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A Comparison of Animal Abundance and Distribution in Similar Habitats in Rookery Bay, Marco Island and Fakahatchee on the Southwest Coast of Florida 1971 - 1972

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US Department of Commerce
National Oceanic and Atmospheric Administration
Miami, FL

University of Miami
Rosenstiel School of Marine and Atmospheric Science
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by

Bernard J. Yokel
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Cswy.
Miami, FL

PRELIMINARY REPORT

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Carlos M. Gutierrez, Secretary

National Oceanic and Atmospheric Administration
Conrad C. Lautenbacher, Jr., Vice-Admiral (Ret.), Administrator

National Ocean Service
Jack Dunnigan, Assistant Administrator

For further information please call or write:

Center for Sponsored Coastal Ocean Research
NOAA/National Ocean Service
1305 East-West Highway
Silver Spring, Maryland 20910

COVER PHOTOGRAPH: NOAA/NOS, Coastal Aerial Photography, image 5wj37813. December 5, 1992. Silver Spring, MD.

PREFACE

[PREPARED IN 2006]

There are a significant number of documents and data related to the marine environment of South Florida that have never been published, and are thus not used by scientific community and academia. These documents and data are important because they can help characterize the state of the coastal environment in the past, and thus are essential when evaluating the current state of degradation and setting restoration goals. Due to the nature of the paper and electronic media on which they exist, and in some cases the conditions in which they are housed, the data and documents are in jeopardy of being irretrievably lost. These materials cannot be located using electronic and manual bibliographic searches because they have not been catalogued or archived in libraries.

The purpose of the Coastal and Estuarine Data Document Archeology and Rescue (CEDAR) for South Florida is to collect unpublished data and documents on the South Florida coastal and estuarine ecosystem; convert and restore information judged valuable to the South Florida restoration effort into electronic and printed form, and distribute it electronically to the scientific community, academia and the public. "Data Archaeology" is used to describe the process of seeking out, restoring, evaluating, correcting, and interpreting historical data sets. "Data Rescue" refers to the effort to save data at risk of being lost to the science community.

This report was originally prepared for The Deltona Corporation by the Rosentiel School of Marine and Atmospheric Science. The work was an early environmental asssessment of the Ten Thousand Islands in Southwest Florida.

NOAA/National Ocean Service/National Centers for Coastal Ocean Science (NCCOS) is not responsible for the accuracy of the findings or the quality of the data in rescued documents.

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Bernard J. Yokel
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Cswy.
Miami, FL

ABSTRACT [PREPARED IN 2006]

The three areas in Rookery Bay, near Marco Island and Fakahatchee Bay were sampled from July 1971 through July 1972, and 1,006,640 individual animals were collected, of which the majority (55%) came from the Marco area. The large disparity between the catches at Marco and the remaining study areas was due mainly to the appearance of high numbers of species of polychaetes and echinoderms that were of very minor importance or absent from the catches in Rookery Bay and Fakahatchee Bay. When only the major classes of animals in the catch are considered (i.e., crustaceans, fish and mollusks) the total counts for Fakahatchee (298,830) and Marco (275,075) are quite comparable but both exceed Rookery Bay (119,388) by a considerable margin. The effects of the red tide outbreak in the summer of 1971 were apparently restricted to the Rookery Bay Sanctuary and may account for some of the observed differences. For the purposes of making controlled comparisons between the study areas, three common habitats were selected in each area so that a mud bottom habitat, a sand-shell bottom habitat and a vegetated bottom habitat were located in each of the study areas. Total catches by habitat types for crustaceans, fish and mollusks and certain of the more abundant species show clearly the overwhelming importance of the vegetated bottom as a habitat for animals. By habitat the vegetated areas had the most "indicator species" with five, the mud habitat was next with three and the sand-shell habitat third with two. Thus the vegetated habitat would be the best choice if a single habitat were to be used to detect environmental changes between study areas.

1. INTRODUCTION

In May 1971 the Marco Island Development Corporation supported a baseline research project in the Ten Thousand Islands in Southwest Florida. This project represents part of a larger environmental survey conducted concurrently in the Rookery Bay Sanctuary and at Marco Island. The total program is significant for several reasons:

1. It represents the first coordinated regional study of the upper Ten Thousand Islands;

2. It is a highly pragmatic study designed to produce quantitative environmental data which can be applied to solving the difficult and complex problems of maintaining valuable coastal environments that exist nearby highly developed areas; and

3. It is an example of the benefits that can be derived from cooperative programs between government sponsored studies and private companies.

In recent years the University of Miami has participated with various governmental agencies, private companies and conservation organizations in projects involving assessment of natural resources and management planning for coastal areas. Behind this participation is the belief that society's record in conserving, managing and renewing the environment can be improved by using ecological principles in land planning and development. This concept requires detailed knowledge of the physical and biological systems as well as social and economic input. The variety and complexity of the problem suggests the mutual benefits that are derived from cooperative interorganization programs such as this one.

2. OBJECTIVES

The overall objective of this research is to provide a general description of the biological conditions in the bay systems on the southwest coast of Florida over an annual cycle and to Investigate the interrelationships between these study areas. The specific objectives were:

1. To describe the general distribution and relative abundance of animals in typical habitats in Fakahatchee Bay arid to coordinate this program with similar and concurrent studies in Rookery Bay and near Marco Island.

2. To compare and describe the animal abundance and distribution in similar habitats in each of the three study areas.

Natural coastal systems show wide annual variation in the numbers of animal species and the numbers of individuals that exist in the system. These are "normal" fluctuations reflecting a complex dynamic system responding to a large number of variables and thus in constant change. It may also be assumed that a bay or estuarine system within or near development may be subject to the same or similar "normal" fluctuations and, in addition, variation due to the effects of man's activities. In order to identify and measure the effect of development it is necessary that a measure of the "natural variation" be available.

In measuring the biological conditions in a developed system what is obtained is a measure of the sum of natural plus man-induced variation. These are not readily separable and as a consequence an accurate measure of the effect of development. Independent of natural fluctuations can seldom be made. In this project an unusual opportunity existed in that nearby the developed areas, and those proposed for development, were similar undeveloped systems. These circumstances made possible an experiment to test if nearby similar bay systems, presumably subject to common environmental conditions, exhibited a similar pattern of natural variation. Thus, in addition to providing a basic description of this coastal system it is also intended to compare the biological data with similar data being collected concurrently in Rookery Bay Sanctuary and the Marco area. This will test the hypothesis that the Fakahatchee Bay system can be used as an estimate of natural fluctuation for Rookery Bay and the Marco region thus permitting a more quantitative estimate to be made of the effort of development.

Graphic and tabular data describing the catches of animals in Fakahatchee Bay by months and by sampling stations appear as an Appendix I to this report. Similar data for Rookery Bay may be found in Study 5 of the Rookery Bay Land Use Studies (Yokel, 1975).

3. DESCRIPTION OF THE STUDY AREA

3.1. Rookery Bay

The Rookery Bay Sanctuary and surrounding uplands (Figure 1) are typical or the sand hill region extending from Cape Romano on the south to the Caloosahatchee and Peace Rivers 35 miles to the north. The region is characterized by relatively high elevations, sandy well drained soils in the uplands with occasional sand dunes (of Pleistocene origin), poorly developed coastal marshes and limited runoff from the interior (Davis, 1943).

The Sanctuary is located about five miles south of Naples, Florida, between the Gulf of Mexico and S.R. 951 (Figure 1). It occupies an area of 5,038 acres that include uplands, marshes, mangrove forests, tidal creeks and open-water areas. The mangrove forest is the dominant habitat by area in the Sanctuary; occupying 2,368 acres or 47.0%. The bays and tidal creeks are next covering 1,746 acres or 35.1% with the tidal marsh environment third occupying 688 acres or 13.7%. Hence these three submerged or intertidal habitat types account for over 95% of the surface area in the Sanctuary. The distribution of surface area by elevations shows a similar pattern in which more than 72% of the area is >2 feet in elevation and is constantly submerged or intertidal.

The principal water bodies in the Sanctuary are Rookery Bay and Henderson Creek. Rookery Bay is essentially a marine lagoon covering 1,034 acres, with an average depth of 3.0 feet and an annual mean tidal range of 1.80 feet. Henderson Creek receives most of the freshwater runoff coining into the Sanctuary. It includes 380 acres with an average depth of 2.5 feet and an annual mean tidal range of 1.95 feet. Both bays have good exchange characteristics with outside waters; the mean renewal rate for Rookery Bay is estimated at 3.2 days and 2 days for Henderson Creek (Lee and Yokel, 1973).

3.2. Marco Island

The Marco study area (Figure 2) is centered at 25° 57' North latitude, at the juncture of the Carolinean and West Indian faunal provinces (Andrews, 1971) and at the approximate northern limit of the extensive mangrove estuarine system that makes up the Ten Thousand Islands. From the northeast the area known as the Big Cypress Swamp stretches seaward east of the study area until it unites with the Ten Thousand Islands. In the western portion of this swamp the southward sheet flow has already been altered by an extensive system of drainage canals that carry the water south to Fahka Union Bay in the Ten Thousand Islands and west to Naples Bay (Courtney, 1974; Carter *et al.*, 1973).

3.3. Fakahatchee Bay

Fakahatchee Bay lies on the northwestern edge of Everglades National Park (Figure 3) approximately 15 miles east and slightly south of Marco Island. It is classified as a shallow inland bay covering an area of 1829 acres with an average depth of 3.9 feet (Carter *et al.*, 1973). Bottom sediments are generally mud grading in some areas to a mix of sand and shell. Extensive areas of the bottom have vegetative cover Including attached and unattached algae and seagrasses. Cuban shoal weed (*Diplanthera wrightii*) is the dominant sea grass mixed with light to moderate amounts of turtle grass (*Thalassia testudinum*). Seagrasses tended to be more prevalent in the northern half of the bay which is somewhat shallower than the southern half.

The northern side of Fakahatchee Bay is bordered by a mangrove forest interlaced with small tidal streams and drained by the Fakahatchee and East rivers that empty into Fakahatchee Bay. Farther north the mangroves grade into brackish tidal marshes. The southern edge of the bay is separated from the Gulf of Mexico by the Ten Thousand Islands. The islands are separated by a complex network of relatively deep tidal waterways that connect the bay with the Gulf.

4. SAMPLING STATIONS

4.1. Rookery Bay

Four stations were selected in the Sanctuary for detailed study of the distribution, abundance and seasonal characteristics of animal populations based on trawl catches. The stations were selected after a survey of both Rookery Bay and Henderson Creek and a determination of the major habitat types that could be quantitatively sampled with a small otter trawl. Three of these stations were selected for the interarea comparisons made in this report (Stations 1, 2 and 4).

Trawl Station 1 is located at the northwestern end of Rookery Bay (Figure 1) and has an average depth of 2.5 feet below mean sea level. This station had the densest vegetative cover. The dominant plant was Cuban shoalweed (*Diplanthera wrightii)*. This seagrass is more correctly known as *Halodule wrightii* but in the interest of consistency in this report it will be referred to as *Diplanthera*. Mixed with the *Diplanthera* were relatively minor quantities of turtlegrass (*Thalassia testudinum*) and along the deeper fringes of the station the phanerogam *Halophila engelmanni*. Together with this rooted vegetation were seasonal accumulations of unattached algae such *Laurencia* sp. and *Gracilaria* sp. The substrate was a mix of sand, mud and shell fragments. For the purposes of the interarea comparisons in this report, this station was characterized as having a vegetated bottom.

Trawl Station 2 is located approximately in the middle of the central basin of Rookery Bay and has an average depth of 4.0 feet below mean sea level. This station has virtually no vegetative cover; on only a few occasions did trawl samples contain relatively small quantities of unattached algae. The substrate here is predominantly mud with some sand and shell fragments. For the purposes of the interarea comparisons in this report this station was characterized as having a mud bottom.

Trawl Station 4 is located in the southwestern end of Henderson Creek and has an average depth of 3.5 feet below mean sea level. The bottom at this station had few seagrasses or attached vegetation. Vegetation taken at this station was usually unattached algae such as *Laurencia* sp. and *Gracilaria* sp.

This station is in the approaches to the channel that connects Rookery Bay and Henderson Creek and therefore, exhibited more tidal current than the other stations. As a consequence substrate particles are larger, firmer and more thoroughly sorted than elsewhere. For the purposes of the interarea comparisons in this report this station was characterized as having a sand/shell bottom.

4.2. Marco Island

Three trawl stations were selected near Marco Island (Figure 2) to be as similar as possible to the stations in Rookery Bay.

Trawl station 1 is located on a shallow water turtle grass flat bordering the Marco River in the area NW of the Route 951 High level bridge to Marco Island. The depth is 2 - 3 feet over muddy sediments. For the purposes of the interarea comparisons in this report this station was characterized as having a vegetated bottom.

Trawl station 2 is located on an open scoured bay bottom in the southern end of Johnson Bay near the Isle of Capri. The depth is 4 feet over a muddy-sand and shell bottom. For the purposes of the interarea comparisons this station was characterized as having a sand/shell bottom.

Trawl station 3 was located in an open bay just east of the S.R. 951 bridge. The depth was 3 - 5 feet over a mud bottom that supported some sponge. For the purposes of the interarea comparisons this station was characterized as having a mud bottom.

4.3. Fakahatchee Bay

As in the Marco Island area the trawl stations in Fakahatchee Bay were selected to be as similar as possible to those in Rookery Bay.

Trawl station 1 is located in the western end of the Bay (Figure 3). The depth is 3 - 4 feet over a mud sand/shell substrate. Slight to moderate amounts of Cuban shoal weed (*Diplanthera wrightii)* and unattached green and brown algae were observed on this station. For the purposes of the interarea comparisons this station was characterized as having a sand/shell bottom.

Trawl station 2 is located on the north side of the bay near the mouth of the Fakahatchee River. The depth is approximately 5 feet over a soft muddy bottom. Very little vegetation was observed on this station. For the purposes of the interarea comparisons this station was characterized as having a mud bottom.

Trawl station 3 is located in the eastern end of the Bay. The depth is 2 - 3 feet over a mud bottom. Relatively dense stands of Cuban shoal weed (*Diplanthera wrightii*) mixed with light to moderate quantities of turtle grass (*Thalassia testudinum)* were observed here. For the purposes of the interarea comparisons this station was characterized as having a vegetated bottom.

Hydrographic data including observed monthly temperature, salinity, oxygen concentrations and the weights of collected vegetation by station for Fakahatchee Bay may be found in Appendix II of this report. Similar data for Rookery Bay may be found in Yokel (1975).

5. METHODS

Sampling of the benthic communities at the three trawling stations in each area was done with a 10 foot otter trawl. The body of the net was made of 3/4 inch bar mesh webbing and fitted with a 1/4 inch bar mesh liner in the cod end. Trawling was conducted after dark simultaneously in each of the three areas using fiber-glass hull boats equipped with outboard engines. Preliminary trawl sampling in Rookery Bay and earlier experience in estuarine areas of Everglades National Park showed that catches of many animals especially fish and crustaceans were improved by sampling at night.

Samples were taken monthly near the new moon phase of the lunar cycle from July 1971 through July 1972. Sampling was conducted on moonless nights to better standardize the sampling method by avoiding variation in catches that may be induced by moonlight.

Prior to trawling at each station, surface and bottom measurements were made of the temperature and dissolved oxygen. Temperature was measured with a bucket thermometer and read to the nearest 0.1 °C; dissolved oxygen was measured with a Yellow Springs Instrument Co. (YSI) Model 54 Oxygen Meter (accuracy ±0.15 ppm). Surface and bottom salinity samples were stored in polyethylene bottles and returned to the laboratory where they were read with a Goldberg temperature compensated refractometer (accuracy ±0.5 ppt).

At each station, seven parallel trawl drags were made in the same direction. Seven drags were used based on work by Roessler (1965) that showed this to be a minimum to detect a 50% change in the population size with 95% confidence. For each drag the net was pulled at a speed of about 1.5 MPH (1,000 RPM on the engine tachometer) for 2.25 minutes during which time the trawl covered approximately 300 feet. This was established as a standard trawl drag and seven such drags were used as a standard effort at each station.

The total catch from each drag was removed from the net and preserved in 10% formalin solution. The preserved samples were sorted in the laboratory and the vegetative material was separated from the animals. The plants were then dried and weighed. Where possible, the animals were identified to species, counted and in the case of fish and certain crustaceans, all or a randomly selected percentage of the catch were measured.

6. ANALYSIS PROCEDURES

Detailed statistical analyses were restricted to the more abundant species in the general classification of fish, crustaceans and mollusks. Analysis of variance techniques and multiple range tests were used to test catches from similar bottom environments in the three study areas. Parametric statistical tests such as these are based on the assumptions that treatment and environmental effects are additive and that the data distributions are normal (Steel and Torrie, 1960). Trawl catch data frequently do not meet these requirements and it has been shown that a transformation to a logarithmic scale produces better agreement (Snedecor and Cochran, 1967). Furthermore, because the data sets contain values of zero for which there is no real logarithm, each monthly catch value has been increased by one. This increase applies only for the purposes of statistical computation and does not affect tabular values of monthly catches. Hence the transformation for statistical analysis became: $\log_{10}$ (monthly catch +1).

For the selected species a two-way analysis of variance was used to test the differences among stations and the seasonal effect represented by months. Where significant differences existed between stations a Newman-Keuls multiple range-test (Steel and Torrie, 1960:110) was applied as a means of comparing each station mean with all others to determine the interarea relationships (Tables 1 - 3).

7. RESULTS AND DISCUSSION

A trawl study of three similar benthic environments in each of three study areas at Rookery Bay Sanctuary, Marco Island and Fakahatchee Bay was conducted from July 1971 to July 1972. The 13 month study collected and identified 1,006,690 animals representing over 190 species and 11 major taxa of animals (Table 4). As is typical of comprehensive estuarine studies, the great majority of animals belong to relatively few species. In this study, considering the total catch of animals from the major study areas, three important taxa represented by crustaceans, fish and mollusks accounted for 69% of the animals collected and over 90% of the species. Considering the study areas individually, these same taxa comprised 96% of the total catch in Rookery Bay, 92% in Fakahatchee Bay and 50% in the Marco area. The relatively low percentage in the Marco area is due to very large catches of polychaete worms (family Sabellidae), other unidentified polychaetes and a small echinoderm (*Leptosynapta parvipatina*: holothurian) during the fall and winter of 1971-72, These large catches were taken in relatively few sampling trips and in the Marco area constituted a "bloom" of abundance for these species not observed in the other two areas.

The crustaceans, fish and mollusks clearly dominated the overall catches and are better understood taxonomically. For these reasons, the comparisons between the three areas will deal mainly with those taxa.

7.1. Crustacea

There have been relatively few systematic surveys of marine and estuarine crustaceans in southern United States. The most comprehensive work was produced by Williams (1965) and represents an exhaustive survey of the decapod crustacean in the Carolinas. Earlier studies by Rathbun (1918, 1925, 1930, 1937) and Holthuis (1951, 1952) have dealt with particular groups in this classification. In south Florida, Tabb and Manning (1961) studied the biota including the crustaceans in Florida Bay and Whitewater Bay in Everglades National Park. More recently, surveys have been made in Biscayne Bay (Anonymous, 1971) and in the Ten Thousand Islands in southwest Florida (Carter, 1973, Section XIV; Evink, 1973).

In the present study a total of 542,127 crustaceans representing over 50 species were collected in the three study areas. These animals represent 54% of the total catch and approximately 25% of the total number of species.

A comparison of the crustacean catches by study area shows that the largest catches were made at Marco and Fakahatchee Bay (43 and 41%, respectively) with 16% coming from Rookery Bay (Figure 4). A further comparison of the distribution of crustaceans in the three general habitat types (sand-shell bottom, mud bottom and vegetated bottom) sampled in the three study areas shows the dominance of the vegetated areas (Table 5). The catches in the vegetated habitat were 2.4 times larger than the catches in the sand-shell habitat and 3.2 times greater than the mud habitat.

The four most numerous species of crustaceans have been selected for individual comparison and analysis. These species together comprise 38% of the crustaceans caught and each constituted 4% or more of the total crustacean catch. The selected species are all decapod crustaceans in suborder Natantia and include the following: *Periclimenes amerlcanus, Periclimenes longicaudatus, Penaeus duorarum* and *Hippolyte pleuracantha.*

The dominant species are caridean or penaeid shrimp and all show certain similarities in their distribution in the study areas. The analysis of variance tests (Table 1) explore the differences and similarities in the catch rates between common habitat types in the three study areas and among months in the 13 month study. Statistical significance among months usually indicates the strong seasonal character of the catch rates observed for some species.

The differences and interrelationships between the study areas for each species in the three habitat types are shown in the multiple range test (Table 1). In the multiple range test study areas are coded (1 = Rookery ; 2 = Fakahatchee Bay; and 3 = Marco area) and in each test the study areas arranged according to mean catch rates; lowest on the left, highest on the right. The patterns of similarities and differences between the three study areas are indicated by the underscored lines. Any study area not underscored by the same line is significantly different. Any set of study areas underscored by the same line are not significantly different (Steel and Torrie, 1960:109).

For seven of the 12 multiple range tests conducted on four species of crustaceans no differences could be detected in the catch rates among the three study areas. The reader will note some small discrepancies in the results of the analysis of variance tests and multiple range tests. In three of the tests, highly significant differences are indicated in the analysis of variance results but no differences in the multiple range tests. These anomalies are due to a slight gap in the sensitivity of the two tests and occur only when the F value for the analysis of variance has between 5 and 6, near the lower limit of F at $P \leq 0.01$. Using a probability level of $P \leq 0.05$ instead of $P \leq 0.01$ for the multiple range test, the differences can be detected in all cases. This will be developed in more detail in the discussion on individual species.

7.1.1. *Hippolyte pleuracantha*

7.1.1.1. Literature

Hippolyte pleuracantha is a caridean shrimp in the family Hippolytidae. It is known in the US from New Jersey to Galveston, Texas (Williams, 1965), A few authors have reported on the taxonomy, life history and distribution of this species (Tabb and Manning, 1961; Tabb *et al.,* 1962a; Williams, 1965; Anonymous, 1971; Carter *et al.,* 1973, Section XIV; Yokel, 1975).

7.1.1.2. Seasonal Abundance and Distribution

H. pleuracantha is the fourth most abundant crustacean species taken in the present study (Figure 5, Table 5). A total of 21,578 individuals were collected from all areas representing 4% of the crustacean catch. The overwhelming majority were taken in the vegetated stations where catches totaled 15,581 (72%) followed by the sand-shell habitat with 5,356 (25%) and the mud habitat with 641 (3%).

The analysis of variance (Table 1) shows no significant difference in catch rates among months or between study areas for the vegetated and mud bottom sampling areas. In the sand-shell habitat significant differences were detected among months ($P \leq 0.05$) and between study areas ($P \leq 0.01$). In the latter habitat the relatively high catches in Fakahatchee Bay (Figure 5) probably account for the differences between study areas as well as the monthly differences.

The relatively close agreement in catch rates between study areas for the vegetated and mud bottom habitats suggests that during the period of the study these habitats supported similar populations of *H. pleuracantha*. This data is especially useful in the case of the vegetated habitat because of the higher catches made there.

These data suggest that *H. pleuracantha* is potentially an indicator species of environmental change. The consistent catch rates in two of the three test habitats suggest that for these two habitats *H. pleuracantha* is responding in a comparable way in all three study areas and presumably changes in the physical or biological conditions in these habitats in one of the study areas could produce detectable changes in the relative abundance of this shrimp.

7.1.2. *Penaeus duorarum*

7.1.2.1. Literature

Penaeus duorarum, commonly known as the pink shrimp, is a member of the family Penaeidae. In the United States this species is found along the south Atlantic coast, from Chesapeake Bay and through the Gulf. The pink shrimp is taken commercially over much of its range, and in Florida supports the most valuable fishery in the State. Landings of pink shrimp from Florida waters come mainly from the Tortugas grounds near Key West, Florida. Because of its commercial importance and extensive range, a large body of literature exists on this species. The most important literature summarizing the life history, and those papers applicable to the southwest coast of Florida, are presented here (Tabb and Manning, 1961; Tabb *et al.*, 1962; Costello and Allen, 1966, 1970; Idyll *et al.*, 1968; Munro *et al.*, 1968; Perez Farfante, 1969; Yokel *et al.*, 1969; Roessler and Rehrer, 1971; Yokel, 1975).

7.1.2.2. Seasonal Abundance and Distribution

The pink shrimp is the third most abundant crustacean and the most abundant penaeid in the current study (Figure 6, Table 5). A total of 53,371 individuals were collected from all areas representing 10% of the total crustacean catch. This species was most abundant in the vegetated habitat where catches totaled 32,845 (61% of the total pink shrimp caught) followed by the sand-shell habitat with 11,490 (22%) and the mud habitat with 9,036 (17%).

The pink shrimp was one of the few species in this study that was taken in all habitats and in all months. While differences in catch rates between seasons and between study areas are apparent (Figure 6), they are less pronounced than for most other species, indicating a more generalized distribution and possibly broader environmental tolerances. Modest seasonal increases in relative abundance can be seen, especially in the vegetated habitat during the warm months beginning in May or June and ending in October or November. Moderate peaks of abundance occurred during the summer or early fall with periods of low relative abundance coming in the winter.

The results of the analysis of variance tests show no significant difference in catch rates among months or between study areas for the vegetated habitat. For the remaining two habitats significant differences were observed among months and between study areas. The results of the multiple range test for the mud habitat contradict the analysis of variance results and indicate, that there is no significant difference between study areas. This reflects the slight differences in the sensitivity of the two tests mentioned earlier. If a probability of $P \leq 0.05$ is applied to the multiple range test it can be shown that there Is no detectable difference in the catch rates between the Marco and Rookery Bay study area and that the catch rates for Fakahatchee Bay are significantly different. This is exactly the pattern observed for the catch rates of *P. duorarum* in the sand-shell habitat.

Since patterns of abundance in the mud and sand-shell habitats of Fakahatchee Bay are apparently different from the corresponding habitats in the Marco and Rookery Bay study areas it is unlikely that the catch rates of *P. duorarum* from these two habitats in Fakahatchee Bay would be useful in explaining or understanding any subsequent fluctuations in abundance at Marco or Rookery Bay. However, the catch rates of *P. duorarum* in the vegetated habitat were relatively consistent between study areas and indicate that catch rates of *P. duorarum* in the vegetated areas may be useful to detect changes in the other study areas.

7.1.3. *Periclemenes americanus*

7.1.3.1. Literature

Periclemenes americanus is a caridean shrimp in the family Palaemonidae. It is known in the US from Beaufort, North Carolina and in Florida from Jupiter Inlet to Hernando County on the Gulf coast (Williams, 1965). A few authors have reported on the, taxonomy, life history and distribution of this species (Tabb and Manning, 1961; Tabb *et al.,* 1962; Williams, 1965; Carter *et al.,* 1973, Section XIV; Yokel, 1975).

7.1.3.2. Seasonal Abundance and Distribution

P. americanus was the most abundant crustacean species taken in the present study (Figure 7; Table 5). A total of 67,181 individuals were collected from all areas representing 12% of the total crustacean catch. This species was most abundant in the vegetated stations where catches totaled 40,411 (60% of the total *P. americanus* caught) followed by the mud habitat with 14,446 (22%) and the sand-shell habitat with 12,324 (18%). *P. americanus* was taken at nearly every station in every month during the study. It was not collected in the mud habitat in two months at Fakahatchee Bay and one month at Marco. This points up its relatively wide distribution in different habitats in all seasons in the mangrove-estuarine environment of southwest Florida. Periods of high relative abundance varied among areas, but occurred most frequently in the winter and spring with peaks between January and March. In the vegetated habitat the period of abundance was longer extending from September through April. After April catches generally declined to a seasonal low during the summer.

While *P. americanus* is apparently widely distributed, the analysis of variance results show that it also exhibits wide variation in the catch rates between areas. The tests between areas were highly significant ($P \leq 0.01$) in all three habitats (Table 1). This suggests that the population of *P. americanus* are reacting independently and that this species would not be especially useful in detecting or understanding differences in the catch rates in similar environments in nearby areas.

7.1.4. *Periclemenes longicaudatus*

7.1.4.1. Literature

Periclimenes longicaudatus is a caridean shrimp in the family Palaemonidae. It is known in the United States from Hatteras, North Carolina to the southwestern Florida coast (Williams, 1965). A few authors have reported on the taxonomy, life history and distribution of this species (Tabb and Manning, 1961; Tabb *et al.,* 1962; Williams, 1965; Carter *et al.,* 1973, Section XIV; Yokel, 1975).

7.1.4.2. Seasonal Abundance and Distribution

P. longicaudatus was the second most abundant crustacean species collected in the current study (Figure 8; Table 5). A total of 63,023 individuals were taken from all areas representing 12% of the total crustacean catch. The vast majority of the individuals were taken in the vegetated habitat where catches totaled 45,279 (72% of the total *P. longicaudatus* caught), followed by the sand-shell habitat with 15,740 (25%) and the mud environment with 2,004 (3%).

This species was common in all three study areas and was present in a high proportion of the monthly samples. In the vegetated areas where catches were highest, the seasonal period of high relative abundance started in August or September and extended through March or April. Peaks of abundance came from October through December. Zero catches, and low relative abundance consistently occurred in the summer months.

The general distribution of this species in the study areas show it to be more seasonal and more strongly oriented toward a vegetated habitat than its close relative *P. amerlcanus.*

The analysis of variance results show that variation associated with months was significant in all three study areas reflecting the strong seasonal characteristics of the catches especially in the sand-shell and vegetated habitats (Table 1). Highly significant differences were also observed between study areas in the sand-shell and mud habitat, however, significant differences could not be detected in the vegetated areas.

These data indicate that *P. longicaudatus* could be used as an indicator species to detect changes in one (and possibly two) of the study areas as measured by the relative abundance of this species. Because of the high variation in catch rates between study areas in the sand-shell and mud habitats it would appear as with several other crustacean species that the catch rates from vegetated habitat would be most useful in such an analysis.

7.2. Fish

There has been relatively few systematic surveys of marine and estuarine fish in southwest Florida. Early surveys included work by Lonnberg (1894) and Evermann and Kendall (1900). More recently comprehensive studies on the fishes of Everglades National Park in Whitewater Bay and Florida Bay have been reported by Tabb and Manning (1961), Roessler (1967) and dark (1970) and Tabb *et al.* (1974). In Fakahatchee Bay in the Ten Thousand Islands, studies of the distribution of fishes are reported by Carter *et al.* (1973: Section XV) and the food habits of dominant species of fish have been studied by Adams *et al.* (1973). Further north Gunter and Hall (1965) investigated the fishes in the Caloosahatchee River and associated estuaries and Wang and Raney (1971) reported on the fishes of Charlotte Harbor.

In the present regional study of selected estuaries in southwest Florida a total of 30,456 fish representing over 59 species were collected. These animals represented 3% of the total catch and approximately 30% of the total number of species.

A comparison of the fish catches by study area shows a majority of the fish (50%) were taken in Fakahatchee Bay With 26 and 24% respectively coming from Mareo and Rookery Bay.

The vegetated areas clearly favor certain species of fish. The high total count of fish in this habitat were due to large catches of pinfish (*Lagodon rhomboides*) and the silver jenny (*Eucinostomus gula*) which accounted for 56% of the fish taken. Five dominant species of fish have been selected for individual discussion and analysis. These species together comprise 75% of the fish caught and Include the following: the pinfish (*Lagodon rhomboides*), the silver jenny (*Eucinostomus gula*), the pigfish (*Orthopristis chrysoptera*), the silver perch (*Bairdiella chrysura*) and the lane snapper (*Lutjanus synagris*). The common fish names are taken from Bailey *et al.* (1970).

7.2.1. Lane Snapper (*Lutjanus synagris*)

7.2.1.1. Literature

The lane snapper is a member of the family Lutjanidae (snappers). It is a common inshore game and food fish ranging in the United States from the Carolinas into the Gulf of Mexico. The literature on this species includes a limited number of reports dealing mainly with distribution, food habits and size data: Reid, 1954; Springer and Bullis, 1956; Springer and Woodburn, 1960; Tabb and Manning, 1961; Gunter and Kail, 1965; Wang and Raney, 1971; Yokel, 1975.

7.2.1.2. Seasonal Abundance and Distribution

The lane snapper was the fifth most abundant fish and the most abundant snapper in the present study (Figure 10; Table 5). A total of 531 Individuals were taken from all study areas representing about 2% of the total fish catch. The total catch was highest in the vegetated habitat where 252 individuals were taken (47% of the total lane snapper caught), followed by the sand-shell habitat with 162 (31%). and the mud habitat with 117 (22%).

Seasonally, lane snapper were most abundant in the study areas between July and January. Peaks of high relative abundance were variable in particular habitats but occurred most frequently in late summer or fall. After January catches usually declined to a low level until June after which increases were usually observed.

The analysis of variance test (Table 2) revealed highly significant differences ($P \leq 0.01$) between months and between study areas in the vegetated habitat. The differences between months reflect the strong seasonal pattern of the catches. The differences between study areas were due to the extraordinary high catches taken in the vegetated habitat in the Marco study area. This is borne out by the multiple range test that shows that for lane snapper no difference in catch rates could be detected between the vegetated areas in Rookery Bay and Fakahatchee Bay but highly significant difference could be shown between these study areas and Marco.

For the mud habitat there was no detectable difference between months but a highly significant difference between study areas. The latter condition reflects the fact that lane snapper did not occur in the mud habitat in Fakahatchee Bay. The multiple range test supports this showing catch rates in Fakahatchee Bay to be significantly different from the other two study areas.

In the sand-shell habitat no differences could be detected in either months or area tests. These data suggest that for the lane snapper the sand-shell habitat would be superior to the other habitats to detect differences between the study areas.

7.2.2. Silver Jenny (*Eucinostomus gul*

7.2.2.1. Literature

The silver jenny is a member of the family Gerridae (mojarras) and is an abundant forage species in the inshore and estuarine areas of the Atlantic and the Gulf of Mexico. A number of authors have reported on habits of this species (Reid, 1954; Kilby, 1955; Springer and Bullis, 1956; Springer and Woodburn, 1960; Tabb and Manning, 1961; Roessler, 1967; Waldinger, 1968; Clark, 1970; Odum, 1970; Wang and Raney, 1971; Adams *et al.,* 1973; Carr and Adams, 1973; Carter *et al.,* 1973, Section XV; Tabb *et al.,* 1974; Yokel, 1975).

7.2.2.2. Seasonal Abundance and Distribution

The silver jenny was the second most abundant fish taken in the current study (Figure 11; Table 5). A total of 8,277 individuals were taken from all study areas representing 27% of the total fish catch. The majority of this species were taken in the vegetated habitat where catches totaled 4,336 individuals (52% of the total silver jenny caught), followed by the sand-shell habitat with 2,533 (31%), and the mud habitat with 1,408 (17%).

The silver jenny was taken in every monthly sample in all study areas and all habitats indicating clearly its wide tolerances and generalized distribution in the estuarine systems of southwest Florida.

Seasonally, the silver jenny were more abundant in the study areas during the summer and early fall (June or July through October). Peaks of high relative abundance came generally between July and September in all habitats. Catches were variable during the fall and early winter but consistently declined to the lowest annual level during March and April.

The analysis of variance test showed differences in monthly catch rates to be significant ($P \leq 0.05$) or highly significant ($P \leq 0.01$) in all study areas (Table 2). As with other species this represents seasonal changes in catch rates. A highly significant difference between study areas was observed in the mud habitat. This represents the relatively low catches of silver jenny in the mud habitat of Fakahatchee Bay compared to the other two study areas and is supported by the multiple range test which shows the mud habitat of Fakahatchee Bay to have the lowest mean catch rates for the silver jenny and to be significantly different from the remaining study areas.

Significant differences could not be detected between the study areas in the sand-shell and vegetated bottom habitats.

The relatively close agreement in catch rates between the three study areas in the sand-shell and mud habitat suggests that the silver jenny population are responding to similar environmental factors in these habitats and that the catch rates of this species could serve as an indicator of environmental change in one of the study areas.

7.2.3. Pigfish (*Orthopristis chrysoptera)*

7.2.3.1. Literature

The pigfish is a member of the family Pomadasyidae (grunts). It is a common fish along the south Atlantic and Gulf coasts and has a minor role as both a food and gamefish, specially in Florida. The literature on this species included reports on the life history, food habits, distribution and spawning habits (Hildebrand and Schroeder, 1928; Hildebrand and Cable, 1930; Gunter, 1945; Reid, 1954; Kilby, 1955; Springer and Bullis, 1956; Springer and Woodburn, 1960; Tabb and Manning, 1961; Roessler, 1967; Clark, 1970; Carter *et al.,* 1973, Section XV; Yokel, 1975).

7.2.3.2. Seasonal Abundance and Distribution

The pigfish was the third most abundant fish and the most abundant grunt in the present study (Figure 12; Table 5). A total of 3,524 individuals were taken from all study areas representing 12% of the total fish catch. The majority of the pigfish taken were taken in the vegetated habitat where catches totaled 1,957 (55% of the total pigfish caught), followed by the sand-shell habitat with 1,086 (31%), and the mud habitat with 481 (14%).

Pigfish showed a strong seasonal distribution especially in the Rookery Bay and Marco study areas. This species was absent from the catches in these areas for the first five months of the study in the Marco area and the first six months (July - December, 1971) in Rookery Bay. In the Fakahatchee area relative abundance was high in the first month of the study and declined swiftly to low levels in common with the other study areas in October through December.

The distribution of the pigfish within the study areas shows a strong preference for vegetated habitat. This apparent association with vegetation is supported by the unusual catches in March, 1972 in the mud habitat in Rookery Bay which was usually barren of macrovegetation. This was among the largest monthly catches of pigfish made during the study and constituted 95% of the total number of this species collected in that habitat in Rookery Bay. The catch was composed entirely of young, apparently newly recruited, pigfish ranging in size from 1 to 3 cm fork length with the majority (60%) in the smallest size category (1.0 ± 0.5 cm). These high catches were associated with one of the fewmonths when quantities of algae were taken in the mud environment (Yokel, 1975). The preference of the young and juvenile pigfish for vegetated bottom habitat is similar to the findings of Hildebrand and Cable (1930) who noted that in North Carolina waters, the young pigfish after reaching a length of 11 mm seek shallow grassy areas.

The analysis of variance test showed highly significant differences in the catch rates among months in all habitats. This reflects the strong seasonal catches described earlier. For the vegetated and mud bottom habitat no detectable difference was found in the catch rates between the study areas. However, a highly significant difference was found between the study areas in the sand-shell bottom. This reflects the high catches of pigfish in the sand-shell habitat of Fakahatchee Bay relative to the other study areas and is supported by the multiple range test that shows a highly significant difference between the catch rates associated with Fakahatchee Bay and the remaining two study areas (Table 2).

The relatively close agreement in catch rates between the three study areas in the vegetated and mud bottom habitat suggests that the population of pigfish are responding to similar environmental factors in these habitats and that the catch rates of this species could serve as an indicator of environmental change in one of the study areas.

7.2.4. Pinfish (*Lagodon rhomboidalis*)

7.2.4.1. Literature

The pinfish is a member of the family Sparidae (porgies) and on abundant forage fish in the inshore and estuarine areas of both the Atlantic and the Gulf of Mexico. A number of studies have produced information on the life history, distribution, food habits and reproductive cycles of this species (Hildebrand and Schroeder, 1928; Hildebrand and Cable, 1938; Gunter, 1945; Reid, 1954; Kilby, 1955; Caldwell, 1957; Roessler, 1967; Hansen, 1969; Cameron, 1969; Adams *et al.,* 1973; Carr and Adams, 1973; Carter *et al.,* 1973, Section XV; Yokel, 1975).

7.2.4.2. Seasonal Abundance and Distribution

Pinfish were the most abundant fish taken in the present study (Figure 13; Table 5). A total of 8,918 individuals were taken from all study areas representing 29% of the total fish catch. The overwhelming majority of pinfish were taken in the vegetated habitat where the total reached 7,001 (79% of the total pinfish caught) followed by the sand-shell habitat with 1,277 (14%) and the mud habitat with 640 (7%). The strong association of pinfish with vegetated bottom has been noted by others (Caldwell, 1957; Gunter, 1945; and Clark, 1970). This preference is further supported by the distributions of pinfish at the mud habitat in Rookery Bay (Figure 13). at this station, both vegetation and pinfish abundance were consistently low except for March 1972 when trawl catches there produced modest amounts of unattached algae and unusually high catches of pinfish. These data agree with earlier studies and suggest that during the period of the life cycle spent in the estuaries, pinfish exhibit a strong preference for benthic vegetation.

Seasonally, pinfish were in greatest abundance during the winter. In the study areas, pinfish appeared in the catches in December or January arid peaked in all habitats and all study areas between March and June. After the peak the catches were variable but generally declined to a low level in October and November and remained low until the winter recruitment. The unusually low numbers of pinfish observed during the summer of 1971 in Rookery Bay Sanctuary were apparently a reflection of an outbreak of red tide in late May and mid-June of that year. The episode in June was the most severe and had the heaviest impact on the parts of the Sanctuary nearest the Gulf. The effects of the outbreak appeared strongly in July and catches of pinfish in these areas (vegetated habitat) were unusually low compared to July of 1970 and 1972 (Yokel, 1975). Pinfish did not reappear in any numbers in the Sanctuary until February 1972. The red tide apparently had little or no effect on the Marco area and was totally absent from Fakahatchee Bay. Hence the result was to reduce catches in Rookery Bay without effecting the other study areas and thus introduce an additional independent source of variation in the relationship between study areas. This had the effect of increasing the likelihood of finding significant differences between study areas.

The analysis of variance tests on this species show significant difference ($P \leq 0.05$) in the catch rates associated with months in all three habitats. As with other species this is an indication of the pronounced seasonal character of the catches. The analysis of variance tests differences in catch rates between study areas shows a highly significant difference in the sand-shell habitat, a significant difference in the vegetated habitat and no detectable difference in the mud habitat.

The strong differences ($P \leq 0.01$) in the sand-shell habitat are an Indication of the large and variable catches of pinfish in Fakahatchee Bay. This is supported by the multiple range test which show the catch rates for Fakahatchee Bay to be significantly different from the other study areas (Table 2). The lower order significance ($P \leq 0.05$) in the vegetated habitat reflects the large and somewhat variable catches in Fakahatchee Bay and possibly the additional variation brought on by the red tide induced mortality in Rookery Bay. For the mud habitat the relatively close agreement in the catch rates between the study areas suggests that the populations of pinfish are responding to similar environmental factors in this common habitat and that significant variations in the catch rates of this species could serve as an indicator of environmental change in one of the study areas.

7.2.5. Silver Perch (*Bairdiella chrysura*)

7.2.5.1. Literature

The silver perch is a member of the family Sciaenidae (drums). It is a common inshore species with a wide distribution extending from New York to Texas. A large number of authors have produced information on the life history, distribution, food habits and reproductive cycles of this species. A list of the more important papers appears here; Welsh and Breder, 1923; Hildebrand and Schroeder, 1928; Hildebrand and Cable, 1930; Gunter, 19A5; Reid, 1954; Kilby, 1955; Darnell, 1958 and 1961; Tabb and Manning, 1961; Roessler, 1967; Clark, 1970; Odum, 1970; Adams *et al.*, 1973; Carter *et al.*, 1973, Section XV; Yokel, 1975.

7.2.5.2. Seasonal Abundance and Distribution

The silver perch was the fourth most abundant fish and the most abundant sciaenid in the present study (Figure 14; Table 5). A total of 1,494 individuals were collected representing 5% of the total fish catch. This species was most abundant in the vegetated habitats where catches totaled 604 (40% of the total silver perch caught), followed by sand-shell habitat with 478 (32%), and the mud habitat with 412 (28%).

Catches of silver perch were variable with a tendency for peak periods to occur in June or July. The catches in Fakahatchee Bay showed an additional lesser peak in full or late winter in all habitats. Periods of low relative abundance appeared consistently in all study areas and in all habitats in December.

At Rookery Bay the summer abundance period in 1971 was apparently affected by an outbreak of red tide in late May and June, The beginnings of the seasonal increase in catches can be seen in May at three habitats and then an abrupt disappearance of the species from all stations in June (Yokel, 1975). Except for a period of very modest catches in September, the catch rates in Rookery Bay remained low until the spring of 1972.

These effects of the red tide are similar to those observed for pinfish in Rookery Bay and represent an independent source of variation that complicates an understanding of the interrelationships between study areas for this species.

The analysis of variance tests (Table 2) for differences in catch rates among months and between study areas for all three habitats showed highly significant differences for all tests except the differences between months in the mud habitat; no difference could be detected in this test.

This result reflects the absence of any consistent temporal pattern in catch rates of silver perch for the study areas in the mud habitat.

These data suggest that the population of silver perch in the three study areas are responding independently and therefore this species would be of little value as an indicator species for environmental changes in nearby areas.

7.3. Mollusks

Systematic investigations of the molluskan fauna of southern Florida are few compared to the studies directed at crustaceans and fish. The most important work is a comprehensive study by Abbott (1954) covering the mollusks of North America. In South Florida, systematic studies have been conducted in Everglades National Park (Tabb and Manning, 1961) and more recently in Biscayne Bay (Anonymous, 1971).

In the present study of selected estuarine environments in southwest Florida, a total of 120,710 mollusks were collected representing at least 72 species. The mollusks comprised 12% of the total animal catch and approximately 37% of the total number of species. A comparison of the molluskan catches by study area shows highest catches at Fakahatchee Bay (49%) followed by Marco (31%) and Rookery Bay (20%). For the study areas generally, periods of high relative abundance of mollusks occurred in winter and spring with highest catches in March and April, 1972 (Figure 15). Periods of low relative abundance were observed in September through November.

The high total catches in the mud habitat at Rookery Bay in March and April, 1972 reflect an unusual occurrence in which extremely large catches of mollusks were taken in both months. This unusual abundance is apparently associated with the moderate amounts of benthic algae taken in March 1972 In the mud habitat. The reasons for the extraordinary numbers of mollusks apparently associated with this algae are not known.

The two most numerous species of mollusks have been selected for individual analysis of their distribution and relative abundance. These species together comprise 58% of the total molluskan catch. The dominant species are the gastropods *Mitrella lunata* and *Bittrium varium*.

Mitrella lunata and *Bittrium varium* are small snails that were taken in moderate to high abundance in all study areas. Despite their small size (*M. lunata* 1/4" maximum; *B. varium* 1/8" maximum) and the possibility that the catches underestimated the relative abundance values due to gear selectivity, they were retained for special discussion because of their dominant numbers and their importance in the community structure.

7.3.1. *Mitrella lunata*

7.3.1.1. Literature

Mitrella lunata is a small littoral gastropod reaching a minimum size of 1/4", found from Massachusetts to Texas (Abbott, 1954). Very little work has been done on this species in south Florida. In a thermal pollution study in south Biscayne Bay, *M. lunata* was reported to be extremely abundant (Anonymous, 1971).

7.3.1.2. Seasonal Abundance and Distribution

Mitrella lunata was the second most abundant mollusk found In this study (Figure 16; Table 5). A total of 30,615 individuals were collected representing 25% of the total molluskan catch. This species was most abundant in the vegetated habitat where catches totaled 12,916 (42% of the total *M. lunata*) followed by the sand-shell habitat with 9,996 (33%) and the mud habitat with 7,703 (25%).

Mean catches of *M. lunata* were highest in all habitats in the Fakahatchee Bay study area and second at Rookery Bay. Peak abundance was consistent in both study areas and came In April or May. Relative abundance in the Marco study area was low in all habitats. The periods of lowest abundance were late summer and fall.

The results of the analysis of variance test for this species will be discussed with *Bittium varium* in the next section.

7.3.2. *Bittium varium*

7.3.2.1. Literature

Bittium varium is a small littoral gastropod reaching a maximum size of 1/8", found from Maryland to Texas (Abbott, 1954). Relatively little literature exists on its biology or distribution in south Florida. In Everglades National Park it was reported to be common in Coot Bay and parts of Whitewater Bay associated with algae and the seagrass *Diplanthera* during periods of high salinity (Tabb and Manning, 1961). This species was also collected in a thermal pollution study in south Biscayne Bay. The individuals were not counted but were reported to be very abundant in algae stations (Anonymous, 1971).

7.3.2.2. Seasonal Abundance and Distribution

Bittium varium was the most abundant mollusk in the present study (Figure 16; Table 3). A total of 39,348 individuals were collected representing 33% of the molluskan catch. This species was most abundant in the vegetated habitat where catches totaled 12,545 (45% of the total *B. varium* caught) followed by sand-shell habitat with 15,903 (40%) and the mud habitat with 5,900 (15%).

As with *Mitrella lunata*, relative abundance of *B. varium* was generally higher in the Fakahatchee Bay and Rookery Bay study areas than in Marco. Monthly catches were variable in all habitats but showed a tendency to be higher during the winter and spring (December-May). Relative abundance was low in all the study areas in summer and fall (June-November).

The analysis of variance tests for both *Mitrella lunata* and *Bittium varium* show significant or highly significant differences in the catch rates among months and between study areas for all habitats. The results of the test on *B. varium* for differences between study areas was significant ($P \leq 0.05$) but this result does not agree with the multiple range test that suggests that there are no detectable differences between the study areas. This discrepancy represents a slight gap in the sensitivities of the two tests discussed in an earlier section. When the multiple range test is conducted at $P \leq 0.05$ a significant difference can be detected and the results change such that Fakahatchee Bay and Rookery Bay are similar to one another but different from Marco.

These results suggest that the populations of both *Mitrella lunata* and *Bittium varium* in common habitats in the three study areas are responding independently in these habitats and thus their relative abundance patterns are dissimilar. These results could also be caused by the selectivity of the fishing gear producing a biased catch rate in one or more of the study areas. Because of the relatively small size of these two species it is likely that this factor is contributing to the observed variation between study areas. For the above reasons, these species are unsuited for use in comparison studies to aid in detecting environmental changes in nearby or adjacent biological systems.

8. DISCUSSION

8.1. Study Areas

The three study areas located in Rookery Bay Sanctuary, near Marco Island in Fakahatchee Bay produced 1,006,640 individual animals of which the majority (55%) came from the Marco area. The large disparity between the catches at Marco and the remaining study areas was due mainly to the appearance of high numbers of species of polychaetes and echinoderms that were of very minor importance or absent from the catches in Rookery Bay and Fakahatchee Bay. Thus the potential for these species to appear suddenly and in large numbers represents a notable and interesting difference in the study areas. However, it is probably not an Important difference in assessing whether species or combinations of species in Fakahatchee Bay can be used to determine if fluctuations other than natural fluctuations are occurring in areas such as Marco and Rookery Bay Sanctuary where development may take place in the watershed of the system (e.g., Rookery Bay Sanctuary) or in the midst of the system as at Marco Island.

When only the major classes of animals in the catch are considered (i.e., crustaceans, fish and mollusks) the total counts for Fakahatchee (298,830) and Marco (275,075) are quite comparable but both exceed Rookery Bay (119,388) by a considerable-margin. The effects of the red tide outbreak in the summer of 1971 were apparently restricted to the Rookery Bay Sanctuary and may account for some of the observed differences. However, it is not expected that the red tide effect could account for all or even a large fraction of the observed differences. The exact reasons for the differences are unknown. As a possible contributing cause it can be pointed out that Rookery Bay Sanctuary represents a secondary or tertiary bay system (i.e., a bay that is two or three interconnected bays removed from the sea) as opposed to the Fakahatchee and Marco areas that are essentially primary bay systems. The position of a bay relative to the sea can affect flushing rates and associated physical and chemical factors and also the efficiency of recruitment of larval and post-larval organisms moving into the bay systems from the sea.

It would thus appear from a consideration of gross catches and physical and geographic factors that Fakahatchee Bay and Marco have more in common than any combination involving Rookery Bay.

This does not negate the comparisons that have been made between Rookery Bay and the other study areas because the catch rates of many species may not be influenced by these factors. This is supported by the statistical data which shows a number of species in all three habitats for which no differences in catch rates could be detected between the study areas.

8.2. Habitats

For the purposes of making controlled comparisons between the study areas, three common habitats were selected in each area so that a mud bottom habitat, a sand-shell bottom habitat and a vegetated bottom habitat were located in each of the study areas. These represented the major benthic environments that could be sampled with a trawl. This design enabled catch rates over an annual cycle from three common habitats in the three bay systems to be statistically compared.

Total catches by habitat types for crustaceans, fish and mollusks and certain of the more abundant species (Table 5) show clearly the overwhelming importance of the vegetated bottom as a habitat for animals. Considering the total catch of animals taken during the entire study 54% were collected in the vegetated habitats. The mud habitat was next with 28% and the sand-shell habitat was third with 18%. These data show that a very high proportion of the total annual crop in the study areas are found in and apparently dependent on the vegetated environments.

Our examination of the data was also made to determine which of the habitats had the most species that might serve as an indicator species. An indicator species being one in which no significant difference could be detected between the study areas. This presumes that within its common habitats in the three study areas the indicator species are responding similarly and that if the environment in one study area should change significantly it could have a detectable effect on the catch rates of indicator species.

By habitat the vegetated areas had the most "indicator species" with five, the mud habitat was next with three and the sand-shell habitat third with two. Thus the vegetated habitat would be the best choice if a single habitat were to be used to detect environmental changes between study areas. The higher population levels found there would also favor this p habitat as a primary sampling area. It is also possible that with only certain species being sought the monthly effort level in each study area (i.e., severe trawl drags) could be reduced which would produce considerable savings in the effort and costs of collecting, sorting and processing the catches.

The possible indicator species by habitat appear below:

Vegetated Habitat	Mud Habitat	Sand-Shell Habitat
	CRUSTACEANS	
Hippolyte pleuracantha	*Hippolyte pleuracantha*	
Penaeus duorarum		
Periclimenes longicaudatus		
	FISH	
Eucinostomus gula	*Lagodon rhomboides*	*Lutjanus synagris*
Orthopristes chrysoptera	*Orthopristes chrysoptera*	*Eucinostomus gula*

One of the objectives of the project was to test the hypothesis that the Fakahatchee Bay system could be used as a measure of natural fluctuation for the Marco and Rookery Bay systems thus enabling the detection and an estimate to be made of environmental change that is likely to occur in the latter two areas. This would permit a better estimate to be made of the effects of development on a biological system. The data presented suggests that using a selected group of species that have shown consistent catch rates between the study areas would allow detection and estimation of the environmental change.

The usefulness of such a detection program would be dependent on using a combination of the indicator species to determine if a trend exists and to formulate an estimate. Thus the more indicator species that it is possible to use, the better. As a minimum program the catch rates of selected species from the vegetated habitat alone might be used to generate an estimate.

It is believed that this project has improved the understanding of the study areas and increased the usefulness of the research underway at Marco and Rookery Bay. The regional scope of the work has significance beyond the solution of practical problems at Marco and Rookery Bay. It represents the only coordinated regional study of these extremely valuable resources.

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