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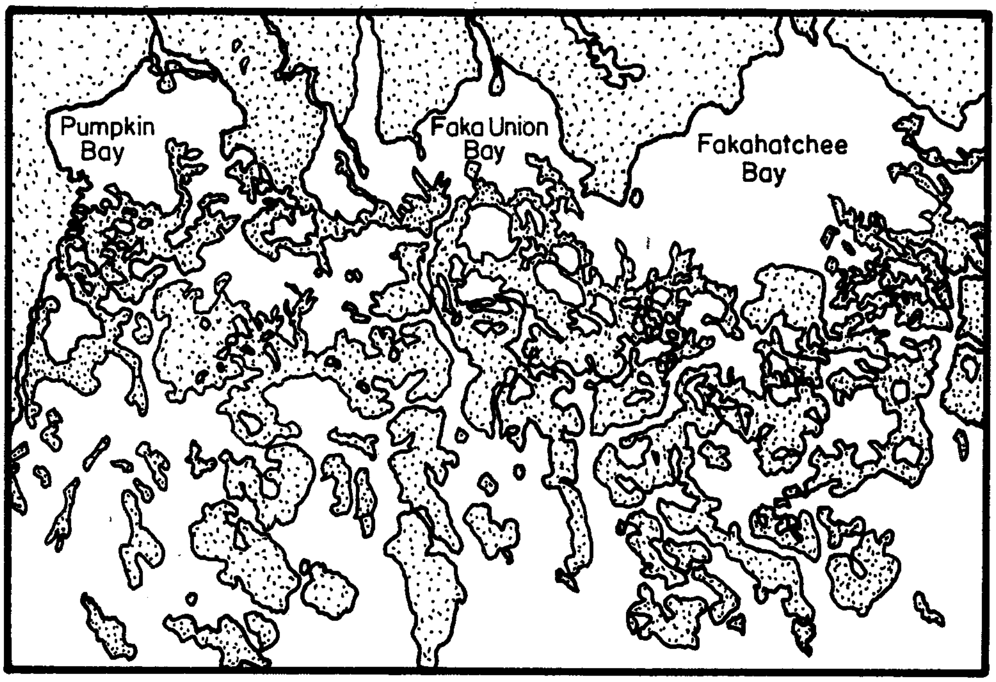

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INTRODUCTION

Estuaries provide nursery habitat for recreationally and commercially important fish and shellfish and their prey species. Many human activities along the coastline degrade the value of estuaries as nursery habitat. Increasing urban, industrial, and agricultural development have contributed heavily to man's modifications of estuaries along a 100-km wide coastal belt stretching from Florida to Texas (Hackney 1978, Lindall et al. 1979, Redelfs 1983), and the rate of these modifications parallels the current annual population explosion of 24 percent, which is about three times that for the entire United States (Thayer and Ustauch 1981). Determination of the biological effect of these alterations is needed to formulate rational management guidelines for protection and conservation of estuarine habitats.

In fisheries of the Gulf of Mexico, estuaries play a particularly important role as nursery grounds. Over 95 percent of the commercial catch and a large proportion of the recreational catch depend on estuaries for survival during some portion of the life cycle (Rounsefell 1975). Many species that are in the Gulf of Mexico as adults are in the estuaries as juveniles. Sykes and Finucane (1966) reported that, while few species are caught commercially in Tampa Bay, the 23 offshore species of major commercial importance inhabit Tampa Bay as juveniles. Thus, for all types of fisheries in the Gulf of Mexico, it is imperative that the value of estuaries as nursery habitat be protected.

Studies that relate species abundances to habitat characteristics and environmental variables and that evaluate the effect on habitat of man made changes lay the foundation for legislation and management to protect estuaries. In this report we present results of a study to evaluate the effect of channeling the drainage from a 600-km wetland known as Golden Gate Estates into a small embayment, Faka Union Bay (Fig. 1), which is a part of the Ten Thousand Islands area of coastal southwest Florida (Fig. 2).

Since we had little quantitative information on Faka Union Bay prior to the channelization, our approach was to compare abundances of major taxa of juvenile fish, macroinvertebrates, and ichthyoplankton (postlarval fish) in Faka Union Bay to that in two adjacent bays not receiving the channelized flow: Fakahatchee Bay, immediately to the east, which is hydraulically connected to Faka Union Bay, and Pumpkin Bay, immediately to the west, which is somewhat isolated from it hydraulically.

STUDY AREA

The Ten Thousand Islands area is a shallow, subtropical estuarine area with a small tidal range (1 meter). The three study bays, which can best be described as mangrove-lined indentations in the southwest Florida mainland, are separated from the Gulf of Mexico by numerous small islands of mangrove surrounded by shallow waters. Several passes connect the bays to the Gulf of Mexico. The study area consists of the water area of the bays, the passes, and the shallow waters surrounding the islands. The entire area, including the islands and ragged shoreline, covers approximately 74.6 km^2 and lies between the towns of Goodland and Chokoloskee.

The water surface area interdigitated with the mangrove islands is approximately 2.5 times larger than the water area of the open bays (Fig 2 and Table 1). The Fakahatchee system, including open bay and inter-island waters, is almost twice as large as the other two bay systems combined. Separation of systems for areal measurements was understandably arbitrary. [Surface areas were calculated by the weight method (Welch 1948)].

Salinities less than that of seawater are maintained over much of the Ten Thousand Islands area by seasonally varying inflows of fresh water. Under natural conditions, most of this water, which originated as rainfall over broad, flat prairies sloping gently to the south, moved into the estuary as sheet flow. The Tamiami Trail (U. S. 1) and its adjacent borrow canal now interrupt the natural sheet flow from areas that lie north of it; however, cuts in the southern bank of the canal and bridges on the Trail at these locations allow some water movement into areas feeding into the three bays. Rain that falls south of the Trail flows unimpeded into the bays, and rain that falls on the surface of the bays adds to the freshwater input. The hydrology of the general area suggests that groundwater seepage is a likely other source of fresh water to these systems. The above sources contribute to the flow of Pumpkin River, a small creek that empties into Pumpkin Bay, and the Fakahatchee and East Rivers, small creeks that empty into Fakahatchee Bay. The Faka Union Canal has substantially altered the pattern of freshwater flow into Faka Union Bay. Furthermore, this study and a subsequent study by Wang and Browder (1986) indicate that the Faka Union Canal has influenced salinities and circulation patterns in Fakahatchee Bay.

SAMPLING METHODS

Monthly sampling visits were conducted from July 1982 through June 1984. A brief description of the stations, the environmental measurements, and the gear and techniques for sampling juvenile fish, macroinvertebrates, and ichthyoplankton follows.

Stations

Seven stations were selected in each bay system - five in the bay and two in the pass (Fig. 1). In addition, two shallow water sampling areas were selected in the near vicinity of the pass stations. The bay stations were selected to be representative of the sublittoral zone of the bays and of the full range of salinities to be found in the bay systems at any one time. The pass stations were located to extend our coverage of the range of salinities to be found in the study area. The adjacent shallow-water sampling sites were selected to represent the sublittoral waters surrounding the numerous small islands between the bays and the Gulf of Mexico. The stations were not marked, so sampling took place in a general location rather than at a specific site. All stations were sampled on high tide ± 3 hrs during daylight hours during the time of the month of the new moon. (High tide occurs at approximately the same time of the day on the same phase of the moon.) Although a pilot study (B. Yokel, Florida Audubon Society, Maitland, pers. comm.) indicated that abundances were approximately twice as great at night as in the daytime, daylight hours were selected for reasons of safety and practicality. Stations were as follows: Pumkin Bay (1-5), pass to Pumpkin Bay (Dismal Pass) (6, 7), Fakahatchee Bay (8-12), Fakahatchee Pass (13, 14), Faka Union Bay (15-19), and Faka Union Pass (20, 21).

Environmental Measurements

The hydrological data at each station were obtained from the surface and near the bottom and included measurements of water temperature, salinity, total dissolved oxygen, turbidity, and water depth. Observations on cloud type, cloud cover, sea state, visibility, water color, and current speed and direction (with the Marsh-McBirney Model 201 Portable Water Current Meter) were also made. Water samples were collected with a specially-designed weighted water sampler. Water temperature measurements were made with a calibrated mercury thermometer and with an electrical thermistor, and the values were recorded to the nearest tenth of a degree Celsius. Salinity determinations were made with a refractometer and recorded to the nearest tenth in parts per thousand. Total dissolved oxygen was measured with a model 51B oxygen-temperature meter, and the values were recorded to the nearest tenth of a milliliter per liter. Estimates of water transparency were based on Secchi disc readings and recorded in meters to the nearest tenth. The depth was measured and recorded at each station to the nearest tenth of a meter.

Gear and Techniques

Biological sampling consisted of ichthyoplankton collections with a plankton net, surface collections with a two-boat trawl (beginning on the third sampling trip), and benthic collections with an otter trawl (beginning on the fourth sampling trip). During the first three sampling trips, a 1-m wide roller-frame trawl similar to that described by Eldred et al. (1961) was used instead of the otter trawl, but it was found to be unsuitable for our study for two reasons. First, the bottom was mud-sand and almost devoid of seagrass, and instead of rolling over the bottom, the roller sank into the soft mud and stirred up the bottom. Second, the gear caught too few organisms to support statistical comparisons of abundances among systems - probably because it was not wide enough to prevent escapement of faster animals. Beginning with the fourth trip, we used a 3-m wide otter trawl almost identical to that used in the Beaufort study (Colby et al. 1985).

The otter trawl net was 5-mm (3/16") bar mesh with a 3-mm (1/8") mesh tail bag. The net measured 3 m at the head and foot rope. It was fitted with a 6 mm (1/4") chain strung between the trawl boards to serve as a tickler chain. The trawl was deployed by paying the net over the side of the boat while making slight way in a circular direction. The trawl boards were deployed when the boat was on station and headed against the direction of the current. Upon release of the boards, the boat moved ahead until the tow ropes were taut. A timed haul of 2 min then began. Towing speed was approximately 3.7 km/hr (2 knots). The otter trawl was not towed directly in the passes; instead tows with the otter trawl were made in the shallow areas adjacent to each pass station.

The surface trawl used was a modification of the net described by Massman et al. (1952) and used in the Beaufort study (Colby et al. 1985). The surface trawl measured 6.6 m at the head rope, 6.2 m at the foot rope, and 0.7 m in depth at the wings. Wing and cod-end mesh was 5-mm (3/16") bar. The gear was towed between two boats, which deployed the net over the stern while maintaining slight headway. When the tow lines came taut, the boats separated, thus opening the net, and a 2-min haul at approximately 3.7 km/hr began.

Although both of these gear were designed specifically to catch juvenile fish, the otter trawl appeared to be highly effective at catching macroinvertebrates. Both gear caught some adult fish as well as juveniles.

Plankton tows of 2-min duration at 3.7 km/hr (2 knots) were made with a 0.5-m diameter net, 2-m long, and 0.505-mm mesh aperture. Since the water depth in most of the investigation area is shallow (about 1 m), we made 0.5 m-subsurface tows. The flow of water through the net was measured with a General Oceanics flow meter suspended from the ring and positioned inside the net. Water volume filterd was computed from flow rate data and noted for each tow. Ichthyoplankton tows were for 2 min at 3.7 km/hr.

The entire sampling was carried out from two 4.88-m (16-ft) shallow draft aluminum boats equipped with 35 h.p. outboard motors, navigational compass, optical range finder, and standard safety equipment. Towing speed was calibrated to a mark on the throttles by running a known distance at a constant speed for a given amount of time. All tows were made against the prevailing current. Replicate tows were made with all three gears.

Trawl samples were preserved in 10 percent buffered formalin. The plankton collections were preserved in 5 percent buffered formalin. The samples were identified to the lowest possible taxonomic unit, counted, and weighed (by species). A record was kept of the number of individuals and weight of each species by gear. In addition, the presence of seagrass, algae, detritus, or shells in the tail bag of the otter trawl was noted following each haul, and the wet volume of seagrass and algae from each haul was measured.

Fishes

The individuals of each fish species in each sample were collectively weighed (wet) to the nearest 0.1 gram. The number and wet weight for each species in each sample was recorded. Standard and total lengths were measured to the nearest millimeter using dial calipers. Standard length was measured from the tip of the snout to the end of the hypural bones (caudal base), and total length was measured from the tip of the snout to the tip of the longest ray of the caudal fin. In samples where more than

50 fish of a species were collected, a 10 percent subsample was weighed and measured; if more than 1,000 were collected, a 5 percent sample was weighted and measured; and if more than 3,000 fish were collected, a 1 percent sample was weighed and measured.

Common and scientific names of all fish are from Robins et al. (1980). The terms "larva", "juvenile", and "adult" as used in this study are defined by Hubbs and Lagler (1958): larva, stage between yolk absorption and acquisition of the minimum adult fin-ray complement; juvenile, stage between acquisition of the minimum adult fin ray complement and sexual maturity; and adult, sexually mature. Most of the fish caught in the trawls were juveniles, because the gear was not suitable for catching adult fish.

Ichthyoplankton

In the laboratory, all detritus, ctenophores, and jellyfish were removed from plankton samples. Identification of fish was made to the lowest possible taxon, although some young specimens could only be grouped as yolk-sac larvae. The number in each taxa was counted and expressed on the basis of unit volume of water filtered. Wet-weight values were determined by filtering each sample through 102 micron mesh netting and then weighing to the nearest milligram. The obtained values were recalculated to express wet weights in grams per cubic meter of water. Samples were transferred into 70 percent ethyl alcohol before sorting. Larval fish and fish eggs were counted and removed from the samples for measuring and further identification. Most fishes were measured for standard length (SL) with an ocular micrometer to the nearest 0.01 mm, while those fish >10 mm were measured to the nearest millimeter. Eggs were not measured or identified to taxa.

Macroinvertebrates

The identification of invertebrates was carried out for most organisms to family and genus. Organisms of commercial importance such as pink shrimp (*Penaeus duorarum*), blue crab (*Callinectes sapidus*), and stone crab (*Menippe mercenaria*), and organisms that occurred in large numbers were identified to species or genus. For those identified only to family, qualitative notes were kept on the predominance of certain species within that family. Laboratory work on invertebrates included morphometric measurements (total length or carapace width) and weighing.

The organisms referred to as macroinvertebrates are those collected in the otter trawl and retained in the 3-mm (1/8 in) mesh net liner. Minimum sizes were about 13-mm total length for shrimp and about 7-mm carapace width for crabs. Counts were made only of those organisms equal to or larger than mesh size. Smaller organisms, which probably were caught only because they were trapped in algae and debris, were noted qualitatively. Most identifications were made at the Miami Laboratory, which some specimens were identified by specialists at various institutions.

DATA ANALYSIS

The data for the three groups of organisms were analyzed separately. Analyses excluded data from the first three months of sampling because of inadequacies of the sampling gear. Environmental data were also analyzed. The data on number of organisms collected were not converted to a unit area basis; therefore, throughout this report, the term "abundance" refers to relative number per unit area and has the same meaning as relative density. Ichthyoplankton numbers are reported as "concentrations", or number per 1,000 cubic meters of water filtered. Fish data from all tows with both surface and otter trawls made on each station visit were combined for analysis. There were two tows with each gear, so a total of four samples for each station visit were combined. At most stations, the water was so shallow that most of the water column was swept by both trawls, and many species were caught in both nets. For analyses of macroinvertebrate abundances, only data from the otter trawl were used, because very few macroinvertebrates were taken in the surface trawl. Data from the two replicate tows with the otter trawl were combined. Data from the two ichthyoplankton tows were also combined.

Combining the samples improved the analysis both by increasing the number of organisms per sample and increasing the frequency of occurrence of each of the major species in samples. Regression analysis indicated that the total number of organisms in the first and second tows were highly positively correlated for each of the three animal groups (corr. coef. = 0.74 for fish, 0.837 for ichthyoplankton, and 0.637 for macroinvertebrates). Although this analysis indicated that the second tow consistently contained fewer organisms than the first (reg. coef. = 0.744, 0.851, and 0.648) (Appendix Tables A1-A3), combining the two tows did not bias the analysis because its objective was to compare abundances among bays rather than to estimate absolute abundances.

The three systems were compared on the basis of environmental variables and the abundances of the major taxa in each animal group. Other factors possibly influencing biological abundances were examined.

Differences in surface salinity, temperature, and oxygen among systems were tested with one-way analysis of variance (ANOVA) (sig. of $F \leq 0.1$), using BMDP (Dixon and Brown 1979). In addition to testing for significant difference in the means of two or more samples by means of the routine F statistic, the BMD program includes Levene's test for equal variances and the Welch and Brown-Forsythe modified F tests assuming unequal variances. Although variances were generally unequal, in only a few instances were conclusions from the Welch and Brown-Forsythe tests different from that based on the standard F test.

Means and standard deviations of all the environmental variables were determined. Pairwise correlations of the environmental variables were made to evaluate relationships between these variables.

The data set used for comparisons of biological abundance among systems excluded data from the first three months of sampling because of the gear deficiencies previously described. Also excluded were data collected in several special low-tide tows. Ichthyoplankton samples with obviously inaccurate flow-volume estimates were also excluded, because concentrations could not be accurately computed for them.

Comparisons of abundance were made for each of the 10 major species of fish, the six major species of macroinvertebrates, and the eight major families of ichthyoplankton. Comparisons were also made of the abundance of the 10 fish species, six macroinvertebrate species, and eight ichthyoplankton species as a whole. First, four-way ANOVAs were used to simultaneously compare abundance between the bay and pass, among seasons, between low salinity and high salinity months, and among the three systems. Then the data were separated into that from the bays and that from the passes, and each data set was analyzed using Duncan's multiple range test, supported by one-way ANOVA, to evaluate whether abundances differed significantly among the three systems. The data were further separated into that for each season, and Duncan tests and one-way ANOVAs were applied to each data set to determine whether abundances differed significantly among the three bays or among the three passes within seasons. The data were also separated into that for low-salinity months and that for high-salinity months, ignoring season, and Duncan tests and one-way ANOVAs were run on these data sets.

The rationale for separating the data by type of site (bay or pass) was that any differences caused by the canal would be expected to be greater in the bays than in the passes because the Faka Union Bay habitats were more directly exposed to the discharge than Faka Union Pass. The rationale for separating the data by type of month (low-salinity or high-salinity) was that any differences between Faka Union Bay and the other two bays might be expected to be greatest during times of highest inflow of fresh water, as reflected by lower salinities. Each month represented by a cruise was designated as being low or high salinity based on average salinities that month in Faka Union Bay. Months when the average salinity was less than or equal to 15.5 ppt (the 2-yr average in Faka Union Bay) were designated as "low-salinity months", and those of higher average salinities were "high-salinity" months. Sampling dates, months they represent, average measured salinity in Faka Union Bay on each date, and our classification as to low or high salinity are given in Table 2. The data were separated by season because four-way ANOVA results indicated that this was another important factor explaining variation in the abundance of major taxa in all three groups. We reasoned that separation by season might reduce our within-system variance, better allowing differences among systems to be detected. The months were assigned to season as follows: winter (Dec.-Feb.), spring (March-May), summer (June-Aug.), and fall (Sept.-Nov.). The season represented by each of the cruises also is shown in Table 2.

Again using the Duncan multiple range test, supported by the one-way ANOVA, we compared abundances in the three systems during the same four-month period of two different years: the dry season of 1983 and the dry season of 1984. The first was abnormally wet, whereas the second was more typical. We knew that canal-influenced environmental differences between

Faka Union Bay and the other two bays would be more distinct during the wet dry season than during the dry one, and we thought that any canal-induced differences in animal abundances might be easier to distinguish during that time also.

Data were transformed $[\log_{10}(N+1.00)]$, where N = number of organisms per station visit (or average number per 1,000 cubic meters of water filtered, in the case of the ichthyoplankton) so that the frequency distribution more nearly approximated the normal distribution. Duncan's multiple range test was used in addition to ANOVA because it can distinguish pairwise differences when three or more units are being compared in an analysis. One-way ANOVAs were used to confirm results of the Duncan tests because of the greater rigor of parametric tests. Results of the Duncan test were also compared to results of the modified least square (LSD) test. Results of the more conservative test differed only slightly from results of the Duncan test in the analyses of fish and macroinvertebrate data. LSD-mod results rather than Duncan test results were reported for those analyses in which the number of samples differed among groups being compared (i.e., all comparisons of ichthyoplankton and comparisons among seasons for all three animal groups). Duncan test results are only approximations when sample sizes are unequal; whereas exact results for uneven sample sizes are provided by LSD-mod. Statistical tests used to compare systems on the basis of biological abundances were from SPSS (Nie et al. 1975).

Arithmetic means are reported with results of the statistical tests, which were performed on log-transformed data, in tables in the analysis sections. The ranking of groups according to log-transformed means can sometimes differ from the ranking of the same groups according to arithmetic means; therefore, the Duncan or LSD-mod test might indicate that mean abundance in system 1 was significantly higher than that in system 2, even though the arithmetic mean of abundance in system 2 was higher than that in system 1. The more patchy the distribution of the organisms and the higher the number of zeros in the data set, the more likely this difference in ranking by the two types of means. This situation occurred occasionally in our results and can be observed in the statistical tables.

In the ANOVAs, a probability level of 0.1 was selected as the criterion for significance. Although using 0.1 instead of 0.05 increased the probability of a Type I error (assuming a difference when there was none), it decreased the probability of making a Type II error (assuming no difference when there was one). The latter can be of considerable concern when dealing with the abundance of marine organisms because of their patchy distribution through space and time. A probability level of 0.05 was the criterion for significance in the Duncan multiple range test because nonparametric tests are less rigorous than parametric tests. A probability level of 0.1 was used for the LSD-mod test.

For some comparisons of means, tests indicated that the variances of the data sets being compared were not homogeneous. Lack of homogeneity of variances can cause both the ANOVA and Duncan tests to fail to recognize true differences. Where differences are indicated by the two tests, there is no problem of interpretation, regardless of whether variances are equal; but, in cases where no significant difference is indicated, results are suspect if variances are unequal. In other words, differences among bays could have been underestimated in some cases due to the distribution of the data.

ENVIRONMENTAL CONDITIONS AND BENTHIC VEGETATION

In this section we will briefly describe salinities and other environmental conditions in the three bay systems and major influencing factors.

Faka Union Canal Discharges

Canal discharges varied considerably annually and from month to month (Fig. 3). Annual discharges in seven years prior to and including the study period were 115.1, 62.5, 72.9, 89.5, 134.0, 214.6, and 238.0 (provisional) cubic meters for the years 1978 through 1984. Monthly variations in discharge reflect the seasonal variation in rainfall. Discharge data were estimated from stage measurements at U.S. Geological Survey station No. 02291143, located at the weir immediately north of U.S. 41 (U.S. Geological Survey, 1978-1984).

Precipitation

Southwest Florida experiences pronounced wet and dry seasons. According to records at Everglades City, a coastal station, rainfall averages over 127 cm (50 in) annually, two thirds of which falls during the wet season - June through October. The dry season extends from November through May (National Environmental and Satellite Data and Information Service 1982-1984).

Mean precipitation at Everglades City for a 36-yr period is given in Figure 4. Annual rainfall at Everglades City averages about 20 cm per month from June through September and less than 5 cm per month from November through January. Monthly rainfall at Everglades City during the period of our study is given, along with rainfall at two other stations - Naples and Ft. Myers - in Table 3. The 1982 rainfall at Everglades City exceeded the long-term average during July-August, fell slightly below the long-term average in September and October, and approximately equalled the long-term average in November and December. Abnormally high rainfall during January-March 1983 exceeded average rainfall considerably, while rainfall was below average the following two months. With the exception of July and August, monthly rainfall was slightly higher than average each month of 1983 after May. Monthly rainfall at the three stations in Table 3 averaged as little as 0.9 cm (January 1984) and as much as 32.8 cm (June 1983).

Data collected during monthly sampling visits indicated that the three bay systems have markedly different salinity regimes (Fig. 4). Faka Union Bay, which receives freshwater discharges from the Faka Union Canal, had significantly lower surface and bottom salinities than the two adjacent bays (Appendix Tables B1 and B2). It also differed significantly from the passes. Mean salinities in the three passes differed little from each other. Salinities in Pumpkin Bay were higher and more stable over time than in the other bays. In Pumpkin Bay, salinities were never below 10 ppt and averaged more than 25 ppt. Salinities were lowest and least stable in Faka Union Bay. Here minimum salinities, which were associated with the rainy season, approached freshwater conditions at all stations. Salinities in Fakahatchee Bay were higher than in Faka Union Bay but lower than in Pumpkin Bay. Salinities in the three passes were similar to each other in both mean and range. They were higher than those in Faka Union and Fakahatchee Bays but similar to those in Pumpkin Bay. In all three passes, salinities were within the 21-35 ppt range at least 74 percent of the time.

Maximum salinities at all stations in the study area approached oceanic salinities at some time during the study period, but the minimum values varied considerably among stations (Fig. 5, 6, and 7). The monthly salinity changes in the bay system paralleled the changes in Faka Union Canal discharges (Fig. 4). Salinity maxima were observed in April (1984) or May (1983), just prior to the start of the rainy season. Minima were attained in September, near the end of the rainy season. Rainfall deviated from its expected seasonal pattern in 1983, and considerable precipitation fell from January through March, which are usually very dry. This rainfall was followed by a decline in salinities in February, March, and April (Fig. 4).

The vertical salinity gradients evident in Faka Union Bay during some times of the year suggest the occurrence of two-layer flow and some stratification (Fig. 8). Similar gradients also were found in Fakahatchee Bay. The largest vertical salinity differences occurred during months with maximum rainfall. The smallest were observed during the dry months of the year.

The difference in average salinities at the bay stations and those at the pass stations were always greater in Faka Union Bay than in either Fakahatchee or Pumpkin Bay (Fig. 9). The greatest differences between bay and pass occurred during months of high canal discharge. The magnitude of these differences exceeded 20 ppt in the Faka Union system.

The observed spatial distribution of salinities in Fakahatchee Bay suggested that this bay as well as Faka Union Bay was being influenced by the Faka Union Canal. Salinities at stations nearest to the passage between the two bays were often lower than those at stations nearer to the mouth of the two creeks emptying into Fakahatchee Bay. This was particularly the case during low-salinity months. The connection between Faka Union and Fakahatchee Bays probably is responsible for the greater variation in salinities over time in Fakahatchee Bay as compared to Pumpkin Bay.

Water Temperature

Our monthly measurements suggested that the annual range in water temperature for the entire study area was about 17°C. Minimum and maximum ater temperatures were 17°C and 34°C at the surface and 16.5°C to 33.8°C at the bottom. There were no significant differences in temperatures among areas (Appendix Tables B3 and B4). Vertical temperature differences were slight. In 97 percent of the observations, the temperature difference between surface and bottom did not exceed 1°C.

Correlation between Hydrographic and Meteorologic Variables

Means and standard deviations of environmental variables (Appendix Table C1) indicate that, for most variables, observations are symmetrically distributed around the mean. Pearson correlation coefficients were primarily in the range $\pm$ 0.2 - 0.8, and a number of the relationships were significant, both for the area as a whole (Appendix Table C2) and for each bay system (Appendix Table C3-C5). Statistically significant correlation coefficients ranged from -0.5 to 0.99. Salinities were more highly correlated with rainfall than with freshwater discharge, even in Faka Union Bay.

Of all the variables, depth and Secchi disk readings showed the most consistent lack of correlation with the other variables. They were highly correlated with each other, however, indicating that the Secchi disk readings were meaningless (undoubtedly because the water was sufficiently transparent to allow the Secchi disk to be seen all the way to the bottom at any of the recorded depths).

Benthic Vegetation

Trawl samples were made over three general types of bottom - sand, mud, and shell on hard bottom. The quantity and type of vegetation in the samples was recorded. General quantity is indicated by month and by station in Figure 10, in which circles of various sizes each represent a range of volumes in liters.

Cover, when present, was mainly unattached macrophytic red algae. *Gracilaria* spp. formed the bulk of the algae caught in the trawls; *Acanthophora spicifera* was another prominent species but much less abundant than *Gracilaria*. Small amounts of *Thalassia* and *Halodule* were present at the shallow sites adjacent to the three outer pass sampling locations. Carter et al. (1973) reported seagrass meadows in Fakahatchee and Faka Union Bays in the early 1970s. Except for small aggregations of *Halophila engelmannii*, we found almost no seagrasses in the bay areas we sampled. Figure 10 suggests that there was more vegetation in our samples during spring and summer months (March-June) than during the fall and winter months, but no statistical tests were made.

FISH

Fish were one of three major types of organisms examined in this study. We will first describe the fish collections and then present results of a statistical comparison of abundance of the 10 major fish species among systems.

Description of Fish Collections

A total of 85,561 individual fish comprising 83 species and 36 families were collected by surface, otter, and roller trawls during the 24 surveys (July 1982 through June 1984). A list of taxa, with total individuals and total weight of each taxa, in collections is given in Table 4. Fish represented 77 percent of the total biomass and 54 percent of the total number of all organisms collected in the trawls. The ten most numerous fish species, listed in decreasing order of number were: bay anchovy (Anchoa mitchilli), yellowfin menhaden (Brevoortia smithi), scaled sardine (Harengula jaguana=H. pensacolae), striped anchovy (Anchoa hepsetus), pinfish (Lagodon rhomboides), silver perch (Bairdiella chrysoura), Cuban anchovy (Anchoa cubana), silver jenny (Eucinostomus gula), rough silverside (Membras martinica), and gulf pipefish (Syngnathus scovelli). These ten species comprised 96.8 percent of all fish caught in our study. The engraulids - bay, Cuban, and striped anchovies - comprised 42.8, 7.4, and 1.8 percent respectively and accounted for more than half the total catch of fish (Table 5). The ten most numerous families - Engraulidae (anchovies), Clupeidae (herrings), Sparidae (porgies), Sciaenidae (drums), Gerridae (mojarras), Atherinidae (silversides), Syngnathidae (pipefish), Haemulidae (grunts), Exocoetidae (halfbeaks), and Gobiidae (gobies) - represented 98.7 percent of all fish caught (Fig. 11). The ten most numerous species in collections from each of the three bay systems are given by percentage total fish caught in that system in Table 6.

Some of the most numerous species also accounted for a high proportion of the total weight of the samples. Seven were dominant in both number and weight, but two that dominated the catch numerically - gulf pipefish and Cuban anchovy - constituted less than one percent of the total fish weight of samples (Table 5). The ten species contributing most to sample weight, in decreasing order, were: bay anchovy, silver perch, silver jenny, redfin needlefish (Strongylura notata), pinfish, striped anchovy, yellowfin menhaden, halfbeak (Hyporhamphus unifasciatus), scaled sardine, and Atlantic needlefish (Strongylura marina). These ten species made up 90 percent of the total fish weight of samples. The bay anchovy accounted for the largest proportion of the weight of the samples.

The total weight of collections, by species, is shown in Table 7 for the top ten species in each system and for the rest of the species combined. The total weight of fish collected in the Pumpkin system was almost twice that of the Fakahatchee system and more than one third as great as that of the Faka Union system, but no tests were made to determine whether significant differences in relative biomass occurred among systems.

The surface and otter trawls used in this study were designed to catch pelagic and bottom fish respectively; therefore, to some extent, they sampled different components of the fish community. But, in most instances, the water was so shallow that the water columns swept by the two different gear overlapped. The otter trawl produced more species of fish, while the surface trawl produced a higher number of individuals. Seventhnine percent (67,308) of the total number of fish were caught by surface trawl, while only 21 percent (18,252) were caught with the otter trawl.

Twelve species were captured exclusively with the surface trawl, while 40 were caught with the otter trawl, and 31 were collected with both the surface and otter trawl (Table 8). Of the 10 most common fish species, all except one, the scaled sardine (which was caught only with the surface trawl), were captured with both gears.

The total number of species sampled in Faka Union, Fakahatchee, and Pumpkin systems were 55, 63, and 64 respectively. Fifty-three percent of the taxa were common to all three systems, and 44 species occurred in all systems at one time or another (Fig. 12). Faka Union had fewer species than the other two systems. There were no truly ubiquitous species that were collected from every system on every survey; however the species encountered most often were also among the most numerous fishes in the samples as a whole.

Two species common to the Fakahachee and Faka Union systems were Paralichthys albigutta (gulf flounder) and Trinectes maculatus (hogchoker). Seven species common to the Faka Union and Pumpkin systems were Selene vomer (lookdown), Lutjanus griseus (mangrove snapper), Harengula jaguana, Anchoviella perfasciata (flat anchovy), Ogcocephalus radiatus (polkydot batfish), Prionotus scitulus (leopard searobin), and Etropus crossotus (fringed flounder). The three species common only to the Fakahatchee and Pumpkin systems were Menticirrhus americanus (southern kingfish), Microgobius gulosus (clown goby), and Citharichthys spilopterus (bay whiff). Seven, eight, and 11 fish species were collected exclusively in the Faka Union, Fakahatchee, and Pumpkin systems respectively.

The most numerous species in our collections were also numerous during previous studies in the Faka Union-Fakahatchee area (Clark 1970, Carter et al. 1973, Yokel 1975, and Collins and Finucane 1984). In an intensive study by the Beaufort Laboratory of the National Marine Fisheries Service during summer and fall of the same years as our study (1982 and 1983), Colby et al. (1985) found that bay anchovy, yellowfin menhaden, rough silverside, silver perch, pinfish, silver jenny, pigfish (Orthopristis chrysoptera), spotfin mojarra (Eucinostomus argenteus), and sand seatrout (Cynoscion arenarius) were the ten most numerous species in samples. The scaled sardine was more numerous in our collections and in an earlier study by Carter et al. (1973) than in the Beaufort Laboratory study. The Cuban anchovy and the gulf pipefish were numerous in our study but not in the other two studies. Sand seatrout, pigfish, and silver jenny were found in lesser quantities in our samples than in the Beaufort Laboratory samples.

Most of the fish collected in our study were species that McHugh (1975) categorized as marine species that use the estuary primarily as a nursery ground, usually spawning and spending most of their adult life at sea, but often returning seasonally to the estuary. Most of the abundant species were forage species that, although not commercially or recreationally important, occupy an important ecological niche in the estuary and supply food to commercial and recreational species.

Three highly-prized recreational species - Lane snapper (Lutjanus synagris), sand seatrout (Cynoscion arenarius), and spotted seatrout

(Cynoscion nebulosus) - occurred in our samples, but none in sufficient quantity to qualify as one of the ten most common species nor to allow statistical analysis. The number collected, by system, is shown in Table 9.

Analysis of Fish Data

According to a four-way ANOVA, some of the variation in abundance of each of the 10 major fish species could be explained by one or more of the four factors tested: site (whether bay or pass), season (winter, spring, summer, or fall), type of month with regard to average salinities in Faka Union Bay (low or high), and system (Fakahatchee, Faka Union, or Pumpkin). Season explained variation in the abundance of eight species; and site, system, and salinity-type-month each were significant factors explaining variation in the abundance of five species (Table 10 and Appendix Table E1). Two-way interactions were also significant explaining factors for variation in the abundance of several species. Significant two-way interactions between system and each of the other three factors suggested that site, season, or type of salinity-month influenced the way that the abundance of several species varied among systems (Table 10 and Appendix Table E1).

One-way ANOVAs on separate data sets for bay and pass stations indicated that the abundance of each of seven fish species differed significantly among systems in the bays but not in the passes (Table 11). Duncan multiple range tests indicated that five of the 10 species were significantly more abundant in Pumpkin Bay than in Faka Union Bay and four of the 10 species were significantly more abundant in Pumpkin Bay than in Fakahatchee Bay (Table 11). The arithmetic means are shown in Table 11 and all of the other tables of statistical results, whereas the analyses were conducted on log-transformed data. This is why, in the case of the yellowfin menhaden, abundance in Faka Union Bay, with the lowest arithmetic mean, does not differ significantly from that in Fakahatchee Bay, which has the highest arithmetic mean, but does differ significantly from that in Pumpkin Bay, with an arithmetic mean that lies between the other two. A similar situation occurs with the striped anchovy in Table 11 and in other cases on other statistical tables. Patchy distributions and a number of zeros in the data base can cause the mean of the log-transformed data, which is similar to the geometric mean, to differ considerably from the arithmetic mean. The order of the means can change when distributions are more patchy in some bays than others.

One-way ANOVAs indicated that yellowfin menhaden and the Cuban anchovy were most abundant in the spring, whereas the striped anchovy, bay anchovy, and rough silverside were most abundant in the summer. Pinfish were equally abundant in spring and summer, and silver jennies were equally abundant in summer and fall (Table 12).

The data were further separated by season, and one-way ANOVAs were run to determine whether species differed significantly among systems (within bays or passes) within seasons (Table 13). Significant differences among systems were found for eight species in one season or another. Summer was the season in which significant differences in abundance among systems were found for the most fish species, but almost as many differed among systems in the spring. Most of the species that differed among systems during the summer differed in other seasons also. Significant differences in the abundance of the bay anchovy among bays were found in all four seasons. In almost all cases, abundances were significantly higher in Pumpkin Bay than in one or both of the other bays.

An alternative separation of the data into that for low and that for high-salinity months (ignoring season) decreased the number of species for which significant differences in abundance were found among systems. Probably this separation, because it cut across seasons, increased, rather than decreased, within-system variance, making among-system variance more difficult to detect.

Table 14 summaries results of analysis of two subsets of data from our study--that from the "wet" dry season (Jan-Apr) of 1983 and the "normal" dry season of 1984. Abundances of several species differed significantly between years. Two species - yellowfin menhaden and pinfish - differed significantly among systems in one or both years. Menhaden was more abundant in Fakahatchee Bay (in 1983 only), and pinfish was more abundant in Pumpkin Bay (in both 1983 and 1984). Both the menhaden and pinfish were more abundant in 1983 than in 1984. Abundances differed between years for more species in Faka Union Pass than in any other area. For all but one species - rough silversides - abundances were greater in Faka Union Pass in 1983 than in 1984.

ICHTHYOPLANKTON

Ichthyoplankton was another major group sampled during this study. An analysis of variation in concentrations of the eight major families will follow a description of the ichthyoplankton collections.

Description of Ichthyoplankton Collections

Fifty taxa of ichthyoplankton (planktonic larval-postlarval fish) were identified from collections made during the study (Table 15). These included 21 families, 30 genera, and 30 species. The majority were found in all three systems and both in the bays and in the passes. These included the clupeids (herrings), engraulids (anchovies), sciaenids (drums), gobiids (gobies), blenniids (blennies), soleids (soles), syngnathids (pipefish), skilletfish *Gobiesox strumosus*), rough silversides, and pinfish. A few were found only in one area. The rainbow runner (*Elagatis bipinnulata*), spotfish mojarra, and Atlantic croaker (*Micropogonias undulatus*) were found only in Fakahatchee Bay. The pigfish was found exclusively in Faka Union Bay. The speckled worm eel (*Myrophis punctatus*) was found only in Pumpkin Bay, and the southern kingfish (*Menticirrhus americanus*) was collected only from Dismal Key Pass (the pass to Pumpkin Bay). More species were found in the bays than in the passes. Out of the 50 taxa, 18 were found exclusively in the bays while just two occurred only in the passes. The number in each taxa collected is given in Table 15. In Table 15, numbers for higher taxonomic levels (i.e., family or genera) include only individuals that could not be identified at a lower taxonomic level (i.e, genera or species), so family numbers are not complete.

A total of 7,588 larval fish were collected during the study. Ninety-three percent of these, or 7,068, were in the eight most numerous families. Best represented was the Engraulidae, representing 35 percent of the total ichthyoplankton in samples. The bay anchovy was the species most common in the portion of the collection of engraulids identified to species level. Gobies and blennies made up 21 and 15 percent of the total larvae respectively. Gobiosoma was the only genus identified. In descending order of number, the other most numerous families were: clingfishes (Gobiesocidae) (6.6 percent), herrings (6.4 percent), porgies (Sparidae) (4.4 percent), drums (2.6 percent), and silversides (Atherinidae) (2.4 percent). All clingfish identified to species level were skilletfish. The herrings included both menhaden and the scaled sardine, although the majority could only be identified as clupeids. Most of the porgies were pinfish; only four sheepshead (Archosargus probatocephalis) were caught. Drums included ten species, but the majority were too young to be identified below family level. Unidentified ichthyoplankton made up 4.7 percent of the total ichthyoplankton collected and consisted of larvae still in the yolk-sac stage and damaged specimens.

Of the 50 taxa collected as ichthyoplankton, 40 were also found in our collections of larger fish from the surface and otter trawls. Those not collected in older stages included the speckled worm eel, the skilletfish, the lined seahorse (Hippocampus erectus) (though a related species, the dwarf seahorse, H. zosterae, was collected in the trawls), the bar jack (Caranx ruber), the rainbow runner, the white grunt (Haemulon plumieri), the black drum (Pogonias cromis), the star drum (Stellifer lanceolatus), and the northern kingfish (Menticirrhis saxatilis). Three of the eight most numerous families - clingfishes, blennies, and gobies - were not represented by any of the ten most numerous species in trawl samples. On the other hand, three families of major fish species in the trawl samples were not among the top eight ichthyoplankton families. Missing were the silversides, pipefish, and mojarras.

Ichthyoplankton as small as 1.2 mm in total length were collected. For most of the major families, the average size of larvae in the bays was greater than that in the passes (Appendix Table D1).

The ichthyoplankton found in estuaries result from spawning both within the estuary and outside it. For many estuarine-dependent species, spawning occurs offshore, but is followed by the movement of larvae or postlarvae into estuaries, their nursery grounds. Other species are thought to spawn within the estuaries. Appendix Table D2 summarizes known information regarding the general spawning sites of species in the ichthyoplankton collections. The recognized economic importance of these species is also indicated.

Analysis of Ichthyoplankton Data

In four-way-ANOVAs, season was a significant factor explaining variation in concentrations of all eight ichthyoplankton families tested (Table 16 and Appendix Table E2). Site (bay or pass) and type of month in terms of salinity (low or high) explained variation in concentrations in four families. System (Faka Union, Fakahatchee, or Pumpkin) explained variation in only three families - the gobies, clingfishes, and blennies. The two-way interaction between season and type of salinity-month was a significant variable explaining abundance in seven families. The significance of the interaction between season and type of salinity-month suggests that ichthyoplankton may have been distributed differently relative to salinity in the different seasons.

One-way analysis of variance of data split into that for bays and that for passes indicated that concentrations of four families differed significantly among systems in the bays, whereas that of only two families differed significantly among systems in the passes (Table 17). Ichthyoplankton were so patchily distributed that the log-transformed means (approximately equal to the geometric means) for each system, which were compared in statistical analysis, ranked differently relative to each other than the arithmetic means reported in Table 17. Because of this, the LSD-mod analysis indicated that goby and blenny concentrations in Fakahatchee Bay were significantly higher than those in Faka Union Bay, even though the arithmetic (nontransformed) means were higher in Faka Union Bay than in Fakahatchee Bay.

All families of ichthyoplankton were found in significantly higher concentrations in the spring (March-May) than in most or all of the other months. Clingfishes and herrings were found in equally high concentrations in the winter (Dec.-Feb.) (Table 18).

The data were further separated by season, and one-way ANOVAs of the separated data sets indicated significant differences among systems in one or more season for six of the eight families (Table 19). Differences among systems were seen during only one season in five of the six families. Concentrations of three families - gobies, clingfishes, and drums - differed significantly among bays during the winter. That of the other three - anchovies, blennies, and silversides - differed among systems during the summer. Differences were also seen in silversides during the spring. By and large, concentrations were significantly greater in Fakahatchee Bay and Pass than in one or both of the other systems.

Separation of the data by low-salinity and high-salinity months, rather than by season, decreased the number of species for which significant differences among systems could be detected - probably for the same reason discussed in the fish analysis section.

Results of the ichthyoplankton analyses are counter to those of the fish analyses, which indicated that fish concentrations were greatest in Pumpkin Bay. However, three of the ichthyoplankton families that differed significantly among systems were not represented by the fish species tested in the other analyses, and three families of species in the fish analysis were not covered by the ichthyoplankton analysis.

Ichthyoplankton concentrations were compared during two dry seasons (January-April) of markedly different rainfall and runoff, the "wet" 1983 and the "dry" 1984 (Table 20). In general, concentrations were significantly higher in 1984 than in 1983 in all systems (the only exception was porgies in Fakahatchee Bay, which were found in higher concentrations in 1983). Four families differed significantly in concentration among systems during one or the other or both of the two years. In all but two instances where significant differences in concentrations among systems were found, they were highest in the Fakahatchee system. This is counter to results for larger fish, in which abundances were greatest in the Pumpkin system in four out of five instances where significant differences among systems were found.

MACROINVERTEBRATES

Macroinvertebrates were the third group of organisms examined in this study. First we will describe the collections and then the results of a comparison of abundance among systems.

Description of Macroinvertebrate Collections

About 25,000 macroinvertebrates representing 70 taxa were identified. As is typical in estuarine systems (Carriker 1967), the majority were decapod crustaceans belonging to a relatively few species. In descending order of abundance, the six dominant species were: grass shrimp (primarily *Palaemonetes intermedius*, but a few individuals of other genera are included in this group) (51 percent), pink shrimp (*Penaeus duorarum*) (20 percent), mud crab (*Neopanope texana*) (11 percent), hermit crab (*Pagurus bonairensis*) (9 percent), arrow shrimp (*Tozeuma carolinense*) (5 percent), and blue crab (*Callinectes sapidus*) (2 percent). These six decapod crustacean species made up 98 percent of the total number of macroinvertebrates in collections. In the remaining 2 percent, *Libinia dubia* (a spider crab), *Bursatella leachii pleii* (the ragged sea-hare), *Alpheus* spp. (snapping shrimp), *Lolliguncula brevis* (a squid), and *Limulus polyphemus* (a horseshoe crab) were predominant (Table 21). Due to collection methods, common sessile or sedentary estuarine groups such as worms and molluscs were not well represented in our collections, but all the taxa collected are shown in Table 21.

Pink shrimp and blue crab are important commercial and recreational fishery species. Grass shrimp, pink shrimp, and mud crab are important in estuarine food chains as they are major dietary items for many sport and commercial fish as well as for the blue crab (Carter et al. 1973). Blue crab fishermen were seen working their traps in the three bays throughout the study period.

We compared the Carter et al. (1973) and Evink (1975) data with our collections from Faka Union and Fakahatchee Bays and ranked the abundances of the eight decapods in the three studies (Table 22). Grass shrimp was the most abundant species both in Evink's study and ours, but the hermit crab was ranked number one by Carter et al. Carter et al. ranked pink shrimp in second place, as did we. But Alpheus spp. was more abundant in Evink's collections; pink shrimp was third. The mud crab was third most abundant in our collections, fourth most abundant in Evink's collections, and fifth in abundance in Carter et al.'s collections. Blue crab was fifth in our study and Evink's but seventh in Carter et al.'s.

Analysis of Macroinvertebrate Data

Four-way analysis of variance indicated that site (bay or pass), season (winter, spring, summer, or fall), type of month with respect to salinity (low or high), and system (Faka Union, Fakahatchee, or Pumpkin) all were significant factors in explaining variation in abundance of three or more of the six most numerous macroinvertebrate species (Table 23 and Appendix Table E3). Site and season each were significant explaining factors for five species, and system and type of month with respect to salinity were significant explaining factors for three species. All four factors were significant in explaining variation in the abundance of pink shrimp and the hermit crab. Grass shrimp abundance varied by site and by season. Arrow shrimp varied only by site. Blue crab abundance varied by season and by type of month with respect to salinity. Mud crab abundance varied by site, season, and system.

Two-way interactions between site and system and season and salinity-month were significant factors explaining variation in abundance of all six species. The importance of these two two-way interactions suggests that (1) abundance varied differently among systems, depending on whether the site was bay or pass, and (2) abundance varied differently by type of salinity-month, depending upon season.

The mean number per station visit for each species is given separately for bay and pass in Table 24, which also shows results of one-way analysis of variance and Duncan multiple range tests. Pink shrimp were significantly more abundant in the bays than in the passes; but this was only true because of their extremely high abundance in Pumpkin Bay relative to anywhere else. Grass shrimp, arrow shrimp, hermit crabs, and mud crabs were more abundant in the passes than in the bays.

Abundance differed significantly among systems for all six species in the bays but for only three species in the passes. Relative abundance among systems differed at the two sites. In the bays, abundances of all six species were highest in Pumpkin Bay. For four out of six species, they were significantly higher in Pumpkin Bay than in Faka Union Bay. For the other two species they were significantly higher in Pumpkin Bay than in Fakahatchee Bay. On the other hand, in the passes, abundances of three species were significantly lower in Pumpkin than in one or the other or both of the other two systems.

Pink shrimp were approximately 15 times more abundant in summer than in winter or spring and approximately three times more abundant in summer than in fall. Summer was also the period of greatest abundance for the mud crab, but this species varied less over the seasons than did pink shrimp (Table 25).

The data were further separated by season, and additional one-way ANOVA and Duncan multiple range tests were run to test variation among systems (separate for bay and pass) within each of the four seasons (Table 26). Significant differences among systems were seen for more species during the spring in the bays and during the winter in the passes. With the exception of pink shrimp in the winter, species that differed significantly among bays were more abundant in Pumpkin Bay in all seasons.

During the winter, four species of macroinvertebrates were significantly less abundant in the pass to Pumpkin Bay than in that to one or both of the other two bays. Since the winter season of the two study years included both low-salinity and high-salinity months, we further separated the winter data by type of month with respect to salinity to determine whether the higher abundances in the other two bays occurred during the high-salinity months. The frequency of occurrence of organisms in samples from low-salinity months was too sparse to allow analysis. Analysis of the data for the high-salinity months confirmed that the significant difference in abundance among passes noted in the larger data set occurred during these months.

The abundance of pink shrimp in Pumpkin Bay did not differ significantly from that in the other two bays in the winter (abundances of pink shrimp were significantly higher in Faka Union Bay than in Fakahatchee Bay, however). When the winter data were further separated into that for low-salinity and that for high-salinity months (there were two low-salinity and four high-salinity winter months), we found that pink shrimp abundance was significantly higher in Pumpkin Bay than in Fakahatchee Bay during the high-salinity winter months, but the frequency of pink shrimp in samples for low-salinity winter months was too low to allow analysis. During the summer, its season of greatest abundance, pink shrimp was significantly more abundant in Pumpkin Bay than in either Fakahatchee or Faka Union Bay. It was significantly more abundant in Faka Union Bay than in Fakahatchee Bay during this season.

Separation of the entire data set by type of month with respect to salinity (ignoring season) did not improve our ability to distinguish differences in abundance among bays. Four out of the six species differed significantly in abundance among bays during low-salinity months, and five of the six species differed significantly in abundance among bays during high-salinity months. In all cases, abundances were higher in Pumpkin Bay than in one or both of the other two bays.

A comparison of macroinvertebrate abundances in two different dry seasons, the "wet" 1983 and the "dry" 1984 (Table 27) indicated that all six species were more abundant in 1983 than in 1984 in one or more of the three bays and in Faka Union Pass (but not Fakahatchee Pass or the pass to Pumpkin Bay). In most cases where significant differences among bays were found, abundances were greatest in Pumpkin Bay. Thus overall abundance was greatest in the relatively low-salinity year - but greatest in the high-salinity bay, even in the relatively high-salinity year.

SUMMARY AND CONCLUSIONS

We compared biological abundances in three adjacent estuarine systems: Faka Union, Fakahatchee, and Pumpkin. Faka Union Bay receives the discharge from the Golden Gate Estates canal system through the Faka Union Canal. Fakahatchee Bay is connected to Faka Union Bay, and the distribution of salinities in Fakahatchee Bay relative to this connection indicated that this bay, also, is influenced by canal effluent. Salinities in Pumpkin Bay indicated that it is less affected by the canal. Means and standard deviations of salinities in passes to the three bays suggested that they are less influenced by the canal than two of the bays.

Ten fish species, eight ichthyoplankton families, and six macroinvertebrate species dominated the samples (Table 28). In statistical analyses of these taxa, we found that abundances varied seasonally and by location (bay or pass) as well as by system. Whether the month of collection was a high-salinity or a low-salinity month also seemed to make a difference in the abundance of some taxa. Several major ichthyoplankton families were more concentrated in the passes, whereas most major species of older fish were more abundant in the bays. Most of the macroinvertebrate species were more abundant in the passes, but blue crabs were more abundant in the bays. Pink shrimp were more abundant in the passes than in Faka Union or Fakahatchee Bay, but abundances in in Pumpkin Bay did not differ from those in the passes.

Spring was the season of peak concentrations of all ichthyoplankton families. Fish were most abundant in spring (3 species), summer (4 species), or fall (1 species). Macroinvertebrate abundances reached a maximum in winter (1 species), winter-spring (1 species), or summer (2 species). The greatest seasonal difference was seen in pink shrimp, which was much more abundant in the summer than at any other time of the year.

When the data were separated into that for the bay and that for the pass, differences in abundance among systems were seen for more taxa in the bays than in the passes. This was particularly true for fish but also true for ichthyoplankton and macroinvertebrates (Table 29).

By separating the data by season as well as by location (bay or pass), we were able to distinguish differences in abundance among systems for eight out of 10 fish species, five out of eight ichthyoplankton families, and all six macroinvertebrate species (Table 30). We found that more fish species differed among systems during the summer than in any other season (spring was a close second), whereas more macroinvertebrate species differed among systems in the spring. Winter and summer were the seasons when the most ichthyoplankton families differed among systems. Overall, more taxa differed among systems in spring and summer in the bays and in fall and winter in the passes (Table 30). Fish species for which significant differences among bays were found during spring, summer, and fall were significantly more abundant in Pumpkin Bay than in one or both of the other two bays. The two fish species that differed significantly among bays in the winter were most abundant in Faka Union Bay. Significant differences among systems were found less frequently for ichthyoplankton families than for fish species. The relative concentrations of ichthyoplankton families among systems differed considerably from the relative abundances of fish species. In most instances where significant differences among systems were found, Fakahatchee Bay had higher concentrations of ichthyoplankton than one or both of the other two systems.

Significant differences in macroinvertebrate abundances among systems were found mainly in the bays in the spring, summer, and fall - but mainly in the passes during the winter. Macroinvertebrate abundances were significantly greater in Pumpkin Bay than in one or both of the other two bays in the spring, summer, and fall. Winter abundances in the passes were lowest in the Pumpkin system. By separating the winter data into that for low and that for high-salinity months, we found that the significant differences in macroinvertebrate abundances among passes occurred during high-salinity winter months.

Differences in biological abundance among systems might reflect the impact of the canal on both Faka Union and Fakahatchee Bay, or they might reflect other, less obvious differences among the three systems. The fact that we see differences in abundance among systems for more species in the bays than in the passes (Table 28) suggests that the differences are related to the canal, because, according to our salinity measurements, Faka Union and Fakahatchee Bays were more affected by canal discharges than their passes.

Effects due to the canal could be of two types - (1) those that are felt primarily during times of high discharge and (2) those that are felt throughout the year. Into the first category fit mechanical effects of the current (physical damage during vulnerable life stages); effects of the distribution of salinities (provision of habitat within the physiological tolerance range of a species and outside of the physiological tolerance range of its predators); and effects of exchange rates between the bays and the Gulf of Mexico (larval transport rates). Effects related to changes in bottom substrate, bottom vegetation cover, or other such aspects of habitat are representative of the second type of effects. The fact that significant differences among systems were indicated not only in the summer and fall, seasons of relatively high discharges, but also in the spring, a season of relatively low discharges, is evidence for the second type of effects - prolonged effects - possibly fundamental habitat changes. Our results do not exclude the possibility that effects of the first type - immediate effects - may also be occurring.

The reversal of the ranking of the systems in order of the abundance of some macroinvertebrate species in the passes during the winter suggests that canal discharges may have some beneficial effect during this time. Canal discharges and other freshwater inputs are generally much lower during the winter than during the summer or fall, and salinities in the passes approach that of oceanic waters. Canal discharges may help to maintain salinities that are more favorable to the survival of estuarine organisms in the passes during that time. Overall abundances of most of the major taxa were lower in the winter than in other seasons. Grass shrimp was the only species that reached peak abundances in the winter and was more abundant in the passes than in the bays.

Our comparison of abundances in the three systems during the same months of two different years - one that was abnormally wet and the other that, by contrast, was dry - indicated that abundances of a number of taxa were highest in Pumpkin Bay in both the dry year and the wet year.

Although, in most cases, abundances in Faka Union and Fakahatchee Bays did not differ significantly, for a few species - notably pink shrimp - abundances were significantly higher in Faka Union Bay than in Fakahatchee Bay. In Carter et al.'s (1973) comparison of these two bays shortly after completion of the canal system, abundances were greater in Fakahatchee Bay. Our results suggest that changes have occurred since that time that make Fakahatchee Bay less supportive of some species than Faka Union Bay. Our salinity measurements indicate that, in comparison to Faka Union and Pumpkin Bay, Fakahatchee Bay is intermediate in conditions influenced by the canal. Perhaps several interacting effects can cause an intermediate situation to be less optimal for some species than either extreme.

There are several possible reasons for the differences in relative abundances (or concentrations) among systems for fish and ichthyoplankton, which are actually two life stages of the same organisms. First of all, not all of the same organisms are involved; the taxa represented by fish species and ichthyoplankton families in the analyses were not entirely overlapping. Three families of ichthyoplankton were not represented by major species in the fish samples; and major ichthyoplankton families did not include the families of several major fish species (Table 30). The three major families of ichthyoplankton that were poorly represented among the fish in trawl samples - gobies, clingfishes, and combtooth blennies - may have habits or microhabitats that make them relatively inaccessible to either surface or bottom trawls. In a study in Everglades National Park, Florida, Thayer et al. (in press) found much higher densities of the clingfish, Gobiesox strumosus, and several species of gobies in mangrove prop-root habitat than in nearby trawlable waters.

Another possible reason for the difference in relative abundance among systems for the two different life stages represented by ichthyoplankton and fish samples is that relative transport rates into the three systems may favor higher concentrations of ichthyoplankton in Fakahatchee and Faka Union Bays, whereas relative survival rates may be greater in Pumpkin Bay.

Several prior studies on marine resources have been conducted in the general area (Carter et al. 1973, Lindall et al. 1974, Evink 1975, and Collins and Finucane 1984). That of Carter et al. (1973) was specifically oriented at evaluating the effect of the canal system, which had been completed just a few years before (1969). The Carter et al. study indicated that man-made alterations of Faka Union Bay were reflected in changes in fish communities: "A greater abundance and diversity of fishes inhabited Fakahatchee Bay, an essentially undisturbed estuary, than Faka Union Bay, a man-influenced environment" (p. 11-4). Our results differ from that of Carter et al. in that abundances were seldom significantly greater in Fakahatchee Bay than in Faka Union Bay. Our results indicated that most species we compared were significantly more abundant in Pumpkin Bay than in Faka Union Bay, and, in a number of cases, than in Fakahatchee Bay.

ACKNOWLEDGMENTS

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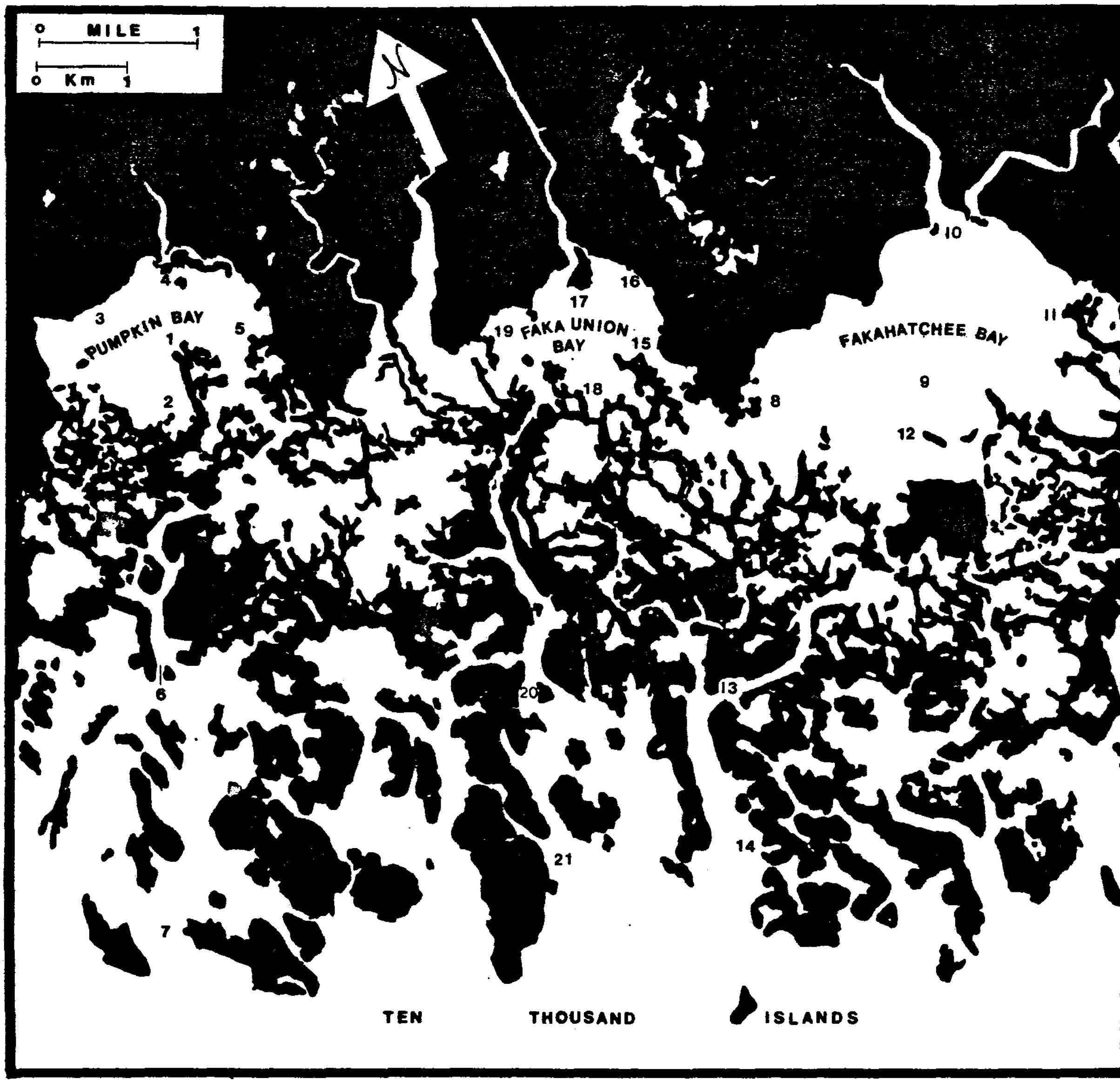


Figure 1. Study area, with the 21 sampling locations indicated.

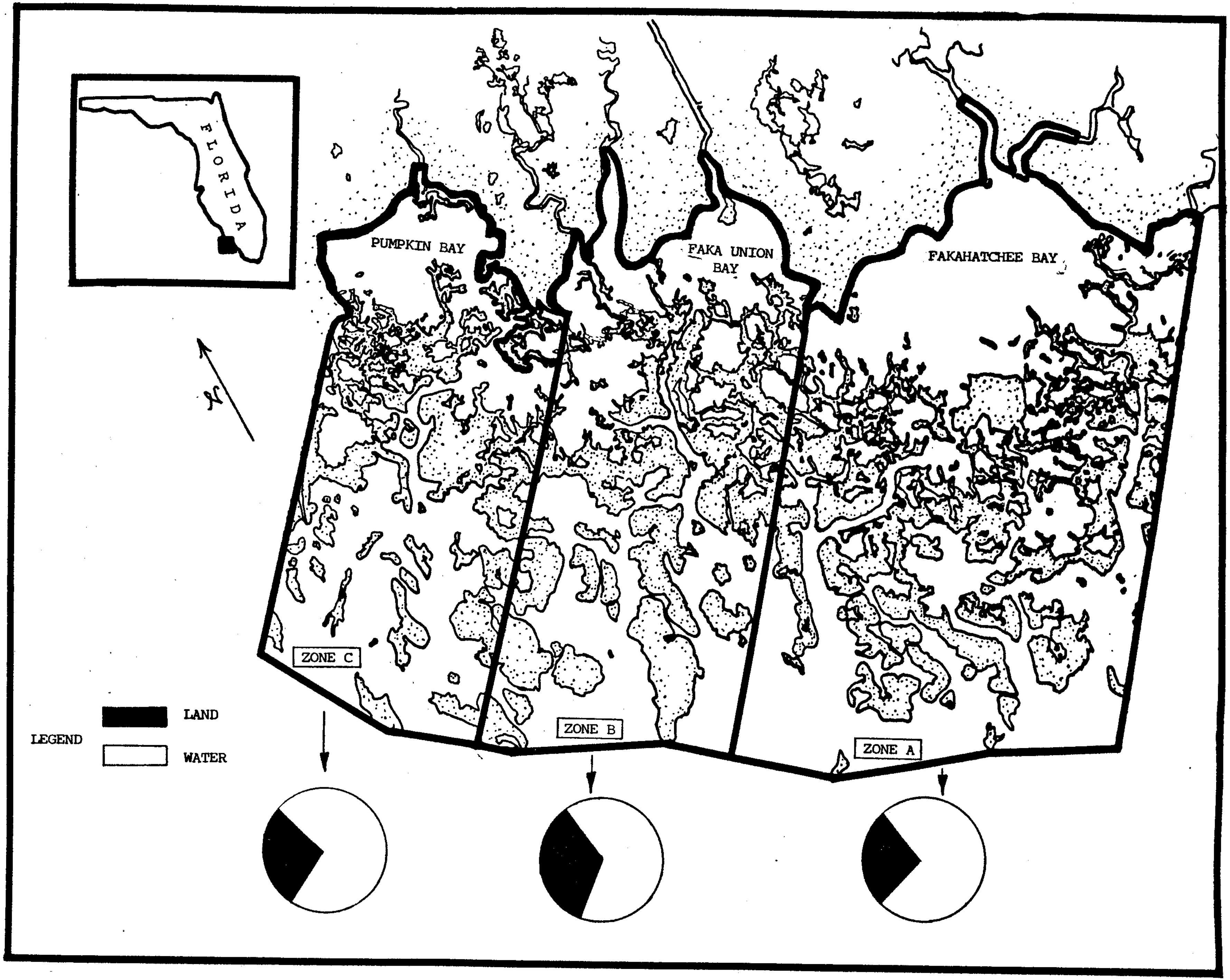


Figure 2. Assumed boundaries used for calculating land and water area of the three bay systems.

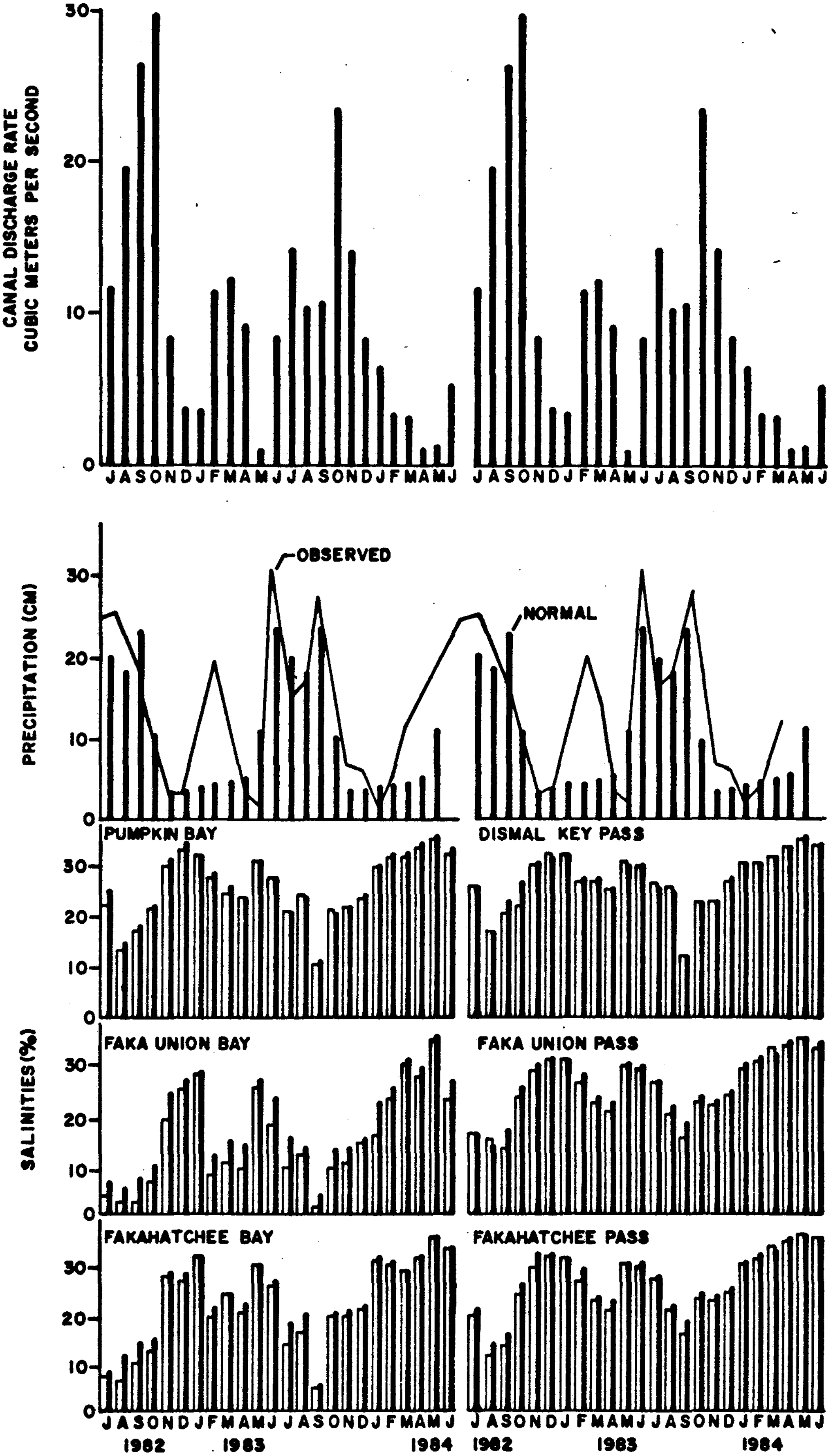


Figure 3. Average Faka Union Canal discharge rate and total precipitation each month and spatially-averaged salinity measurements in the indicated areas during the monthly sampling visit. (Bars for precipitation are averages of three stations - Everglades City, Ft. Myers, and Naples - for each month from July, 1982, through June, 1984. Points connected by lines represent the 34-yr average for each month of the year at Everglades City.)

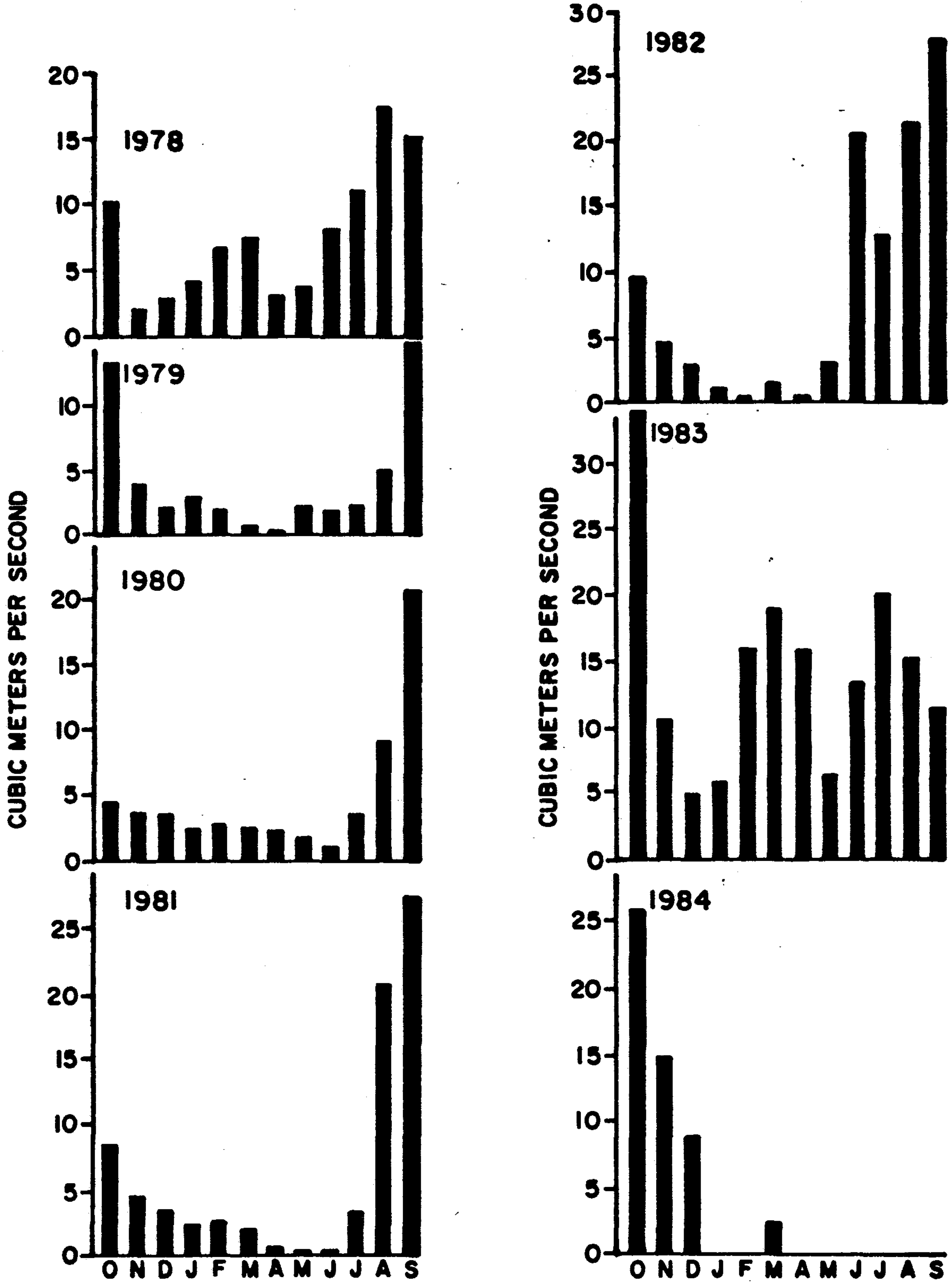


Figure 4. Approximate average discharge rates of the Faka Union Canal into Faka Union Bay, by month, for the water years 1978 through 1984.

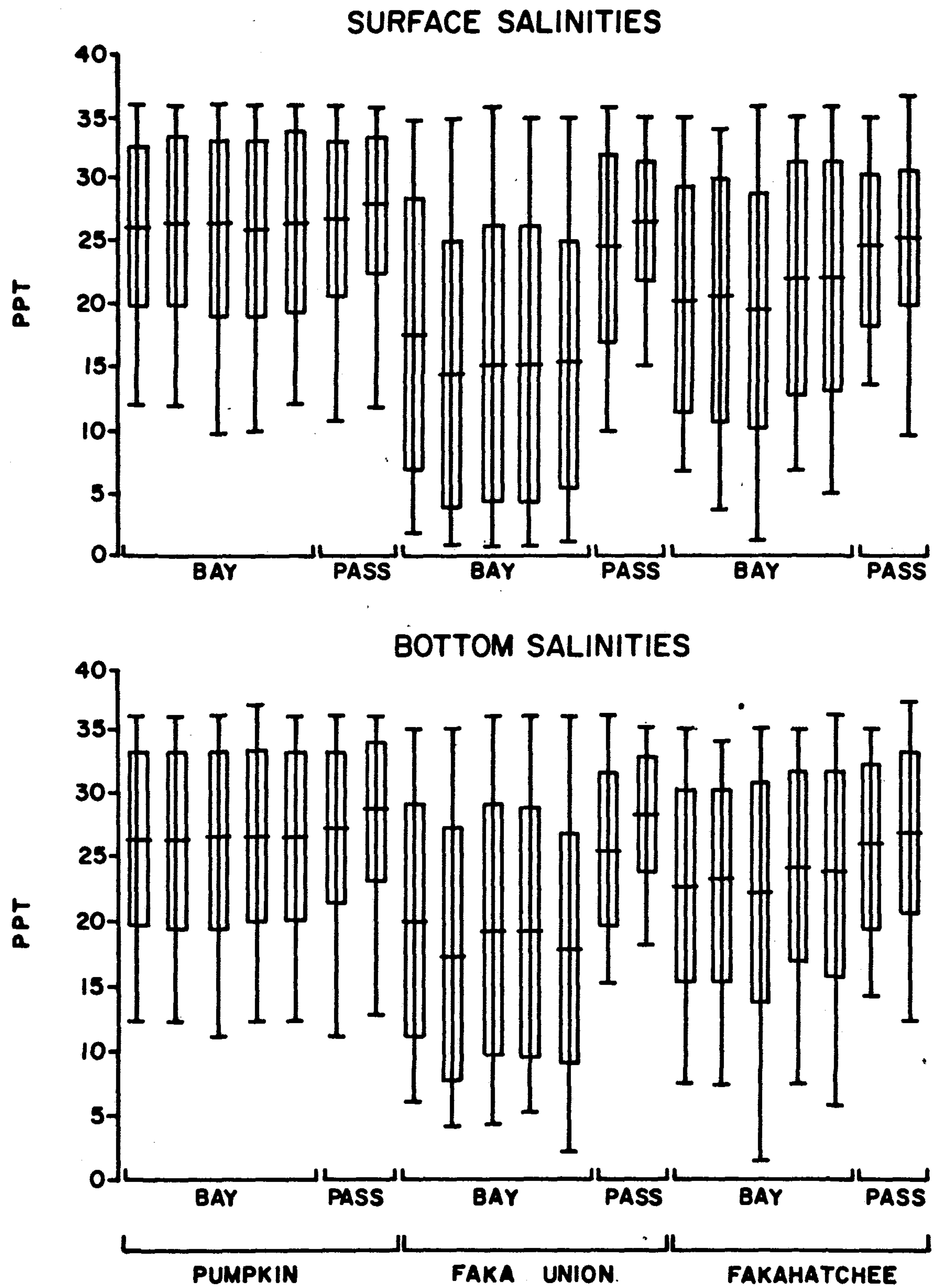


Figure 5. Range, mean, and standard error of the mean in salinities during the 2-yr study period (July 1982 - June 1984) at each of the 21 sampling locations, grouped by system and zone (bay or pass).

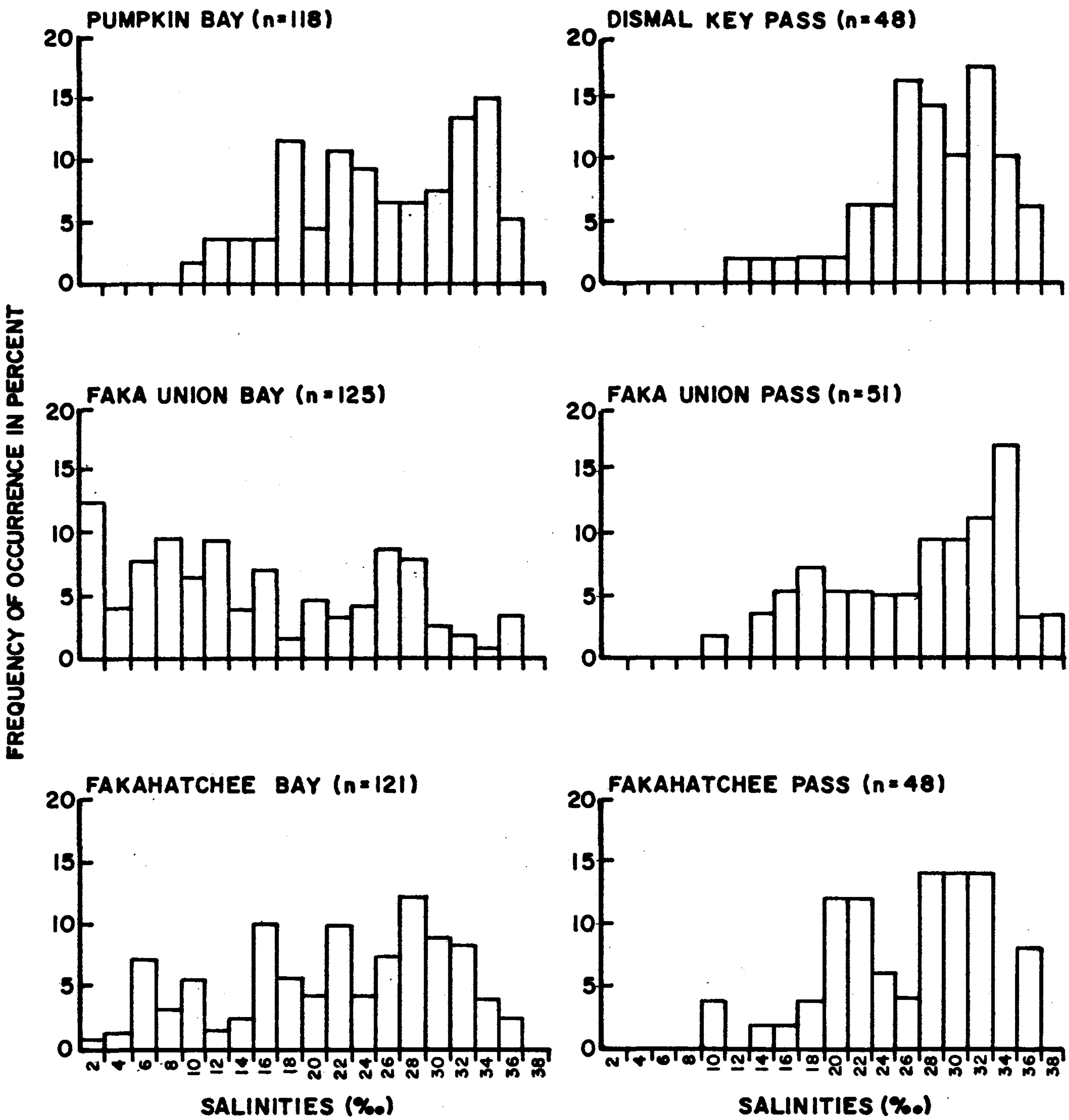


Figure 6. Surface salinities, by frequency of occurrence in monthly measurements, in each of the systems and zones, July, 1982, through June, 1984.

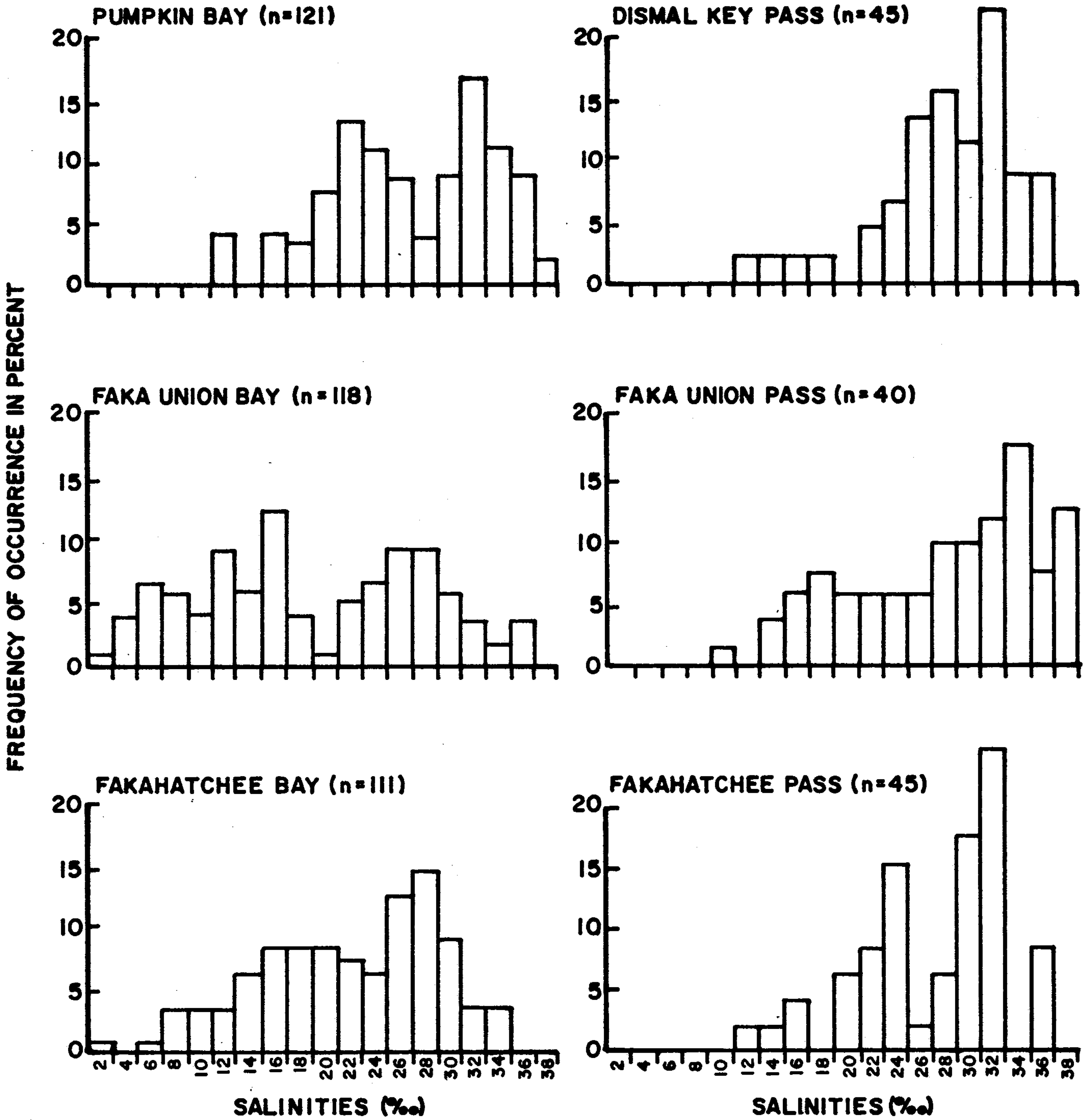


Figure 7. Bottom salinities, by frequency of occurrence in monthly measurements, in each of the systems and zones, July, 1982, through June, 1984.

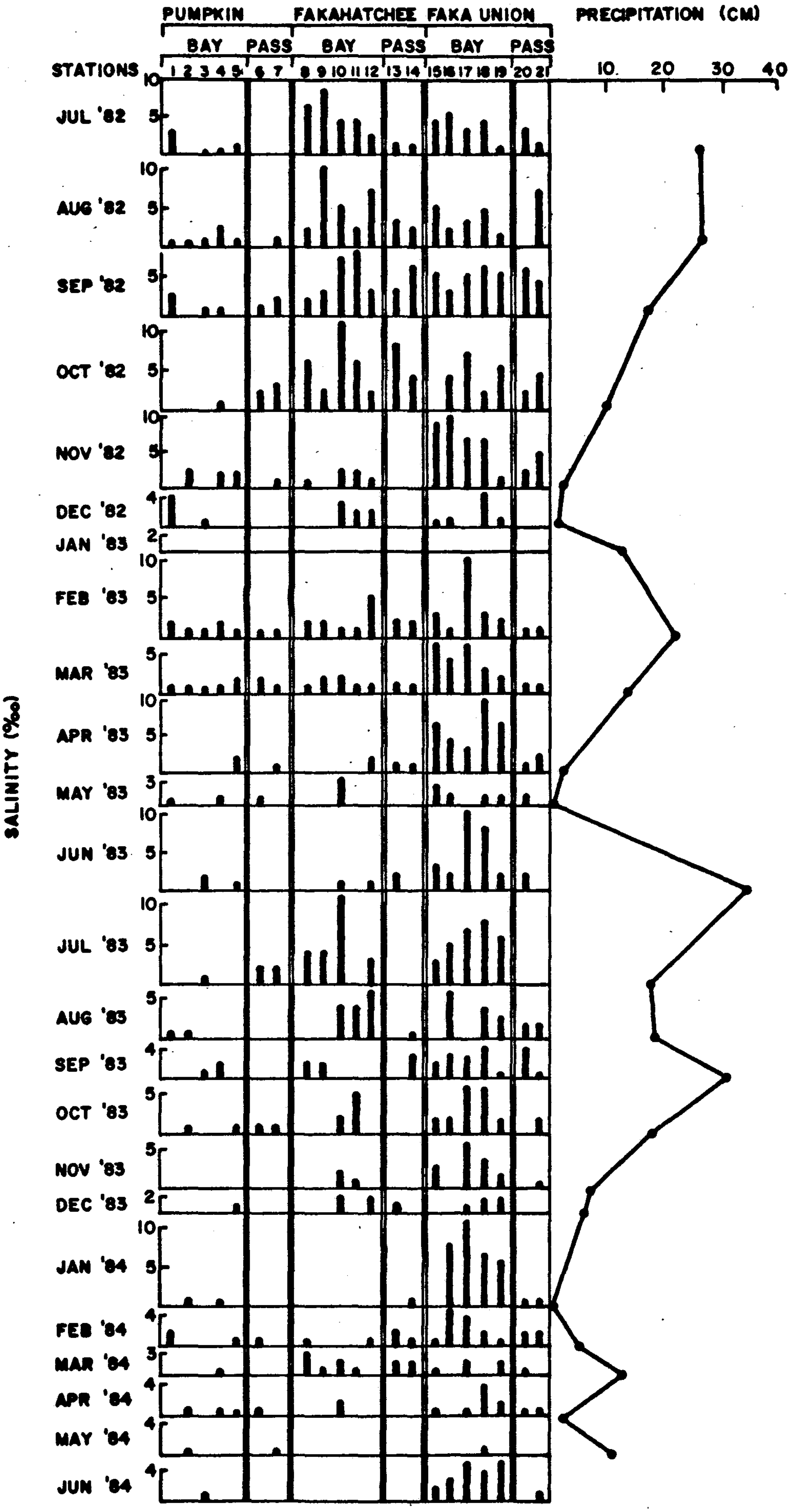


Figure 8. Difference between surface and bottom salinities, by sampling location and month of sampling (bars), and monthly precipitation (points connected by line), averaged for Everglades City, Naples, and Ft. Myers.

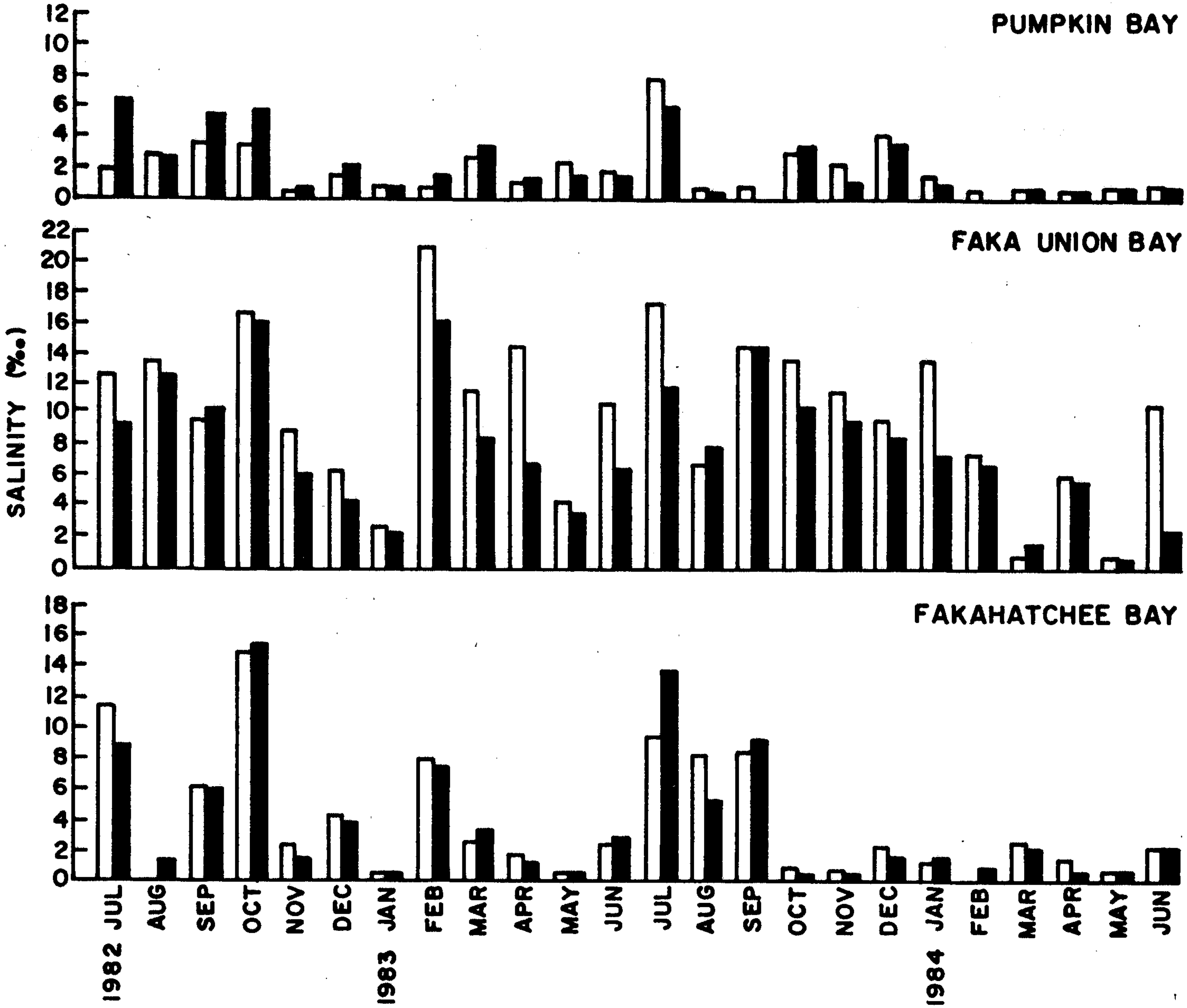


Figure 9. Difference between bay (average of five locations) and pass (average of two locations) salinities at surface and on bottom on each monthly sampling visit, July, 1982, through June, 1984, in each of the three systems.

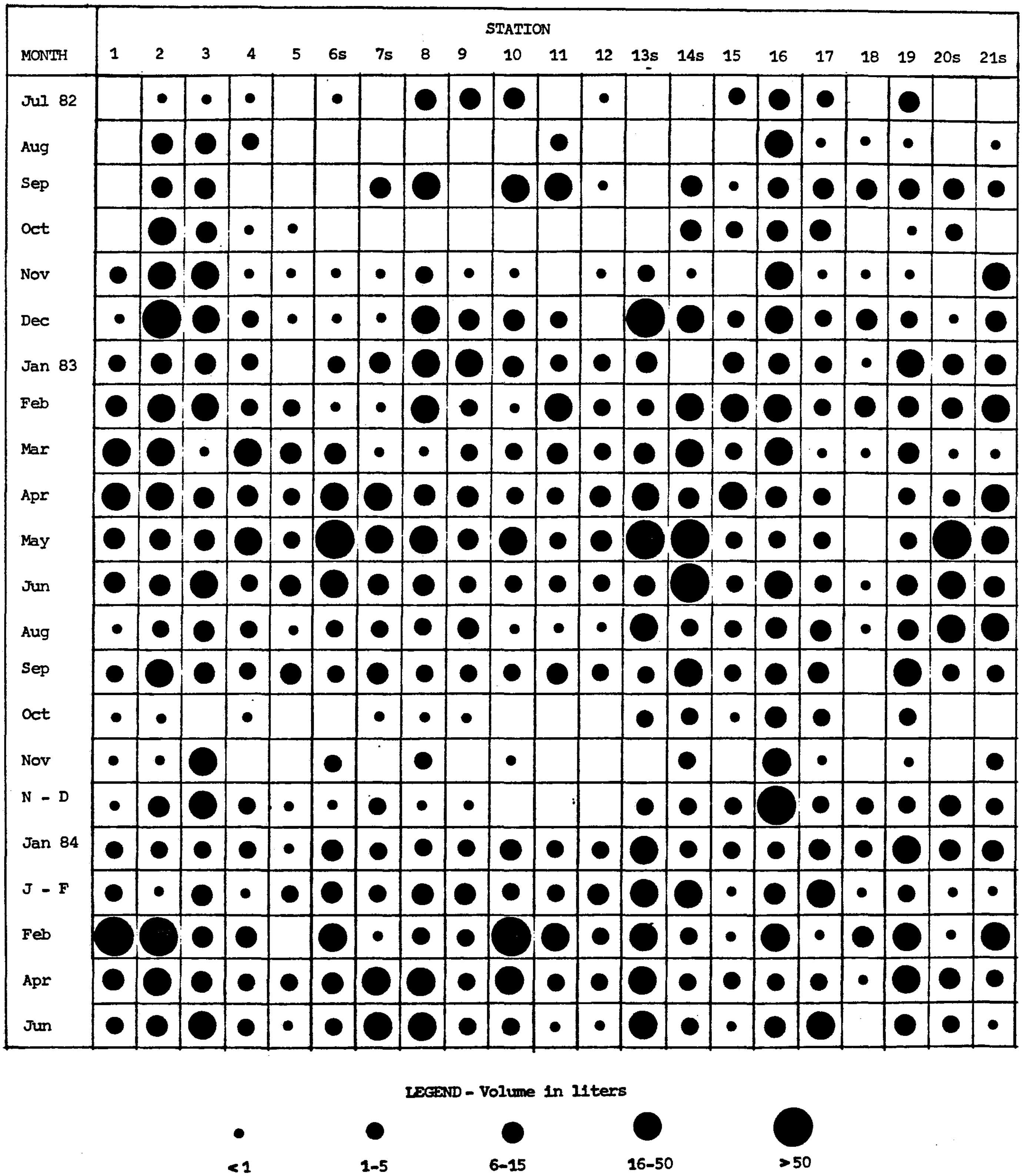


Figure 10. Relative volume of benthic vegetation in hauls of the otter trawl, by sampling location and month.

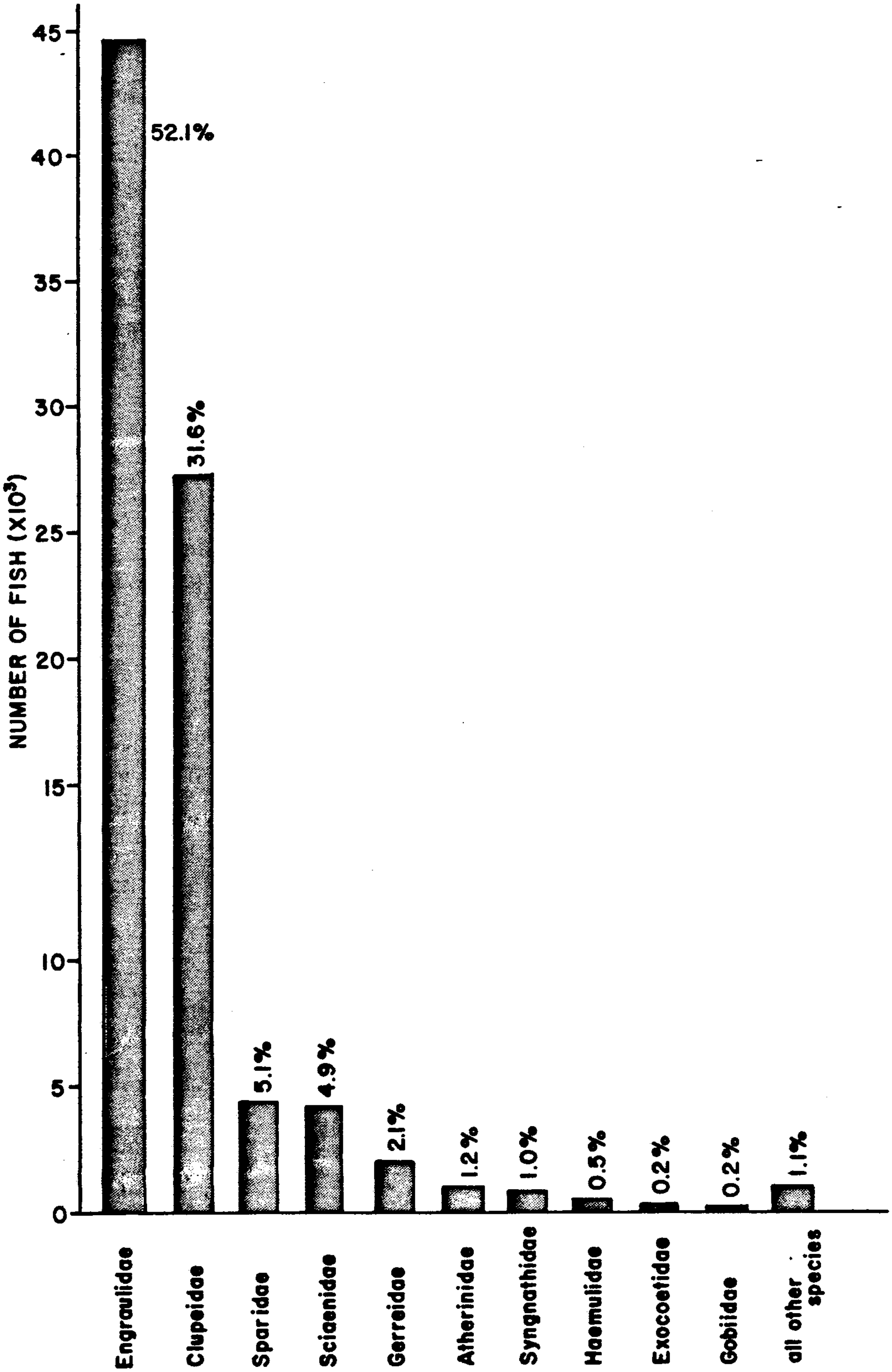


Figure 11. The ten most numerous families of fish in collections, by percent of total individuals caught.

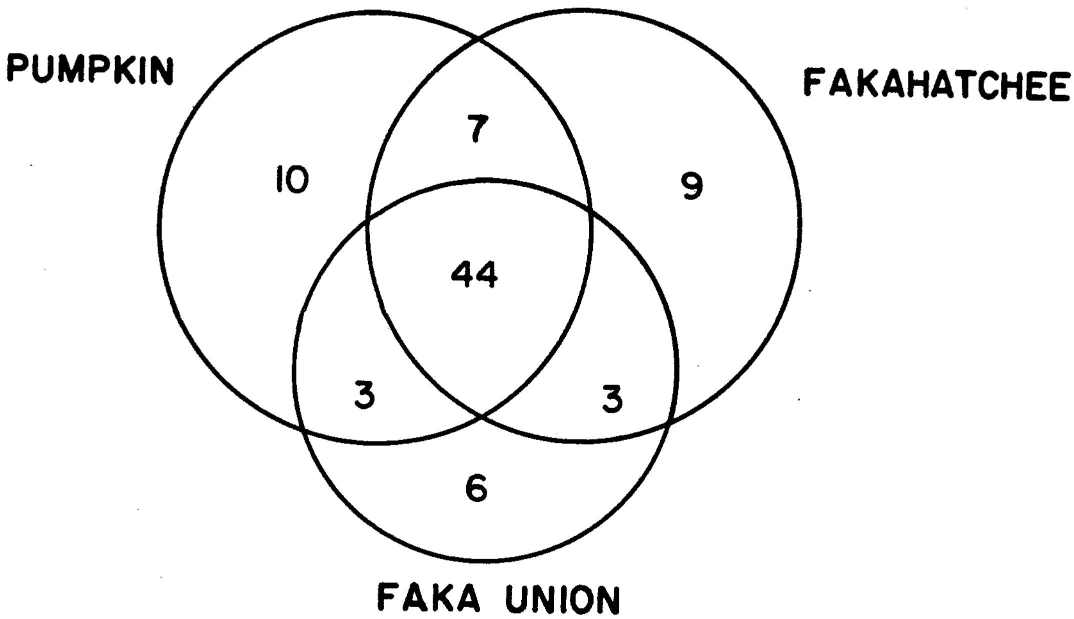


Figure 12. Number of fish taxa, showing number caught only in each of the systems, number caught in each pair of systems, and number caught in all three systems.

Table 1. Area of land and water, by system.

Systems	Area (km^2)		
	Inner Bay	Inter-island	Total
Fakahatchee			
Water	8.8	16.3	25.1
Land	0	9.9	9.9
Total	8.8	26.2	35.0
Faka Union			
Water	2.4	11.6	14.0
Land	0	7.2	7.2
Total	2.4	18.8	21.2
Pumpkin			
Water	3.1	10.2	13.3
Land	0	5.1	5.1
Total	3.1	15.3	18.4
Combined			
Water	14.5	38.1	52.4
Land	0	22.2	22.2
Total	14.5	60.3	74.6

Table 2. Sampling dates, by cruise number, and month, season, and type of month with respect to mean salinity in Faka Union Bay.

Cruise	Dates	Month Represented	Season	Type of Month (Sal.)	Mean Sal. (ppt)
1	July 20-28, 1982	July	Summer	Low	3.6
2	Aug. 24-26, 1982	Aug.	Summer	Low	2.4
3	Sept. 28-30, 1982	Sept.	Fall	Low	3.4
4	Oct. 25-27, 1982	Oct.	Fall	Low	6.4
5	Nov. 15-17, 1982	Nov.	Fall	High	19.0
6	Dec. 13-15, 1982	Dec.	Winter	High	25.2
7	Jan. 10-12, 1983	Jan.	Winter	High	28.2
8	Feb. 14-17, 1983	Feb.	Winter	Low	7.8
9	March 14-16, 1983	March	Spring	Low	10.6
10	April 11-13, 1983	April	Spring	Low	7.4
11	May 9-11, 1983	May	Spring	High	25.7
12	June 13-15, 1983	June	Summer	High	18.4
13	July 11-13, 1983	July	Summer	Low	9.2
14	Aug. 1-3, 1983	Aug.	Summer	Low	12.2
15	Sept. 6-8, 1983	Sept.	Fall	Low	1.2
16	Oct. 3-5, 1983	Oct.	Fall	Low	9.2
17	Nov. 1-4, 1983	Nov.	Fall	Low	10.0
18	Nov. 29-Dec. 1, 1983	Dec.	Winter	Low	14.8
19	Jan. 16-18, 1984	Jan.	Winter	High	16.0
20	Jan. 30-Feb. 1, 1983	Feb.	Winter	High	23.2
21	Feb. 27-29, 1984	March	Spring	High	30.2
22	April 2-4, 1984	April	Spring	High	28.6
23	April 30-May 2, 1984	May	Spring	High	35.0
24	June 4-6, 1984	June	Summer	High	23.2

Mean salinity = 15.5 ppt

Table 3. Monthly precipitation (centimeters) at Everglades City, Naples, and Ft. Myers and the average for the three stations, from July 1982 through May 1984.

Year	Month	Everglades City	Naples	Ft. Myers	Mean
	July	25.86	22.45	28.77	25.70
	Aug.	32.94	19.13	26.82	26.29
1982	Sept.	15.77	21.13	23.60	20.17
	Oct.	11.83	8.02	12.70	10.85
	Nov.	3.61	4.95	2.82	3.78
	Dec.	1.65	7.03	0.68	3.12
	Jan.	13.74	8.20	11.43	11.13
	Feb.	14.83	22.27	27.48	21.54
	March	9.14	15.32	18.82	14.43
	April	2.74	5.66	3.40	3.94
	May	1.67	1.63	1.57	1.63
1983	June	27.38	25.48	45.52	32.79
	July	20.32	13.97	12.12	15.47
	Aug.	23.14	14.57	16.41	18.03
	Sept.	40.79	23.06	24.69	29.51
	Oct.	30.99	10.03	11.15	17.39
	Nov.	4.52	8.43	9.29	7.42
	Dec.	6.32	5.11	8.22	6.55
	Jan.	1.14	1.24	0.38	0.91
	Feb.	2.03	5.41	8.08	5.18
1984	March	8.97	11.35	16.21	12.17
	April	2.16	1.37	2.77	2.11
	May	10.79	11.96	7.11	9.96

Table 4. List of fish taxa collected in trawls in Pumpkin, Faka Union, and Fakahatchee Bays during the two year survey (July 1982-June 1984).

		Total No.	Total Wt.
1	*Dasyatis sabina* - Atlantic stingray	1	139.0
2	*Elops saurus* (leptocephalus & adult)- ladyfish	267	166.0
3	*Albula vulpes* - bonefish	2	0.2
4	*Brevoortia smithi* - yellowfin menhaden	17,346	3,708.7
5	*Harengula jaguana* - scaled sardine	9,560	2,724.0
6	*Opisthonema oglinum* - Atlantic thread herring	48	32.4
7	*Brevoortia* sp. - menhaden	90	9.5
8	*Anchoa cubana* - cuban anchovy	1,526	371.3
9	*Anchoa hepsetus* - striped anchovy	6,364	4,037.4
10	*Anchoa mitchilli* - bay anchovy	36,678	27,485.3
11	*Anchoviella perfasciata* - flat anchovy	5	1.1
12	*Synodus foetens* - inshore lizard fish	68	712.4
13	*Arius felis* - hardhead catfish	60	914.8
14	*Bagre marinus* - gafftopsail catfish	18	541.0
15	*Opsanus beta* - gulf toadfish	34	1,005.9
16	*Ogcocephalus radiatus* - polka-dot batfish	5	819.7
17	*Hyporhamphus unifasciatus* - half beak	201	3,045.3
18	*Strongylura marina* - Atlantic needlefish	24	2,044.6
19	*Strongylura notata* - redfin needlefish	94	5,461.2
20	*Strongylura timucu* - timucu	45	1,012.2
21	*Lucania parva* - rainwater killifish	82	12.3
22	*Fundulus confluentus* - marsh killifish	1	5.0
23	*Gambusia affinis* - mosquito fish	1	0.1
24	*Membras martinica* - rough silverside	983	1,316.2
25	*Fundulus grandis* - gulf killifish	2	0.3
26	*Hippocampus zosterae* - dwarf seahorse	17	2.0
27	*Syngnathus louisianae* - chain pipefish	64	36.4
28	*Syngathus scovelli* - gulf pipefish	795	215.0
29	*Diplectrum formosum* - sand perch	3	12.5
30	*Serranus subligarius* - belted sandfish	1	0.5
31	*Mycteroperca microlepis* - gag	1	8.2
32	*Chloroscombrus chrysurus* - Atlantic bumper	20	4.6
33	*Oligoplites saurus* - leather jacket	22	130.9
34	*Selene vomer* - lookdown	2	24.0
35	*Trachinotus falcatus* - permit	1	3.0
36	*Lutjanus* sp. - snapper	3	0.7
37	*Eucinostomus* sp. - mojarra	3	0.7
38	*Lutjanus griseus* - mangrove snapper	2	9.3
39	*Lutjanus synagris* - lane snapper	36	40.9
40	*Eucinostomus argenteus* - spotfin mojarra	476	588.8
41	*Eucinstomus gula* - silver jenny	1,350	7,843.0
42	*Orthopristis chrysoptera* - pigfish	384	163.4

Table 4. Continued.

		Total No.	Total Wt.
43	Archosargus probatocephalus - sheepshead	76	966.9
44	Lagodon rhomboides - pinfish	4,279	5,286.3
45	Bairdiella chrysoura - silver perch	3,951	18,856.6
46	Cynoscion arenarius - sand seatrout	121	252.9
47	Cynoscion nebulosus - spotted seatrout	49	190.9
48	Cynoscion regalis - weakfish	1	4.8
49	Leiostomus xanthurus - spot	5	57.8
50	Menticirrhus americanus - southern kingfish	3	164.5
51	Menticirrhus littoralis - gulf kingfish	2	26.1
52	Micropogon undulatus - Atlantic croaker	2	8.5
53	Cynoscion sp. - trout	1	0.5
54	Umbrina coroides - sand drum	4	0.7
55	Chaetodipterus faber - Atlantic spadefish	8	56.2
56	Pomacentrus fuscus - dusky damselfish	5	0.5
57	Decodon puellaris - red hogfish	1	0.1
58	Sparisoma radians - bucktooth parrotfish	1	1.0
59	Mugil cephalus - striped mullet	1	70.0
60	Mugil curema - white mullet	13	1.7
61	Chasmodes saburrae - Florida blenny	4	2.4
62	Gobionellus shufeldti - freshwater goby	9	2.1
63	Gobiosoma robustum - code goby	171	39.6
64	Microgobius gulosus - clown goby	2	1.1
65	Microgobius thalassinus - green goby	2	0.3
66	Gobiosoma bosci - naked goby	1	0.3
67	Gobiidae - goby	12	3.2
68	Prionotus tribulus - bighead searobin	9	18.3
69	Prionotus scitulus - leopard searobin	2	5.6
70	Ancylopesetta quadrocellata - ocellated flounder	2	64.5
71	Citharichthys spilopterus - bay whiff	2	22.0
72	Etropus crossotus - fringed flounder	2	7.0
73	Paralichthys albigutta - gulf flounder	6	590.9
74	Achirus lineatus - lined sole	23	10.6
75	Trinectes maculatus - hogchoker	3	16.2
76	Symphurus plagiusa - black cheek tongue fish	66	171.1
77	Monacanthus hispidus - planehead filefish	15	19.3
78	Lactophrys quadricornis - scrawled cowfish	1	12.2
79	Sphoeroides nephelus - southern puffer	11	308.8
80	Sphoeroides spengleri - bandtail puffer	1	4.1
81	Chilomycterus schoepfi - striped burrfish	9	187.5
82	Anchoa lyolepis - dusky anchovy	1	0.1
83	Floridichthys carpio - goldspotted killifish	1	0.2
		85,563	92,083.2

Table 5. Percentage of catch, by number and by weight, of the most abundant fish species in trawls, July 1982 - June 1984.

Scientific Name	Common	Total Number Caught	Percentage of Number	Total Weight (grams)	Percentage of Weight
Anchoa mitchilli	bay anchovy	36,678	42.9	27,485	30.0
Brevoortia smithi	yellowfin menhaden	17,346	20.3	3,709	4.0
Harengula jaguana	scaled sardine	9,560	11.2	2,724	3.0
Anchoa hepsetus	striped anchovy	6,364	7.4	4,037	4.4
Lagodon rhomboides	pinfish	4,279	5.0	5,286	5.7
Bairdiella chrysoura	silver perch	3,951	4.6	18,857	20.5
Anchoa cubana	cuban anchovy	1,526	1.8	371	.4
Eucinostomus gula	silver jenny	1,350	1.6	7,843	8.5
Membras martinica	rough silverside	983	1.1	1,316	1.4
Syngnathus scovelli	gulf pipefish	795	1.0	215	.2
Hyporhamphus unifasciatus	halfbeak	201	.2	3,045	3.3
Strongylura notata	redfin needlefish	94	.1	5,461	5.9
Strongylura marina	Atlantic needlefish	24	<.1	2,045	2.2
All Other Species		2,412	2.8	9,689	10.5
Total		85,563	100.0	92,083	100.0

Table 6. Ten most abundant taxa of fish collected in each bay in surface and otter trawls, listed in decreasing order of abundance.

FAKAHATCHEE SYSTEM		PUMPKIN SYSTEM		FAKA UNION SYSTEM	
Species	Number	Species	Number	Species	Number
Brevoortia smithi	13,308	Anchoa mitchilli	13,105	Anchoa mitchilli	13,351
Anchoa mitchilli	10,222	Harengula jaguana	9,320	Bairdiella chrysoura	1,610
Anchoa hepsetus	1,464	Anchoa hepsetus	3,669	Anchoa hepsetus	1,231
Lagodon rhomboides	1,033	Brevoortia smithi	3,238	Lagodon rhomboides	893
Bairdiella chrysoura	882	Lagodon rhomboides	2,353	Brevoortia smithi	800
Anchoa cubana	561	Bairdiella chrysoura	1,459	Eucinostomus gula	539
Eucinostomus gula	294	Membras martinica	812	Anchoa cubana	361
Harengula jaguana	240	Anchoa cubana	604	Syngnathus scovelli	289
Syngnathus scovelli	202	Eucinostomus gula	516	Elops saurus	241
Orthopristis chrysoptera	136	Syngnathus scovelli	304	Eucinostomus argenteus	192
Subtotal	28,342		35,380		19,507
All other species	631		1,043		660
Total	28,973		36,423		20,167

Table 7. Total weights (grams wet weight) of the 10 fish species with highest total weights in samples from each bay system and the total area for the entire sampling period.

	ENTIRE SYSTEM		FAKA UNION SYSTEM		FAKAHATCHEE SYSTEM		PUMPKIN BAY	
	SPECIES	WEIGHT	SPECIES	WEIGHT	SPECIES	WEIGHT	SPECIES	WEIGHT
1.	*Anchoa mitchilli*	27,485.3	*Anchoa mitchilli*	10,667.7	*Anchoa mitchilli*	7,204.3	*Anchoa mitchilli*	9,613.3
2.	*Bairdiella chrysoura*	18,856.6	*Bairdiella chrysoura*	6,370.1	*Bairdiella chrysoura*	4,682.7	*Bairdiella chrysoura*	7,803.8
3.	*Eucinostomus gula*	7,843.0	*Eucinostomus gula*	3,181.8	*Brevoortia smithi*	2,183.6	*Strongylura notata*	3,307.8
4.	*Strongylura notata*	5,461.2	*Strongylura notata*	1,800.1	*Eucinostomus gula*	1,893.5	*Lagodon rhomboides*	3,302.7
5.	*Lagodon rhomboides*	5,286.3	*Anchoa hepsetus*	1,224.7	*Hyporhamphus unifaciatus*	1,052.5	*Eucinostomus gula*	2,767.7
6.	*Anchoa hepsetus*	4,037.4	*Lagodon rhomboides*	1,064.8	*Lagodon rhomboides*	918.8	*Harengula jaguana*	2,672.0
7.	*Brevoortia smithi*	3,708.7	*Archosargus probatocephalus*	895.5	*Ogcocephalus radiatus*	694.8	*Anchoa hepsetus*	2,133.0
8.	*Hyporhamphus unifasciatus*	3,045.3	*Strongylura timucu*	468.6	*Anchoa hepsetus*	679.7	*Hyporhamphus unifasciatus*	1,578.6
9.	*Harengula jaguana*	2,724.0	*Hyporhamphus unifasciatus*	414.2	*Opsanus beta*	659.6	*Strongylura marina*	1,527.7
10.	*Membras martinica*	1,316.2	*Synodus foetens*	239.4	*Paralichthys albigutta*	366.7	*Brevoortia smithi*	1,404.2
	All other species	10,136.0	All other species	5,691.6	All other species	2,703.3	All other species	3,959.1
Total		91,944.0	Total	28,834.7	Total	23,039.5	Total	40,069.9

Table 8. Taxa collected by surface and otter trawls from Faka Union, Fakahatchee and Pumpkin Bays, July 1982 - June 1984.

SURFACE TRAWL ONLY	OTTER TRAWL ONLY	SURFACE and OTTER TRAWL
Brevoortia sp.	Albula vulpes	Symphurus plagiusa
Harengula jaguana	Bagre marinus	Achirus lineatus
Strongylura marina	Ogcocephalus radiatus	Paralichthys albigutta
Strongylura notata	Anchoviella perfasciata	Prionotus tribulus
Strongylura timucu	Fundulus confluentus	Gobiidae
Fundulus grandis	Diplectrum formosum	Microgobius gulosus
Oligoplites saurus	Serranus subligarius	Gobiosoma robustum
Trachinotus falcatus	Mycteroperca microplepis	Cynoscion nebulosus
Mugil cephalus	Selene vomer	Cynoscion arenarius
Mugil curema	Lutjanus sp.	Bairdiella chrysoura
Anchoa lyolepis	Eucinostomus sp.	Lagodon rhomboides
Gambusia affinis	Lutjanus griseus	Archosargus probatocephal
	Cynoscion regalis	Eucinostomus gula
	Leiostomus xanthurus	Eucinostomus argenteus
	Menticirrhus americanus	Chloroscombrus chrysurus
	Menticirrhus littoralis	Syngnathus scovelli
	Micropogon undulatus	Syngnathus louisianae
	Cynoscion sp.	Hippocampus zosterae
	Umbrina coroides	Membras martinica
	Chaetodipterus faber	Lucania parva
	Pomacentrus fuscus	Hyporhamphus unifasciatu
	Decodon puellaris	Opsanus beta
	Sparisoma radians	Arius felis
	Chasmodes saburrae	Synodus foetens
	Gobionellus shufeldti	Anchoa mitchilli
	Microgobius thalassinus	Anchoa hepsetus
	Gobiosoma bosci	Anchoa cubana
	Prionotus scitulus	Opisthonema oglinum
	Ancylopesetta quadrocellata	Brevoortia smithi
	Citharichthys spilopterus	Elops saurus
	Etropus crossotus	Orthopritis chrysoptera
	Trinectes maculatus	
	Monacanthus hispidus	
	Lactophrys quadricornis	
	Sphoeroides nephelus	
	Sphoeroides spengleri	
	Chilomycterus schoepfi	
	Floridichthys carpio	
	Dasyatis sabina	
	Lutjanus synagris	
TOTAL NUMBER OF SPECIMENS:		
9,854	181	75,528
TOTAL NUMBER OF TAXA:		
12	40	31

Table 9. Number of individuals of selected recreational and commercial species in samples from the Fakahatchee, Faka Union, and Pumpkin systems.

Species	Fakahatchee	Faka Union	Pumpkin
Lutjanus synagris (Lane snapper)	3	30	3
Cynoscion arenarius (Sand seatrout)	16	28	77
Cynoscion nebulosus (Spotted seatrout)	3	28	18

Table 10. Significant factors[1] explaining variation in abundance of each of the 10 major fish species.

	Site	Syst	Seas	Salm	Site Syst	Site Seas	Site Salm	Syst Seas	Syst Salm	Seas Salm
Yellowfin Menhaden	X	X	X	X		X		X	X	X
Scaled Sardine										
Cuban Anchovy			X		X		X			X
Striped Anchovy	X	X	X	X		X				X
Bay Anchovy	X	X		X				X		
Rough Silverside		X	X	X	X	X	X	X	X	X
Gulf Pipefish			X							X
Silver Jenny	X		X	X		X				
Pinfish		X	X		X			X	X	X
Silver Perch	X		X		X	X				
All 10 Species	X	X	X	X	X			X		X

[1] According to four-way ANOVA ($p \leq 0.1$).

Note: Site = location (bay or pass), Syst = system, Seas = season, Salm = salinity-month.

Table 11. Mean number per station visit of ten most numerous fish species, by location, with significant differences between systems indicated.[1,2,3]

	System Means (with Duncan Group Assignments)			Entire Area Mean	ANOVA F Prob.	Hom. Var. F Prob.
	Fakahatchee	Faka Union	Pumpkin			
Bays						
Yellowfin Menhaden	125.24 A,B	7.09 A	25.59 B	52.64	<u>0.042</u>	0.000
Scaled Sardine	2.29	0.00	88.76	30.35	<u>0.171</u>	0.000
Cuban Anchovy	3.22	0.43	4.77	2.81	0.229	0.000
Striped Anchovy	7.88 A,B	9.95 A	33.35 B	17.06	<u>0.058</u>	0.001
Bay Anchovy	92.01 A	54.12 A	113.20 B	86.44	<u>0.011</u>	0.696
Rough Silverside	0.71 A	0.09 A	7.05 B	2.62	<u>0.000</u>	0.000
Gulf Pipefish	1.45	1.87	2.24	1.85	0.133	0.560
Silver Jenny	0.27 A	1.03 B	0.89 A,B	0.73	<u>0.043</u>	0.001
Pinfish	5.94 A	3.90 A	19.50 B	9.78	<u>0.000</u>	0.000
Silver Perch	2.44 A	5.93 A,B	9.90 B	6.09	<u>0.002</u>	0.003
Total of 10 sp.	241.44 A	84.41 A	305.25 B	210.37	<u>0.000</u>	0.088
Passes						
Yellowfin Menhaden	3.76	1.24	13.12	6.04	0.481	0.000
Scaled Sardine	0.00	0.00	0.00	0.00		
Cuban Anchovy	5.31	7.52	2.45	5.10	0.279	0.018
Striped Anchovy	15.17	3.48	3.98	7.54	0.660	0.180
Bay Anchovy	12.83	36.57	13.50	20.97	0.449	0.984
Rough Silverside	0.81	0.95	1.26	1.01	0.914	0.898
Gulf Pipefish	1.17	1.45	1.64	1.42	0.894	0.374
Silver Jenny	2.17	0.79	1.71	1.56	0.681	0.419
Pinfish	9.74	10.26	7.26	9.09	0.715	0.812
Silver Perch	14.83	22.76	9.98	15.86	0.283	0.256
Total of 10 sp.	65.79	85.02	54.90	68.57	0.832	0.900

1 Significant according to both one-way ANOVA ($p \leq 0.1$) and Duncan Multiple Range Tests ($p \leq 0.05$).

2 ANOVA F-test probabilities indicating significant differences are underlined.

3 The same letter beside two or more values on the same line indicates the values are not significantly different. Those values on the same line that do not have the same letter beside them differ significantly from each other. Where no group assignments are shown, none of the seasons differ significantly. The higher the alphabetic letter, the higher the relative value of the mean.

Note: Sample sizes were 105 for each of the bays and 42 for each of the passes.

Table 12. Mean number per station visit of the 10 major fish species during each season, with significant differences among seasons indicated.[1,2]

Species	Winter		Spring		Summer		Fall	
	Mean	Group	Mean	Group	Mean	Group	Mean	Group
Yellowfin Menhaden	1.80	A	132.08	B	5.22	A	0.32	A
Scaled Sardine								
Cuban Anchovy	1.15	B	8.88	B	0.11	A	2.41	A
Striped Anchovy	1.20	A	26.67	B	23.69	C	7.84	A
Bay Anchovy	52.87	A	47.01	A	115.30	B	72.41	A
Rough Silverside	0.32	A	0.19	A	9.65	B	0.72	A
Gulf Pipefish	1.33	B	2.33	B	2.45	B	0.91	A
Silver Jenny	0.64	A,B	0.12	A	0.94	B,C	2.39	C
Pinfish	7.02	B	18.47	C	11.57	C	0.42	A
Silver Perch	3.79	B	4.53	B	26.42	B	6.18	A
All 10 Species	70.10	A	314.87	B	197.26	B	93.61	A

[1] Significant according to both one-way ANOVA ($p \leq 0.1$) and LSD-mod tests ($p \leq 0.1$).

[2] The same letter beside two or more values on the same line indicates the values are not significantly different. Those values on the same line that do not have the same letter beside them differ significantly from each other. Where no group assignments are shown, none of the seasons differ significantly. The higher the alphabetic letter, the higher the relative value of the mean.

Note: Sample sizes: winter = 126, spring = 126, summer = 84, and fall = 105.

Table 13. Mean number per station visit, by system and bay or pass, in major fish species for which significant differences in abundance among systems were indicated in one or more season.[1,2] (Only those species for which significant differences were found in a given season are included.)

	Winter			Spring		
	FH	FU	PU	FH	FU	PU
Bays						
Yellowfin Menhaden				435.63 B	21.97 A	74.87 A,B
Bay Anchovy	76.20 A	82.97 B	54.93 A,B	105.53 B	13.77 A	63.07 B
Gulf Pipefish				2.80 A,B	1.33 A	3.60 B
Silver Jenny	0.17 A	1.60 B	0.63 A			
Pinfish				11.63 A	4.37 A	38.53 B
All 10 Species				584.17 B	50.17 A	582.83 B
Passes						
Bay Anchovy				4.83 A,B	9.33 A	23.50 B

	Summer			Fall		
	FH	FU	PU	FH	FU	PU
Bays						
Yellowfin Menhaden	0.15 A	0.40 A	18.35 B			
Striped Anchovy	27.55 A	20.95 A,B	46.35 B			
Bay Anchovy	42.55 A	107.90 A,B	310.50 B	134.32 A,B	24.92 A	85.44 B
Rough Silverside	2.35 A	0.10 A	34.65 B	0.76 A	0.20 A	1.60 B
Pinfish	3.05 A	6.40 A,B	27.25 B			
Silver Perch				0.52 A	4.16 A,B	7.16 B
All 10 Species	80.95 A	157.25 A	471.90 B	138.44 A,B	52.00 A	110.60 B
Passes						
Gulf Pipefish				0.20 A	1.60 B	1.00 A,B
Pinfish				0.10 A,B	1.10 B	0.00 A

Footnotes to Table 13.

[1] Significant according to both one-way ANOVA ($p \leq 0.1$) and Duncan Multiple Range ($p \leq 0.05$) tests.

[2] The same letter beside two or more values for a given species within each season indicates the values are not significantly different. Those values on the same line that do not have the same letter beside them differ significantly from each other. Where no group assignments are shown, none of the seasons differ significantly. The higher the alphabetic letter, the higher the relative value of the mean.

Note: FH = Fakahatchee, FU = Faka Union, PU = Pumpkin.

Note:

Sample Sizes

	winter	spring	summer	fall
bays	30	30	20	25
passes	12	12	8	10

Table 14. List of major species of fish indicating cases of statistically significant differences in abundance between January - April periods of 1983 and 1984 and among systems within periods.

	Bays					Passes				
	High Period [a]			Systems [b]		High Period [a]			Systems [b]	
	PU	FH	FU	1983	1984	PU	FH	FU	1983	1984
Yellowfin Menhaden	1983	1983	1983	FH PU FU		1983	1983			
Scaled Sardine										
Cuban Anchovy								1983		
Striped Anchovy										
Bay Anchovy								1983		
Rough Silverside	1984	1984						1984		
Gulf Pipefish	1984	1984								
Silver Jenny		1984						1983		
Pinfish			1983	PU FU FH	PU FH FU			1983		
Silver Perch										
All 10 species								1983	PU FH FU	PU FH FU

a Only cases in which one year is significantly higher than the other (based on ANOVA, sig of F = 0.1) are listed.

b Listed from left to right in order of abundance from highest to lowest. Horizontal bars connect systems that are not significantly different from each other (based on Duncan's multiple-rank test, sig of F = 0.05). Only cases in which at least one system is significantly different from another are shown.

Note: January - April, 1983, was abnormally wet.
January - April, 1984, was dry.

Key: PU = Pumpkin, FH = Fakahatchee, and FU = Faka Union.

Table 15. Total number[1] of ichthyoplankton of each taxa collected in the study area from July 1982 through June 1984. (Numbers for lower taxa, such as families, do not include numbers of those identified to higher taxonomic levels, such as species.) (Data for February 19 83 and for station 20 on March 1983 and January 1984 were excluded because they could not be used in the analysis due to a malfunctioning flow meter on those dates.)

ELOPIDAE	3
OPHICHTHIDAE	
Myrophis punctatus	2
CLUPEIDAE	424
Brevoortia sp.	56
Harengula pensacolae	6
ENGRAULIDAE	2,565
Anchoa hepsetus	16
A. mitchilli	103
GOBIESOCIDAE	
Gobiesox strumosus	499
BELONIDAE	
Strongylura marina	2
CYPRINODONTIDAE	
Lucania parva	4
ATHERINIDAE	167
Membras martinica	18
Hippocampus erectus	2
SYNGNATHIDAE	
Syngnathus spp.	51
PERCIFORMES	3
CARANGIDAE	
Caranx spp.	1
C. ruber	2
Elagatis bipinnulata	1
Oligoplites saurus	9
GERREIDAE	8
Eucinostomus argenteus	2
HAEMULIDAE	
Haemulon plumieri	1
Orthopristis chrysoptera	1
SCIAENIDAE	141
Bairdiella chrysoura	14
Cynoscion sp.	3
C. nebulosus	13
C. regalis	7
Menticirrhus spp.	2
M. americanus	1
M. saxatilis	1
Micropogonias undulatus	6
Pogonias cromis	6
Stellifer lanceolatus	2

Table 15. Continued.

SPARIDAE	15
Archosargus probatocephalus	4
Lagodon rhomboides	51
GOBIIDAE	1,583
Gobiosoma spp.	1
TRIGLIDAE (?)	5
BLENNIIDAE	1,100
PLEURONECTRIFORMES	18
SOLEIDAE	23
Archirus lineatus	11
Trinectes maculatus	8
TETRAODONTIDAE	1
Sphoeroides nephelus	2
DIODONTIDAE	
Chilomycterus schoepfi	2
Unidentified yolksac larvae	71
Unidentified larvae	285
Total larvae	7,322
Fish eggs	11,430

[1] Raw numbers, not adjusted for volume of water filtered.

Table 16. Significant factors[1] explaining variation in concentration of each of the eight major ichthyoplankton families.

	Site	Syst	Seas	Salm	Site Syst	Site Seas	Site Salm	Syst Seas	Syst Salm	Seas Salm
Anchovies	X		X							X
Gobies		X	X	X						X
Clingfishes	X	X	X	X	X					X
Blennies	X	X	X							X
Porgies			X						X	X
Herrings	X		X	X						X
Silversides			X							
Drums			X	X						X
All 10 families			X				X			X

[1] According to four-way ANOVA ($p \leq 0.1$).

Note: Site = location (bay or pass), Syst = system, Seas = season, Salm = salinity-month.

Table 17. Mean number per station visit of eight most numerous ichthyoplankton families, by location, with significant differences between systems indicated.[1,2,3]

	System Means (with Duncan Group Assignments)					
	Fakahatchee	Faka Union	Pumpkin	Entire Area Mean	ANOVA F Prob.	Hom. Var. F Prob.
Bays						
Anchovies	118.06	71.23	118.50	102.60	0.379	0.463
Gobies	125.75 B	136.99 A	69.53 A,B	110.76	0.075	0.444
Clingfishes	42.02 A	78.41 B	16.05 A	45.49	0.001	0.028
Blennies	64.16 B	80.54 A,B	29.54 A	58.08	0.095	0.339
Porgies	7.14	6.07	26.32	13.18	0.837	0.092
Herrings	20.81	12.86	37.82	23.83	0.277	0.004
Silversides	17.60 B	8.58 A	5.86 A	10.68	0.013	0.000
Drums	16.11	9.69	8.49	11.43	0.244	0.021
All 8 families	441.67	404.37	312.11	386.05	0.677	1.000
Passes						
Anchovies	178.43	367.10	256.64	267.39	0.892	0.511
Gobies	53.56	33.96	79.54	55.69	0.422	0.721
Clingfishes	28.31 B	15.91 A,B	4.77 A	48.99	0.025	0.056
Blennies	145.48 B	94.44 B	58.50 A	99.47	0.003	0.479
Porgies	5.71	8.05	113.23	42.33	0.464	0.000
Herrings	40.22	52.67	61.51	51.47	0.918	1.000
Silversides	8.68	11.16	28.82	16.22	0.787	0.835
Drums	8.93	6.86	14.93	10.24	0.865	0.519
All 8 families	469.31	590.15	617.93	559.13	0.806	1.000

[1] Significant according to both one-way ANOVA ($p \leq 0.1$) and LSD-mod tests ($p \leq 0.1$).

[2] ANOVA F-test probabilities indicating significant differences are underlined.

[3] The same letter beside two or more values on the same line indicates the values are not significantly different. Those values on the same line that do not have the same letter beside them differ significantly from each other. Where no group assignments are shown, none of the seasons differ significantly. The higher the alphabetic letter, the higher the relative value of the mean.

Note: Sample sizes

	Fakahatchee	Faka Union	Pumpkin
Bay	105	104	105
Pass	42	42	41

Table 18. Mean concentration per station visit of the eight major ichthyoplankton families during each season, with significant differences among seasons indicated.[1,2]

Species	Winter Mean	Winter Group	Spring Mean	Spring Group	Summer Mean	Summer Group	Fall Mean	Fall Group
Anchovies	61.28	A	350.58	C	142.60	B	23.90	A
Gobies	42.06	A	243.41	C	23.09	A,B	40.65	B
Clingfishes	56.02	C	64.40	C	2.91	A	9.67	B
Blennies	44.67	A	170.96	B	15.93	A	24.04	A
Porgies	5.01	B	69.75	C	1.00	A,B	0.00	A
Herrings	52.76	B	58.62	B	0.00	A	0.00	A
Silversides	2.13	A	35.14	B	3.44	A	4.34	A
Drums	6.00	A	29.20	B	4.99	A	0.68	A
All 8 Families	269.92	A	1,132.83	B	193.96	A	103.28	A

[1] Significant according to both one-way ANOVA ($p \leq 0.1$) and LSD-mod tests ($p \leq 0.1$).

[2] The same letter beside two or more values on the same line indicates the values are not significantly different. Those values on the same line that do not have the same letter beside them differ significantly from each other. Where no group assignments are shown, none of the seasons differ significantly. The higher the alphabetic letter, the higher the relative value of the mean.

Note: Sample sizes: winter = 126, spring = 126, summer = 84, and fall = 105.

Table 19. Mean number per station visit, by system and bay or pass, in major ichthyoplankton families for which significant differences in abundance among systems were indicated in one or more season.[1,2] (Only those families for which significant differences were found in a given season are included.)

	Winter			Spring		
	FH	FU	PU	FH	FU	PU
Bays						
Gobies	130.93 B	3.12 A	17.51 A			
Clingfishes	77.62 A,B	102.26 B	29.21 A			
Silversides				49.49 B	20.97 A,B	17.30 A
Drums	13.51 B	1.16 A	5.05 A,B			
Passes						
Clingfishes				349.16 B	164.94 A	195.93 A

	Summer			Fall		
	FH	FU	PU	FH	FU	PU
Bays						
Anchovies				64.25 A,B	41.29 A	157.45 B
Blennies				32.98 B	8.57 A	2.68 A
Silversides				9.33 B	0.00 A	1.27 A,B

[1] Significant according to both one-way ANOVA ($p \leq 0.1$) and LSD-mod ($p \leq 0.1$) tests.

[2] The same letter beside two or more values for a given species within each season indicates the values are not significantly different. Those values on the same line that do not have the same letter beside them differ significantly from each other. Where no group assignments are shown, none of the seasons differ significantly. The higher the alphabetic letter, the higher the relative value of the mean.

Note: FH = Fakahatchee, FU = Faka Union, PU = Pumpkin.

Note:

Sample Sizes

	winter	spring	summer	fall
bays	30	30	20	25
passes	12	12	8	10

Table 20. List of major families of ichthyoplankton indicating cases of statistically significant differences in abundance between January - April periods of 1983 and 1984 and among systems within periods. (Indicated in parentheses are those systems or years in which significant differences were indicated by two-way ANOVA but not by one-way ANOVA. Which systems differed significantly from each other was not indicated.)

	Bays					Passes				
	High Period [a]			Systems [b]		High Period [a]			Systems [b]	
	PU	FH	FU	1983	1984	PU	FH	FU	1983	1984
Anchovies	1984	1984	1984			1983	1983			
Gobies	1984	1984	1984							
Clingfishes	1984	1984	1984		FU FH PU	(1984)	(1984)	(1984)	(FH FU PU)	(FH FU PU)
Combed Blennies	1984	1984	1984				1984			FH FU PU
Porgies	1984	1983						1984	PU FH FU	
Herrings	1984	1984				1984	1984	1984		
Silversides			1984					1984		
Drums	1984	1984	1984	(FH PU FU)	(FH PU FU)		1984	1984		
All 8 Families	1984	1984	1984				1984			

a Only cases in which one year is significantly higher than the other (based on ANOVA, sig of F = 0.1) are listed.

b Listed from left to right in order of abundance from highest to lowest. Horizontal bars connect systems that are not significantly different from each other (based on Duncan's multiple-rank test, sig of F = 0.05). Only cases in which at least one system is significantly different from another are shown.

Note: January - April, 1983, was abnormally wet.
January - April, 1984, was dry.

Key: PU = Pumpkin, FH = Fakahatchee, and FU = Faka Union.

Table 21. Taxonomic list of invertebrates collected in benthic trawls, July 1982 - June 1984.

Mollusca	
Pelycypoda	Clams (bivalves)
Amygdalum papyrium	
Tellina spp.	
Macoma spp.	
Anomalocardia cuneimeris	
Crassostrea virginica	
Codakia orbiculata	
Laevicardium mortoni	
Gastropoda	Snails
Bulla striata	
Batillaria minima	
Busycon contrarium	
Cerithium sp.	
Haminoea sp.	
Littorina spp.	
Modulus modulus	
Melongena corona	
Nassarius vibex	
Polinices duplicatus	
Aplysiidae	
Bursatella leachii pleii	Ragged sea-hare
Cephalopoda	
Lolliguncula brevis	Brief squid
Annelida	
Polychaeta	
Onuphidae magna	
Pectinaridae	
Cistenides gouldi	Gold-crown worm
Chaetopteridae	
Chaetopterus variopedatus	Parchment worm
Arthropoda	
Xiphosura	
Limulus polyphemus	

Table 21. (Continued 2).

Crustacea	
Cirripedia	Barnacle
Belanus amphitrite	
Amphipoda	
Isopoda	
Penaeidea	
Penaeus duorarum	Pink shrimp
Caridea	
Pasiphaeidae	
Leptochela serratorbita	
Palaemonidae	Grass shrimp
Leander tenuicornis	
L. paulensis	
Palaemon floridanus	
Palaemonetes intermedius	
P. paludosus	
P. pugio	
P. vulgaris	
Periclimenes americanus	
P. longicaudatus	
Alpheidae	Snapping shrimp
Alpheus armillatus	
A. heterochaelis	
A. normanni	
Hippolytidae	Grass shrimp
Hippolyte pleuracantha	
H. zostericola	
Latreutes fucorum	
L. parvulus	
Thor floridanus	
Tozeuma carolinense	Arrow shrimp
Processidae	
Ambidexter symmetricus	

Table 21. (Continued 3).

Paguridaea	Hermit crab
Pagurus bonairensis	
P. longicarpus	
Porcellanidae	
Petrolisthes galathinus	
Brachyura	
Majidae	
Libinia dubia	Spider crab
L. emarginata	
Metoporhaphis calcarata	
Portunidae	Swimming crab
Callinectes ornatus	
C. sapidus	Blue crab
Portunus gibbesi	
P. sayi	
Xanthidae	Mud crab
Eurypanopeus depressus	
Menippe mercenaria	Stone crab
Neopanope texana	
Panopeus herbstii	
Panopeus simpsoni	
Rhithropanopeus harrisii	
Grapsidae	
Aratis pisoni	Mangrove crab
Ocypodae	
Uca pugilator	Fiddler crab
Uca spp.	
Echinodermata	Sea stars
Asteroidea	
Echinaster sp.	
Ophiuroidea	Brittle star
Holithuridae	Sea cucumber
Holithuria floridana	
Chordata	
Amaroucium pellucidum	Sea pork
Molgula sp.	Sea squirt

Table 22. Number of macroinvertebrates of major taxa collected in Faka Union and Fakahatchee Bays in present study and two previous studies.

Taxa	Carter et al. 1973		Evink 1975		Present Study	
	No.	Rank	No.	Rank	No.	Rank
Palaemonetes spp. (grass shrimp)	1,704	3	2,002	1	3,307	1
Penaeus duorarum (pink shrimp)	2,889	2	196	3	748	2
Neopanope texana (mud crab)	475	5	117	4	473	3
Pagurus bonairensis (hermit crab)	many	1 (?)	40	7	317	4
Callinectes sapidus (blue crab)	85	7	73	5	215	5
Tozeuma carolinense (arrow shrimp)	536	4	28	8	34	6
Libinia dubia (spider crab)	109	6	42	6	28	7
Alpheus spp. (snapping shrimp)	20	8	392	2	11	8

Table 23. Significant factors[1] explaining variation in abundance of each of the six major macroinvertebrate species.

	Site	Syst	Seas	Salm	Site Syst	Site Seas	Site Salm	Syst Seas	Syst Salm	Seas Salm
Pink Shrimp	X	X	X	X	X	X		X		X
Grass Shrimp	X		X		X					X
Arrow Shrimp	X				X					X
Hermit Crab	X	X	X	X	X					X
Blue Crab			X	X	X			X		X
Mud Crab	X	X	X		X	X				
All Six Species	X	X	X	X	X			X		X

[1] According to four-way ANOVA ($p \leq 0.1$).

Note: Site = location (bay or pass), Syst = system, Seas = season, Salm = salinity-month.

Table 24. Mean number per station visit of the six most numerous macroinvertebrate species, by location, with significant differences between systems indicated.[1,2,3]

	System Means (with Duncan Group Assignments)			Entire Area Mean	ANOVA F Prob.	Hom. Var. F Prob.
	Fakahatchee	Faka Union	Pumpkin			
Bays						
Pink Shrimp	1.25 A	4.72 B	24.03 C	10.00	<u>0.000</u>	0.000
Grass Shrimp	12.68 A	15.05 A,B	27.42 B	18.38	<u>0.003</u>	0.175
Arrow Shrimp	0.29 B	0.04 A	1.06 B	0.46	<u>0.019</u>	0.000
Hermit Crab	2.14 B	0.61 A	2.06 B	1.60	<u>0.000</u>	0.039
Blue Crab	1.06 A,B	0.56 A	1.42 B	1.01	<u>0.036</u>	0.049
Mud Crab	1.74 A	2.26 A	4.25 B	2.75	<u>0.003</u>	0.013
All Six Species	19.15 A	23.24 A	60.23 B	34.21	<u>0.000</u>	0.419
Passes						
Pink Shrimp	8.05 B	9.26 B	9.74 A	9.02	0.768	1.000
Grass Shrimp	41.71 A	78.76 B	21.71 A	47.39	<u>0.028</u>	0.188
Arrow Shrimp	1.00	21.17	4.57	8.91	<u>0.001</u>	0.000
Hermit Crab	11.79	17.36	10.36	13.71	0.164	0.262
Blue Crab	1.29	1.02	0.83	1.05	0.235	0.963
Mud Crab	20.43 B	4.67 A	12.26 A	12.45	<u>0.001</u>	0.407
All Six Species	84.26	132.24	59.48	275.98	0.119	0.126

[1] Significant according to both one-way ANOVA ($p \leq 0.1$) and Duncan Multiple Range Tests ($p \leq 0.05$).

[2] ANOVA F-test probabilities indicating significant differences are underlined.

[3] The same letter beside two or more values on the same line indicates the values are not significantly different. Those values on the same line that do not have the same letter beside them differ significantly from each other. Where no group assignments are shown, none of the seasons differ significantly. The higher the alphabetic letter, the higher the relative value of the mean.

Note: Sample sizes were 105 for each of the bays and 42 for each of the passes.

Table 25. Mean number per station visit of the six major macroinvertebrate species during each season, with significant differences among seasons indicated.[1,2]

Species	Winter		Spring		Summer		Fall	
	Mean	Group	Mean	Group	Mean	Group	Mean	Group
Pink Shrimp	2.49	A	2.05	A	32.32	C	9.51	B
Grass Shrimp	40.91	C	15.98	B	22.82	A,B	25.50	A
Arrow Shrimp	1.83		2.31		4.64		3.39	
Hermit Crab	4.50		6.05		4.41		4.43	
Blue Crab	1.49	B	1.32	B	0.50	A	0.52	A
Mud Crab	2.76	A,B	6.60	B	11.77	C	2.54	A
All Six Species	53.99	B	34.29	A,B	76.46	B	45.90	A

1 Significant according to both one-way ANOVA ($p \leq 0.1$) and LSD-mod tests ($p \leq 0.1$).

2 The same letter beside two or more values on the same line indicates the values are not significantly different. Those values on the same line that do not have the same letter beside them differ significantly from each other. Where no group assignments are shown, none of the seasons differ significantly. The higher the alphabetic letter, the higher the relative value of the mean.

Note: Sample sizes: winter = 126, spring = 126, summer = 84, and fall = 105.

Table 26. Mean number per station visit, by system and bay or pass, in major macroinvertebrate species for which significant differences in abundance among systems were indicated in one or more season.[1,2] (Only those species for which significant differences were found in a given season are included.)

	Winter			Spring		
	FH	FU	PU	FH	FU	PU
Bays						
Pink Shrimp	1.20 A	4.07 B	2.73 A,B	0.40 A	0.67 A	4.23 B
Grass Shrimp				8.20 A,B	9.07 A	19.23 B
Arrow Shrimp				0.37 A,B	0.00 A	1.13 B
Hermit Crab	2.43 B	0.47 A	2.13 B	2.93 A	1.40 A	2.77 B
Mud Crab				2.27 A,B	0.80 A	3.93 B
All Six Species				14.97 A,B	12.83 A	33.00 B
Passes						
Grass Shrimp	83.92 B	105.58 B	6.92 A			
Arrow Shrimp	1.08 A	17.58 B	0.00 A			
Blue Crab	2.25 B	1.50 A,B	0.08 A			
Mud Crab	10.75 B	2.25 A	0.67 A			
All Six Species	117.75 B	143.50 B	12.17 A			

	Summer			Fall		
	FH	FU	PU	FH	FU	PU
Bays						
Pink Shrimp	2.25 A	12.40 B	87.65 C	1.52 A	4.24 A	22.44 B
Hermit Crab				1.00 A,B	0.04 A	1.56 B
Blue Crab	0.15 A	0.15 A	1.00 B	0.08	1.12 A	1.76 B
Mud Crab	1.70 A	4.25 A,B	9.05 B			
All Six Species	11.65 A	27.75 A,B	140.10 B	5.36 A	22.24 A,B	45.96 B
Passes						
Arrow Shrimp				0.10 A	34.70 B	0.50 A
Mud Crab	54.63 B	9.38 A	22.13 A,B	7.50 B	1.30 A	0.70 A

Footnotes to Table 26.

[1] Significant according to both one-way ANOVA ($p \leq 0.1$) and Duncan Multiple Range ($p \leq 0.05$) tests.

[2] The same letter beside two or more values for a given species within each season indicates the values are not significantly different. Those values on the same line that do not have the same letter beside them differ significantly from each other. Where no group assignments are shown, none of the seasons differ significantly. The higher the alphabetic letter, the higher the relative value of the mean.

Note: FH = Fakahatchee, FU = Faka Union, PU = Pumpkin.

Note:

	Sample Sizes			
	winter	spring	summer	fall
bays	30	30	20	25
passes	12	12	8	10

Table 27. List of major species of macroinvertebrates indicating cases of statistically significant differences in abundance between January - April periods of 1983 and 1984 and among systems within periods. (Indicated in parentheses are those systems or years in which significant differences were indicated by two-way ANOVA but not by one-way ANOVA. Which systems differed significantly from each other was not indicated.)

	Bays					Passes				
	High Period [a]			Systems [b]		High Period [a]			Systems [b]	
	PU	FH	FU	1983	1984	PU	FH	FU	1983	1984
Pink Shrimp	(1983)	(1983)	(1983)	PU FU FH	PU FU FH			1983		
Grass Shrimp	(1983)	(1983)	(1983)	(PU FU FH)	(PU FU FH)			1983		
Arrow Shrimp	1983	1983		PU FH FU				1983		
Hermit Crab		1983	1983	FH PU FU	PU FH FU			1983		
Blue Crab	1983	1983	1983			1983		1983		
Mud Crab		1983		(FH PU FU)	(FH PU FU)			1983	(FH FU PU)	(FH PU FU)
All 6 Taxa		1983	1983	(PU FH FU)	(PU FU FH)			1983		

a Only cases in which one year is significantly higher than the other (based on ANOVA, sig of F = 0.1) are listed.

b Listed from left to right in order of abundance from highest to lowest. Horizontal bars connect systems that are not significantly different from each other (based on Duncan's multiple-rank test, sig of F = 0.05). Only cases in which at least one system is significantly different from another are shown.

Note: January - April, 1983, was abnormally wet.
January - April, 1984, was dry.

Key: PU = Pumpkin, FH = Fakahatchee, and FU = Faka Union.

Table 28. The ten most abundant fish species and their families[1] and the eight most abundant families of ichthyoplankton.[2]

Fish Species, by Family	Ichthyoplankton Families
HERRINGS (Clupeidae)	HERRINGS
Yellowfin Menhaden	
Scaled Sardine	
ANCHOVIES (Engraulidae)	ANCHOVIES
Cuban Anchovy	
Striped Anchovy	
Bay Anchovy	
SILVERSIDES (Atherinidae)	SILVERSIDES
Rough Silverside	
PORGIES (Sparidae)	PORGIES
Pinfish	
DRUMS (Sciaenidae)	DRUMS
PIPEFISHES (Syngnathidae)	
	GOBIES (Gobiidae)
	CLINGFISHES (Gobiesocidae)
	COMBTOOTH BLENNIES (Blenniidae)

1 Bottom and surface-trawl samples.

2 Plankton-tow samples.

Table 29. Number of significant taxa, by groups, in data separated by location (bay or pass).

Group	Bays	Passes
Fish	7	0
Ichthyoplankton	4	2
Macroinvertebrates	6	3
All three groups	17	5

Table 30. Number of taxa, by group, for which significant differences among systems were detected in each season.[1]

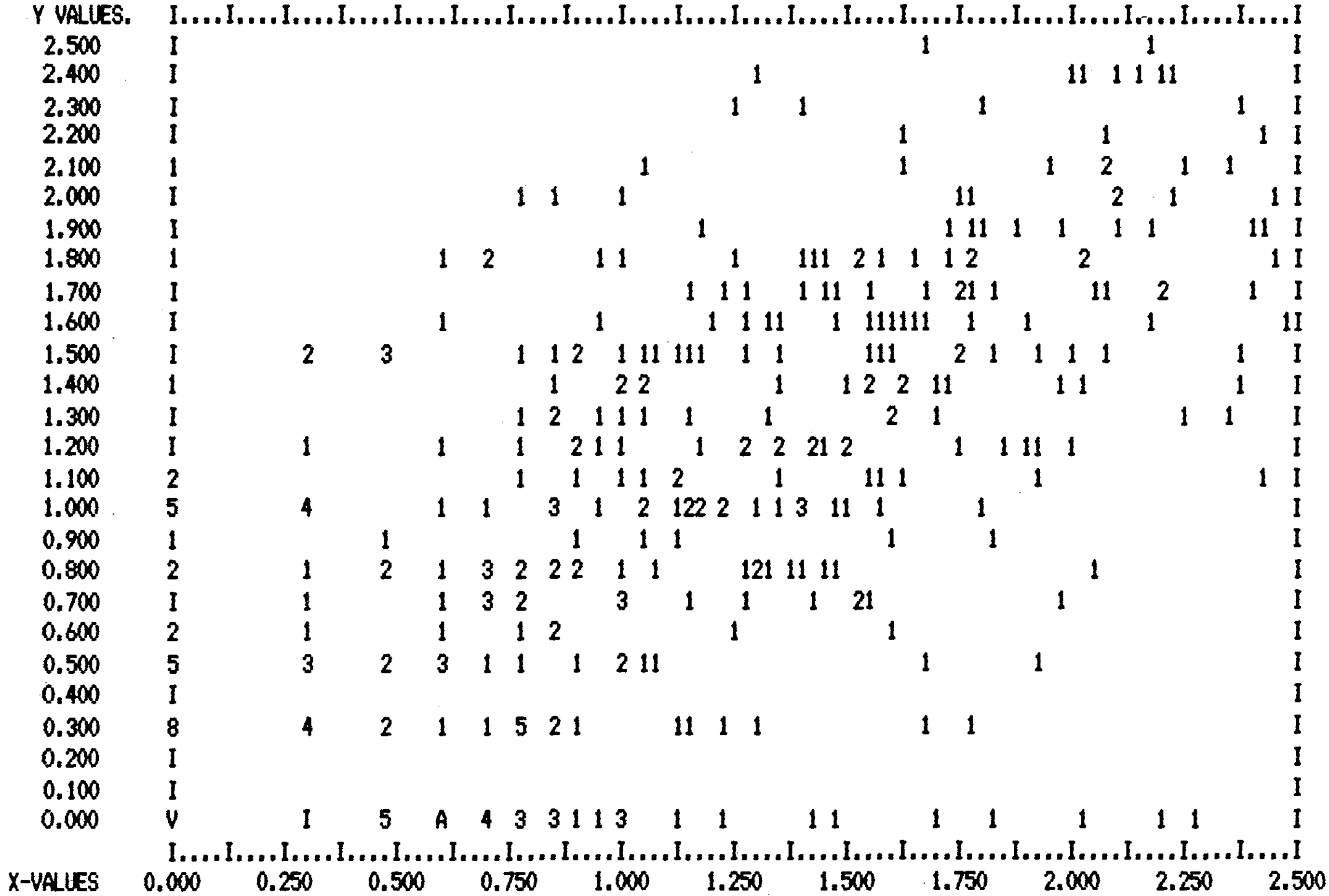
	Winter	Spring	Summer	Fall
Bays				
Fish	2	4	5	3
Ichthyoplankton	3	1	3	0
Macroinvertebrates	2	5	3	3
All three groups	7	10	11	6
Passes				
Fish	0	1	0	2
Ichthyoplankton	0	1	0	0
Macroinvertebrates	4	0	1	2
	4	2	1	4

[1] Significant difference was indicated by both ANOVA ($p \leq 0.1$) and Duncan Multiple Range ($p \leq 0.05$) or LSD-mod ($p \leq 0.1$) tests.

APPENDIX A

In the following regression analyses, independent and dependent variables are indicated in the table heading. F values and probabilities are given in the 'analysis of variance' section. Confidence limits for regression parameters are determined at the $P = 0.05$ level. The number (or frequency code) of observations falling in each of the 25 x 100 grids is shown for each analysis.

Appendix Table A1. Regression estimates, 95% confidence limits, and significance test (F) for the number of fish [log (N+1)] in the first (x) and second (y) tows at the same station. Numbers in plot are counts of observations in the 25 x 100 grid.



DESCRIPTIVE STATISTICS

	MEAN	DEVIATION	CORRELATION
INDEPENDENT VARIABLE(X)	1.178	0.807	0.740
RESPONSE VARIABLE(Y)	1.091	0.812	

ANALYSIS OF VARIANCE

SOURCE	D.F.	S.S.	M.S.	F-VALUE	P(>F:H0)
REGRESSION	1	165.904	165.904	554.661	0.000
RESIDUAL	459	137.291	0.299		
TOTAL	460	303.195			

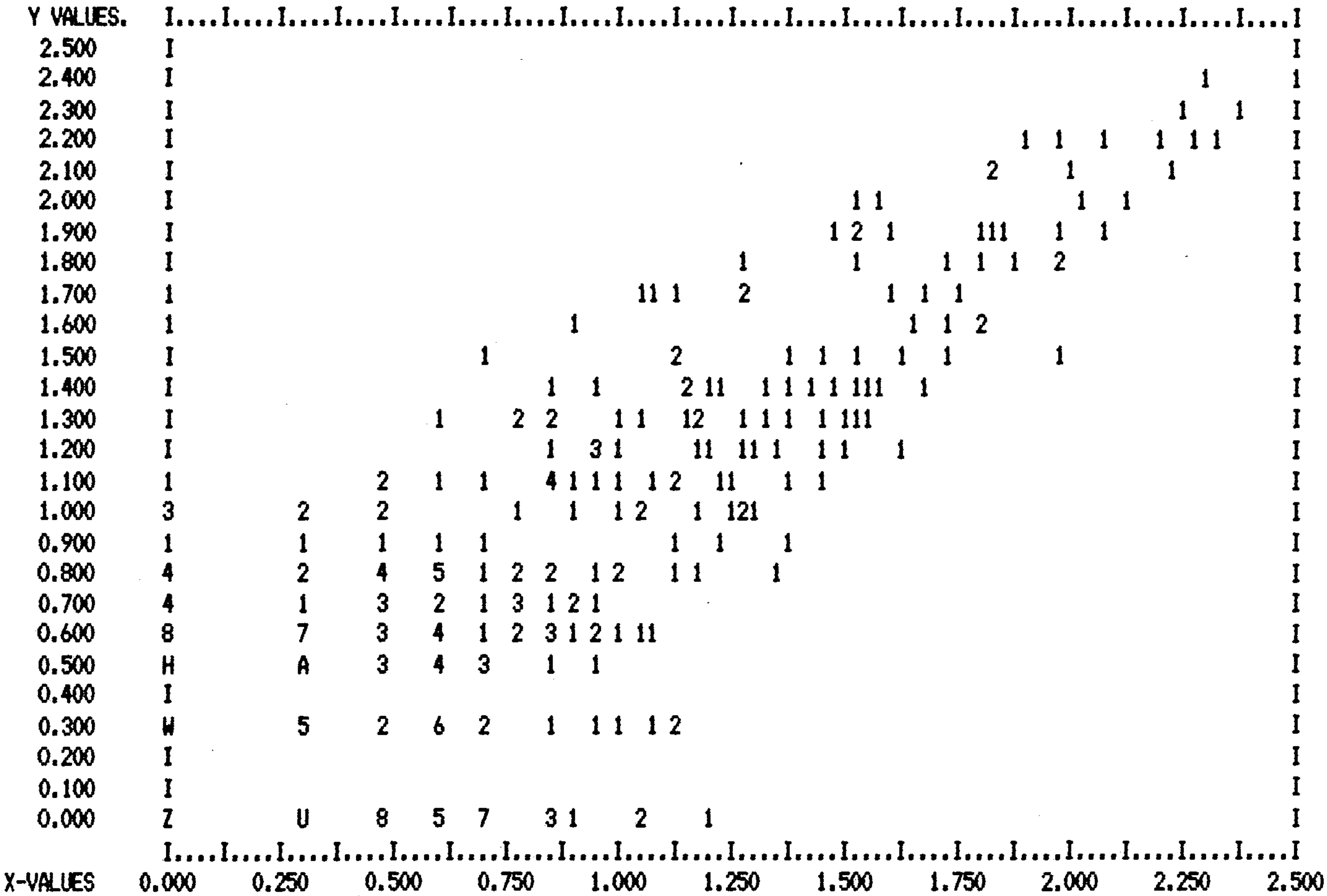
REGRESSION PARAMETERS

	ESTIMATE	S.E.	L.C.L.	U.C.L.
REGRESSION COEFFICIENT	0.744	0.032	0.682	0.806
INTERCEPT	0.215	0.045	0.126	0.303

FREQUENCY CODES

1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	>35

Appendix Table A2. Regression estimates, 95% confidence limits, and significance test (F) for the number of fish larvae and eggs [log (N+1)] in the first (x) and second (y) tows at the same station. Numbers in plot are counts of observations in the 25 x 100 grid.



DESCRIPTIVE STATISTICS

	MEAN	DEVIATION	CORRELATION
INDEPENDENT VARIABLE(X)	0.644	0.647	
			0.837
RESPONSE VARIABLE(Y)	0.687	0.657	

ANALYSIS OF VARIANCE

SOURCE	D.F.	S.S.	M.S.	F-VALUE	P(>F:H0)
REGRESSION	1	136.255	136.255	1049.919	0.000
RESIDUAL	449	58.270	0.130		
TOTAL	450	194.525			

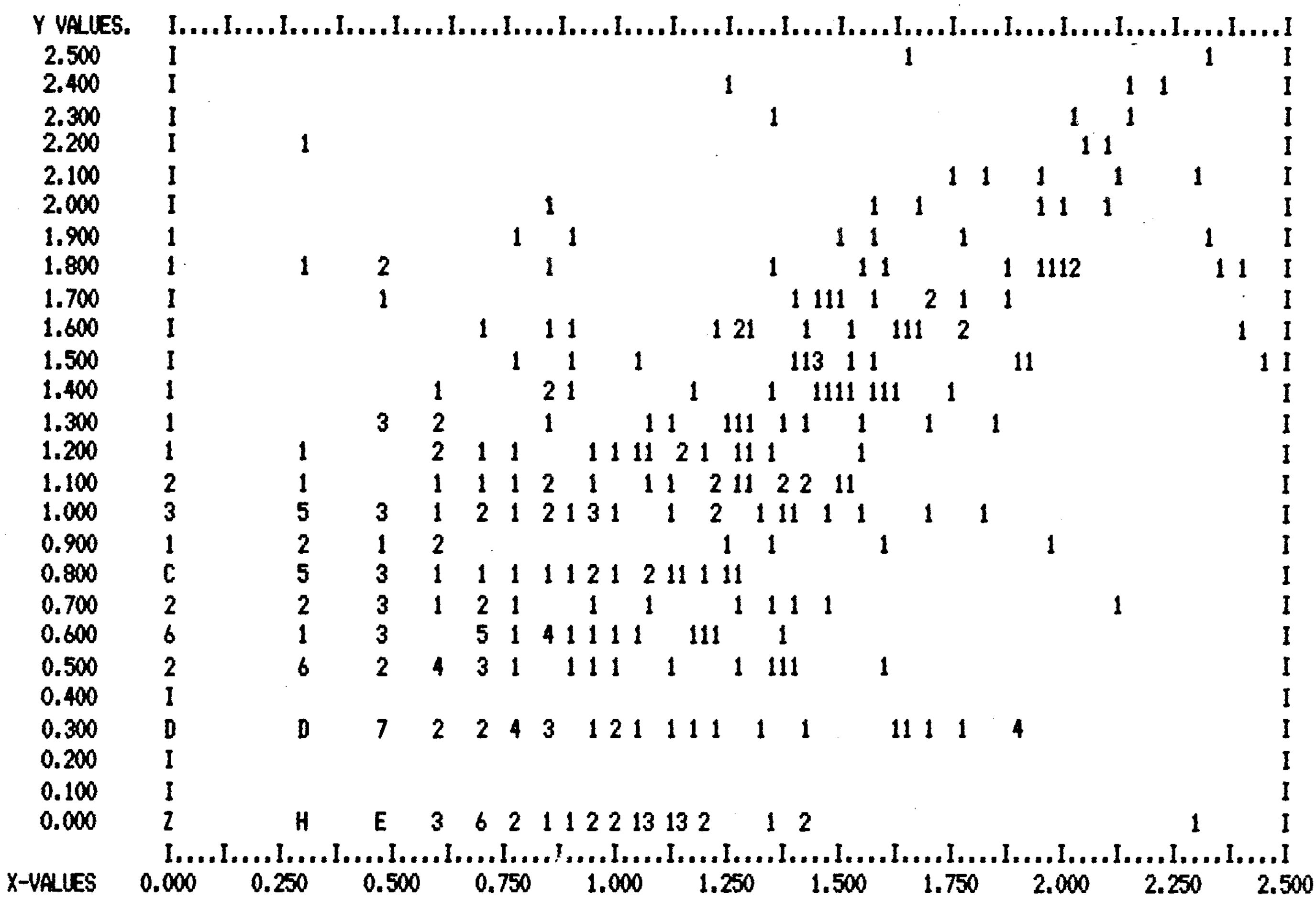
REGRESSION PARAMETERS

	ESTIMATE	S.E.	L.C.L.	U.C.L.
REGRESSION COEFFICIENT	0.851	0.026	0.799	0.902
INTERCEPT	0.139	0.024	0.092	0.186

FREQUENCY CODES

1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	>35

Appendix Table A3. Regression estimates, 95% confidence limits, and significance test (F) for the number of macroinvertebrates [log (N+1)] in the first (x) and second (y) tows at the same station. Numbers in plot are counts of observations in the 25 x 100 grid.



DESCRIPTIVE STATISTICS

	MEAN	DEVIATION	CORRELATION
INDEPENDENT VARIABLE(X)	0.794	0.662	
			0.637
RESPONSE VARIABLE(Y)	0.760	0.674	

ANALYSIS OF VARIANCE

SOURCE	D.F.	S.S.	M.S.	F-VALUE	P(>F:H0)
REGRESSION	1	92.655	92.655	342.546	0.000
RESIDUAL	502	135.786	0.270		
TOTAL	503	228.441			

REGRESSION PARAMETERS

	ESTIMATE	S.E.	L.C.L.	U.C.L.
REGRESSION COEFFICIENT	0.648	0.035	0.579	0.717
INTERCEPT	0.245	0.036	0.174	0.317

FREQUENCY CODES

1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	>35

APPENDIX B

Comparison of environmental variables by means of one-way Analysis of Variance

In the following tables, frequency plots and basic statistical parameters are given for each of six groups (Faka Union Bay, Faka Union Pass, Fakahatchee Bay, Fakahatchee Pass, Pumpkin Bay, and Pumpkin Pass). Group means are indicated by an 'M' in the plots if they coincide with the character "*", otherwise by an 'N'. The 'analysis of variance' section includes the standard F test, Leven's robust test for equal variance, and the Welsh and Brown-Forsythe tests for equal means when variances are not assumed equal. Basic statistic parameters are provided for all groups combined.

Appendix Table B1. Descriptive statistics and one-way analysis of variance tests for surface salinity in the six bay-pass ecological zones. Individual observations are indicated by a *, group means are indicated by 'M' if they coincide with *, otherwise with an 'N'.

```
         FAKAHATCHEE COMPLEX            FAKA UNION COMPLEX              PUMPKIN COMPLEX
             BAY     PASS                  BAY     PASS                   BAY     PASS
MIDPOINTS
  39.000)
  37.500)
  36.000)*                  *              *                *               *****            *
  34.500)******             ***            ****             ******          ************     ******
  33.000)**                                                                 ******           **
  31.500)*************      *******        ***              ******          **************** ********
  30.000)*********          *****          ********         ***             **********       ***
  28.500)************       ********       ***              *******         ********         *******
  27.000)**                 *              *                *               *                M
  25.500)*********          M*             **********       M****           M********        *******
  24.000)****               ****           ***              **              ***********      ***
  22.500)***********        *****          *******          ****            *************    ***
  21.000)M**                               *                                *****
  19.500)*****              *****          ****             ***             *******          *
  18.000)******             *                               **              **               **
  16.500)*******            **             ******           ***             *****            *
  15.000)****                              M****            ***             ***
  13.500)***                *              *****            *               *                *
  12.000)                   **             *******                          ****
  10.500)*******            *              *********                        **               *
   9.000)**                                                 *
   7.500)****                              **************
   6.000)*                                 ********
   4.500)********                          ***
   3.000)*                                 ***
   1.500)*                                 **************
   0.000)
```

	Fakahatchee Bay	Fakahatchee Pass	Faka Union Bay	Faka Union Pass	Pumpkin Bay	Pumpkin Pass
MEAN	21.512	25.438	15.322	25.460	25.983	27.426
STD.DEV.	9.166	6.497	10.094	6.809	6.646	5.840
R.E.S.D.	9.686	6.841	10.976	7.227	7.111	5.796
S. E. M.	0.833	0.938	0.925	0.983	0.607	0.852
MAXIMUM	36.000	36.000	36.000	36.000	36.000	36.000
MINIMUM	1.000	10.000	1.000	9.000	10.000	11.000
SAMPLE SIZE	121	48	119	48	120	47

ALL GROUPS COMBINED (EXCEPT CASES WITH UNUSED VALUES FOR AREA)

MEAN	22.418
STD.DEV.	9.230
R.E.S.D.	9.606
S. E. M.	0.412
MAXIMUM	36.000
MINIMUM	1.000
SAMPLE SIZE	503

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
BETWEEN GROUPS	9677.3938	5	1935.4788	29.07	0.0000
WITHIN GROUPS	33090.9979	497	66.5815		
TOTAL	42768.3917	502			
LEVENE'S TEST FOR EQUAL VARIANCES		5, 497		11.78	0.0000
ONE-WAY ANALYSIS OF VARIANCE TEST STATISTICS FOR WITHIN-GROUP VARIANCES NOT ASSUMED TO BE EQUAL					
WELCH		5, 181		25.28	0.0000
BROWN-FORSYTHE		5, 446		33.81	0.0000

Appendix Table B2. Descriptive statistics and one-way analysis of variance tests for bottom salinity in the six bay-pass ecological zones. Individual observations are indicated by a *, group means are indicated by 'M' if they coincide with *, otherwise with an 'N'.

```
         FAKAHATCHEE COMPLEX              FAKA UNION COMPLEX                PUMPKIN COMPLEX
             BAY     PASS                     BAY     PASS                     BAY     PASS
MIDPOINTS
  39.000)
  37.500)                                                                    **
  36.000)*                *             **              *                    ****                **
  34.500)******           ***           ***             ******               *************** ****
  33.000)**                             *               *                    ****                **
  31.500)***************  ***********   *****           *********            **************21 ***********
  30.000)**********       ******        *****           ***                  *********           ***
  28.500)*************    ******        *********       ******               *****               M******
  27.000)***              N             ****            N                    M                   *
  25.500)**********       **            ***********     *****                *********           ********
  24.000)*                ***           ******          ***                  *********           **
  22.500)M**********      ******        ******          ***                  ***********         **
  21.000)*                              *               **                   *******             *
  19.500)*************    ******        *               **                   *********
  18.000)*****                          M**             ***                  ***                 *
  16.500)*********                      ********        *                    *                   *
  15.000)*                **            ********        **                   *****
  13.500)*********        *             ******          *                                        *
  12.000)****             *             ************                         ****
  10.500)*                              *****                                *                   *
   9.000)                               *
   7.500)****                           *******
   6.000)                               ******
   4.500)*                              ********
   3.000)
   1.500)*                              *
   0.000)
```

	FAKAHATCHEE BAY	FAKAHATCHEE PASS	FAKA UNION BAY	FAKA UNION PASS	PUMPKIN BAY	PUMPKIN PASS
MEAN	23.161	26.542	18.405	26.646	26.607	28.032
STD.DEV.	7.762	6.028	9.136	6.132	6.662	5.591
R.E.S.D.	8.231	6.511	10.146	6.608	7.258	5.324
S. E. M.	0.706	0.870	0.838	0.885	0.608	0.815
MAXIMUM	36.000	36.000	36.000	36.000	37.000	36.000
MINIMUM	1.000	12.000	2.000	14.000	11.000	11.000
SAMPLE SIZE	121	48	119	48	120	47

ALL GROUPS COMBINED
(EXCEPT CASES WITH UNUSED VALUES
FOR AREA)

MEAN	23.968
STD.DEV.	8.146
R.E.S.D.	8.472
S. E. M.	0.363
MAXIMUM	37.000
MINIMUM	1.000
SAMPLE SIZE	503

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
BETWEEN GROUPS	6035.2740	5	1207.0548	22.00	0.0000
WITHIN GROUPS	27274.0970	497	54.8775		
TOTAL	33309.3711	502			
LEVENE'S TEST FOR EQUAL VARIANCES		5, 497		10.49	0.0000

ONE-WAY ANALYSIS OF VARIANCE
TEST STATISTICS FOR WITHIN-GROUP
VARIANCES NOT ASSUMED TO BE EQUAL

	DF	F VALUE	TAIL PROBABILITY
WELCH	5, 181	18.96	0.0000
BROWN-FORSYTHE	5, 450	25.31	0.0000

Appendix Table B3. Descriptive statistics and one-way analysis of variance tests for surface temperature in the six bay-pass ecological zones. Individual observations are indicated by a *, group means are indicated by 'M' if they coincide with *, otherwise with an 'N'.

```
     FAKAHATCHEE COMPLEX              FAKA UNION COMPLEX              PUMPKIN COMPLEX
          BAY     PASS                     BAY     PASS                     BAY     PASS

     ................ ........................................................................
MIDPOINTS
 35.000)
 34.300)**
 33.600)**
 32.900)*              **                              *              *                *
 32.200)***                         ******             *              *****            ***
 31.500)**             *            *                  ***            ****             *
 30.800)               ******       ************       ****           ******           *****
 30.100)*****          ***          ***************    ***            **********
 29.400)***                         ****               ***            **               **
 28.700)**************20 *          **********         ***            ***********      *
 28.000)******         ****         ***                *              **********       *******
 27.300)**********     ***          ****               **             *******
 26.600)***                         M****              *              *                *
 25.900)M*******       **           *****              M              M***
 25.200)*******        M*           **************17   **             *********        M
 24.500)***                         **                 *              *                *
 23.800)*********      *****        ******             ****           *******          ****
 23.100)***            ***          ****               *              ******           ****
 22.400)***            **           ******             **             **               ***
 21.700)*******        *****        *****              ******         ***********      **
 21.000)****           *            ********           ****           ************     *
 20.300)******         ****         *****              *****          ******           **
 19.600)****                                                          **               ***
 18.900)***                                                           *                *
 18.200)****           **                                             *                **
 17.500)*              *                                                               **
 16.800)**             *
```

MEAN	25.569	25.223	26.575	25.800	25.769	25.247
STD.DEV.	4.159	4.446	3.630	4.201	3.919	4.678
R.E.S.D.	4.370	4.876	3.998	4.818	4.368	5.203
S. E. M.	0.378	0.642	0.333	0.606	0.358	0.682
MAXIMUM	34.000	33.000	32.500	33.000	33.000	33.000
MINIMUM	17.000	17.000	20.000	20.000	18.500	17.200
SAMPLE SIZE	121	48	119	48	120	47

ALL GROUPS COMBINED
(EXCEPT CASES WITH UNUSED VALUES
FOR AREA)

MEAN	25.814
STD.DEV.	4.074
R.E.S.D.	4.445
S. E. M.	0.182
MAXIMUM	34.000
MINIMUM	17.000
SAMPLE SIZE	503

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
BETWEEN GROUPS	108.2564	5	21.6513	1.31	0.2589
WITHIN GROUPS	8223.0790	497	16.5454		
TOTAL	8331.3353	502			
LEVENE'S TEST FOR EQUAL VARIANCES		5, 497		2.06	0.0686
ONE-WAY ANALYSIS OF VARIANCE TEST STATISTICS FOR WITHIN-GROUP VARIANCES NOT ASSUMED TO BE EQUAL					
WELCH		5, 170		1.39	0.2306
BROWN-FORSYTHE		5, 324		1.22	0.2983

Appendix Table B4. Descriptive statistics and one-way analysis of variance tests for bottom temperature in the six bay-pass ecological zones. Individual observations are indicated by a *, group means are indicated by 'M' if they coincide with *, otherwise with an 'N'.

	FAKAHATCHEE COMPLEX		FAKA UNION COMPLEX		PUMPKIN COMPLEX	
MIDPOINTS	BAY	PASS	BAY	PASS	BAY	PASS
34.300)						
33.600)	**					
32.900)	***	**				
32.200)	***		*	**	****	**
31.500)	*		*****		***	
30.800)	*	*	**********	***	*******	****
30.100)	*	*********	***********	*****	***	****
29.400)	**		*****	***	*********	**
28.700)	**************23	*	**************	***	******	
28.000)	*********	****	*****	**	***********	*******
27.300)	********	**	*****	****	***********	*
26.600)	*	*			*	
25.900)	*****	**	M******		****	
25.200)	M*********	M	***************	M**	M*********	M*
24.500)	***		***		****	**
23.800)	************	******	*********	*****	****	*****
23.100)	*	**	******	*	***	**
22.400)	**	**		**	**	**
21.700)	*********	***	****	****	*********	***
21.000)	*****	***	*****	*****	*************	*
20.300)	******	****	**********	**	*********	*
19.600)	*****		***	***	***	***
18.900)	*	*		*	**	*
18.200)	*****	**	*		**	***
17.500)		*				
16.800)	***	*				**
16.100)						

MEAN	25.345	24.950	26.170	25.404	25.380	24.979
STD.DEV.	4.138	4.411	3.713	4.108	3.939	4.543
R.E.S.D.	4.364	4.831	4.034	4.676	4.329	4.985
S. E. M.	0.376	0.637	0.340	0.593	0.360	0.663
MAXIMUM	33.800	33.000	32.000	32.200	32.500	32.500
MINIMUM	17.000	17.000	18.000	19.000	18.000	16.500
SAMPLE SIZE	121	48	119	48	120	47

ALL GROUPS COMBINED
(EXCEPT CASES WITH UNUSED VALUES FOR AREA)

MEAN	25.482
STD.DEV.	4.059
R.E.S.D.	4.404
S. E. M.	0.181
MAXIMUM	33.800
MINIMUM	16.500
SAMPLE SIZE	503

ANALYSIS OF VARIANCE TABLE

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	TAIL PROBABILITY
BETWEEN GROUPS	85.5990	5	17.1198	1.04	0.3935
WITHIN GROUPS	8183.7200	497	16.4662		
TOTAL	8269.3190	502			
LEVENE'S TEST FOR EQUAL VARIANCES		5, 497		1.30	0.2607
ONE-WAY ANALYSIS OF VARIANCE					
TEST STATISTICS FOR WITHIN-GROUP					
VARIANCES NOT ASSUMED TO BE EQUAL					
WELCH		5, 171		1.09	0.3696
BROWN-FORSYTHE		5, 333		0.98	0.4269

APPENDIX C

Means, Standard Deviations, and Cross Correlations of Environmental Variables

Variable Name	Description
STEMP	surface temperature
BTEMP	bottom temperature
SSL	surface salinity
BSAL	bottom salinity
SOXY	surface oxygen
BOXY	bottom oxygen
SECHI	secchi disk
RAINFALL	rainfall at Everglades City, Naples, and Ft. Myers
FWDSCH	Faka Union Canal discharges

Appendix Table C1. Means and standard deviations of environmental data.

Entire Golden Gate Area

VARIABLE	CASES	MEAN	STD DEV
STEMP	624	25.4037	3.9506
BTEMP	623	25.0581	3.8979
SSAL	624	23.7194	8.6104
BSAL	624	25.0962	7.5817
SOXY	538	7.0792	1.2287
BOXY	537	6.9477	1.3149
SECHI	601	0.8792	0.3035
DEPTH	624	1.4308	0.7518
RAINFALL	597	45.9529	36.5532
FWDSCH	457	15259.3063	8002.4475

Faka Union Bay Area

VARIABLE	CASES	MEAN	STD DEV
STEMP	214	25.9215	3.7208
BTEMP	214	25.5084	3.6767
SSAL	214	20.4294	10.0362
BSAL	214	22.6505	8.7480
SOXY	189	7.2730	1.0258
BOXY	188	7.1255	1.1781
SECHI	207	0.9116	0.2955
DEPTH	214	1.3710	0.6727
RAINFALL	205	44.3190	36.9196
FWDSCH	156	15299.8846	7910.9736

Fakahatchee Bay Area

VARIABLE	CASES	MEAN	STD DEV
STEMP	206	25.0544	4.0514
BTEMP	206	24.8063	4.0079
SSAL	206	23.8155	7.9123
BSAL	206	25.1214	6.9083
SOXY	174	6.8684	1.3032
BOXY	174	6.7563	1.3741
SECHI	198	0.9141	0.3004
DEPTH	206	1.4913	0.7398
RAINFALL	197	46.8239	36.1671
FWDSCH	151	15036.6225	8140.1356

Pumpkin Bay Area

VARIABLE	CASES	MEAN	STD DEV
STEMP	204	25.2132	4.0439
BTEMP	203	24.8389	3.9874
SSAL	204	27.0735	5.9915
BSAL	204	27.6363	5.9268
SOXY	175	7.0794	1.3225
BOXY	175	6.9469	1.3734
SECHI	196	0.8097	0.3046
DEPTH	204	1.4324	0.8363
RAINFALL	195	46.7908	36.6833
FWDSCH	150	15441.2733	8005.6333

Appendix Table C2. Pearson correlation coefficients for entire study area, July 1982 - June 1984.

	STEMP	BTEMP	SSAL	BSAL	SOXY	BOXY	SECHI	DEPTH	RAINFALL	FWDSCH
STEMP	1.0000	0.9916	-0.2910	-0.3294	-0.3530	-0.3355	0.0015	0.0493	0.5272	0.1677
	(624)	(623)	(624)	(624)	(538)	(537)	(601)	(624)	(597)	(457)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.485	P=0.110	P=0.000	P=0.000
BTEMP	0.9916	1.0000	-0.2864	-0.3271	-0.3691	-0.3454	-0.0016	0.0414	0.5037	0.1618
	(623)	(623)	(623)	(623)	(538)	(537)	(600)	(623)	(596)	(456)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.484	P=0.151	P=0.000	P=0.000
SSAL	-0.2910	-0.2864	1.0000	0.9703	0.0688	0.1217	0.0575	0.1531	-0.4761	-0.1193
	(624)	(623)	(624)	(624)	(538)	(537)	(601)	(624)	(597)	(457)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.055	P=0.002	P=0.080	P=0.000	P=0.000	P=0.005
BSAL	-0.3294	-0.3271	0.9703	1.0000	0.0772	0.1218	0.0839	0.1466	-0.5010	-0.1350
	(624)	(623)	(624)	(624)	(538)	(537)	(601)	(624)	(597)	(457)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.037	P=0.002	P=0.020	P=0.000	P=0.000	P=0.002
SOXY	-0.3530	-0.3691	0.0688	0.0772	1.0000	0.9162	-0.1397	-0.0534	-0.1965	-0.2670
	(538)	(538)	(538)	(538)	(538)	(537)	(537)	(538)	(511)	(398)
	P=0.000	P=0.000	P=0.055	P=0.037	P=0.000	P=0.000	P=0.001	P=0.108	P=0.000	P=0.000
BOXY	-0.3355	-0.3454	0.1217	0.1218	0.9162	1.0000	-0.1046	-0.0201	-0.2456	-0.2612
	(537)	(537)	(537)	(537)	(537)	(537)	(536)	(537)	(510)	(397)
	P=0.000	P=0.000	P=0.002	P=0.002	P=0.000	P=0.000	P=0.008	P=0.321	P=0.000	P=0.000
SECHI	0.0015	-0.0016	0.0575	0.0839	-0.1397	-0.1046	1.0000	0.4454	-0.0151	0.2051
	(601)	(600)	(601)	(601)	(537)	(536)	(601)	(601)	(574)	(435)
	P=0.485	P=0.484	P=0.080	P=0.020	P=0.001	P=0.008	P=0.000	P=0.000	P=0.359	P=0.000
DEPTH	0.0493	0.0414	0.1531	0.1466	-0.0534	-0.0201	0.4454	1.0000	0.0553	0.0482
	(624)	(623)	(624)	(624)	(538)	(537)	(601)	(624)	(597)	(457)
	P=0.110	P=0.151	P=0.000	P=0.000	P=0.108	P=0.321	P=0.000	P=0.000	P=0.089	P=0.152
RAINFALL	0.5272	0.5037	-0.4761	-0.5010	-0.1965	-0.2456	-0.0151	0.0553	1.0000	0.2401
	(597)	(596)	(597)	(597)	(511)	(510)	(574)	(597)	(597)	(457)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.359	P=0.089	P=0.000	P=0.000
FWDSCH	0.1677	0.1618	-0.1193	-0.1350	-0.2670	-0.2612	0.2051	0.0482	0.2401	1.0000
	(457)	(456)	(457)	(457)	(398)	(397)	(435)	(457)	(457)	(457)
	P=0.000	P=0.000	P=0.005	P=0.002	P=0.000	P=0.000	P=0.000	P=0.152	P=0.000	P=0.000

(COEFFICIENT / (CASES) / SIGNIFICANCE) (A VALUE OF 99.0000 IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED)

Appendix Table C3. Pearson correlation coefficients for Faka Union area, July 1982 - June 1984.

	STEMP	BTEMP	SSAL	BSAL	SOXY	BOXY	SECHI	DEPTH	RAINFALL	FWDSCH
STEMP	1.0000	0.9874	-0.2246	-0.2514	-0.2776	-0.3059	-0.0039	0.0819	0.5030	0.1515
	(214)	(214)	(214)	(214)	(189)	(188)	(207)	(214)	(205)	(156)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.478	P=0.116	P=0.000	P=0.030
BTEMP	0.9874	1.0000	-0.2136	-0.2467	-0.3159	-0.3280	-0.0211	0.0610	0.4751	0.1471
	(214)	(214)	(214)	(214)	(189)	(188)	(207)	(214)	(205)	(156)
	P=0.000	P=0.000	P=0.001	P=0.000	P=0.000	P=0.000	P=0.381	P=0.187	P=0.000	P=0.033
SSAL	-0.2246	-0.2136	1.0000	0.9718	0.1860	0.2561	0.1733	0.2863	-0.4783	-0.1181
	(214)	(214)	(214)	(214)	(189)	(188)	(207)	(214)	(205)	(156)
	P=0.000	P=0.001	P=0.000	P=0.000	P=0.005	P=0.000	P=0.006	P=0.000	P=0.000	P=0.071
BSAL	-0.2514	-0.2467	0.9718	1.0000	0.1769	0.2351	0.1815	0.2753	-0.5055	-0.1370
	(214)	(214)	(214)	(214)	(189)	(188)	(207)	(214)	(205)	(156)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.007	P=0.001	P=0.004	P=0.000	P=0.000	P=0.044
SOXY	-0.2776	-0.3159	0.1860	0.1769	1.0000	0.8401	0.0587	0.1154	-0.1273	-0.2201
	(189)	(189)	(189)	(189)	(189)	(188)	(189)	(189)	(180)	(140)
	P=0.000	P=0.000	P=0.005	P=0.007	P=0.000	P=0.000	P=0.211	P=0.057	P=0.044	P=0.004
BOXY	-0.3059	-0.3280	0.2561	0.2351	0.8401	1.0000	0.0623	0.0916	-0.2543	-0.2343
	(188)	(188)	(188)	(188)	(188)	(188)	(188)	(188)	(179)	(139)
	P=0.000	P=0.000	P=0.000	P=0.001	P=0.000	P=0.000	P=0.198	P=0.106	P=0.000	P=0.003
SECHI	-0.0039	-0.0211	0.1733	0.1815	0.0587	0.0623	1.0000	0.4102	0.0103	0.1986
	(207)	(207)	(207)	(207)	(189)	(188)	(207)	(207)	(198)	(149)
	P=0.478	P=0.381	P=0.006	P=0.004	P=0.211	P=0.198	P=0.000	P=0.000	P=0.443	P=0.008
DEPTH	0.0819	0.0610	0.2863	0.2753	0.1154	0.0916	0.4102	1.0000	0.1361	0.0304
	(214)	(214)	(214)	(214)	(189)	(188)	(207)	(214)	(205)	(156)
	P=0.116	P=0.187	P=0.000	P=0.000	P=0.057	P=0.106	P=0.000	P=0.000	P=0.026	P=0.353
RAINFALL	0.5030	0.4751	-0.4783	-0.5055	-0.1273	-0.2543	0.0103	0.1361	1.0000	0.2362
	(205)	(205)	(205)	(205)	(180)	(179)	(198)	(205)	(205)	(156)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.044	P=0.000	P=0.443	P=0.026	P=0.000	P=0.001
FWDSCH	0.1515	0.1471	-0.1181	-0.1370	-0.2201	-0.2343	0.1986	0.0304	0.2362	1.0000
	(156)	(156)	(156)	(156)	(140)	(139)	(149)	(156)	(156)	(156)
	P=0.030	P=0.033	P=0.071	P=0.044	P=0.004	P=0.003	P=0.008	P=0.353	P=0.001	P=0.000

(COEFFICIENT / (CASES) / SIGNIFICANCE) (A VALUE OF 99.0000 IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED)

Appendix Table C4. Pearson correlation coefficients for Fakahatchee area, July 1982 - June 1984.

	STEMP	BTEMP	SSAL	BSAL	SOXY	BOXY	SECHI	DEPTH	RAINFALL	FWDSCH
STEMP	1.0000	0.9939	-0.3449	-0.3720	-0.3501	-0.3105	0.0620	0.1083	0.5375	0.1152
	(206)	(206)	(206)	(206)	(174)	(174)	(198)	(206)	(197)	(151)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.193	P=0.061	P=0.000	P=0.080
BTEMP	0.9939	1.0000	-0.3407	-0.3647	-0.3549	-0.3169	0.0624	0.0973	0.5212	0.1065
	(206)	(206)	(206)	(206)	(174)	(174)	(198)	(206)	(197)	(151)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.191	P=0.082	P=0.000	P=0.097
SSAL	-0.3449	-0.3407	1.0000	0.9701	0.1287	0.1765	0.0830	0.0810	-0.5512	-0.1217
	(206)	(206)	(206)	(206)	(174)	(174)	(198)	(206)	(197)	(151)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.045	P=0.010	P=0.123	P=0.124	P=0.000	P=0.068
BSAL	-0.3720	-0.3647	0.9701	1.0000	0.1248	0.1687	0.1134	0.0716	-0.5469	-0.1294
	(206)	(206)	(206)	(206)	(174)	(174)	(198)	(206)	(197)	(151)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.050	P=0.013	P=0.056	P=0.153	P=0.000	P=0.057
SOXY	-0.3501	-0.3549	0.1287	0.1248	1.0000	0.9363	-0.3108	-0.1126	-0.2936	-0.2859
	(174)	(174)	(174)	(174)	(174)	(174)	(174)	(174)	(165)	(128)
	P=0.000	P=0.000	P=0.045	P=0.050	P=0.000	P=0.000	P=0.000	P=0.070	P=0.000	P=0.001
BOXY	-0.3105	-0.3169	0.1765	0.1687	0.9363	1.0000	-0.2653	-0.0258	-0.2829	-0.2783
	(174)	(174)	(174)	(174)	(174)	(174)	(174)	(174)	(165)	(128)
	P=0.000	P=0.000	P=0.010	P=0.013	P=0.000	P=0.000	P=0.000	P=0.367	P=0.000	P=0.001
SECHI	0.0620	0.0624	0.0830	0.1134	-0.3108	-0.2653	1.0000	0.4720	-0.0378	0.1523
	(198)	(198)	(198)	(198)	(174)	(174)	(198)	(198)	(189)	(144)
	P=0.193	P=0.191	P=0.123	P=0.056	P=0.000	P=0.000	P=0.000	P=0.000	P=0.303	P=0.034
DEPTH	0.1083	0.0973	0.0810	0.0716	-0.1126	-0.0258	0.4720	1.0000	0.0115	-0.0072
	(206)	(206)	(206)	(206)	(174)	(174)	(198)	(206)	(197)	(151)
	P=0.061	P=0.082	P=0.124	P=0.153	P=0.070	P=0.367	P=0.000	P=0.000	P=0.436	P=0.465
RAINFALL	0.5375	0.5212	-0.5512	-0.5469	-0.2936	-0.2829	-0.0378	0.0115	1.0000	0.2601
	(197)	(197)	(197)	(197)	(165)	(165)	(189)	(197)	(197)	(151)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.303	P=0.436	P=0.000	P=0.001
FWDSCH	0.1152	0.1065	-0.1217	-0.1294	-0.2859	-0.2783	0.1523	-0.0072	0.2601	1.0000
	(151)	(151)	(151)	(151)	(128)	(128)	(144)	(151)	(151)	(151)
	P=0.080	P=0.097	P=0.068	P=0.057	P=0.001	P=0.001	P=0.034	P=0.465	P=0.001	P=0.000

(COEFFICIENT / (CASES) / SIGNIFICANCE)   (A VALUE OF 99.0000 IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED)

Appendix Table C5. Pearson correlation coefficients for Pumpkin area, July 1982 - June 1984.

	STEMP	BTEMP	SSAL	BSAL	SOXY	BOXY	SECHI	DEPTH	RAINFALL	FWDSCH
STEMP	1.0000	0.9931	-0.3278	-0.3902	-0.4570	-0.4185	-0.0708	-0.0116	0.5584	0.2334
	(204)	(203)	(204)	(204)	(175)	(175)	(196)	(204)	(195)	(150)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.162	P=0.434	P=0.000	P=0.002
BTEMP	0.9931	1.0000	-0.3344	-0.3986	-0.4583	-0.4142	-0.0683	-0.0100	0.5290	0.2296
	(203)	(203)	(203)	(203)	(175)	(175)	(195)	(203)	(194)	(149)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.171	P=0.444	P=0.000	P=0.002
SSAL	-0.3278	-0.3344	1.0000	0.9653	-0.0460	-0.0243	0.0304	0.0631	-0.5655	-0.1833
	(204)	(203)	(204)	(204)	(175)	(175)	(196)	(204)	(195)	(150)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.273	P=0.375	P=0.336	P=0.185	P=0.000	P=0.012
BSAL	-0.3902	-0.3986	0.9653	1.0000	-0.0102	0.0041	0.0642	0.0677	-0.5705	-0.1856
	(204)	(203)	(204)	(204)	(175)	(175)	(196)	(204)	(195)	(150)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.447	P=0.478	P=0.186	P=0.168	P=0.000	P=0.011
SOXY	-0.4570	-0.4583	-0.0460	-0.0102	1.0000	0.9499	-0.1409	-0.0840	-0.1686	-0.3077
	(175)	(175)	(175)	(175)	(175)	(175)	(174)	(175)	(166)	(130)
	P=0.000	P=0.000	P=0.273	P=0.447	P=0.000	P=0.000	P=0.032	P=0.134	P=0.015	P=0.000
BOXY	-0.4185	-0.4142	-0.0243	0.0041	0.9499	1.0000	-0.1002	-0.0686	-0.2042	-0.2812
	(175)	(175)	(175)	(175)	(175)	(175)	(174)	(175)	(166)	(130)
	P=0.000	P=0.000	P=0.375	P=0.478	P=0.000	P=0.000	P=0.094	P=0.183	P=0.004	P=0.001
SECHI	-0.0708	-0.0683	0.0304	0.0642	-0.1409	-0.1002	1.0000	0.4720	-0.0120	0.2690
	(196)	(195)	(196)	(196)	(174)	(174)	(196)	(196)	(187)	(142)
	P=0.162	P=0.171	P=0.336	P=0.186	P=0.032	P=0.094	P=0.000	P=0.000	P=0.435	P=0.001
DEPTH	-0.0116	-0.0100	0.0631	0.0677	-0.0840	-0.0686	0.4720	1.0000	0.0218	0.1121
	(204)	(203)	(204)	(204)	(175)	(175)	(196)	(204)	(195)	(150)
	P=0.434	P=0.444	P=0.185	P=0.168	P=0.134	P=0.183	P=0.000	P=0.000	P=0.381	P=0.086
RAINFALL	0.5584	0.5290	-0.5655	-0.5705	-0.1686	-0.2042	-0.0120	0.0218	1.0000	0.2230
	(195)	(194)	(195)	(195)	(166)	(166)	(187)	(195)	(195)	(150)
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.015	P=0.004	P=0.435	P=0.381	P=0.000	P=0.003
FWDSCH	0.2334	0.2296	-0.1833	-0.1856	-0.3077	-0.2812	0.2690	0.1121	0.2230	1.0000
	(150)	(149)	(150)	(150)	(130)	(130)	(142)	(150)	(150)	(150)
	P=0.002	P=0.002	P=0.012	P=0.011	P=0.000	P=0.001	P=0.001	P=0.086	P=0.003	P=0.000

(COEFFICIENT / (CASES) / SIGNIFICANCE) (A VALUE OF 99.0000 IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED)

APPENDIX D

Information on Ichthyoplankton

Appendix Table D1. The total number collected, size range (mm), mean length (mm), and standard deviation of the mean of the eight most abundant families of ichthyoplankton in Fakahatchee, Faka Union, and Pumpkin Bay and their passes, July 1982 - June 1984.

	Fakahatchee Complex								Faka Union Complex								Pumpkin Complex											
	Bay				Pass				Bay				Pass				Bay				Pass				TOTAL			
Families	N	Size range(mm)	Mean (mm)	st. dev.	N	Size range(mm)	Mean (mm)	st. dev.	N	Size range(mm)	Mean (mm)	st. dev.	N	Size range(mm)	Mean (mm)	st. dev.	N	Size range(mm)	Mean (mm)	st. dev.	N	Size range(mm)	Mean (mm)	st. dev.	N	Size range(mm)	Mean (mm)	st. dev.
Engraulidae	202	1.9-42.0	5.00	4.66	136	1.3-19.0	3.37	1.69	192	2.5-55.0	8.05	8.80	208	1.8- 8.1	3.43	1.09	349	1.5-50.0	7.51	7.77	168	2.0-10.5	3.90	1.64	1255	1.3-55.0	5.58	6.05
Gobiidae	267	1.3- 6.5	3.18	1.14	78	1.6- 6.5	2.84	1.02	153	1.7- 8.0	3.42	1.29	85	1.3- 4.9	2.45	0.70	196	1.3-13.0	3.56	1.43	121	1.3- 6.0	2.75	1.04	900	1.3-13.0	3.14	1.23
Blenniidae	141	1.3- 7.0	3.46	1.06	117	1.2- 7.0	3.57	1.21	146	1.7- 5.5	3.45	0.68	99	2.2- 5.2	3.34	0.76	93	2.2- 7.0	3.68	1.11	40	2.0- 7.0	3.91	1.14	636	1.3- 7.0	3.52	0.99
Gobiesocidae	98	1.4- 5.5	3.08	0.89	36	1.9- 5.8	3.31	0.92	140	1.3- 5.3	3.09	0.83	13	1.2- 7.0	3.20	1.43	41	1.8- 4.5	3.26	0.60	8	1.5- 5.3	3.11	1.38	336	1.2- 7.0	3.14	0.88
Clupeidae	40	2.0-22.0	8.21	5.54	40	2.5-14.5	6.24	2.27	34	5.3-22.0	11.40	6.00	44	3.5-15.0	6.58	2.46	55	1.8-23.0	8.20	5.40	34	2.5-19.0	7.57	4.26	247	1.8-23.0	7.95	4.79
Sparidae	33	3.0-16.0	9.19	3.23	12	4.0-17.0	9.46	4.16	21	4.8-15.0	10.82	2.90	12	2.2-13.0	5.93	4.09	20	1.9-16.0	6.80	3.46	22	2.4-13.0	8.40	2.85	120	1.9-17.0	8.63	3.61
Sciaenidae	47	1.5-13.0	3.17	1.91	24	1.2- 3.5	2.26	0.56	25	2.0-49.0	7.86	12.18	8	1.9- 3.8	2.58	0.69	28	1.8-20.0	5.08	3.72	33	1.5-15.0	3.11	2.47	165	1.2-49.0	4.03	5.44
Atherinidae	54	3.0 20.0	6.44	3.34	14	3.3-13.0	5.43	2.54	27	3.0-11.0	4.97	2.14	15	3.5- 8.5	5.77	1.59	20	3.0-29.0	7.92	6.84	18	3.0-10.0	5.27	1.65	148	3.0-29.0	6.07	3.59

Appendix Table D2. Larval fish collected, with known spawning and nursery areas, and economic importance, according to available published information.

Species	Spawning Grounds	Nursery Areas	Importance/Uses
Elopidae (tarpon)	offshore	inshore	sport fish
Myrophis punctatus (speckled worm eel)	offshore	offshore and estuary	-
Brevoortia sp. (menhaden)	offshore	estuary	bait fish and fish by-products
Harengula pensacolae (scaled sardine)	offshore	estuary	bait fish and fish by-products
Anchoa hepsetus (striped anchovy)	offshore and estuary	estuary	bait fish
A. mitchilli (bay anchovy)	offshore and estuary	estuary	bait fish
Gobiesox strumosus (stippled clingfish)	inshore	inshore	-
Strongylura marina (Atlantic needlefish)	inshore and fresh water	inshore and fresh water	occassional food source
Lucania parva (rainwater killifish)	fresh water	estuary	-
Membras martinica (rough silverside)	inshore	inshore	bait fish
Hippocampus erectus (lined seahorse)	inshore	inshore	-
Syngnathus sp. (pipefish)	offshore and inshore	offshore and inshore	-
Caranx ruber (bar jack)	offshore	offshore	recreational food source
Elagatis bipinnulata (rainbow runner)	offshore	offshore	recreational food source
Oligoplites saurus (leatherjack)	inshore	inshore	-
Eucinostomus argenteus (spotfin mojarra)	offshore	estuary	baitfish and food source
Haemulon plumieri (white grunt)	offshore	inshore	limited commercial food source
Orthopristis chrysoptera (pigfish)	inshore	inshore	limited commercial food source
Bairdiella chrysoptera (silver perch)	estuary	estuary	baitfish and occassional food source
Cynoscion nebulosus (spotted seatrout)	estuary	estuary	commercial food source
C. regalis (weakfish)	estuary	estuary	commercial food source
Menticirrhus americanus (southern kingfish)	inshore	inshore	commercial food source
M. saxatilis (northern kingfish)	inshore	inshore	commercial food source
Micropogonias undulatus (Atlantic croaker)	offshore	estuary	commercial food source
Pogonias cromis (black drum)	estuary	estuary	limited commercial and recreational food source
Stellifer lanceolatus (star drum)	inshore	inshore	fish by-products
Archosargus probatocephalus (sheepshead)	offshore	inshore	commercial food source
Lagodon rhomboides (pinfish)	offshore	inshore	bait fish and occassional food source
Gobiosoma sp. (goby)	estuary	estuary	-
Triglidae (?) (searobin)	inshore	inshore	occassional food source
Blenniidae (combtooth blenny)	inshore	inshore	-
Mugil curema (white mullet)	offshore	estuary	commercial food source
Achirus lineatus (lined sole)	inshore	estuary	occassional food source
Trinectes maculatus (hogchoker)	estuary	estuary and fresh water	occassional food source
Sphoeroides nephelus (southern puffer)	inshore	inshore	mildly toxic
Chilomycterus schoepfi (stripped burrfish)	offshore	inshore	-

APPENDIX E

Results of four-way ANOVA comparisons of biological abundances.

Appendix Table E1. F-statistic probability levels for factors tested in four-way ANOVA of number of fish per station visit. Significance is assumed for factors with F-probabilities ≤ 0.1 (underlined).

	Species 1	2	3	4	5	6	7	8	9	10	Tot
Main Effects											
Site	0.000	0.232	0.302	0.018	0.000	0.644	0.365	0.049	0.104	0.005	0.002
System	0.001	0.183	0.823	0.036	0.004	0.000	0.118	0.204	0.000	0.171	0.001
Season	0.000	0.251	0.001	0.000	0.126	0.000	0.000	0.000	0.000	0.000	0.000
Salmon	0.000	0.131	0.807	0.015	0.013	0.008	0.300	0.001	0.241	0.783	0.000
2-way Interactions											
Site-Syst	0.526	0.506	0.047	0.362	0.658	0.000	0.748	0.112	0.007	0.003	0.048
Site-Seas	0.016	0.650	0.531	0.010	0.743	0.001	0.166	0.057	0.337	0.017	0.741
Site-Salm	0.102	0.340	0.001	0.250	0.465	0.067	0.139	0.126	0.833	0.582	0.293
Syst-Seas	0.000	0.735	0.730	0.157	0.022	0.000	0.110	0.431	0.009	0.632	0.006
Syst-Salm	0.020	0.311	0.691	0.289	0.347	0.001	0.239	0.221	0.074	0.808	0.518
Seas-Salm	0.000	0.483	0.002	0.023	0.595	0.000	0.016	0.109	0.014	0.138	0.083
3-way Interactions											
Site-Syst-Seas	0.529	0.964	0.861	0.465	0.007	0.000	0.297	0.550	0.327	0.410	0.106
Site-Syst-Salm	0.939	0.627	0.445	0.838	0.730	0.948	0.294	0.833	0.212	0.514	0.647
Site-Seas-Salm	0.646	0.805	0.009	0.537	0.334	0.560	0.496	0.054	0.333	0.829	0.372
Syst-Seas-Salm	0.001	0.884	0.874	0.905	0.408	0.000	0.651	0.013	0.478	0.871	0.410
4-way Interaction	0.151	0.988	0.599	0.965	0.982	0.445	0.783	0.464	0.993	0.094	0.486
Resid Mean Sq. Err.											
4-way	0.193	0.070	0.128	0.289	0.728	0.056	0.104	0.065	0.269	0.293	0.601
3-way (ex salm)	0.315	0.069	0.135	0.290	0.725	0.071	0.105	0.069	0.273	0.291	0.621
3-way (ex seas)	0.372	0.067	0.135	0.360	0.756	0.112	0.111	0.072	0.341	0.317	0.691

Species Key

1. Yellowfin Menhaden
2. Scaled Sardine
3. Cuban Anchovy
4. Striped Anchovy
5. Bay Anchovy
6. Rough Silverside
7. Gulf Pipefish
8. Silver Jenny
9. Pinfish
10. Silver Perch

Site(Bay or Pass) System(Fakahatchee, Faka Union, or Pumpkin) Salmon(Low or High-salinity month)
Season[Winter(Dec-Feb), Spring(Mar-May), Summer(Jun-Aug), or Fall(Sep-Nov)]

Appendix Table E2. F-statistic probability levels for factors tested in four-way ANOVA of ichthyoplankton concentration. Significance is assumed for factors with F-probabilities $\leq$ 0.1 (underlined).

	Species 1	2	3	4	5	6	7	8	Tot
Main Effects									
Site	0.006	0.197	0.070	0.001	0.213	0.031	0.836	0.956	0.314
System	0.652	0.035	0.000	0.000	0.247	0.278	0.045	0.210	0.511
Season	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Salmon	0.785	0.043	0.000	0.433	0.790	0.000	0.363	0.000	0.343
2-way Interactions									
Site-Syst	0.460	0.347	0.059	0.121	0.267	0.928	0.148	0.801	0.940
Site-Seas	0.905	0.483	0.759	0.347	0.277	0.581	0.797	0.797	0.866
Site-Salm	0.381	0.271	0.041	0.258	0.615	0.186	0.284	0.495	0.058
Syst-Seas	0.433	0.101	0.251	0.310	0.162	0.568	0.293	0.966	0.247
Syst-Salm	0.145	0.045	0.862	0.188	0.044	0.363	0.392	0.439	0.437
Seas-Salm	0.000	0.000	0.020	0.033	0.002	0.015	0.142	0.000	0.000
3-way Interactions									
Site-Syst-Seas	0.284	0.620	0.085	0.455	0.291	0.998	0.439	0.278	0.371
Site-Syst-Salm	0.651	0.865	0.168	0.846	0.153	0.566	0.418	0.521	0.677
Site-Seas-Salm	0.518	0.782	0.826	0.643	0.855	0.760	0.869	0.800	0.961
Syst-Seas-Salm	0.947	0.468	0.677	0.631	0.068	0.720	0.755	0.980	0.592
4-way Interaction	0.854	0.837	0.924	0.895	0.051	0.954	0.928	0.908	0.794
Resid Mean Sq. Err.									
4-way	0.978	0.810	0.613	0.802	0.294	0.455	0.369	0.353	0.937
3-way (ex seas)	1.248	1.009	0.678	0.915	0.353	0.481	0.411	0.380	1.185

Species Key

1. Anchovies
2. Gobies
3. Clingfishes
4. Combtooth Blennies
5. Porgies
6. Herrings
7. Silversides
8. Drums

Site(Bay or Pass) System(Fakahatchee, Faka Union, or Pumpkin) Salmon(Low or High-salinity month)
Season[Winter(Dec-Feb), Spring(Mar-May), Summer(Jun-Aug), or Fall(Sep-Nov)]

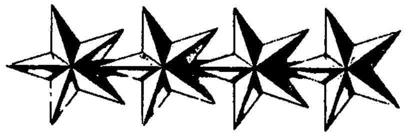
Appendix Table E3. F-statistic probability levels for factors tested in four-way ANOVA of number of macroinvertebrates per station visit. Significance is assumed for factors with F-probabilities ≤ 0.1 (underlined).

	Species 1	2	3	4	5	6	Tot
Main Effects							
Site	0.003	0.000	0.000	0.000	0.891	0.000	0.000
System	0.000	0.130	0.103	0.032	0.146	0.011	0.021
Season	0.000	0.000	0.117	0.043	0.000	0.000	0.000
Salmon	0.000	0.440	0.337	0.067	0.082	0.542	0.016
2-way Interactions							
Site-Syst	0.002	0.000	0.000	0.001	0.034	0.000	0.000
Site-Seas	0.037	0.690	0.929	0.542	0.621	0.000	0.587
Site-Salm	0.761	0.137	0.283	0.697	0.397	0.676	0.583
Syst-Seas	0.034	0.217	0.027	0.743	0.007	0.244	0.060
Syst-Salm	0.539	0.643	0.405	0.392	0.533	0.107	0.456
Seas-Salm	0.015	0.026	0.012	0.000	0.066	0.989	0.049
3-way Interactions							
Site-Syst-Seas	0.074	0.196	0.299	0.159	0.431	0.101	0.188
Site-Syst-Salm	0.531	0.736	0.491	0.857	0.181	0.645	0.798
Site-Seas-Salm	0.651	0.873	0.034	0.796	0.430	0.712	0.663
Syst-Seas-Salm	0.413	0.130	0.419	0.987	0.352	0.949	0.690
4-way Interaction	0.637	0.665	0.901	0.465	0.187	0.738	0.782
Resid Mean Sq. Err.							
4-way	0.203	0.424	0.108	0.200	0.072	0.196	0.458
3-way (ex seas)	0.253	0.462	0.114	0.208	0.080	0.218	0.483

Site(Bay or Pass), System(Fakahatchee, Faka Union, or Pumpkin), Salmon(Low or High-salinity month), Season[Winter(Dec-Feb), Spring(Mar-May), Summer(Jun-Aug), or Fall(Sep-Nov)]

Species Key

1. Pink Shrimp
2. Grass Shrimp
3. Arrow Shrimp
4. Hermit Crab
5. Blue Crab
6. Mud Crab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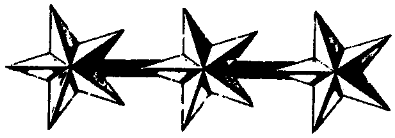
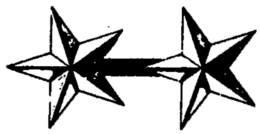
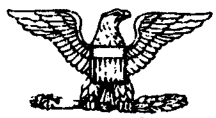

Lieutenant General


Major General


Brigadier General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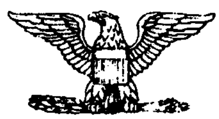
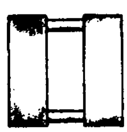

Colonel (left)


Lieutenant Colonel


Major


Captain


First Lieutenant


Second Lieutenant


CWO W-4


CWO W-3


CWO W-2


WO W-1