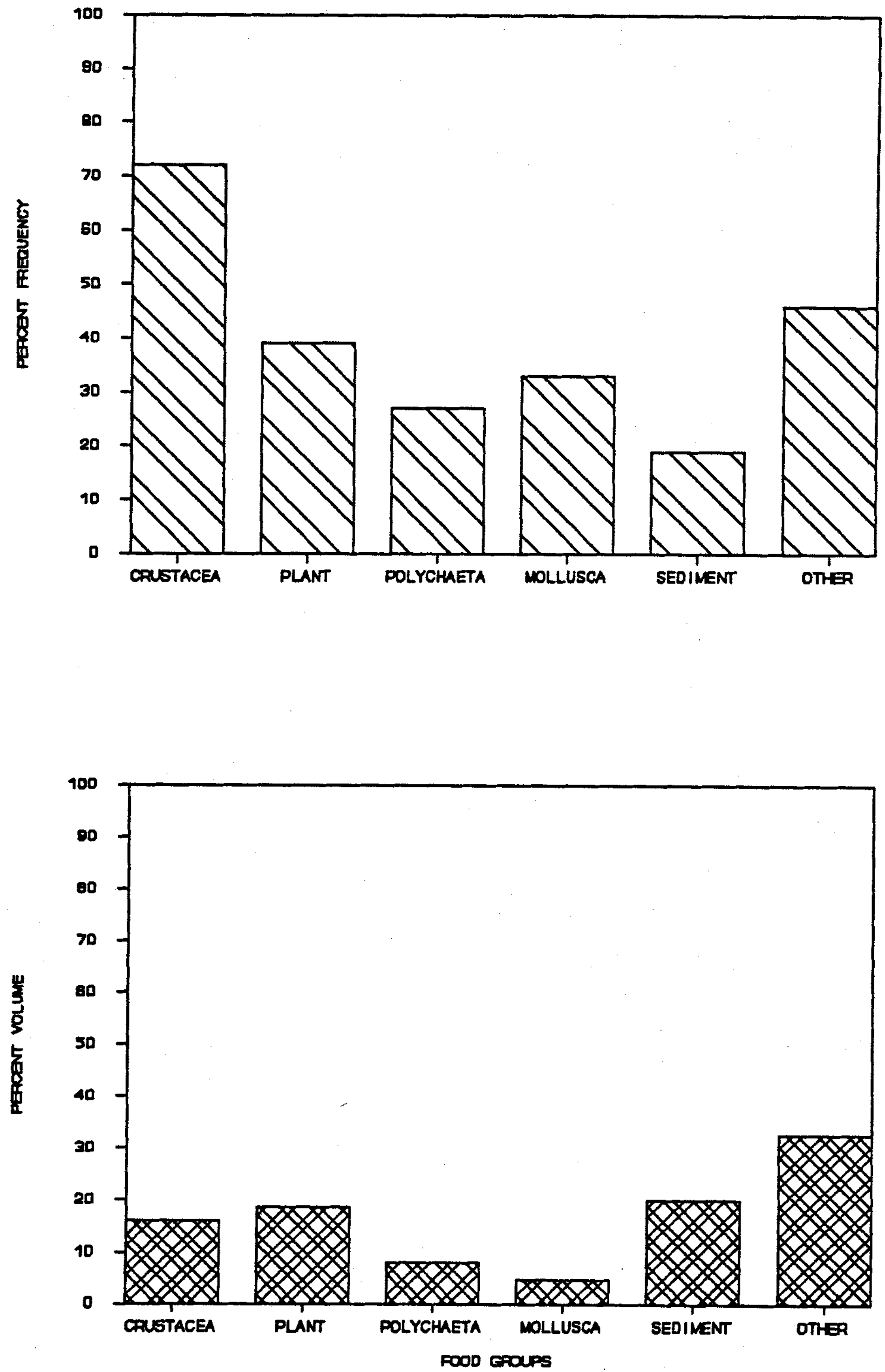


Figure 14. Percent frequency and volume of prey consumed by all pinfish.

These included ostracods, isopods, tanaids, and shrimps (Penaeidae). Vegetation (algae and marine plants), ranked second in frequency (37%) and volume (19%). Polychaetes ranked third (27% occurrences, 8% volume) and mollusks, chiefly bivalves and gastropods ranked fourth (33.5% occurrences, 5% volume). Nereidae was the predominant polychaete family. Of molluscan prey, *B. exustus*, and *C. maculosa* were predominant.

Animal remains and miscellaneous invertebrates ("other" category in Fig. 14) comprised 31% of the food volume. Sediment contributed about 19% of the occurrences, and comprised about 20% of the volume. Food consumption varied significantly (P<.001) by predator size. Intermediate-sized pinfish (60-102 mm) consumed crustaceans and vegetation more often than polychaetes and bivalves while small-sized pinfish consumed crustacean and polychaetes more frequently than vegetation and bivalves (Fig. 15 A & B).

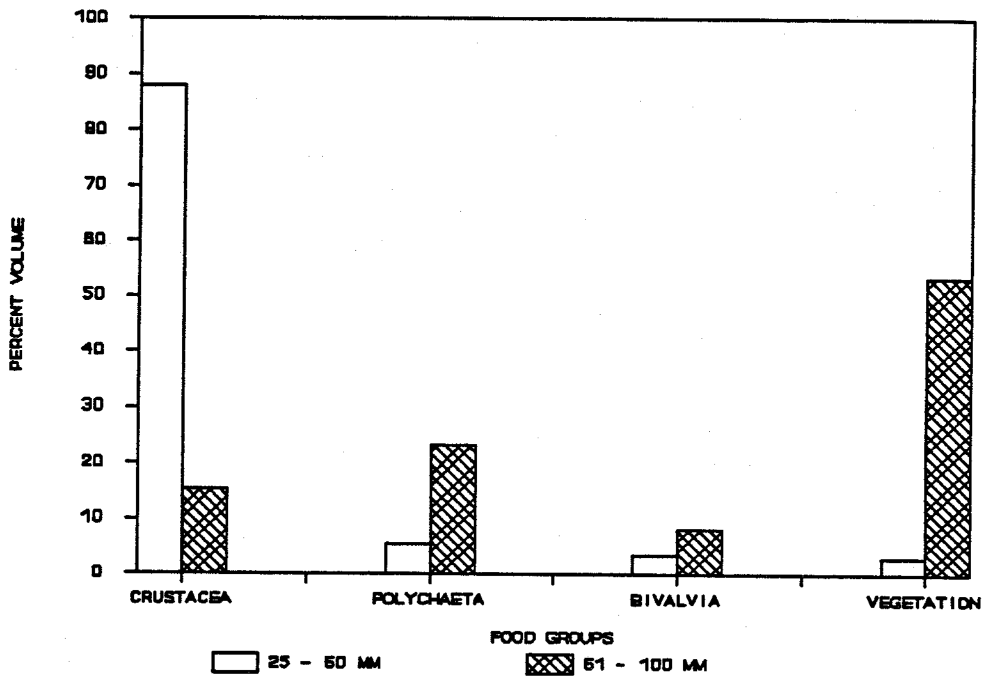


Figure 15 A. Percent volume of prey consumed by pinfish according to two 40 mm size classes.

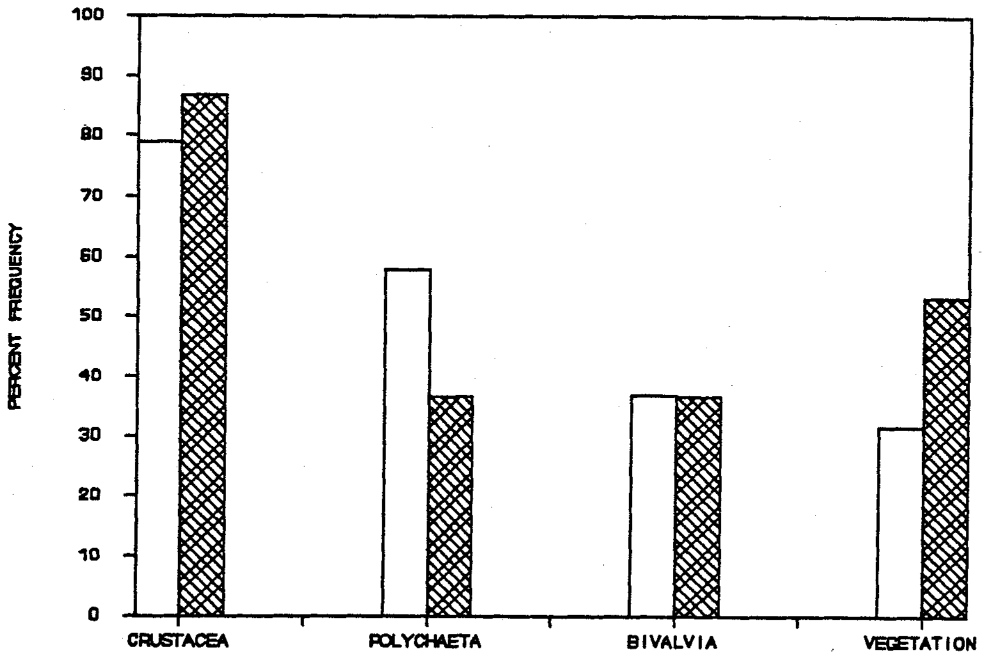


Figure 15 B. Percent frequency of prey consumed by pinfish according to two 40mm size classes. Figure legends are the same as shown in Fig. 15A.

No significant differences were found between small and medium-sized pinfish. By season, highly significant ($x^2$ = 16.1; P<0.001) differences were found in the prey frequencies of polychaetes ($x^2$ = 8.3; P<0.05) and bivalves ($x^2$ = 13.6) whereas vegetation differences were significant ($x^2$ = 8.2) (Fig. 16). Polychaetes were eaten more often in summer (by frequency and volume) and vegetation was consumed proportionately more often during fall-spring than in summer. Bivalves were most common in spring-summer (48% and 58% of the time, respectively). Specimen samples were too low to investigate statistical difference between sites.

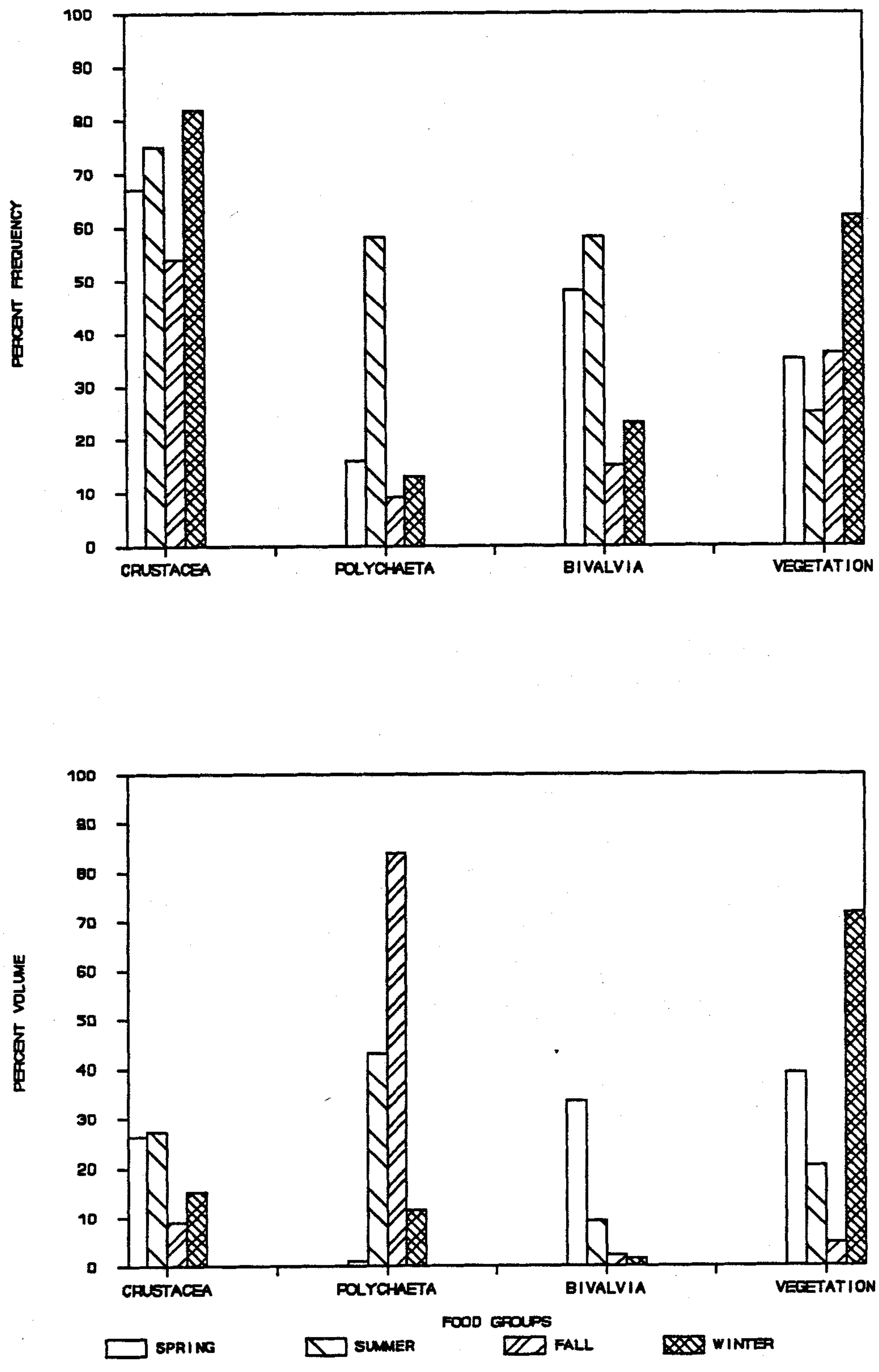


Figure 16. Percent frequency and volume of prey consumed by pinfish by season.

## Pigfish

### *Occurrence/Abundance*

The vast majority of this species (75%) was caught at site 2 where 23% of the effort was made (Appendix I). Most (68%) pigfish occurred in late spring (May-June) during 28% of the sampling trips. Monthly differences in abundance approached significance (0.1 P>0.05) indicating some degree of seasonality at the Clearwater Pass site. Sample sizes were inadequate to evaluate abundance among sites. Salinities for collections in which pigfish were caught ranged from 12 to 30 o/oo; water temperature ranged from 17 to 33 oC (Appendix V). Temperature was significantly (P<0.05) correlated to abundance at site 2.

### *Size*

Of 131 pigfish, lengths ranged from 20 to 169 mm long (mean = 66.6 $\pm$ 5.5 mm). Mean lengths of pigfish differed significantly (P<0.001; $F_{2,123}$ = 63.3) by site. Mean length of fish caught in site 3 (124 $\pm$ 9.1 mm, n = 16) were larger than those caught at site 1 (mean = 54 $\pm$ 20.7 mm, n = 14) or at site 2 (mean = 57 $\pm$ 3.8 mm, n = 96). Mean size of fish within sites 1 and 2 were statistically similar. Size composition varies significantly (P<0.001; $F_{3,86}$ = 29.2) over time. At the Clearwater Pass site mean length was significantly smaller in May (45.2 mm, n = 43) than in June (62.5 mm, n = 25) or other months (July, September); mean size of fish caught in July (mean = 72 mm, n = 12) and September (mean = 75 mm, n = 7) were statistically similar. All fish <40 mm occurred in May (n = 47). A length-weight relationship was calculated for 125 pigfish (20-169 mm) (combined sexes and unsexed fish < 50 mm) was Log W = -4.76286 + 3.07037 (Log L); r = 0.99. The 95% confidence interval about the slope (b) ranged from 3.0044 to 3.13634.

### *Reproductive Activity*

No pigfish were seen in gravid condition. Of 86 fish sexed, eight (108-169 mm) collected from October to January revealed early signs (stage III) of gonad maturity. One nearly ripe (stage IV) male specimen (124 mm) was caught in January. The smallest maturing (stage III) males and females were 108 and 123 mm, respectively. Overall, the F:M ratio of .43:1 was significantly different from 1:1. More males were caught all months but May.

### *Food*

Of 129 stomachs, 125 (95%) contained food items. Of 67 prey types identified and listed in Appendix VIII, most belonged to five prey groups: Crustacea, Polychaeta, Mollusca (bivalves), and Ophiuroidea (brittlestars) (Fig. 17).

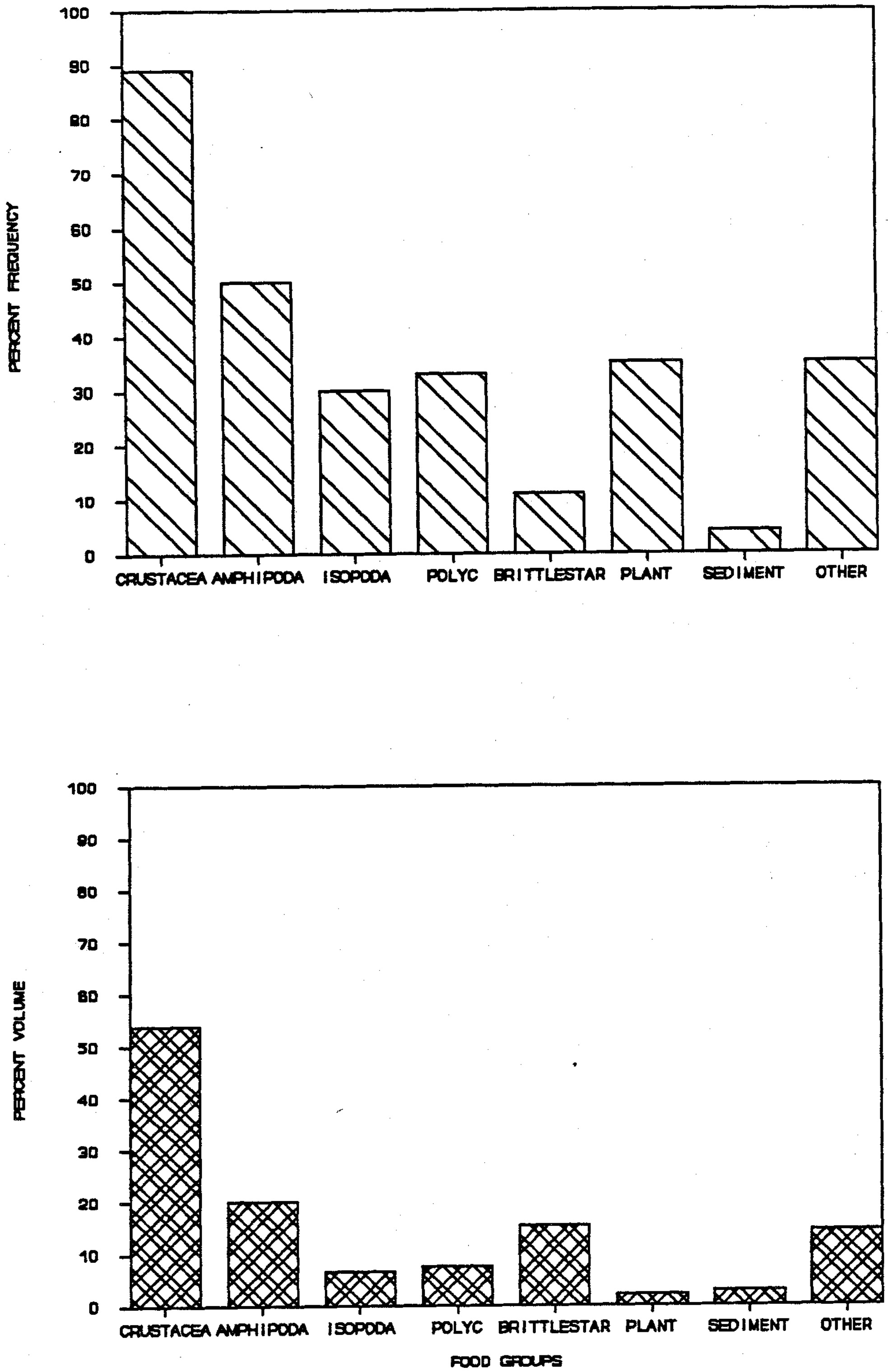


Figure 17. Percent frequency and volume of prey consumed by pigfish.

Crustacea was the most important food category, by frequency (90%) and volume (54%); by frequency, amphipods (50%) mostly, Gammaridae) and isopods (28%) mostly, *Cymodoce faxoni* were the predominant crustacea. Ophiuroidea (15%) and polychaeta (8%) were ranked second and third by food weight. The dominant group of polychaetes were the burrowing worms, Sedentaria. Of molluscan prey, *B. exustus* was the predominant species. Large number of crushed mollusks were found usually in one fish. Vegetation, polychaetes, and mollusks co-dominated in terms of the second most important food group by frequency, while brittlestars were next in importance. *H. wrightii* was the most recognizable plant species. Sediment together with animal remains (34% frequency, 14% volume) were contained in the "other" category. Shrimps, crabs, mollusks, polychaetes, brittlestars, and vegetation were found only in fish >40 mm. Differences in food consumptions varied significantly by size. Both groups consumed crustaceans more often than polychaetes and mollusks (Fig. 18 A & B).

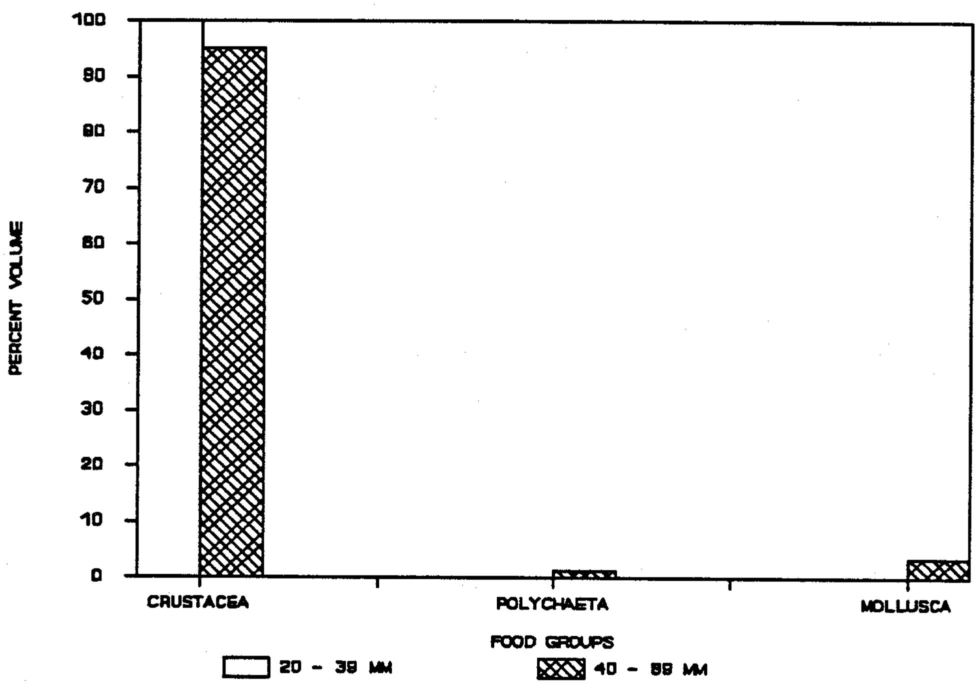


Figure 18 A. Percent volume of prey consumed by pigfish according to two 20 mm size classes.

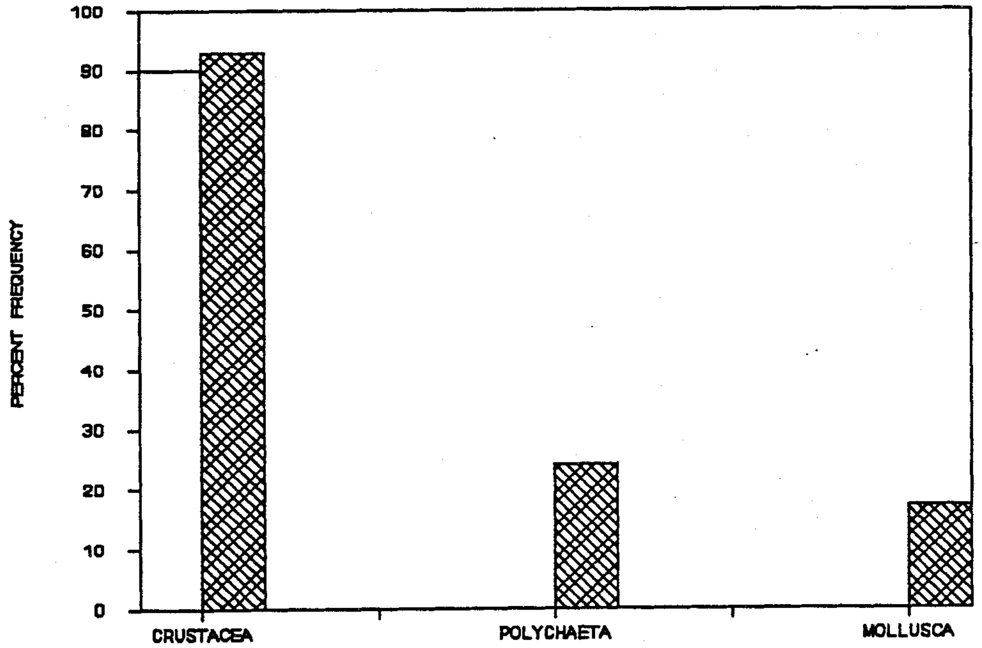


Figure 18 B. Percent frequency of prey consumed by pigfish according to two 20 mm size classes. Legends are as in Fig. 18A.

When food groups were considered separately, significant differences in food consumption were found between small and medium sized juveniles. Larger pigfish contained a significantly higher proportion of polychaetes and mollusks. Crustacean differences were non-significant.

### Silver Perch

#### *Occurrence/Abundance*

Most (70%) fish occurred at the Clearwater Pass site during 23% of the sampling trips (Appendix I). Overall, silver perch were caught from January to June, September to October, and December with most (42%) caught in winter during only 24% of the sampling trips (Appendix II). Environmental data for successful catches are listed in (Appendix V).

#### *Size*

Of 64 silver perch, lengths ranged from 12 to 177 mm (mean = 108 $\pm$ 47 mm). Recruitment of the smallest specimens (12-40 mm) occurred in May of 1979-80 and June at site 4 and May-June 1979 at site 2. There was no significant ($P>0.05$) difference in the mean lengths of fish caught by month or site.

#### *Reproductive Activity*

Fish with gonads of stages III-VII were considered mature. Of 38 specimens, 79.5-177 mm, collected from January through May, 33 individuals greater than 95.7 mm had mature gonads. In March-April 1980, 26 silver perch were captured in Whitewater Bay comprising 16 females and 10 males. Of the 16 females, four had a gonadal stage IV with lengths of 151, 158, 166, and 167 mm. The other 12 females, of approximately the same size, were gravid. All of the 10 males ranging in length from 95 to 142 mm were mature. Five specimens 79.5-108 mm were immature. All 22 fish (12-157 mm) collected in June, September, October, and December had inactive gonads (stages I and II). The size at which gonadal maturity is first reached (95 mm) is similar for both sexes. Of the 61 specimens sexed, 34 were females and 27 were males giving a F:M ratio of 1.3:1. There was no significant deviation from unity.

Fecundity estimates were determined for 11 females with mature ova. The lengths of these fish ranged from 139.3 to 177.4 mm; the body weight from 55.3 to 123.8 gms and the fecundity from 45,175 to 129,489 eggs. The mean fecundity of the 11 fish was 90,407. Mean relative fecundity was 1247 ova per gram with a standard error of $\pm$130. Plots of fecundity (F) against length (L) and weight (W) revealed that egg counts increased with length and in respect to body weight. $Log_{10}$ transformation and fitting of a straight line by the least squares regression method provided the following formulas to: (1) estimate fecundity (F) from fish length(L):log F = -3.37346 + 3.8112 Log L with r = .68 (P<0.005); and 95% confidence interval of 3.1 about the slope, and (2) estimate fecundity (F) from body weight (W):log F = 3.30394 + 1.0178 log W with r = .55 (P<0.1>.05) and 95% confidence interval of 1.49 about the slope.

*Food*

Of 57 stomachs, 51 (89%) contained food. Of 38 prey taxa found (Appendix IX) most belonged to three major groups: Crustacea, Polychaeta, and Nematodea. Crustaceans were by far the most important food group, by occurrence (82%) and weight (50%) (Fig. 19 A-B).

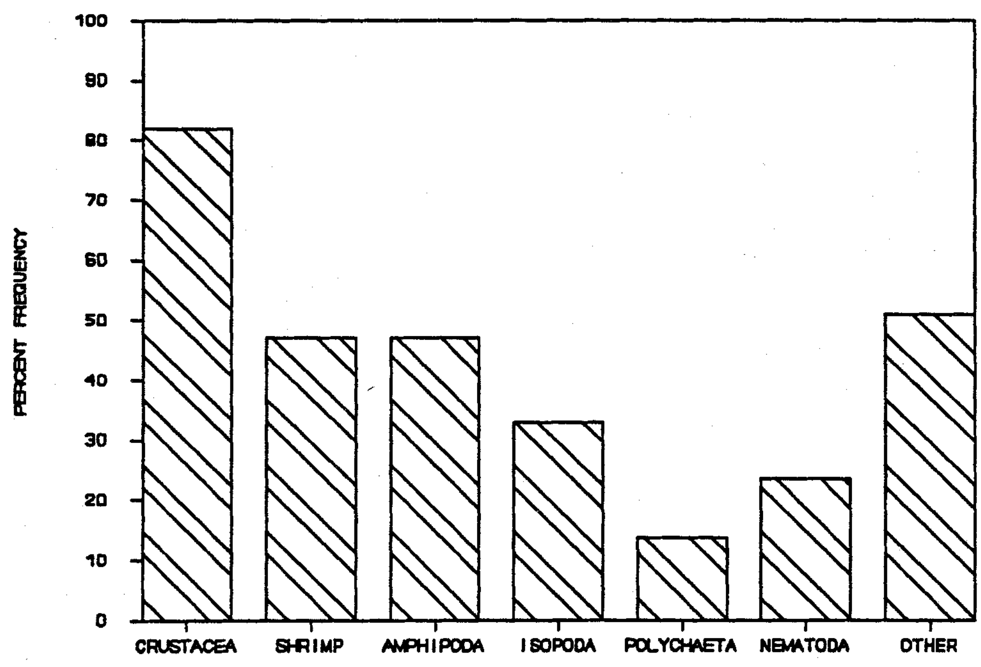


Figure 19 A. Percent frequency of prey consumed by all silver perch.

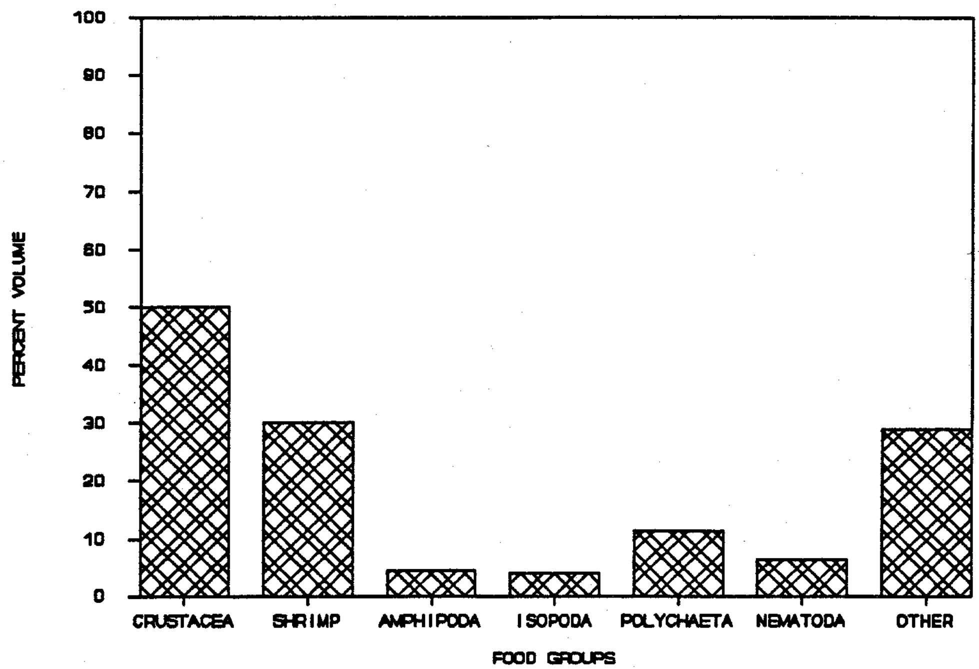


Figure 19 B. Percent volume of prey consumed by all silver perch.

These included amphipods, especially gammaridae, isopods, especially *Erichsonella* sp., and shrimps (Penaeidae), especially *P. duorarum*. Nematodes and polychaetes ranked second by occurrences (23%) and volume (11%), respectively. Pectinariidae was the most commonly consumed polychaete family. Collectively, fish, mollusca, vegetation and porifera contributed very little to the overall diet (1.1% by volume) and together with UID animal remains formed the "other" category. The volumetric consumption of crustacea was relatively uniform across three size classes of silver perch, ranging from 43 to 91% (Table 7). Pink shrimp and nematode consumption increased with increasing fish size whereas, the importance of isopoda decreased with increasing fish size. Fish and crabs were absent from all specimens < 93 mm. The most diverse diet was exhibited by the largest fish. Polychaetes were found only in the stomachs of fish taken at site 2 and represented 93% of the volume in summer. Penaeid shrimp dominated the diet at this site in fall-winter (pers. observ.). The sample size was statistically inadequate to confirm food differences by predator size, season, or site.

Table 7. Percentage volumetric occurrence of foods by major prey taxa in the stomachs of three size classes of silver perch.

| Food Taxa | Volumetric occurrence (%) | | |
|---|---|---|---|
| | ≤50 mm SL (N = 7) | 51-92 mm SL (N = 10) | ≥93 mm SL (N = 34) |
| Pisces | | | 4.0 |
| Crustacea (total) | 90.1 | 86.0 | 41.8 |
| Shrimp (total) | 3.7 | 47.1 | 27.1 |
| *Penaeus duoratum* | - | 1.2 | 10.3 |
| Amphipoda | 4.0 | 10.7 | 3.2 |
| Isopods | 16.8 | 10.8 | 1.8 |
| Polychaeta | 8.4 | 4.2 | 12.1 |
| Nematoda | - | .2 | 7.6 |
| Other[1] | 1.5 | 9.6 | 33.5 |
| TOTAL | 100.0 | 100.0 | 100.0 |

[1]Unidentified animal remains, porifera, sipunculida, mollusca, and vegetation.

## DISCUSSION

### Environmental Conditions

Salinities in the Whitewater Bay area are strongly dependent upon seasonal and annual variations in freshwater inflow (Taft and Harbaugh 1964, Clark 1971). In this study, a gradual decline of salinities occurred in summer (1979) with lows occurring in fall. These results are in agreement with those reported by Tabb et al. (1962), Clark (1971), and Davis and Hilsenbeck (1974). Tabb et al. (1962) found that salinity minima in Whitewater Bay during fall was due to an earlier 3-month lag in park runoff across the Tamiami Trail (N. of ENP) during normal to heavy summer rainfall, followed by gradual increases in salinity over a 3-5 month period. May (1979) data probably reflects the heavy unseasonal rainfall which occurred in the area during April 22-25 (South Florida Water Management District 1979)

The annual lows and highs in water temperature closely agree with those of Davis and Hilsenbeck (1974) and Clark (1971). These studies and others (Collier and Hedgepeth 1950, Dawson 1955) in shallow Gulf estuaries have found water temperatures closely correlated with air temperature.

### Relative Abundance and Occurrence

All species with the exception of silver jenny, reached their highest total abundance at the Clearwater Pass site. Silver jenny was most abundant at the Ponce de Leon Bay site. Idyll and Yokel (1970), Clark (1971) and Davis and Hilsenbeck (1974) all reported a similar instance for these species among the same sites as those sampled here. The Clearwater Pass area has many characteristics listed by Tabb et al. 1962, Clark 1971, and Costello et al. (1986) considered favorable for the abundance of these species. In addition to dense vegetative cover (more so here than at any other site sampled) as evidenced by trawl samples, macrophyte surveys (Brook 1982), and previous observations (Tabb et al. 1962, Clark 1971, Davis and Hilsenbeck 1974 ), it has shallow depths (1-2 m) with nearby channels to use as refuge from cold temperatures, calm waters, few predators (Tilmant et al. 1990), moderate salinities, and abundant food sources (see Results, foods). The role of vegetation in providing habitat and food resources has been documented by many for pink shrimp Costello and Allen (1970 and numerous references therein), Fore and Schmidt 1973a, Yokel 1975, Thayer et al. 1979, Zieman 1982, Leber 1983, 1985, Costello et al. 1986, and Holmquist et al. 1989ab), for blue crab (Lippson 1973, Heck and Orth 1980, Orth and Van Montfrans 1982, Wilson et al. 1987, Ryer 1987), and for the forage species, (Fore and Schmidt 1973a, Schmidt 1979, Zieman 1982 and numerous references therein), Colby et al. 1985, Thayer and Chester 1989, Sogard et al. 1987, 1989a,b,c). Dense vegetation provides the greatest densities and biomass of potential prey organisms as opposed to non-vegetated or sparsely vegetated sites (Orth 1977, Brook 1978, Stoner 1980, Wacasey 1967), and refuge from predation (Zieman 1982 and numerous references therein).

Seasonal fluctuations in the catches varied among species. In this study as with others, (Caldwell (1957), Tabb and Manning (1961), Clark (1971), Yokel (1975), and Schmidt (1979) highest numbers of pigfish occurred from spring through fall. For silver jenny, however, the summer-fall pattern of peak abundance reported by Clark (1971) Waldinger (1968), and Schmidt (1979) was not found here as the abundance of juveniles in spring through fall was offset by the occurrence of large numbers of gravid adults during winter-spring. Shrimp occurred year-round, with greatest numbers taken in summer-fall-winter. This same pattern is similar to Costello et al. (1986) in Florida Bay and Idyll and Yokel (1970) in the Whitewater Bay area. Seasonal changes in abundance in this study may be due to variations in parental fecundity, larval mortality and/or the location of post-larvae in the estuary as suggested by Roessler and Rehrer (1971) who reported that post-larval shrimp catches at Little Shark River in 1967, were approximately three times greater than in 1966 while Tabb et al. (1962) reported seasonal variability in post-larval shrimp catches during 1957-61 at the Buttonwood Canal. Roessler (1967) also reported much larger catches of pinfish in March-May 1964 (N = 3789) than during the same months in 1963 (N = 77) from the Buttonwood Canal catches. These differences may be attributed to high larval mortality in some years, spring or summer peaks came in between sampling dates, or post-larvae entered the estuary elsewhere.

Habitat quality (i.e., water circulation, tidal range, environmental parameters, sediment) can also regulate the relative abundance and seasonal occurrence of these species in the estuary (Costello et al. 1986, Holmquist et al. 1989a; 1989b, Sogard et al. 1989a; 1989b; 1989c). Offshore waters of the Gulf of Mexico, which are demonstrated sources of young penaeid shrimp (Roessler and Rehrer 1971, Allen et al. 1980) and larval forage fish (Jannke 1971, Collins and Finucane 1984), extend by tidal action first into the Ponce de Leon-Oyster Bay area adjacent to the western margin of Whitewater Bay where these species settle out as epibenthic post-larvae (Idyll and Yokel 1970, Clark 1971, this study). These juveniles concentrate near inlets where tidal currents are moderate (Williams 1965) so as to facilitate a movement seaward or inland should migrations occur with a tidal cycle (Tabb et al. 1962). North and east of this area, circulation is influenced more by seasonal variations in runoff and only minimally by tides (Tabb et al. 1962, Taft and Harbaugh 1964). Conversely, only three species, shrimp, blue crab, and silver jenny (see section on "Size") occurred at the inner-most estuarine zone (site 5), which was characterized by lack of sediment, extreme salinity fluctuations associated with strong currents (often > 2 kts., pers. observ.) and/or runoff facilitated by the annual rise in sea level from April to October (Allen et al. 1980).

No significant correlations were found between resident species (silver perch, silver jenny, blue crab) abundance and salinity or temperature at the time of sampling. These species can tolerate large variations in salinity and temperature (Roessler 1967, Tagatz 1968, Jannke (1971). On the other hand, the abundance of seasonal species were correlated with either salinity (pinfish) or temperature (pigfish) or both (shrimp). However, Roessler (1967), suggested that season exerts more influence on the catches of forage fishes than salinity or temperature and believed that these parameters may be more important where spawning occurs when determining recruitment success. Young pink shrimp have broad tolerances for salinity and temperature. For example, in south Florida, juveniles occur in salinities ranging between 0 and 65 °/oo (Tabb et al. 1962) with highest abundance from 30 to 50°/oo (Tabb, D. C. cited in Costello and Allen 1970), and in temperatures from 11 to 40 °C (Costello et al. 1986); however, temperatures below 18 °C restrict shrimp feeding activity and they are rare at temperatures approaching 36 °C (Tabb et al. 1962). Salinities and temperature ranges (1 to 35°/oo, 16 to 32 °C, respectively) found in this study are well within the tolerance limits of pink shrimp and, except for temperatures, extend beyond the ranges within which juveniles have been reported most abundant. At the most productive sites in Whitewater Bay (1 & 2), during the season of highest juvenile abundance, temperature ranged from 17 to 32 °C and salinities from about 11 to 26°/oo. Accordingly, Costello et al. (1986) suggested that maximum recruitment and survival, but not necessarily optimum osmoregulation, occurred within the ranges of highest abundance. In Florida Bay, they reported that densities of juveniles were highest at salinities from 33 to 41 °/oo (Costello et al. 1986) while in North Carolina shrimp density was highest between 25 and 30°/oo (Weinstein et al. 1977), yet a salinity range from 11 to 26°/oo in the present study did not ensure high shrimp abundance where benthic vegetation was virtually non-existent. Furthermore, Hoese (1960) and Dall (1981) found that salinity is not very important to young shrimp if other environmental factors are ideal. As in this study and others (Eldred et al. 1961, Tabb et al. 1962, Idyll and Yokel 1970), movements of larger juveniles (>16 mm CL) to deeper waters in winter could be a function of growth and/or a seaward migration to spawn; however, these migrations may be local to escape cold water conditions (Eldred et al. 1961, Costello and Allen 1970). Consequently, correlations of shrimp as well as pinfish and pigfish abundance with salinity and/or temperature may only be autocorrelates since the end of the wet season-beginning of the dry season and the extensive migrations of juvenile shrimp, pinfish, and pigfish to their offshore spawning grounds coincide, and pronounced variations in salinity are related to seasonal fluctuations caused by rainy summers and water loss through evaporation during dry winters in the Whitewater Bay region (Taft and Harbaugh 1964). This suggests that salinity and temperature range might not be an important feature in maintaining community cycles in the estuary.

Size

Consideration of size composition is included in this report because it is as important to know which sizes, as indicative of age, growth, and movements, are present as to which species are present. With the exception of pigfish and silver perch, the size composition of most of the species in this study agrees closely to those reported in other estuarine areas. For pink shrimp, the length range (5-30 mm CL) was similar to that shown by Tabb et al. (1962) for Whitewater Bay locations and Saloman (1962) for Tampa Bay. The smallest sized juveniles (5-6 mm) occurred in this study at sites 2, 3, and 4 during June-July. Assuming a reported growth rate of 2 mm CL/month in estuaries (Tabb et al. 1962), juveniles 5-6 mm were probably spawned offshore February-March. A second group of similarly-sized shrimp occurred during this study in October, suggesting an August offshore spawning period. These findings, as those reported by Tabb et al. (1962), Yokel (1975) and Robblee et al.(in prep.) suggest bimodal recruitment for the inshore nursery areas based on bimodality of catch from the offshore Tortugas fishery. The occurrence of larger (>16 mm) juveniles at site 3 may be due to water depth and salinity/temperature interactions as mentioned earlier. Water depths and salinity were greater at this site than at other sites. As juveniles grow, they move gradually into deeper and saltier water (Tabb et al. 1962, Yokel 1975, Williams 1984). Stationary mean sizes from January to May may be due to movement out of the area presumably offshore by shrimp larger than 18 mm CL as shown by Tabb et al. (1962). Females occurred more often and were larger than males at sizes greater than 18 mm CL. Similar sex size disparities in estuaries were reported by Eldred et al. (1961), Tabb et al. (1962), Saloman (1966), and Kutkuhn (1966).

Length-weight values have been determined for shrimp from other areas and they do not always correspond to values presented here because of deviations possibly resulting from how the data are collected and pooled (sex and size of shrimp) and environmental factors in other geographic regions. Also, size and seasonal differences probably influence values as shown by Higman et al. (1972) for shrimp (2-17 mm CL) from Whitewater Bay. Kutkuhn (1966) determined the linear slopes from male and female shrimp ~7-50 mm CL to be 3.04 and 2.79, respectively, based on 1,680 shrimp taken from south Florida commercial catches August 1960-January 1961. From carapace length-weight relationships, 95% confidence intervals were determined about the b (slope) value and compared with linear slope values provided by Tabb, Dubrow, and Jones (1962), Higman et al. (1972), and Kutkuhn (1966). Slope values given by Tabb et al. (1962) (sexes combined) and Kutkuhn (1966), [male and female shrimp] differed significantly from the pooled slope (8-month) value given in this study. These differences could be attributed to the specific monthly equations obtained from shrimp in fall and winter. However, slope differences among all studies were non-significant when compared to slope values obtained for shrimp in July/September during this study. Data from this study illustrate that one should not calculate weight of shrimp caught during specific monthly periods such as June or January using an equation derived from data that had been pooled from a combination of months. Mean weights and mean lengths used by Higman et al. (1972) can yield b values that differ from those obtained using individual weights and lengths (Ricker 1958, p. 191).

Blue crab size composition in this study (12-194 mm CW) was typical of the general pattern of juveniles and adults reported by Tagatz (1968) in the St. John's River.

The length range of silver jenny (22-96 mm TL) is similar to those reported in other nearby estuarine areas. In this study smaller silver jenny occurred more often in inland areas while larger fish occurred at the outer-most estuarine site (Ponce de Leon Bay). A similar size grouping was found by Kerschner et al. (1985) along Florida's east central coast. They concluded that differences in vegetational parameters contributed to the observed size separation. Young-of-the-year present in both March and November collections could represent a protracted spawning period, two distinct spawning peaks, or sampling bias. Clark collected fish <20 mm SL in Whitewater/Oyster Bay from May to January, with an apparent peak from May to July. Reid (1954) and Yokel (1975) reported an almost identical recruitment period while Charles (1975) and Tabb and Manning (1961) reported recruitment peaks of abundance from May to July and September to November, respectively. The length weight relationship for juvenile and adult fish had a value of b (3.1001) which was within the .05 range presented by Charles (1975); growth was nearly isometric ($b = 3.1001$). At least two age groups (see above) were distinguished by mean size analysis as the mean length of age 1 fish is 57 mm SL while fish of 80 mm SL are in their second year (Charles 1975).

For pinfish, a similar size range was reported by Clark (1971) at the same sites as those sampled in this study. He attributed differences in size to vegetation and season. Similarly to the present study, Clark (1971) reported recruitment of 20-25 mm fish from December to June, while Tabb and Manning (1961) and Schmidt (1979), in western Florida Bay reported the smallest individuals caught in March, April, and February, respectively. Bimodality in winter and spring has also been noted by the above authors, but sample sizes were inadequate to confirm those findings in this study. Variations in fish size between sites one and two may be due to differences in food availability and habitat structure (see also Foods section). In this study as in others (Carr and Adams 1973; Stoner 1979, 1980), larger pinfish consume vegetation and crustaceans (amphipods) more often than smaller fish and are found in higher abundance at densely vegetated sites (site 2) than at non-vegetated sites or sparsely vegetated sites (site 1). Caldwell (1957) found a similar length-weight relationship for fish from Cedar Key. He determined Log W = -4.3734 + 2.9136 log L based on an unknown number of fish over a 23-80 mm SL size range. Growth was nearly isometric (b = 3.089)

The size composition of pigfish differed somewhat in the present study from that reported by Clark (1971) and Yokel (1975) and may have been due to time of sampling. Here, fish <40 mm occurred in the catches in May only, while Clark (1971) reported recruitment of fish < 20 mm from January to May with the majority taken from February to April; Yokel (1975) and Weinstein et al. (1977) observed smallest size grouping (1.0-1.5 cm) from December to May. Juveniles reportedly leave the shallows at 90 mm FL (Yokel 1975) or ~125 mm SL in winter (Clark 1971) presumably to avoid the cold or for movement offshore for spawning (Springer and Woodburn 1960). A similar pattern was expected for this study, yet fish as large as 169 mm SL (N = 8; mean 124 +/- 9.1 mm) remained in the deeper, higher saline waters at the Oyster Bay site during winter. This may have been due to a pre-spawning migration (see spawning section). No information for this species has been reported on mean fish size differences in relation to water depth or salinity. The length/weight relationship for juveniles and young adults had a value of b (3.0704); growth was nearly isometric. No other information on their length/weight relationships is known.

The length composition of silver perch in this study (12-177 mm) is similar to that reported by Springer and Woodburn (1960), Odum (1971), and Fore and Schmidt (1973a); but differs from others (Clark 1971, Yokel 1975) in that larger fish were caught in this study. These differences could be due to gear selectivity. Springer and Woodburn (1960), Odum (1971), and Fore and Schmidt (1973a) used seines and trawls with variable mesh ( .3- ≥.95 cm) nets while Clark (1971) and Yokel (1975) used bottom trawls only with small mesh (.3 cm) nets. Young silver perch 12-37 mm appeared in the catches May (1979-80) and June; Clark (1971) reported that recruitment of small juvenile (mostly < 20 mm) occurred from February to October with pea Manning (1961) observed juveniles 10-15 mm in abundance from March through June. In this study, the presence of small juveniles in May and June samples only, probably represents sampling bias. Jannke (1971) reported larvae in Little Shark River year around. Young-of-the-year fish reach a modal length of 185 mm at age 1 (Roessler 1967). All fish seen in this study (12-177 mm) were probably within their first year.

Reproductive Activity

Pink shrimp spawning occurs year-around at the offshore Tortugas grounds, with peak activity based on larval abundance spring through fall (Costello and Allen 1970 and others). In this study as in Tabb et al. (1962) no ripe females were found, even though size ranges of shrimp in both studies included adults. The overall F:M 1.1:1 sex ratio found in this study corresponds identically to those reported by Eldred et al. (1961) and Tabb et al. (1962) and is in close agreement with Saloman (1965) who reported a 1:1 ratio in lower Tampa Bay.

The crab sex ratio found in this study (.89:1) differs somewhat with that reported by Oesterling (1976) along Florida's midwest coast. He noted a ratio (.81:1) from commercial catches and suggested that sex composition is related to salinity and season. Except for this study, no estimates of sex ratio have been reported for unfished populations.

Little is known on the reproductive activity of silver jenny. In earlier studies (Reid 1954, Kilby 1955, Clark 1971, Charles 1975, Yokel 1975), inferences on a winter-spring spawning season were based on the estuarine recruitment of juveniles <20 mm. Spawning activity seen in this study (occurrence in April of running ripe fish at the Ponce de Leon site) supports the findings of Collins and Finucane (1984) who found a spring-summer occurrence of small larval mojarra (presumably silver jenny) in the Ten Thousand Islands/Whitewater Bay area. Elsewhere, near-ripe fish have been reported in winter outside of Biscayne Bay (Charles 1975). The overall sex ratio (1.1:1) assumed the expected distribution. Sex ratio of this species is previously undetermined.

Pinfish reportedly spawn in late fall and winter offshore in deeper waters (Caldwell 1957), and enter park estuaries as young juveniles (Tabb and Manning 1961, Roessler 1967, Clark 1971, Schmidt 1979). Collins and Finucane (1984) reported the occurrence of small larvae (<4 mm) approximately 40 km due west of Cape Sable in February indicating an offshore winter spawn. No running ripe fish were caught during this study nor were they reported in the above mentioned studies. No published information is available on sex ratio.

Again, the offshore/inshore Ten Thousand Islands/Cape Sable area was indicated by Collins and Finucane (1984) as an important spawning ground for pigfish based on the abundance of small (< 4 mm) larvae nearly year round with peak catches in February. In the literature, spawning period is inferred based on the recruitment of young fish to the estuary. The inshore occurrence of ripening fish as reported here from October to January has not been noted elsewhere (Springer and Woodburn 1960, Clark 1971). This pre-spawning condition, combined with the predominance of males in the catches suggests that pigfish were in a pre-spawning migration. Similarly, Tibbo and Humphreys (1966) reported a separation of the sexes for nearshore fish in pre-spawning condition. Other studies have failed to report pigfish sex ratio.

The reproductive activity of silver perch in park waters is better known than other species studied here. Jannke (1971), reported in the Little Shark River low to high spawning activity based on the abundance of small (< 3 mm NL) larvae year around with a peak in spring. Collins and Finucane (1984) indicated the Ten Thousand Islands/Whitewater Bay estuarine zone as an important spawning area based on the abundance of small larvae during February-May-August. In western Florida Bay in February, Tabb and Manning (1961) reported running ripe fish of both sexes in Conchie channel. Ripe females collected in March-April during this study represent the first account of silver perch in spawning condition from park waters other than western Florida Bay. Sexual maturity is reached by both sexes within their first year. Fecundity estimates are lacking in earlier studies.

<u>Foods</u>

Studies concerning pink shrimp diets are relatively few (Eldred et al. 1961, Williams 1965, Odum 1971, Sastrakusumah 1971, Leber 1983). Of these, only Sastrakusumah (1971) and Leber (1983) have investigated seasonal and ontogenetic variation in diets. Most previous food data on *P. duorarum* are based on the frequency of occurrence method, a technique that assesses feeding trends but often fails to provide an accurate interpretation of the importance of a given food item. However, the six main food items grouped by percent frequency of occurrence were the same items grouped by percent food wet weight (see Fig. 5, Appendix VI). A similar situation existed for other decapods examined in coastal waters (Jewett and Feder 1982, 1983). In this study, as in those mentioned above, foods were dominated by generically similar small crustaceans, bivalves, gastropods, polychaetes, and plant material. However, Ophiuroids (brittlestars), an important food source in this study, are rarely taken by these shrimp elsewhere.

Sediment presumably ingested incidentally while seeking out prey items (Eldred et al. 1961), may represent a resource of importance. Dall (1968), Odum (1971), and Moriarty (1977) suggested that the nutritional benefit of sediment in penaeid diets may be derived from a film of organic carbon, including bacteria on sediment particles. Mid-Whitewater Bay is the center of highest abundance for juvenile pink shrimp (Idyll and Yokel 1970) and forage fishes (Clark 1971), and where, according to Scholl (1963), the highest carbon-nitrogen ratios in sediments are found. Carbon is also obtained by shrimp from benthic algae (Stoner and Zimmerman 1988). Taken together, these results indicate that young *Penaeus* may benefit from ingesting sediment in addition to utilizing the bacteria within the sediment.

Variation in shrimp food habits with locality and season was related to food availability and habitat structure while trophic ontogeny can be attributed to morphology. Here, and as in Leber (1983), ontogenetic shifts in prey were reported and can be explained, in part, by shrimp morphogenesis. Stoner and Zimmerman (1988) found that ontogenetic variation in the diets of *Penaeus* spp. is related to increasing size of the chelae and mouth parts. For example, shrimp <10 mm CL fed heavily on small, immotile crustacea (amphipods) and plant material because these food items could be easily ingested while faster moving, larger food items such as mollusks, brittlestars, and certain crustacea could only be captured and ingested easily by larger shrimp and were rarely found in small shrimp. Such was the case at the Oyster Bay site where brittlestars were the dominant prey for larger shrimp. Sastrakusumah (1971), who found no pronounced ontogenetic or seasonal differences in the feeding habits, based his conclusions on obvious patterns rather than systematic analysis.

Food habits of shrimp were dramatically different from site to site. In this study, crustaceans, brittlestars, and bivalves occurred in the diet more often at sites devoid of vegetation (sites 3 and 5) while vegetation and polychaetes occurred more often in the diets of shrimp at sites 1 and 2 with seagrass/algal cover, indicating that: (1) variation in prey diversity and abundance among sites was related to differences in macrobenthic flora and fauna and habitat characteristics reported by Brook among the sites sampled. Additionally, vegetated habitats support greater densities and biomass of potential prey items than unvegetated or sparsely vegetated substrates (Orth 1977, Brook 1978, and others), and they may also provide shelter from shrimp predators (Boesch and Turner 1984); or (2) bottom vegetation is accessible and taken preferentially over motile, elusive prey such as certain crustaceans and mollusks. Neither factor considered alone is completely satisfactory; however, both factors may be working simultaneously.

Seasonal variability in feeding also seems to reflect seasonal fluctuations in food abundance and climatological conditions. One good example illustrates this relationship; the dominance of algal consumption (*B. oestedi* sporangia) by shrimp at the eastern Whitewater Bay site in fall coincides with peak reproductive activities (Morrison 1982) and seasonal availability of sporangia in this area. Conversely, a reduction in feeding activity of juveniles was reported in Buttonwood Canal during winter by Sastrakusmah (1971), but no explanation was given. Air temperatures were examined at the onset of Sastrakasumah's study during December 1962 and January 1963 (NOAA, 1963, 1964). These data show several near-freezing events (2-5$^{o}$C) during both months at Flamingo (ENP) with a December monthly mean of 17$^{o}$C. Given that water temperatures (which are closely correlated with air temperatures) of <18$^{o}$C restrict shrimp feeding behavior it is probable that the unusually cold winter in 1962-63, resulted in a reduction of shrimp feeding behavior, not seen in this study.

Relatively few studies have been directed toward the foods and feeding habits of blue crabs (Darnell 1958, Tagatz 1968, Odum 1971, Laughlin 1982) in Florida waters. Here, and as reported in the aforementioned studies, crabs feed on almost any consumable-sized mollusk or crustacean available, confirming that it is an opportunistic benthic carnivore. As in Tagatz's study, and this study, diet did not change with crab size, season, or locality. Conversely, Laughlin (1982) reported marked differences in crab diet by size, season, and station in the Florida Panhandle area, but he used a much larger sample size (N = 4,129) than Tagatz (N = 660) or the present study. The wide diversity of crustacean and mollusks prey types consumed here could be due to high macrofaunal abundance and diversity (reflecting prey availability) as reported by Brook (1982) at the Clearwater Pass site. He found that bivalves (particularly *B. exustus*) were a dominant group at Clearwater Pass (attached to *Udotea* sp.) and were eaten by all crab sizes, extensively. Similarly, Tagatz reported that bivalves were a preferred prey and a major cause for the greater concentration of crabs (<60 mm CW) in certain shallow areas.

Based on earlier food studies, the results in this study demonstrate as wide a variety of prey items as have been reported for silver jenny in the North River (ENP) (Odum 1971), Ten Thousand Islands (Adams et al. 1974), Indian River lagoon (Kerschner et al. 1985), northeastern Gulf coast (Carr and Adams 1973), and in the Biscayne Bay region (Charles 1975, Brook 1977). Silver jenny are opportunistic benthic carnivores that feed on polychaetes, crustaceans, and mollusks. As in the above studies, sediment is consumed while feeding on macrobenthic organisms. Significant variations in diet among sites and season appeared to be influenced by habitat structure as shown from data provided by Brook (1982), and its affect on food availability. For example, consumption of polychaetes was greatest at mid- and outer estuarine sites 1 and 4, but they were not found in the diet at the innermost site in Tarpon Bay. Brook (1982) found greatest abundance of polychaetes on soft bottoms at sites 1 to 4 with lowest densities on rocky bottom at Tarpon Bay. Odum (1971) also reported a similar absence of polychaetes in silver jenny diet from habitats similar to site 5. Seasonal diets were coincident with seasonal trends in the availability of major prey groups in the field. Brook (1982) reported that a shift in dominance at site 4 occurred in summer from polychaetes to crustaceans (amphipods) which corresponded with a maximum consumption of crustacea by these fish in summer at this site more so than during any other season compared. Charles (1975) reported fewer polychaetes in the diet in winter. Here, as with Carr and Adams (1973) and Kerschner et al. (1985), a transition in diet was found, from planktivory on copepods in smaller fish to carnivory on almost exclusively polychaete material in larger fish. Data from this study were statistically inadequate to confirm these findings.

Except for minor differences, the food analysis results obtained in this study confirms the findings of other quantitative food studies reported for pinfish in the North River area (Odum 1971), Ten Thousand Islands (Adams et al. 1974), and along the northeast Gulf Coast (Caldwell 1958, Hansen 1969, Carr and Adams 1973, and Stoner 1980) in that it is clearly an epibenthic omnivore. The variety of organisms found in the stomachs (61 taxa) is also suggestive of an opportunistic pattern of feeding. In this study, as with Stoner (1980), the importance of small crustacea and amphipods decreased with fish length (40-150 mm) while plant material became more important with increasing fish size. Pinfish undergo distinct ontogenetic changes in dentition with growth (Caldwell 1957, Stoner 1980). Juveniles 23-35 mm are characterized by conical and canine teeth, well adapted for capturing small animal prey whereas fish > 35 mm develop chisel-shaped incisors, which are required to graze plant material. Here, and as was indicated by Stoner (1980) seasonal variations in diet may be due to seasonal prey abundance patterns. Brook (1982) reported polychates, a important food item in the diet at site 2 in summer, was more common at this site in summer. Increased vegetation consumption by pinfish in fall and spring may be due to: 1) plant material is taken in response to its abundance and/or 2) it is taken as an alternative food since grassblades lend protection to more small species and inhibit their consumption. Stoner (1979) reported that pinfish approach sediment only at night which may explain the large amounts of sediment found in the diet. Circumstantial evidence provided by Scholl (1963) on nutrients (see shrimp foods) suggests that pinfish as well as shrimp may derive nutritional benefit from sediment ingesta.

The results of the food analysis for pigfish in this study differs with earlier studies in Tampa Bay (Springer and Woodburn 1960) and along the northeast Gulf coast (Reid 1954; Carr and Adams 1973) in that brittlestars and vegetation commonly occurred in the diet along with a variety of invertebrates, including crustaceans, polychaetes and mollusks. The variety of benthic prey organisms in the stomach (67) may also reflect the general strategy of a feeding opportunist. The presence of large amounts of brittlestars in the guts of 6 fish 114-169 mm from the Oyster Bay site was not surprising. Among all macrobenthic sites sampled, maximum brittlestar abundance occurred here (Brook, unpubl. data). It appeared that changes in diet occurred with ontogeny in relation to fish morphology. Qualitative differences in diet found among size groups in the above studies (mollusks and polychaetes occurrences only in fish >40 mm) were confirmed statistically in this study. Unlike the above studies, however, adult fish collected here contained enough plant material (pers. observ.) by occurrences (33%) to suggest omnivory. Further work is needed to confirm if food value is obtained by pigfish from plant ingesta. Even though the diet of this species suggests the importance of food availability, especially at the Oyster Bay site, feeding trends might also be influenced by other biotic and abiotic factors such as vegetation density, seasonal abundance of both potential prey and predators and/or age specific behavior of pigfish (Stoner 1980).

In the silver perch dietary analysis, results suggest as wide an array of prey types as have been found for silver perch along the northeast Gulf coast (Reid 1954, Carr and Adams 1973) and in the 10,000 Islands (Adams et al. 1974), but differs in regards to major food groups consumed. In the present study crustaceans (mostly amphipods, isopods, and shrimps) and polychaetes were the main foods, suggesting silver perch is a benthic carnivore. However, elsewhere, they depend more on shrimp and fish and less on polychaetes (Reid 1954, Springer and Woodburn 1960, Carr and Adams 1973, Adams et al. 1974, Stickney et al. 1975) and were classified by Chao and Musick (1977) as a pelagic feeder based on the lack of sedentary benthos in their diets. Here, and as reported by others (Reid 1954, Carr and Adams 1973, Adams et al. 1974, Stickney et al. 1975) silver perch appeared to pass through transitional changes in food habits with growth. The diet also appeared to vary by season. It is likely that the high percentages of polychaetes in the diet at Clearwater Pass during summer may be due to prey availability in the field. Brook (1982) observed greatest concentrations of polychaetes in summer at this study site. Furthermore, the data suggests the importance of penaeid shrimp in the diet at a time (fall/winter) when those prey are a major invertebrate component of trawl catches at Clearwater Pass (Idyll and Yokel 1970, Davis and Hilsenbeck 1974, this study). Stickney et al. (1975) and Stoner (1980) found distinct seasonal differences in the diet.

## SUMMARY/CONCLUSIONS

Among the dominant epibenthic species studied, silver jenny, silver perch, and blue crab were considered residents in the estuary while pink shrimp, pinfish, and pigfish may be classified as seasonal/cyclical visitors. Juvenile pink shrimp, the most abundant animal studied occurred year-round, most abundantly during summer, fall and winter while pigfish showed abundance maxima in late spring and summer. Blue crab and silver perch occurred most often in winter-spring while silver jenny and pinfish occurred in nearly equal numbers year-round. With the exception of silver jenny, all species occurred in greatest numbers at the Clearwater Pass site in mid-Whitewater Bay. Target species and the macrobenthos were usually sampled simultaneously (Brook 1982).

Spatial variations in species abundances among the study sites may be explained, in part, by spatial and temporal patterns of food availability and habitat quality (i.e., vegetation, sediment). Little or no sediment covers the rock floor at the inner-most estuarine site at Tarpon Bay. Virtually devoid of vegetation, it contained few macrobenthic organisms, whereas, at Clearwater Pass, the center of highest abundance and diversity for macrobenthic flora and fauna, is where the highest carbon-nitrogen ratios in sediments are found, suggesting that ingested sediments, may represent a resource of importance. Similarly, forage fish communities in Florida Bay are richer and more diverse where sediments are of high organic content (Thayer and Chester 1989).

Temporal changes in abundance of these species were related to seasonal variations in prey abundance at the sites sampled and related to seasonality of cover in the case of vegetated habitats. The role of vegetation in providing habitat and food resources for these species has been documented by many (Zieman 1982, and most recently, Holmquist et al. 1989, 1991, Thayer and Chester 1989, Sogard et al. 1989a, 1989b, 1989c). Macrobenthos abundance and diversity was greatest at Clearwater Pass. These forms comprised the major prey groups in diets of the target species at this site. Brook (1982) found a shift in dominance at the Ponce de Leon Bay site in summer from polychaetes to amphipods which corresponded to their maximum consumption by silver jenny in summer. Correspondingly, algal (*B. oerstedi*) sporangia were consumed by shrimp only during fall at the eastern Whitewater Bay site during peak seasonal reproductive activities of *Batophora*. Here, as in Laughlin (1982) and Leber (1983), the seasonality of prey types, were indicated from shrimp/fish guts. Data in those studies further show that these species mediate the seasonal distribution and abundance of other organisms.

Maximum abundance in the summer of these trawlable fishes is often related to an earlier influx of larval and post-larval organisms. Catches of small juveniles of pink shrimp and pigfish suggests post-larval settlement at Clearwater Pass, whereas catches of young silver jenny and pinfish indicates post-larval settlement in eastern Whitewater Bay for these species. Except for blue crab, catches of larger specimens of all species studied occurred in the deep, higher salinity waters at the Oyster Bay site. Salinity and temperature were identified as variables important in evaluating the abundance of seasonal species at the Whitewater Bay sites, however, these relationships may only be autocorrelates as the end of the rainy season-beginning of the dry season and the extensive migrations of shrimp, pinfish, and pigfish to their offshore spawning grounds coincide, and the rainy season strongly influences salinity in this region. Additionally, all target species were found well within their known salinity and temperature tolerances, suggesting that at the sites sampled, salinity and temperature were probably not limiting factors. Factors other than vegetation and salinity may be important in regulating fish and decapod abundance (Holmquist et al. 1989b, Sogard et al. 1989a).

The evolution of seasonality in spawning activity and recruitment of these species may be evidenced by their seasonal occurrence at the sites samples. Residents, silver perch, silver jenny, and blue crab were found to spawn at the Clearwater Pass and the Ponce de Leon Bay sites. Although no gravid pink shrimp, pigfish, or pinfish were collected during this study, pigfish may have been in a pre-spawning condition during fall-winter. Size at first maturity for those species found spawning was achieved during their first year of growth. Silver perch fecundity (counts of mature ova) ranged from 45,175 for a 142 mm sized fish to 182,000 for a 160 m size fish and was directly related to length and weight. Spawning occurred from November to May. Sex ratios approached unity for pink shrimp, blue crab, silver perch, and silver jenny; whereas two ratios favored males (pinfish and pigfish).

A single regression line represented the weight-SL relationship for combined sexes of: silver jenny [Log W = -4.7449 + 3.1001 (Log L)]; pigfish [Log W = -4.76286 + 3.07037 (Log L)]; pinfish [Log W = -4.71684 + 3.08891 (Log L)]; and pink shrimp [Log W = -3.5534 +* 3.289 (Log L)]. When investigating pink shrimp CL-weight relationship, significant differences occurred among months. Growth was isometric for all species examined.

The stomach contents analysis indicated that juvenile pink shrimp, pinfish and possibly pigfish were omnivores. In these species, crustaceans (amphipods and isopods) and plant material (marine alga and spermatophores) were among the major food items; polychaetes, mollusks, and brittlestars (rarely taken elsewhere) were also important. Sediment was frequently found in the diet. On the other hand, silver jenny, silver perch, and blue crab exhibited carnivorous feeding stages, consuming primarily crustaceans (amphipods and shrimps), polychaetes and mollusks (bivalvia). Of molluscan prey the scorched mussel *B. exustus* was the most recognizable species.

Spatial, temporal, and ontogenetic variations in food habits were observed among the species sampled. Shrimp exhibited dramatic differences in diet with size, season and locality. Higher feeding activity was reported in fall-winter than in summer and may vary in response to climatological conditions. Feeding diversity was lowest at the Tarpon Bay site and highest at the eastern Whitewater Bay site. Seasonally, diet diversity for shrimp was lowest in spring-winter and highest in fall. Blue crab ate similar foods at all sites. The diets of seasonal dominants shrimp, pinfish and pigfish exhibited pronounced seasonal and growth differences in diet. Whereas, trophic ontogeny can be explained by the increasing range of prey sizes and types with fish/shrimp body and mouth size (morphogenesis) as reported by numerous authors (e.g., Ross 1978, Stoner 1980, Kerschner et al. 1985, Stoner and Zimmerman 1988), variation in shrimp and silver jenny food habits with locality and season, and pinfish with season, was apparently related to food availability and habitat structure. There is some evidence that blue crab, silver perch, and pigfish diets were similarly related, however more work is needed to substantiate that hypothesis. Data provided in this study further verify the conclusion that these species were sufficiently opportunistic in their food habits to take advantage of the availability of major prey groups found at the sampled sites by Brook (1982).

In summary, the seasonal abundance of the target species at a site was related to feeding habits as a reflection of prey availability and vegetative cover, and recruitment and spawning activity as a reflection of seasonal effects. Interactions between habitat complexity, biotic communities and fish/decapod abundance clearly requires further research. Because several of these species recruit from habitats outside of the estuary, offshore conditions (i.e., variability in parental fecundity, and in planktonic mortality, salinity, temperature) must also be considered as possible sources of regulation of recruitment pattern. It may be that patterns of estuarine abundance, as reported in this study, are influenced by long-term evolutionary adaption than by short-term ecological or behavioral response to environmental parameters.

Implications for future research-Considering the large abundance of pink shrimp at sites within Whitewater Bay (when compared to sites 3-5) and the fact that this species feeds upon almost every dominant benthic macroinvertebrate, it is likely that pink shrimp are a crucial factor in the food web throughout Whitewater Bay and they may play an important role in determining abundance of small macrofauna. Such a role was given to dominant generalist feeders by Murdoch (1969), Virnstein (1977), and Laughlin (1982) and to *P. duorarum* in Apalachee Bay by Leber (1983, 1985). Clearly further field testing of these relationships among estuaries with different environmental conditions is needed as these factors may have different influences on the distribution of both consumer and prey type. The results of this study may also pertain to food web modeling. Cohen (197) suggested that an animal that passes through ontogenetic trophic stages may represent more than one kind of food web. The high variability of food habits with season and locality further compounds the issue. Also, the fact that *Penaeus* are omnivorous, carnivorous, detritivorous, and cannibalistic precludes their placement on any one trophic level throughout their life cycle (Moriarty 1977). I recommend that trophic stages rather than the species as a whole be considered for food web models in the estuary and that this web be treated as dynamic and flexible in time and space as suggested for fishes by Stoner (1979, 1980), for crabs by Laughlin (1982), and for *Penaeus* spp. by Stoner and Zimmerman (1988).

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Appendix I. Numbers of pink shrimp, blue crab, silver jenny, pinfish, pigfish, and silver perch collected by roller frame trawl (RFT), otter trawl (OT), and gill net (GN) by stations in Whitewater Bay-Shark River estuary, 1979-80. Number of samples and number of individuals caught from June 1979 through May 1980 are given in parenthesis under number of sample and number of individuals, respectively for Sites 1-3. Site descriptions are in Table 1.

| | Site 1 | | | Site 2 | | | Site 3 | | | Site 4 | | | Site 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RFT | OT | GN | RFT | OT | GN | RFT | OT | GN | RFT | OT | GN | RFT | OT | GN | TOTAL |
| No. Samples | 5 (11) | 2 | 4 | 5 (11) | 3 | 4 | 4 (11) | 1 | 4 | 9 | 7 | 2 | 7 | 6 | 2 | 98 |
| No. pink shrimp | 37 (1139) | - | - | 229 (1309) | 3 | - | 21 (155) | 2 | - | 116 | 120 | - | 31 | 10 | - | 3172 |
| No. blue crab | 1 (2) | 11 | 7 | 16 (45) | 2 | 1 | - (1) | - | 2 | 1 | 2 | 5 | 1 | 7 | 2 | 105 |
| No. silver jenny | 1 (43) | 44 | - | - (24) | 28 | - | - (1) | - | - | 1 | 120 | - | 1 | 5 | - | 268 |
| No. pinfish | 2 (12) | 37 | 4 | 6 (106) | 31 | 1 | - (3) | 1 | - | - | - | - | - | - | - | 203 |
| No. pigfish | 2 (3) | 10 | - | 11 (47) | 39 | 1 | - (14) | 2 | - | 1 | 1 | - | - | - | - | 131 |
| No. silver perch | - | 1 | 5 | - (15) | 9 | 21 | - | - | 2 | 1 | 7 | 3 | - | - | - | 64 |
| <u>% Successful</u> | | | | | | | | | | | | | | | | |
| pink shrimp | 100.0 (100.0) | 0 | 0 | 100.0 (100.0) | 33.3 | 0 | 75.3 (100.0) | 100.0 | 0 | 77.8 | 100.0 | 0 | 71.4 | 100.0 | 0 | |
| blue crab | 9.1 (18.1) | 100.0 | 75.0 | 27.2 (81.8) | 66.3 | 25.0 | - (9.1) | 0 | 50.0 | 11.1 | 28.6 | 100.0 | 14.2 | 66.7 | 100.0 | |
| silver jenny | 9.1 (81.8) | 100.0 | 0 | - (72.7) | 100.0 | 0 | - (9.1) | 0 | 0 | 11.1 | 100.0 | 0 | 14.2 | 33.3 | 0 | |
| pinfish | 18.1 (54.5) | 100.0 | 75.0 | 9.1 (90.9) | 100.0 | 25.0 | - (27.2) | 100.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| pigfish | 18.1 (9.1) | 100.0 | 0 | 18.1 (72.7) | 100.0 | 25.0 | - (65.6) | 100.0 | 0 | 11.1 | 14.3 | 0 | 0 | 0 | 0 | |
| silver perch | 0 | 50.0 | 50.0 | - (63.6) | 66.3 | 75.0 | 0 | 0 | 50.0 | 11.1 | 71.4 | 50.0 | 0 | 0 | 0 | |

Appendix II. Total effort (number of samples, all gears combined) and number of pink shrimp, blue crab, silver jenny, pinfish, pigfish, and silver perch collected by month, 1979-80.

| Month | Pink Shrimp | | Blue Crab | | Silver Jenny | | Pinfish | | Pigfish | | Silver Perch | | Number of Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | % Total | No. | % Total | No. | % Total | No. | % Total | No. | % Total | No. | % Total | |
| January | 413 | 13.0 | 8 | 7.6 | 20 | 7.5 | 12 | 5.9 | 2 | 1.5 | 3 | 4.7 | 5 |
| February | 310 | 9.8 | 5 | 4.8 | 15 | 5.6 | 10 | 4.9 | - | 0 | 5 | 7.8 | 7 |
| March | 393 | 12.4 | 21 | 20.0 | 45 | 16.8 | 14 | 6.9 | 7 | 5.3 | 19 | 29.7 | 12 |
| April | 169 | 5.3 | 19 | 18.1 | 25 | 9.3 | 9 | 4.4 | 4 | 3.0 | 10 | 15.6 | 15 |
| May | 78 | 2.5 | 24 | 22.9 | 73 | 27.2 | 71 | 35.0 | 56 | 42.8 | 6 | 9.4 | 19 |
| June | 98 | 3.1 | 6 | 5.7 | 37 | 13.5 | 19 | 9.4 | 29 | 22.1 | 8 | 12.5 | 8 |
| July | 105 | 3.3 | 3 | 2.9 | 9 | 3.4 | 7 | 3.4 | 13 | 9.9 | - | 0 | 5 |
| September | 355 | 11.2 | 1 | 1.0 | 16 | 6.0 | 16 | 7.9 | 8 | 6.1 | 10 | 15.6 | 6 |
| October | 354 | 11.2 | 1 | 1.0 | 9 | 3.4 | 12 | 5.9 | 5 | 3.8 | 1 | 2.0 | 11 |
| November | 345 | 10.9 | 5 | 4.8 | 11 | 4.1 | 11 | 5.4 | 6 | 4.6 | - | 0 | 5 |
| December | 552 | 17.4 | 14 | 13.3 | 8 | 3.0 | 22 | 10.8 | 1 | 1.0 | 2 | 3.1 | 5 |
| TOTALS | 3172 | | 105 | | 268 | | 203 | | 131 | | 64 | | 98 |

Appendix III. List of secondary species and number of individuals collected in bottom trawls, March 1979-May 1980. Site descriptions are in Table 1. Fish are classified as B = Benthic, E = Epibenthic, P = Pelagic based on their feeding position in the water column.

| | Site | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Arthropoda | | | | | |
| Class Crustacea | | | | | |
| Family Penaeida | | | | | |
| *Penaeus sp.* | 3 | 13 | 1 | 1 | 5 |
| *Trachypenaeus sp.* | | 1 | 6 | 192 | |
| *Trachypenaeus constrictus* | | | 7 | 220 | |
| *Sicyonia typica* | | | 1 | 2 | |
| Family Palaemonidae | | | | | |
| *Periclimenes americanus* | 1 | 115 | | 19 | 4 |
| *Periclimenes longicaudatus* | 1 | 128 | | 8 | |
| *Leander paulensis* | 1 | 4 | 17 | 12 | |
| Family Alphaeidae | | | | | |
| *Alphaeus heterochaelis* | 19 | 21 | 1 | 3 | |
| *Alpheus armillatus* | | | | 1 | |
| Family Hippolytidae | | | | | |
| *Hippolyte pleuracantha* | | 6 | | | |
| *Tozeuma carolinensis* | | 2 | | | |
| Family Porcellanidae | | | | | |
| *Petrolisthes armatus* | | | | 3 | |
| Family Portunidae | | | | | |
| *Callinectes ornatus* | | | 2 | | |
| *Portunus spinimanus* | | | 11 | 9 | |
| *Portunus gibbesii* | | | 9 | 29 | |
| Family Majidae | | | | | |
| *Libinia dubia* | | 1 | 3 | 2 | |
| *Metoporhapis calcarata* | | | 1 | | 1 |
| *Stenorynchus seticornis* | | | 3 | 3 | |
| Family Xanthidae | | | | | |
| *Neopanope sp.* | | | | 2 | |
| *Neopanope packardii* | | 1 | | 9 | |
| *Neopanope Texana* | | 2 | | | |

| | Site | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| *Panopeus occidentalis* | | | 5 | | 1 |
| *Menippe mercenaria* | | | | 1 | 1 |
| *Rithropanopeus harrisii* | | | 1 | | 5 |
| *Pachygrapsus transversus* | 1 | | | 1 | |
| | | | | | |
| Family Squillidae | | | | | |
| *Squilla empusa* | | | | 2 | |
| *Squilla rugosa* | | | | 1 | |
| | | | | | |
| Class Merostomata | | | | | |
| *Limulus polyphemus* | | | | 1 | |
| | | | | | |
| Echinodermata | | | | | |
| Class Asteroidea | | | | | |
| *Echinaster sentus* | | | 1 | | |
| | | | | | |
| Class Ophiuroidea | | | 6 | | |
| Class Holothuroidea | | | | | |
| *Bursatella leachii* | | | 1 | 1 | |
| | | | | | |
| Subtotal (Invertebrates) | 26 | 296 | 76 | 522 | 17 |
| | | | | | |
| Chordata - Fishes | | | | | |
| Class Chondrichthyes | | | | | |
| Family Dasyatidae | | | | | |
| *Dasyatis americana* - E | | | 1 | | |
| | | | | | |
| Class Osteichthyes | | | | | |
| Family Ophichthidae | | | | | |
| *Myrophis punctatus* - B | | | | | 1 |
| | | | | | |
| Family Clupeidae | | | | | |
| *Opisthonema oglinum* - P | | | | 2 | |
| *Harengula jaguana* - P | | | 1 | 4 | |
| | | | | | |
| Family Engraulidae | | | | | |
| *Anchoa cayorum* - P | | | | 1 | |

Appendix III, Continued.

| | Site | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| *Anchoa cubana* - P | | | | 39 | |
| *Anchoa mitchilli* - P | | | | 4 | 5 |
| *Anchoa hepsetus* - P | | | | 70 | |
| Family Synodontidae | | | | | |
| *Synodus foetens* - E | 6 | 2 | | 2 | |
| Family Batrachoididae | | | | | |
| *Opsanus beta* - B | 22 | 13 | 1 | 1 | 1 |
| *Porichthys porossimus* - B | | | | 5 | |
| Family Arridae | | | | | |
| *Arius felis* - B | | | | 5 | |
| *Bagre marinus* - B | | | | 2 | |
| Family Ophidiidae | | | | | |
| *Ophidion holbrooki* - B | | | | 1 | |
| Family Ogcocephalidae | | | | | |
| *Ogcocephalus radiatus* - B | | 1 | 11 | 6 | |
| Family Syngnathidae | | | | | |
| *Syngnathus floridae* - E | 1 | 1 | | 3 | |
| *Syngnathus scovelli* - E | 1 | 5 | 1 | | |
| *Hippocampus erectus* - E | 1 | 1 | | | |
| Family Serranidae | | | | | |
| *Diplectrum formosum* - E | | | | 1 | |
| Family Carangidae | | | | | |
| *Chloroscombrus chrysurus* - P | | | | 6 | |
| Family Lutjanidae | | | | | |
| *Lutjanus synagris* - E | 2 | 7 | 1 | 1 | |
| Family Gerridae | | | | | |
| *Eucinostomus argenteus* - E | 1 | 1 | 1 | | 39 |

Appendix III, Continued.

| | Site | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Family Pomadasyidae | | | | | |
| *Haemulon plumieri* - E | 3 | 37 | | | |
| Family Sparidae | | | | | |
| *Archosargus probatocephalus* - E | | 1 | | | |
| *Archosargus rhomboidalis* - E | | 1 | | | |
| Family Sciaenidae | | | | | |
| *Cynoscion nebulosus* - E | | 1 | | 1 | |
| *Menticirrhus americanus* - E | 1 | | | 9 | |
| *Leiostomus xanthurus* - E | 5 | 4 | | 1 | |
| Family Cyprinodontidae | | | | | |
| *Lucania parva* - E | | 1 | | | |
| Family Ephippidae | | | | | |
| *Chaetodipterus faber* - E | 1 | 1 | 1 | | |
| Family Gobiidae | | | | | |
| *Microgobius gulosus* - B | 9 | 1 | | | 5 |
| *Gobiosoma robustum* - B | 2 | 14 | 2 | 1 | |
| Family Triglidae | | | | | |
| *Prionotus scitulus* - B | | | | 1 | |
| *Prionotus tribulus* - B | 1 | 3 | 1 | 3 | |
| Family Bothidae | | | | | |
| *Paralichthys albigutta* - B | 2 | | | | |
| *Paralichthys lethostigma* - B | | | | 1 | |
| *Etropus crossotus* - B | | | | 9 | |
| Family Solidae | | | | | |
| *Archirus lineatus* - B | 14 | 29 | 11 | 2 | 5 |
| *Trinectes maculatus* - B | 1 | 6 | | 1 | 3 |
| Family Cynoglossidae | | | | | |
| *Symphurus plagiusa* - B | | 11 | 8 | 21 | 1 |

Appendix III, Continued.

| | Site | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Family Balistidae | | | | | |
| *Monocanthus hispidis* - E | | 1 | 3 | 3 | |
| *Monocanthus ciliatus* - E | | 2 | 3 | 1 | |
| Family Ostraciidae | | | | | |
| *Lactrophys quadricornis* - E | | | 2 | | |
| Family Tetraodontidae | | | | | |
| *Sphoeroides nephelus* - E | | | 7 | | |
| *Sphoeroides parvus* - E | | | | 3 | |
| Family Diodontidae | | | | | |
| *Chilomycterus schoepfi* - E | | 7 | 8 | 1 | |
| Subtotal (Fish) | 73 | 151 | 63 | 215 | 61 |

Total Invertebrates, all sites = 937

Total Fish, all sites = 563

Appendix III, Continued.

| | Site | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Family Balistidae | | | | | |
| *Monocanthus hispidis* - E | | 1 | 3 | 3 | |
| *Monocanthus ciliatus* - E | | 2 | 3 | 1 | |
| Family Ostraciidae | | | | | |
| *Lactrophys quadricornis* - E | | | 2 | | |
| Family Tetraodontidae | | | | | |
| *Sphoeroides nephelus* - E | | | 7 | | |
| *Sphoeroides parvus* - E | | | | 3 | |
| Family Diodontidae | | | | | |
| *Chilomycterus schoepfi* - E | | 7 | 8 | 1 | |
| Subtotal (Fish) | 73 | 151 | 63 | 215 | 61 |

Total Invertebrates, all sites = 937

Total Fish, all sites = 563

Appendix IV. List of secondary species and number of individuals collected in gill nets, September 1979-May 1980. Site descriptions are in Table 1. Fish classifications are as in Appendix III.

| | Site | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Arthropoda | | | | | |
| Class Crustacea | | | | | |
| Family Penaeidae | | | | | |
| *Trachypenaeus sp.* | | | | 1 | |
| Family Portunidae | | | | | |
| *Portunus gibbesii* | | | 6 | 6 | |
| Family Majidae | | | | | |
| *Libinia dubia* | | | 1 | 2 | |
| Family Xanthidae | | | | | |
| *Neopanope packardii* | | | | 2 | |
| *Rithropanopeus harrissi* | | | | 1 | |
| Subtotal (Invertebrates) | | | 7 | 12 | |
| Chordata - Fishes | | | | | |
| Class Chondrichthyes | | | | | |
| Family Carcharhinidae | | | | | |
| *Carcharhinus leucas* - E | 1 | | | | 2 |
| Family Sphyrnidae | | | | | |
| *Sphyrna tiburo* - E | | 4 | | 3 | |
| Class Osteichthyes | | | | | |
| Family Elopidae | | | | | |
| *Elops saurus* - P | 2 | 4 | 1 | | 9 |
| Family Ophichthidae | | | | | |
| *Ophichthus gomesi* - B | | | | 1 | |
| Family Clupeidae | | | | | |
| *Opisthonema oglinium* - P | 11 | 20 | 39 | 14 | |
| *Harangula jaguana* - P | 6 | 3 | 4 | 5 | |
| *Brevoortia smithi* - P | 1 | | 1 | | |

Appendix IV, Continued.

| | Site | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Family Engraulidae | | | | | |
| *Anchoa mitchilli* - P | | | | 1 | |
| Family Synodontidae | | | | | |
| *Synodus foetens* - E | | | 1 | | |
| Family Batrachoididae | | | | | |
| *Opsanus beta* - B | | | | 1 | |
| Family Arridae | | | | | |
| *Arius felis* - B | 21 | 7 | 18 | 16 | 7 |
| *Bagre marinus* - B | 20 | 14 | 15 | 5 | 5 |
| Family Belonidae | | | | | |
| *Strongylura notata* - P | 1 | | | | |
| Family Echeneidae | | | | | |
| *Echeneis nuacrates* - E | 1 | | | | |
| Family Carangidae | | | | | |
| *Oligoplites saurus* - P | | 1 | | | |
| *Caranx hippos* - P | 1 | 2 | 1 | 3 | 2 |
| Family Lutjanidae | | | | | |
| *Lutjanus synagris* - E | | | 1 | | |
| *Lutjanus griseus* - E | 3 | | | | |
| Family Gerreidae | | | | | |
| *Eucinostomus argenteus* - E | | | 1 | | |
| Family Sciaenidae | | | | | |
| *Cynoscion nebulosus* - E | 1 | 1 | | | |
| *Leiostomus xanthurus* - E | | | | 1 | |
| Family Mugilidae | | | | | |
| *Mugil curema* - E | 8 | 1 | | | |
| *Mugil trichodon* - E | 1 | | | | |

Appendix V. Environmental parameters of successful catches of pink shrimp, blue crab, silver jenny, pinfish, pigfish, and silver perch, 1979-1980. Mean values have 95% confidence intervals.

| | Mean | Range | N |
|---|---|---|---|
| Pink Shrimp | | | |
| Salinity (°/oo) | 19.8 ± 2.18 | .9 - 35.3 | 70 |
| Temperature (°C) | 24.9 ± 1.0 | 16.0 - 32.7 | 70 |
| Blue Crab | | | |
| Salinity | 19.0 ± 3.0 | 1.0 - 32.2 | 37 |
| Temperature | 25.3 ± 1.4 | 16.0 - 32.1 | 37 |
| Silver Jenny | | | |
| Salinity | 18.7 ± 2.4 | 2.4 - 30.1 | 36 |
| Temperature | 25.2 ± 1.4 | 16.0 - 30.9 | 36 |
| Pinfish | | | |
| Salinity | 20.4 ± 30.5 | 10.7 - 30.5 | 29 |
| Temperature | 25.3 ± 32.7 | 17.4 - 32.7 | 29 |
| Pigfish | | | |
| Salinity | 23.0 ± 2.3 | 11.7 - 30.4 | 26 |
| Temperature | 26.8 ± 1.4 | 17.4 - 32.7 | 25 |
| Silver Perch | | | |
| Salinity | 22.4 ± 2.5 | 13.1 - 31.5 | 23 |
| Temperature | 25.0 ± 1.7 | 17.2 - 30.9 | 23 |

Appendix VI. Percentage composition (frequency of occurrence and volume) of stomach contents of 2,478 juvenile pink shrimp (6-28 mm CL). Foods of four size classes of pink shrimp: 6-10,11-15,16-20, and >21 mm CL are expressed as percent volume. Plus (+) denotes less than .5 percent.

| Food Item | Frequency | Volume | Size Class (mm) | | | |
|---|---|---|---|---|---|---|
| | | | ≤10 | 11-15 | 16-20 | ≥21 |
| Invertebrates | | | | | | |
| Crustacea Total | 57.0 | 42.0 | 32.7 | 48.0 | 42.4 | 25.2 |
| Penaeida | + | + | | + | | + |
| UID Natanita remains | .8 | 2.4 | .6 | 1.6 | 3.3 | 2.0 |
| Isopoda total | + | + | | + | + | |
| *Cymodoce faxoni* | + | + | | + | + | |
| Amphipoda total | + | + | | + | + | + |
| Gammaridea | + | + | + | + | + | + |
| Tanaidacea | + | + | | + | + | |
| UID Crustacean remains | 55.0 | 40.0 | 31.7 | 46.9 | 39.0 | 22.9 |
| Echinodermata total | 5.0 | 4.0 | 1.9 | 2.4 | 4.0 | 9.0 |
| Ophiuroidea | 5.0 | 4.0 | | 2.4 | 4.0 | 9.0 |
| Holothuridea total | + | + | | | + | |
| *Synapta lydriiformis* | + | + | | | + | |
| Mollusca total | 10.0 | 5.3 | 4.3 | 3.6 | 4.5 | 13.1 |
| Bivalvia total | 4.7 | 2.4 | 1.1 | 1.7 | 2.3 | 5.0 |
| *Laevicardium mortoni* | + | + | | + | + | + |
| *Nucula proxima* | + | + | | | + | + |
| *Carditamera floridana* | + | + | + | | | |
| *Cuminigia coarctata* | + | + | | | + | + |
| *Brachidontes exustus* | 3.2 | + | | + | .6 | .6 |
| *Anomalocardia auberiana* | + | + | | | | + |
| *Amysdalum papyrium* | + | + | | + | + | |
| Ostreidae | + | + | | + | + | |
| *Crassinella mactrecae* | + | + | + | | | |
| UID Bivalve remains | 3.9 | 1.8 | .8 | 1.4 | 1.5 | 4.1 |
| Gastropoda total | 5.8 | 1.4 | 2.5 | .9 | .9 | 4.4 |
| *Odostomia laevigata* | .6 | + | + | + | + | + |
| *O. sp.* | .9 | + | | + | + | + |
| *Caecum sp.* | + | + | | + | + | + |
| *Crepidula maculosa* | + | + | | + | + | + |
| *Hydrobia sp.* | + | + | | | + | + |
| UID Gastropod remains | 4.7 | 1.2 | + | .8 | + | 4.0 |

Appendix VI. Continued.

| Food Item | Frequency | Volume | Size Class (mm) ≤10 | 11-15 | 16-20 | ≥21 |
|---|---|---|---|---|---|---|
| *Lolliguncula brevis* | + | + | | + | + | |
| UID Mollusc remains | 3.1 | 1.5 | .8 | 1.0 | 1.3 | 3.7 |
| | | | | | | |
| Polychaetea total | 11.0 | 8.0 | .83 | 4.7 | 10.3 | 11.2 |
| Errantia | + | + | | + | + | + |
| Nereidae | + | + | | + | .5 | .5 |
| Sedentaria | + | + | | + | + | |
| Pectinariidae | + | .8 | | + | 1.4 | |
| Sabellariidae | + | + | | + | + | |
| UID Polychaete remains | 10.0 | 7.0 | .8 | 4.2 | 8.0 | 10.0 |
| | | | | | | |
| Sipuncula total | + | .7 | | 1.0 | .6 | + |
| *Phasicolon sp.* | + | + | | + | + | |
| | | | | | | |
| Nemerta | + | + | | | + | |
| Nematoda | + | + | | + | | + |
| Porifera | + | + | 1.9 | + | | + |
| Hydroida | + | + | | + | .5 | |
| Foraminifera | 6.7 | + | + | + | + | |
| | | | | | | |
| UID Pisces remains | + | + | | + | + | |
| UID Animal remains | 8.0 | 9.1 | 20.1 | 6.0 | 8.2 | 18.1 |
| Plant Material total | 17.0 | 9.9 | 14.8 | 9.9 | 10.6 | 6.3 |
| Algae total | 7.0 | 5.0 | 6.5 | 3.9 | 6.2 | 3.4 |
| Chlorophyceae | 1.3 | .5 | 3.3 | + | .6 | + |
| *Batophora oerstedii* | 6.2 | 3.9 | 2.8 | 2.9 | 5.1 | 3.0 |
| *Valonia sp.* | 2.4 | + | + | .6 | .5 | + |
| Rhodophyceae | + | + | | | | + |
| UID Algae remains | + | + | + | + | + | + |
| UID Spermatophyta remains | + | 1.9 | | 2.5 | 1.9 | 1.2 |
| *Halodule wrightii* | + | + | | + | | |
| UID Plant Material | + | 2.9 | 1.9 | 3.5 | 2.3 | 1.6 |
| Detritus | + | + | | + | | |
| Sediment | 27.0 | 20.0 | 23.0 | 23.0 | 18.0 | 16.1 |
| | | | | | | |
| Number of Shrimp | 2748 | | 265 | 1311 | 1012 | 160 |
| Total volume (ml) | | 17.638 | .725 | 6.487 | 8.128 | 2.298 |

Appendix VII. Percentage composition (frequency of occurrence and volume of stomach contents of 84 blue crabs. Foods of three size classes of blue crab: <60, 60-120, and >120 mm CW are expressed as percent volume. Plus (+) denotes less than .5 percent.

| Food Item | Frequency | Volume | Size Class (mm) | | |
|---|---|---|---|---|---|
| | | | ≤60 | 61-120 | ≥120 |
| UID Pisces | + | + | | + | 3.1 |
| Crustacea total | 22.6 | 42.7 | 12.5 | 33.1 | 58.0 |
| UID Natantia remains | 1.2 | + | | + | |
| Ostracoda | 1.2 | + | | + | |
| Tanaidacea | 1.2 | + | | + | |
| UID Xanthidae remains | 11.9 | 26.1 | + | 11.7 | 43.8 |
| UID Portunidae remains | 7.0 | 5.7 | | 4.5 | 8.0 |
| UID Brachyura remains | 3.5 | 5.3 | | 5.8 | 6.0 |
| UID Crustacea remains | 10.7 | 6.0 | 12.2 | 11.2 | + |
| Echinodermata total | 2.3 | + | 3.6 | | |
| Ophiuroidea | 2.3 | + | 3.6 | | |
| Mollusca total | 78.6 | 49.5 | 65.3 | 60.4 | 37.9 |
| Bivalvia total | 73.6 | 47.1 | 63.1 | 54.5 | 37.2 |
| *Brachidontes exustus* | 46.4 | 27.7 | 22.7 | 38.7 | 20.0 |
| *Anomalocardia auberiana* | 4.7 | .5 | + | .8 | + |
| *Atrina serrata* | 1.2 | + | | + | + |
| *Lima pellucida* | 2.3 | + | | + | + |
| *Codaki orbiculata* | 1.2 | + | | | .5 |
| *Cumingia coarctata* | 4.7 | 1.8 | 1.8 | 4.1 | |
| *Amygdalum papyrium* | 3.6 | 1.1 | | 2.9 | + |
| *Nucula proxima* | 2.3 | + | + | + | |
| *Laevicadium mortoni* | 3.6 | 1.0 | | + | 1.8 |
| *Pitar fulminatus* | 1.2 | + | | | + |
| *Transenella conradina* | 1.2 | + | | | 10.5 |
| *Tagelius plebeius* | 1.2 | 5.2 | | | + |
| *Mytilopsis leucaphaeta* | 1.2 | + | | | + |
| Ostreidae | 1.2 | + | | | + |
| UID Bivalve remains | 22.6 | 9.2 | 38.4 | 7.3 | 3.6 |
| Gastropoda total | 18.0 | 2.5 | 2.2 | 5.7 | .8 |
| *Crepidula maculosa* | 7.1 | + | + | + | + |
| *Bulla striata* | 1.2 | + | | + | |
| *Acteocina conaliculata* | 2.3 | + | + | + | |
| *Cerithium ebuneum* | 1.2 | + | + | + | + |

Appendix VII. Continued

| Food Item | Frequency | Volume | Size Class (mm) | | |
|---|---|---|---|---|---|
| | | | ≤60 | 61-120 | ≥120 |
| *Cerithium muscarum* | 1.2 | + | | + | |
| *Odostomia impressa* | 1.2 | + | | + | |
| *O. sp.* | 2.3 | + | + | + | + |
| *Haminoea succinea* | 1.2 | + | | + | |
| *Bittium varium* | 2.3 | + | | + | + |
| *Cerithiopsis greeni* | 1.2 | + | | + | |
| *Caecum sp.* | 1.2 | + | | + | |
| *Turbonilla sp.* | 1.2 | + | | + | |
| Melanellid | 1.2 | + | | + | |
| Vermetidae | 1.2 | + | | + | |
| *Marginella apicina* | 1.2 | + | | + | |
| *Nassarius vibex* | 1.2 | + | | + | |
| *Hydrobida* | 1.2 | + | | | + |
| UID Gastropod remains | 14.2 | 1.7 | 1.8 | 3.1 | + |
| Polychaeta total | 4.8 | + | | | + |
| Pectinariidae | 1.2 | + | | | + |
| Sedentaria | 1.2 | + | | | + |
| Nerridae | 1.2 | + | | | + |
| UID Polychaete remains | 1.2 | + | | + | |
| Sipuncula total | 8.3 | .9 | 1.2 | 2.6 | + |
| *Phasicolon sp.* | 2.3 | + | | .7 | + |
| Hydroida | 1.3 | | + | | |
| Formainifera | 10.7 | + | + | + | |
| UID Animal remains | 10.7 | + | 9.9 | 1.7 | |
| Plant Material total | 13.0 | 1.2 | | 2.3 | + |
| Chlorophyaceae | 1.2 | + | | | + |
| *Batophora oerstedii* | 1.2 | + | + | + | |
| UID Algae remains | 3.7 | + | | .9 | |
| UID Spermatophyta remains | 9.3 | .6 | + | 1.2 | + |
| *Halodule wrightii* | 2.3 | + | | + | + |
| Sediment | 4.8 | .8 | 6.6 | + | + |
| Number of crabs | 84 | | 33 | 36 | 15 |
| Total volume (ml) | | 15.306 | 1.769 | 6.076 | 7.461 |

Appendix VIII. Percentage composition (percent frequency of occurrence and volume) of foods eaten by 197 pinfish and 125 pigfish.

| Food Items | Pinfish Frequency | Pinfish Volume | Pigfish Frequency | Pigfish Volume |
|---|---|---|---|---|
| | | Percentage | | |
| Pisces total | 5.08 | .41 | .03 | .37 |
| Engraulidae | .01 | 0.00 | | |
| UID Pisces remains | 5.08 | .4 | .03 | .37 |
| | | | | |
| Crustacea total | 72.08 | 16.4 | 88.8 | 54.30 |
| Caridea | 1.02 | .08 | 1.6 | .03 |
| *Alpheus sp.* | 1.02 | 0.00 | 1.6 | .99 |
| Penaeidea | .51 | .08 | 3.2 | 1.07 |
| UID Penaeid remains | 7.61 | 2.0 | 4.0 | .17 |
| Isopod total | | 1.27 | 29.6 | 6.47 |
| *Erichsonella sp.* | 5.08 | .33 | 12.0 | .41 |
| *E. attenuata* | 3.55 | .22 | -- | -- |
| *Cymodoce faxoni* | 14.21 | .65 | 24.0 | 6.06 |
| UID Isopod remains | 2.03 | .02 | -- | -- |
| Amphipoda total | 15.22 | 1.16 | 50.0 | 20.34 |
| Gammaridea | 2.53 | 1.14 | 48.0 | 20.26 |
| Caprellidea | 1.52 | .02 | 1.6 | .08 |
| Copepoda | 8.1 | .2 | 8.0 | .84 |
| Xanthidae total | -- | -- | 3.2 | 1.7 |
| *Neopanope sp.* | -- | -- | 1.6 | .99 |
| Stomatopoda | -- | -- | .8 | .07 |
| Ostracoda | 24.87 | .22 | 12.0 | .1 |
| Mysidacea | 2.03 | .78 | -- | -- |
| Tanaidacea | 5.58 | .05 | 10.4 | .4 |
| UID Crustacean remains | 32.99 | 10.54 | 44.8 | 21.78 |
| | | | | |
| Echinodermata total | 3.05 | 1.48 | 11.2 | 15.34 |
| Ophiuroidea | 3.05 | 1.47 | 11.2 | 15.34 |
| Holothuroidea | .51 | .01 | -- | -- |
| | | | | |
| Mollusca total | 33.5 | 4.65 | 31.2 | 1.77 |
| Nudibranchia | -- | -- | .8 | .05 |
| Cephalopoda total | 1.52 | .17 | -- | -- |
| *Lolliguncula brevis* | 1.52 | .17 | -- | -- |
| Bivalvia total | 25.38 | 2.18 | 25.6 | 1.01 |

Appendix VIII. Continued

| | Pinfish | | Pigfish | |
|---|---|---|---|---|
| | Percentage | | | |
| Food Items | Frequency | Volume | Frequency | Volume |
| *Brachidontes exustus* | 16.24 | 1.71 | 7.2 | .07 |
| *Anomalocardia papyrium* | 3.05 | .06 | -- | -- |
| *Laevicardium mortoni* | 1.52 | .04 | 2.4 | .18 |
| *Nucula acuta* | .51 | 0.00 | -- | -- |
| *N. proxima* | -- | -- | .8 | .04 |
| *Semela proticua* | .51 | 0.00 | .8 | .03 |
| *Amygdalum papyrium* | -- | -- | .8 | .13 |
| *Tellina sp.* | -- | -- | .8 | .01 |
| *Cumingia coarctata* | -- | -- | 4.0 | .06 |
| *Polymesoda maritima* | -- | -- | 2.4 | .04 |
| *Marginella apicina* | -- | -- | .8 | 0.00 |
| UID Bibalve remains | 6.09 | .35 | 18.4 | .44 |
| Gastropoda total | 16.24 | 2.31 | 0.00 | .44 |
| *Bulla striata* | 1.02 | .02 | 2.4 | .01 |
| *Crepidula masculosa* | 7.61 | 1.92 | 2.4 | .02 |
| *Acteocina canaliculata* | 3.05 | .24 | .8 | 0.00 |
| *Odostomia sp.* | 4.57 | .06 | 2.4 | .02 |
| *Bittum varium* | 2.03 | .03 | -- | -- |
| *Haminon elegans* | 1.52 | .02 | .8 | 0.00 |
| *H. succinea* | 1.02 | .01 | .8 | 0.00 |
| *Turbonella sp.* | .51 | 0.00 | -- | -- |
| *Caecum sp* | 1.52 | 0.00 | .8 | 0.00 |
| *Nassarius vibex* | -- | -- | .8 | 0.00 |
| *Cerithium eburneum* | -- | -- | .8 | 0.00 |
| UID Gastropod remains | 1.52 | .02 | 3.2 | .15 |
| UID Mollusc remains | -- | -- | 2.34 | .6 |
| | | | | |
| Polychaete total | 26.9 | 7.8 | 33.8 | 7.56 |
| Errantia total | 2.03 | 1.98 | .8 | 1.33 |
| Nereidea | 1.52 | 1.96 | -- | -- |
| Sedentaria total | 6.6 | .1 | 5.6 | .03 |
| Pectinariidae | .51 | .01 | .8 | .01 |
| Sabellidae | .51 | .04 | .8 | .01 |
| UID Polychaete remains | 12.2 | 5.67 | 13.6 | 6.19 |
| | | | | |
| Sipuncula | 11.57 | .15 | 8.0 | .19 |

Appendix VIII. Continued

| | Pinfish | | Pigfish | |
|---|---|---|---|---|
| | Percentage | | | |
| Food Items | Frequency | Volume | Frequency | Volume |
| *Phasicolon sp.* | .51 | .16 | -- | -- |
| Nematodea | 3.05 | .01 | .8 | .01 |
| Pycnogonida | -- | -- | .8 | .01 |
| Acanthocephala | 30.46 | 1.47 | 9.6 | .34 |
| Porifera | 7.11 | .47 | 5.6 | .97 |
| Hydroida | 7.11 | 1.02 | 5.6 | .37 |
| Foraminifera | 18.27 | .04 | 14.4 | .02 |
| Bryozoa | 2.03 | .05 | 1.6 | .02 |
| | | | | |
| UID Animal Debris | 46.19 | 27.26 | 34.4 | 14.04 |
| Plant Material total | 39.09 | 18.61 | 35.2 | 1.98 |
| Chlorophyceae total | 6.09 | 1.25 | 3.04 | .36 |
| *Bataphora oerstedii* | .51 | .18 | -- | -- |
| *Halodule wrightii* | 2.03 | .04 | 3.2 | .38 |
| *Syringodium filiforme* | -- | -- | .8 | .08 |
| UID Spermatophyte remains | 6.09 | .03 | 24.8 | 1.13 |
| UID Plant material | 27.4 | 9.8 | 1.6 | .02 |
| Detritus | | .05 | -- | -- |
| Sediment | 18.78 | 19.87 | 4.0 | 2.72 |
| | | | | |
| Number of fish | 197 | | 125 | |
| Total volume (ml) | | 24.128 | | 20.125 |

Appendix IX. Percentage composition (percent frequency of occurrence and volume) of foods eaten by 215 silver jenny and 51 silver perch.

| Food Items | Silver Jenny | | Silver Perch | |
|---|---|---|---|---|
| | Percentage | | | |
| | Frequency | Volume | Frequency | Volume |
| Pisces total | .93 | .03 | 5.89 | .03 |
| Engraulidae | .93 | .03 | — | — |
| UID Pisces remains | | | 5.89 | .03 |
| | | | | |
| Crustacea total | 46.51 | 9.96 | 82.3 | 49.64 |
| Caridea | — | — | 11.76 | 5.79 |
| *Alpheus sp.* | — | — | 1.96 | 4.12 |
| Penaeidea | — | — | 27.45 | 15.69 |
| UID Penaeid remains | 1.4 | .46 | 17.64 | 4.12 |
| Isopod total | 13.2 | .08 | 33.3 | 3.75 |
| *Erichsonella sp.* | .93 | .02 | 27.45 | .97 |
| *E. attenuata* | .93 | .02 | 13.73 | .31 |
| *Cymodce faxoni* | 2.33 | .04 | 11.76 | 1.73 |
| *Paracereis caudata* | 1.39 | 0.00 | 1.96 | .25 |
| UID Isopod remains | .46 | 0.00 | 1.96 | .6 |
| Amphipoda total | 10.7 | .48 | 47.06 | 4.41 |
| Gammaridea | 8.12 | .45 | 47.06 | 4.41 |
| Caprellidea | 2.79 | .02 | — | — |
| Copepoda | .46 | .18 | — | — |
| Xanthidae total | .93 | .16 | 1.96 | 2.29 |
| Stomatopoda | 1.4 | .03 | — | — |
| Ostracoda | — | — | 7.84 | .12 |
| Mysidacea | — | — | 5.88 | .43 |
| Tanaidacea | 5.11 | .62 | 11.76 | .08 |
| UID Crustacean remains | 27.44 | 7.86 | 43.14 | 8.84 |
| | | | | |
| Echinodermata total | 1.4 | .41 | — | — |
| Ophiuroidea | 1.4 | .41 | — | — |
| | | | | |
| Mollusca total | 24.19 | 2.74 | 3.92 | .19 |
| Cephalopoda total | .93 | .21 | — | — |
| *Lolliguncula brevis* | .93 | .21 | — | — |
| Bivalivia total | 9.3 | .82 | 1.96 | .16 |
| *Brachidontes exustus* | .47 | .01 | — | — |
| *Anomalocardia papyrium* | .47 | 0.00 | — | — |
| *Tellina sp.* | 1.86 | .06 | — | — |

Appendix IX. Continued.

| Food Items | Silver Jenny Frequency | Silver Jenny Volume | Silver Perch Frequency | Silver Perch Volume |
|---|---|---|---|---|
| | Percentage | | | |
| *Marginella apinica* | .47 | .07 | — | — |
| UID Bivalve remains | 6.05 | .12 | 1.96 | 1.96 |
| Gastropoda total | 14.4 | .86 | 1.96 | .02 |
| *Bulla striata* | 3.25 | .30 | — | — |
| *Crepidula masculosa* | .47 | 0.00 | — | — |
| *Acteocina canaliculata* | 2.33 | .08 | — | — |
| *Odostomia sp.* | 1.86 | .08 | 1.96 | .02 |
| *Haminon elegans* | .47 | 0.00 | — | — |
| *H. succinea* | .47 | 0.00 | — | — |
| *Turbonella sp.* | 2.32 | .12 | — | — |
| UID Gastropod remains | 2.32 | .2 | — | — |
| UID Mollusc remains | 3.26 | .86 | — | — |
| Polychaete total | 43.72 | 43.29 | 13.72 | 11.34 |
| Errantia total | 7.44 | 18.19 | — | — |
| UID Ermatia remains | 16.4 | 4.65 | — | -_ |
| Nerridae | 2.79 | 1.85 | — | — |
| Sedentaria total | 7.44 | 7.27 | 1.96 | 10.20 |
| Pectinariidae | 3.72 | 4.21 | 1.96 | 10.20 |
| Sabellidae | .93 | .02 | — | — |
| Opheliidae | .93 | .05 | — | — |
| Maldanidae | 2.32 | 2.6 | — | — |
| Capitellidae | .47 | .35 | — | — |
| Luberinida | .47 | .01 | — | — |
| UID Sedentaria remains | 2.32 | .04 | — | — |
| UID Polychaete remains | 25.589 | 17.77 | 9.8 | .8 |
| Sipuncula | 9.77 | 1.05 | 1.96 | .02 |
| Nematodea | .93 | .02 | 23.53 | 6.41 |
| Acanhtocephala | .47 | .02 | — | — |
| Porifera | 1.4 | .81 | 3.92 | .1 |
| Hydroida | 14.42 | .85 | — | — |
| Foraminifera | 4.19 | .02 | — | — |
| UID Animal debris | 53.02 | 23.78 | 47.06 | 27.93 |
| Plant Material total | 7.91 | 1.22 | 5.88 | .8 |
| Chlorophyceae total | — | — | 5.88 | .12 |

Appendix IX. Continued.

| Food Items | Silver Jenny | | Silver Perch | |
|---|---|---|---|---|
| | Percentage | | | |
| | Frequency | Volume | Frequency | Volume |
| *Cladophora sp.* | — | — | 3.92 | .25 |
| *Polysiphonia sp.* | — | — | 1.96 | .33 |
| Spermatophyta total | 1.39 | .55 | — | — |
| UID Spermatophyte remains | — | — | 1.96 | .1 |
| Sediment | 18.14 | 16.33 | — | — |
| Number of Fish | 215 | | 51 | |
| Total Volume (ml) | | 17.87 | | 4.851 |