FINAL REPORT

CM 47 & CM 73

"IMPOUNDMENT MANAGEMENT"

D. B. Carlson
Indian River Mosquito Control District

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Enclosed are the final reports of the three principal investigators on contract CM 47 and its extension, CM 73, jointly title "Impoundment Management." Each P.I. has filed a separate summary of his work.

The goals of the project were:

1) Investigate the effects of re-opening an impounded marsh to the estuary.

2) Propose water management techniques which would depend on passive water control measures sufficient to control mosquito production, while minimally disruptive to the marsh resident and marsh transient fauna, and marsh flora.

The study area was a 50 acre, privately owned diked high salt marsh located on the barrier island at the south end of Indian River County. Carlson's report contains a complete study site description. A single existing 18 inch culvert in the impoundment dike was opened to the estuary. Sampling techniques and equipment were devised to provide baseline data on zooplankton, marsh vegetation, basic water quality parameters, fish, macrocrustaceans, and mosquito larvae. During the first year of the project, no water control structures were placed on the culvert, and no chemicals applied to the marsh to control mosquito breeding.

At the end of one year's study, a flapgate riser was placed on the culvert; and at 1.5 years, a second culvert installed to serve as a reference for changes made in the configuration of the first culvert (see Gilmore's report). Chemicals were used during this second year to control mosquitoes. An integral part of this project was the establishment of substantial data bases on the Harbor Branch Foundation's computer for fishes, and the Institute of Food and Agricultural Sciences, University of Florida, for vegetation and zooplankton, for data gathered during the field study period.

The project began on February 22, 1982 and field work ended January 1, 1984.

All data has not yet been analysed, but we can summarize the major accomplishment of the study thus far:

1) Developing and validating new zooplankton and fish sampling techniques for the shallow-water marsh habitat.

2) Providing the first study of zooplankton in the inside ditches of high-marsh impoundments, an important man-made artifact present in most mosquito control impoundments, and in ponds and depressions.

3) Continuing and extending the fish trophic work begun in this marsh in its pre- and immediate post-impoundment condition by Harrington and Harrington.

4) Providing the first systematic study of fish movement into and out of the impounded salt marsh through several different water control structures, monitored over a period of several years. Special attention was given to the interplay of high-marsh, inside ditch, and estuary.

5) Establishing important vegetation growth base-line data in the experimental cell, and an adjacent completely enclosed cell. This portion of the study will be continued for several more years by Dr. Rey.

6) Reconfirming the mosquito potential of this high-marsh area, as well as the efficiency of high-water levels in eliminating mosquito breeding in this habitat.

7) First examination of the effect of culvert(s) on water movement into and out of an impounded high marsh.

Major conclusions of this work include:

1) Passive water management techniques are not, in themselves, sufficient to provide reliable mosquito control in the impounded high-marsh.

2) Even when water levels allow access to mosquito breeding sites, larvivorous fish are inadequate to control flood-water, salt marsh _Aedes_ spp. mosquitoes in this habitat. Such floodings from rainfall and tides, with resulting mosquito broods, were repeatedly observed during the study.

3) Water levels sufficient to control mosquitoes stressed the marsh vegetation, but the extent of this stress was not determinable over the two years of this study.

4) Marsh resident and transient fish were shown to locate and use the single culvert to travel in and out of the marsh. Fourteen species of marsh residents, and 36 transients were identified.

5) Qualitatively, zooplankton in the impounded high marsh resemble those in the Indian River Lagoon.

6) Tentatively, isolation and size have been shown as important variables in zooplankton dynamics as well as water quality in the high marsh habitat. Further analysis of zooplankton samples is expected to confirm this.

7) Preliminary analysis indicates that normal mosquito control schedules for closing, pumping, and re-opening impounded marshes can, with minor modification, be tailored to fit the major periods of fish ingress and egress from the marsh. A rich variety of transient and resident fish should be able to use the marsh under these conditions.

Substantial work remains before all data gathered during CM 47 and CM 73 are analyzed. Zooplankton, in particular, have proved difficult and time consuming. Dr. Rey will provide IRMCD periodic updates on further progress in analysis of this material.

A minimum of five publications will result from this work (two each from Dr. Rey and Mr. Gilmore, and one from Mr. Carlson). A summary of work to date was recently presented at a special symposium arranged by Mr. Carlson held at the American Mosquito Control Association's annual meeting, in Toronto. A similar presentation will be made this April at the Florida Anti-Mosquito Association's Spring meeting, in Key West.

Perhaps more important, since the onset of CM 47 all three P.I.'s have been named to the State of Florida's Technical Advisory Subcommitee on Mosquito Control Impoundments. Mr. Gilmore served as the first chairman of this group, and Mr. Carlson is its second chairman. As a result, the information gained through CM 47 and CM 73 is being distributed and used to help develop managment plans far in advance of formal publication.

Glennon Dodd

Project co-ordinator
Indian River Mosquito Control District

"MOSQUITO PRODUCTION IN A SALT MARSH MOSQUITO CONTROL IMPOUNDMENT UNDER DIFFERING WATER MANAGEMENT REGIMES"

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ABSTRACT

Mosquito production was monitored for 2 years in a southeast Florida salt-marsh mosquito control impoundment continuously connected to the estuary by culverts. Some marsh locations were shown to produce large numbers of *Aedes* spp. from rainfall and tidal flooding in this impoundment which was not artifically flooded by pumping of estuarine water. Water retention with flapgate risers attached to culverts reduced but did not eliminate salt-marsh mosquito oviposition. *Aedes* spp. larvae were found where *Batis maritima* and/or *Salicornia virginica* was present, however, mosquito presence was not always associated with the occurrence of these plants or of specific marsh elevations. Although larvivorous fish were present, they usually were not able to adequately control mosquitoes.

"MOSQUITO PRODUCTION IN A SALT MARSH MOSQUITO CONTROL IMPOUNDMENT UNDER DIFFERING WATER MANAGEMENT REGIMES."

INTRODUCTION

Numerous studies have documented Aedes spp. mosquitoes produced from various coastal salt marsh habitats (Chapman and Ferrigno 1956, Haeger 1960, Harrington and Harrington 1961, Clements and Rogers 1964, Zimmerman and Turner 1982, Balling and Resh 1983, Carlson 1983). Preadult Aedes numbers have been shown to fluctuate in response to physical manipulations of the marsh as well as with environmental factors (Clements and Rogers 1964).

Gravid female salt marsh Aedes oviposit on the moist high marsh soil. Impoundments on the east-central coast of Florida are high salt marshes which were diked in the 1950's and 1960's and are flooded to control the salt-marsh mosquitoes *Ae. sollicitans* (Walker) and *Ae. taeniorhynchus* (Wiedemann). Flooding these areas with water eliminates ovipositional sites, thus effectively and economically reducing their populations (Provost 1977, Shisler et al. 1979). While being an excellent method of salt-marsh mosquito control, impoundments have possible environmental liabilities including interruption of the exchange of organisms and detritus between the marsh and estuary, and stressing or killing vegetation by excessive or prolonged flooding (Gilmore et al. 1981).

When originally constructed, impoundments were managed solely for mosquito and sandfly control. However, current impoundment management goals are becoming multipurpose; for natural resource enhancement as well as mosquito control. Impoundment management concerns can address the high marsh habitat as a fisheries resource, for wildfowl use and also water quality enhancement.

This study reports Aedes mosquito production from an unmanaged (not artifically flooded) impoundment in Indian River County, Florida under two different water management regimes. It also gives information on physical marsh characteristics and attempts to correlate mosquito production to these marsh factors. It was conducted as one component of a cooperative research project which also examined the effects on fish, macroinvertebrates, zooplankton and vegetation of first opening the marsh to the adjacent estuary via an 18 inch (45.7 cm) culvert for 16 months, then retaining water with flapgate risers to 1.0 ft. NGVD for 6 months. The marsh was reopened for the remaining 2 months of the study. This study quantifying the effects of different water management schemes is background information necessary for the development of impoundment management plans based on scientifically proven principles.

MATERIALS AND METHODS

Study Site Description.

Historical (1956-1980)

The 50 acre impoundment studied (Impoundment #12 -- Bidlingmayer and McCoy 1978 [*]) has been the object for several intensive research projects over the past 27 years. Located on the barrier island at the Indian River-St. Lucie county border, this marsh, prior to impounding, was first the site for an icthyological study in 1956. At that time, the marsh was described as "an expansive 'parkland' of saltwort (Batis maritima L.) and glasswort (Salicornia perennis Mill.) interspersed with black mangrove [Avicennia germinans (L)]. The aggregate areas of Batis-Salicornia and of black mangrove are roughly coequal". The periphery of the marsh consisted primarily of alternating black mangrove, red mangrove (Rhizophora mangle L.), white mangrove (Laguncularia racemosa Gaertn.), sea oxe-eye (Borrichia frutescens (L.)) and buttonwood (Conocarpus erectus L.). At that time, 16 fish species were observed utilizing the marsh, feeding on a wide variety of organisms. During the study, a synchronous high tide and rainfall caused "a massive well-synchronized mosquito hatch" on September 9 (Harrington and Harrington 1961). Haeger (1960) reported the emergence of this same brood between September 17-20. He stated concerning the adult mosquito exodus that "the migrants started to depart in waves".

This marsh was impounded in March 1966. Thirty months later it was again studied, this time to determine the effects of impounding on marsh fishes. At the time of this second study (September and October, 1968), almost all vegetation had died from artificial flooding of the marsh with water pumped from the Indian River lagoon. During this study, there was no seasonal connection of the marsh with the estuary. The marsh was then described as "an open expanse of water broken only by the emergent trunks of dead mangroves". The authors also found a decrease from 16 to 5 fish species present. These fish were feeding primarily on vegetation (Harrington and Harrington 1982).

In 1978, the Indian River Mosquito Control District (IRMCD) ceased pumping estuarine water into the impoundment at the property owners' request. In 1979 this area served as the site for further marsh research comparing fish populations and habitat in open versus closed salt marsh impoundments (Gilmore et al. 1981). By then the impoundment had essentially dewatered, receiving input solely from rainfall. Marsh water levels fluctuated through evaporation and percolation. In this 1979-1980 study, when the marsh was still not connected to the Indian River lagoon, Gilmore et al. showed 12 fish species present under stressed environmental conditions.

Present study (1982-1984)

The impounded marsh contains a 1-3 m wide perimeter ditch which abuts 2.5 of the 4 impoundment sides. Many portions of this ditch are filled with mud and organic debris. Part of the northern and the entire eastern side are an undiked upland hammock. A shallow cove, part of the Indian River lagoon, lies southwest of the impoundment and contains extensive Halodule spp. seagrass beds. Several large depressions occur over the marsh surface, some of which retain water even during extremely dry periods. Ruppia maritima L. (widgeongrass) is and has been a common plant in these permanent and semi-permanent ponds (Gilmore et al. 1981).

The marsh surface is primarily vegetated with Batis maritima, Salicornia virginica L. and S. bigelovii Torr. Black, red and white mangroves were widely dispersed with the greatest regrowth along the perimeter ditch. Figure 3 generally depicts the occurrence and location of major marsh vegetation prior to this study in 1980 while Figures 4 and 5 show this for January 1984. There were well defined drainage patterns from the marsh interior to the perimeter ditch. Marsh elevations (excluding all depressions) were determined from U.S. Coast and Geodetic Survey benchmark Y-306, and ranged from -0.35 to 1.80 feet NGVD. Most elevations were between 0.40 and 0.70 ft NGVD (Fig. 2).

The study commenced in February 1982 when an 18 inch (45.7 cm) culvert (Culvert A) was opened to the adjacent cove, allowing unobstructed flow of water between the Indian River lagoon and the impoundment. This water management regime was continued until July 1983 when a flapgate riser was attached to the culvert. The flapgate riser top was set at 1.0 ft. NGVD to trap water from rainfall and incoming tides to this elevation while still allowing water movement into the culvert. When impoundment water levels exceeded 1.0 ft., spillage into the estuary occurred. In September 1983, an additional 18 inch culvert with flapgate riser was installed at the northwest corner of the impoundment (Culvert B) to allow increased tidal flow into the marsh. The riser height was set so that no water could exit over it. On January 19, 1984, the flapgate riser was removed on the original culvert (Culvert A) reestablishing free water flow to the lagoon. Culvert B was sealed.

As part of the experimental design to not apply larvicides into the study area during the first year, preadult mosquitoes produced between February 1982 and May 1983 were not treated with insecticides but were allowed to emerge as adults. During most of the second year of the study (i.e. from June 1983 to March 1984) broods were treated either from the ground with diesel oil or, when broad scale applications were necessary, from the air with Altosid (methoprene) adsorbed to sand (Rathburn et al. 1979).

Mosquito Sampling.

Because of ovipositional habits, the aggregation of later instar larvae, and the contracting and expanding water surface area of the preadult habitat, salt-marsh mosquitoes are non-randomly distributed. Totally random sampling for salt-marsh mosquitoes can greatly misrepresent cohort occurrence and size. Therefore this study used stratified sampling

(Southwood 1978) similar to Zimmerman and Turner 1982.

The stratified sampling design used established twelve quadrats, which covered the entire marsh surface. Each quadrat was sampled twice weekly for immature mosquitoes. The quadrats were designated North A,B,C, West A,B,C, South A,B,C, and East A,B (Fig. 1). On each sampling visit, mosquitoes were sought out in all quadrats. Through experience those vegetated areas shown to produce mosquitoes were most thoroughly examined yet no areas were neglected. Broods were randomly sampled by taking 5-350 ml dips per quadrat, then the mean number per dip in a quadrat over the cohort duration was determined.

Marsh inaccessability caused by loose substrates or dense vegetation usually makes traversing the entire marsh surface impossible. We were fortunate that this particular impoundment can be freely walked therefore thoroughly sampled. We feel when such marsh accessibility is possible that this sampling methodology is a better representation of salt-marsh mosquito presence as compared to alternate techniques such as sampling stations (e.g., Clements and Rogers 1964, Carlson 1983). However, most impoundments, especially when flooded, severely limits sampling to stations, usually from the dike.

Marsh Flooding

Rain data was collected during each site visit by a tube rain gauge located at the northeast marsh corner (Fig. 24). Maximum and minimum marsh and estuary water elevations were measured biweekly with a grease pole (Fig. 12, 13).

A series of maps showing the extent of marsh flooding at sequential elevations was compiled during the second year of the study. They were prepared by ground-truthing water coverage at established elevations (Figs. 6-11).

On all visits, a range of mosquito landing rates were taken. A landing rate is the number of mosquitoes landing on a person in a one minute period. Because of the extensive flight range of salt-marsh mosquitoes (which has been shown to be as great as 20 miles by Provost (1952)) this landing rate figure does not mean that all mosquitoes biting here emerged from this area, but it does help to give a better picture of overall mosquito activity (in particular adult mosquito activity) in the marsh (Fig. 23).

RESULTS

Impoundments on the east coast of Florida are intended to control *Aedes taeniorhynchus* and *Ae. sollicitans* which are produced in high marshes by rainfall or high tides. Over the 2 year study, the vast majority of mosquito broods were produced by rainfall. However, 4 large tidal surges inundated the entire marsh to the upland hammock producing mosquitoes on each occasion. These tidal inundations occurred in September 1982 and in June, August, and September 1983. On each occasion significant mosquito broods were produced in several marsh locations (Figs. 14, 19, 22).

In this study, overall aliquots showed *Ae. taeniorhynchus* to be most common. This coincides with Harrington and Harrington (1961), who showed by fish gut analysis that *Ae. taeniorhynchus* comprised the vast majority of mosquitoes consumed. However, in our study on occasion *Ae. sollicitans* was the largest aliquot component. Although these two salt-marsh mosquitoes comprised the overwhelming majority of mosquitoes encountered, several other species were infrequently collected in small numbers. They were *Anopheles atropos* Dyar and Knab, *An. bradleyi* King, *An. walkeri* Theobald, *Culex nigripalpus* Theobald and *Cx. salinarius* Coquillett. The freshwater mosquitoes *Anopheles walkeri* and the two *Culex* spp. were encountered at a time when large amounts of rainfall lowered salinities.

March 8, 1982 -- January 1, 1983.

During this 10 month period, unobstructed water flowed between the impounded marsh and the Indian River lagoon through the existing 18 inch (45.7 cm) culvert (Culvert A). Mosquito broods triggered by both rainfall and tidal flooding occurred in North A, B and C, East B and C, and West A and B. Broods varied greatly in size as is shown on Figs. 14-22. Mosquito landing rates during this period are shown to fluctuate greatly but with periods of intensive adult activity. In March, April, June, July, and August landing rates exceeded 30 per minute and reached as high as 75 per minute (Fig. 23). A landing rate of merely 5 per minute is considered to be genuinely annoying.

In the North and East areas from March through August 1982 flooding was primarily rainfall induced, an expected occurrence in southeast Florida high marshes at that time of the year. These locations were distant from the perimeter ditch, thus commonly inundated by rainfall but irregularly by tidal fluctuations unless estuarine water elevations exceed 0.75 ft NGVD (Figs. 9-11). Mosquitoes were produced here from rainfall induced flooding as can be seen from Figures 17-22 . However, West A and B are in close proximity to the perimeter ditch and more frequently flooded by tides as well as rainfall. Flooding to an elevation of 0.60 ft NGVD is sufficient to inundate large portions of the West quadrats (Fig. 8). This was reflected with as many as 1,444 preadult mosquitoes collected there in one dip on May 6 by the first thorough tidal flooding of this area after our study commenced. The landing rates of 75 per minute experienced in the marsh in early June were probably produced by this brood from the study site and nearby unmanaged impoundments (Fig. 23). Much tidal flooding in the West quadrats occurred during the spring due to lower elevations and close proximity to the perimeter ditch.

Mosquitoes were never found in the 3 South quadrats and rarely in East A and West C. South A and B directly abut the perimeter ditch, thus were inundated frequently throughout this study period. The vast majority of South C and East A extended into the adjacent upland hammock and was dry throughout the study since elevations were as high as 1.80 ft NGVD (Fig. 2).

On September 10, the annual peak high tides began after much of the marsh had been dry for the previous two months. From this tidal surge the entire impoundment (except South C and East A) remained flooded until early December. The initial tidal surge produced large broods in numerous marsh locations (Figs. 14,18,19,21,22). This resulted in landing rates ranging from 5-20 for the entire month of September and continuing into October (Fig. 23). For the three months following September the impoundment functioned as a managed flooded impoundment, effectively eliminating salt-marsh Aedes ovipositional sites. On December 6, the high tides began to recede, temporarily drying the marsh. By early January 1983 the impoundment reflooded to about 80 percent water cover.

During the 3 month period of tidal flooding, water levels fluctuated. Water level tracings on the high marsh and also in the Indian River lagoon show that a standing water head developed within the marsh. Daily water level fluctuations outside the impoundment were greater than those within it (R. G. Gilmore, personal communication). Water level fluctuations within the impoundment probably hatched some Aedes eggs on the North and East banks. However, this was not reflected in our sampling.

January 1 -- July 12, 1983.

From January through March 1983, the study site received heavy rainfall (22 inches) which reflooded the marsh to fall 1982 levels but which did not produce mosquitoes. Apparently the marsh surface had not become ovipositionally attractive during the dry down period or eggs had not completed development before inundation.

Spring is normally a dry season in central Florida. A comparison of rainfall and mosquitoes in April-May 1982 (rainfall=9.2 in.) with April-May 1983 (rainfall=4.7 in.) shows much greater rainfall and consequently greater mosquito production in more marsh locations in 1982. During this 1983 period a combination of tides and rainfall resulted in 3 large but localized broods which were chemically treated.

July 13, 1983 -- March 8, 1984.

On July 13, the installation of a flapgate riser in Culvert A altered water management on the marsh by trapping rainfall and high tides. Set at an elevation of 1.0 ft. NGVD, this structure kept locations shown to produce mosquitoes flooded without excessive water penetrating into upland areas. In July 1983 as in 1982, little rainfall (1982=1.9 in., 1983=1.0 in.) or tidal flooding resulted in no mosquitoes.

Rainfall in August of 1982 (4.3 in.) and 1983 (5.1 in.) was similar but in 1983 with the flapgate riser in place more of the marsh remained flooded trapping rainfall. In addition a tidal surge produced a mosquito brood in East C during this month. No mosquitoes occurred in the West sections during this period in 1983 as opposed to 1982, when several large broods were produced there from the drying and reflooding of the West sections (Fig. 14,15,16).

September, October and November of 1982 and 1983 were similar both in water coverage (nearly 100%) and that mosquitoes were produced only on the tidal surge. In early September 1982, high fall tides penetrated the marsh through Culvert A followed by the marsh remaining flooded until early December 1983.

In 1983 the installation of an additional 18 in. culvert (Culvert B) with flapgate riser on Sept. 28 enhanced tidal access into the marsh. During both years tides kept the marsh flooded during October and November. However, while in 1982 water levels began to recede in early December, in 1983 high water retained by the flapgate risers kept the marsh flooded through January 18, 1984 when the flapgates were removed to allow free water exchange. No real differences in mosquito production were apparent between these years as constant inundation at elevations from 1.0 to 1.7 ft NGVD effectively eliminated ovipositional sites. The marsh quickly dewatered to approx. 50 percent flooding after opening the culverts. On Jan. 31 Culvert B was closed from the estuary. From Jan. 19 to March 8, 1984, water elevations on the marsh were between <0.3 and 0.5 ft NGVD. Marsh water elevations lower than 0.4 ft NGVD usually dried the marsh flats. However, even with marsh water elevations less than 0.4 ft. rainfall can cause isolated pockets of water from the perimeter ditch which are not reflected by the water level recorders.

DISCUSSION

Although it is well documented that high salt marshes in Florida produce salt-marsh mosquitoes (Nielsen and Nielsen 1953, Haeger 1960, Harrington and Harrington 1961, Clements and Rogers 1964), mosquito control districts in Florida are regularly in the position of defending their control operations in those areas to environmental permitting agencies. The question presently asked by these organizations is: Does the particular marsh you are proposing to manage cause a mosquito problem and what documentation is available to prove it?

This study corroborates previously mentioned studies showing that high salt marshes in Florida often produce extremely high densities of both Ae. taeniorhynchus and Ae. sollicitans from rainfall or tidal flooding. From a mosquito control standpoint this information further validates the decision to impound these high salt marshes. Local mosquito control agencies in association with the Florida Department of Health made impounding decisions on a marsh by marsh basis. When the marsh was shown to produce mosquitoes, the entire high marsh was diked and subsequently flooded. The data presented also shows that merely trapping rain and tidal intrusion on the marsh surface with flapgate risers can be a beneficial tool in diminishing but not eliminating *Aedes* ovipositional sites.

This study reaffirms Clements and Rogers (1964), that in a non-artifically flooded impoundment high tides and rainfall are not adequate to flood an impoundment during the entire mosquito producing period. During some time of the year artificial flooding is necessary.

Our work shows no simple correlation between marsh elevations and the location of preadult mosquitoes. Preadult mosquitoes were generally found where *Batis maritima* and *Salicornia virginica* were in dense accumulations. However, not all *Batis* and *Salicornia* locations at similar elevations produced mosquitoes. These plants are presently very common on the marsh surface. Continued monitoring is necessary to determine if changes in the vegetation profile will correlate with changes in preadult mosquito location. The second year of this study showed fewer mosquito sites but this was not a surprise. The retention of trapped water over a larger portion of the marsh eliminated ovipositional sites.

Of the larvivorous resident marsh fish, *Cyprinodon variegatus* Lacépede (sheepshead minnow), *Fundulus confluentus*

Goode and Bean (marsh killifish) and Gambusia affinis Baird and Girard (mosquitofish) were those most commonly trapped during this study. Fundulus grandis Baird and Girard (gulf killifish) and Dormitator maculatus (Poey) (fat sleeper) were also collected but infrequently (G. Gilmore, personal communication). These fish frequently were unable to control large synchronous mosquito broods allowing intolerable numbers of biting adults to emerge.

Todd and Giglioli (1983) in Grand Cayman, W.I. also showed that larvivorous marsh fish were not capable of adequately controlling large hatches of salt-marsh mosquitoes. They attributed this phenomenon to the immediate hatching of large numbers of mosquito eggs, dilution of predatory fish and delayed increase of fish numbers. All of these factors apparent in Grand Cayman marshes were probably occurring in South Florida as well. In addition, dense Batis and Salicornia beds where larvae were usually found were an impediment to fish movement here as well. The authors have also observed this inability of fish to control mosquito larvae in inland watewater retention areas [**].

We feel that larvivorous marsh fish may play a beneficial role in reducing mosquitoes during periods of high tidal flooding when mosquitoes hatch along upland marsh locations from slight water level fluctuations. Migrating fish can feed on these widely dispersed larvae. However, our observations indicate that large synchronous mosquito broods produced by tidal flooding were not noticeably reduced by fish predation and during complete tidal flooding fish do have easy access to larval areas. As can be seen from Figs. 10 and 11 flooding elevations of 0.90 ft. or greater flood all mosquito producing areas. Figure 12, which shows the extent of flooding during the study, clearly shows that these elevations were reached on many occasions yet flooding induced mosquito broods were documented on at least 4 occasions. In a marsh, rainfall induced mosquito hatching will oftentimes result in pockets of immature mosquitoes isolated from fish. Of course then, fish are unable to play a predatory role. In such cases, ditching may allow fish migration to larval locations.

This study mimicked flooding levels as suggested by Provost 1974 on a mangrove island in Brevard County, Florida. That is, flooding levels were established to eliminate mosquito oviposition sites while not inundating black mangrove pneumatophores or other high marsh vegetation. Our flooding elevation of 1.0 ft. NGVD adequately met these criteria in our study site.

Seasonal artificial flooding by pumping of estuarine water when augmented by passive water retention can produce excellent mosquito control results while still allowing effective connection of the marsh to the estuary through the proper placement of culverts with flapgate risers and careful management of water levels. Necessary flooding elevations will vary between impoundments, depending on the elevations of known mosquito producing sites.

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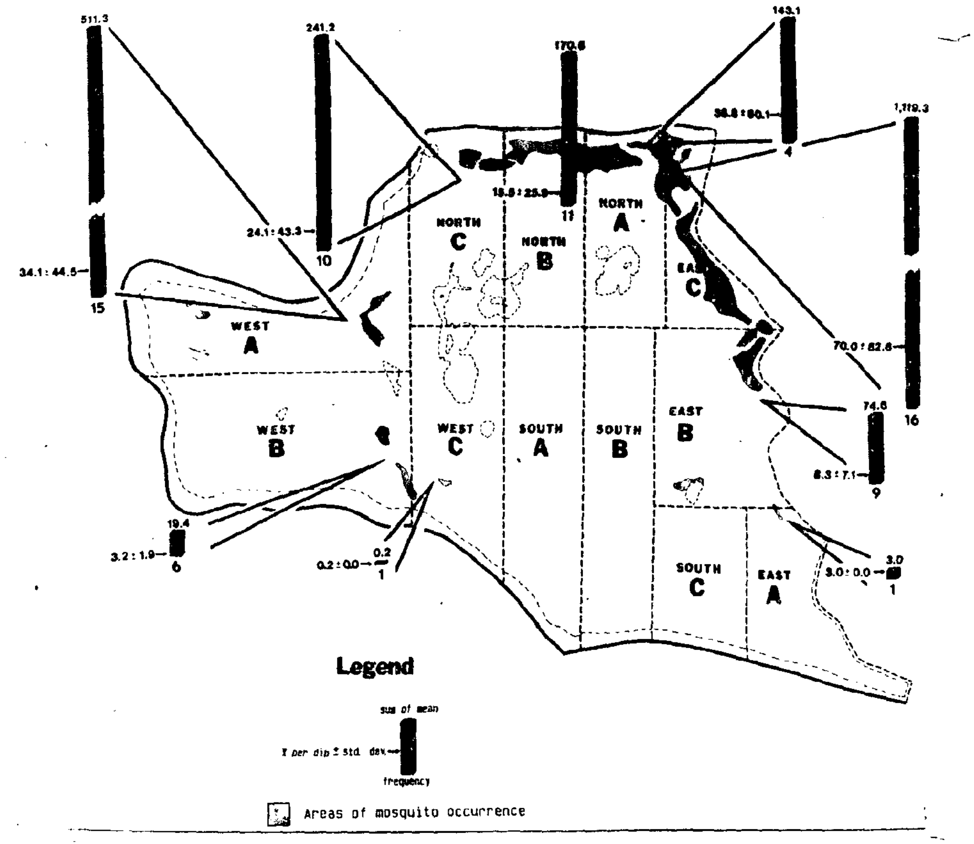

Figure 1. Mosquito sampling quadrats and overall mosquito production during study.

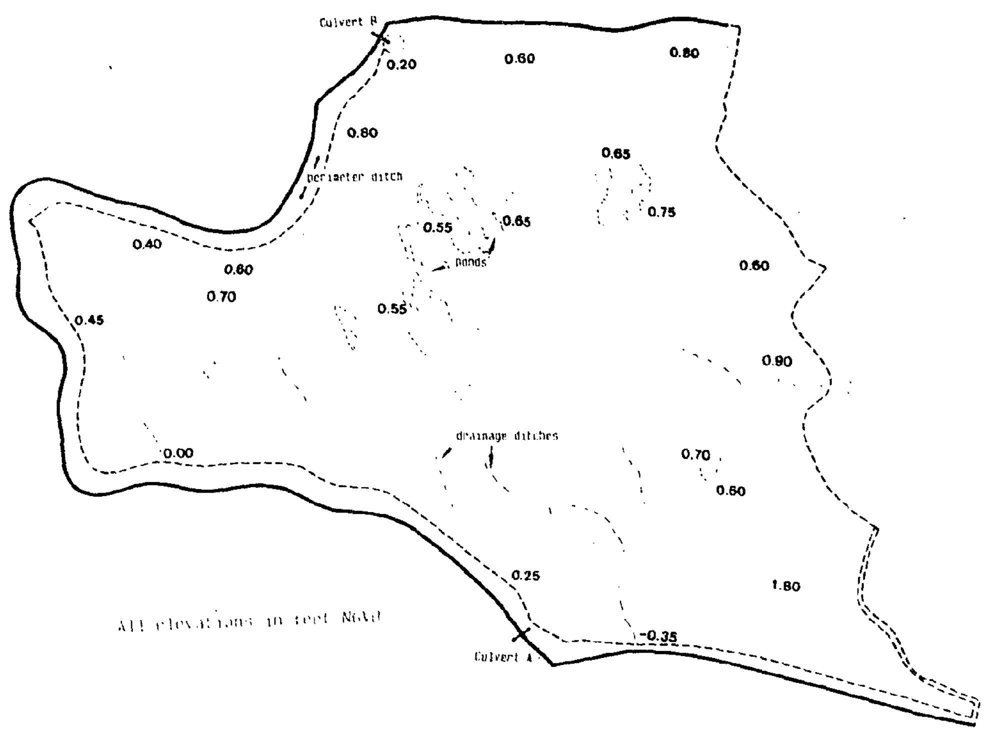

Figure 2. Representative marsh elevations at Indian River County Impoundment #12.

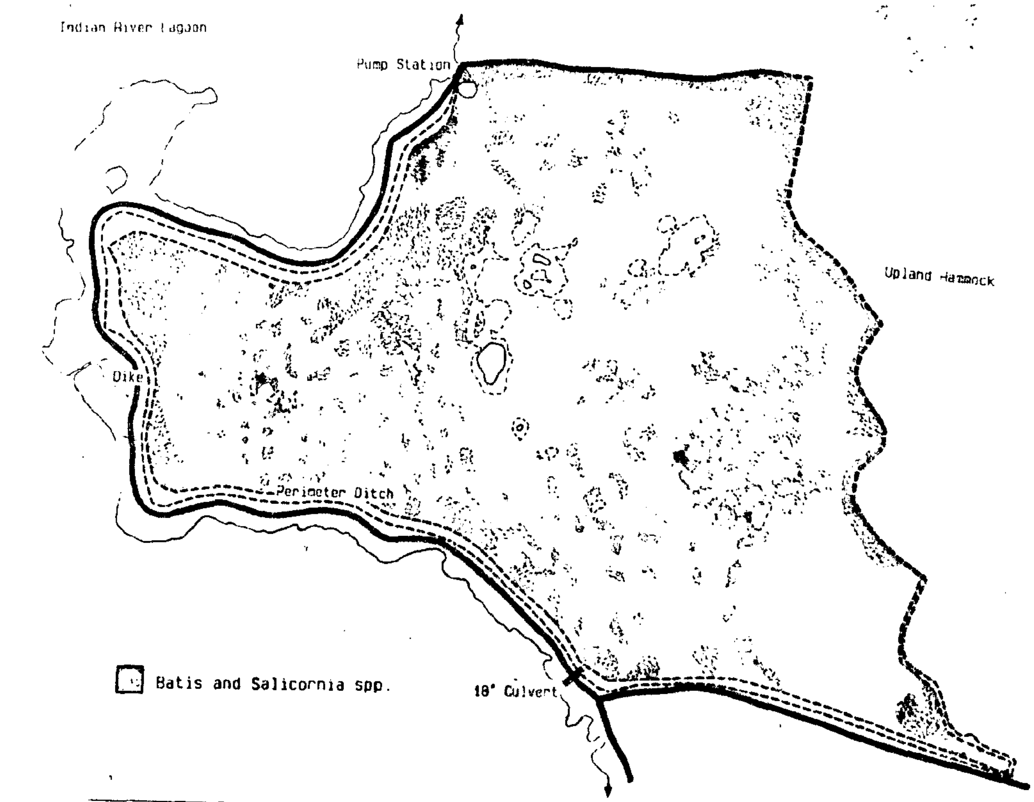

Figure 3. Approximate occurrence and location of marsh vegetation at Impoundment #12 in 1980.

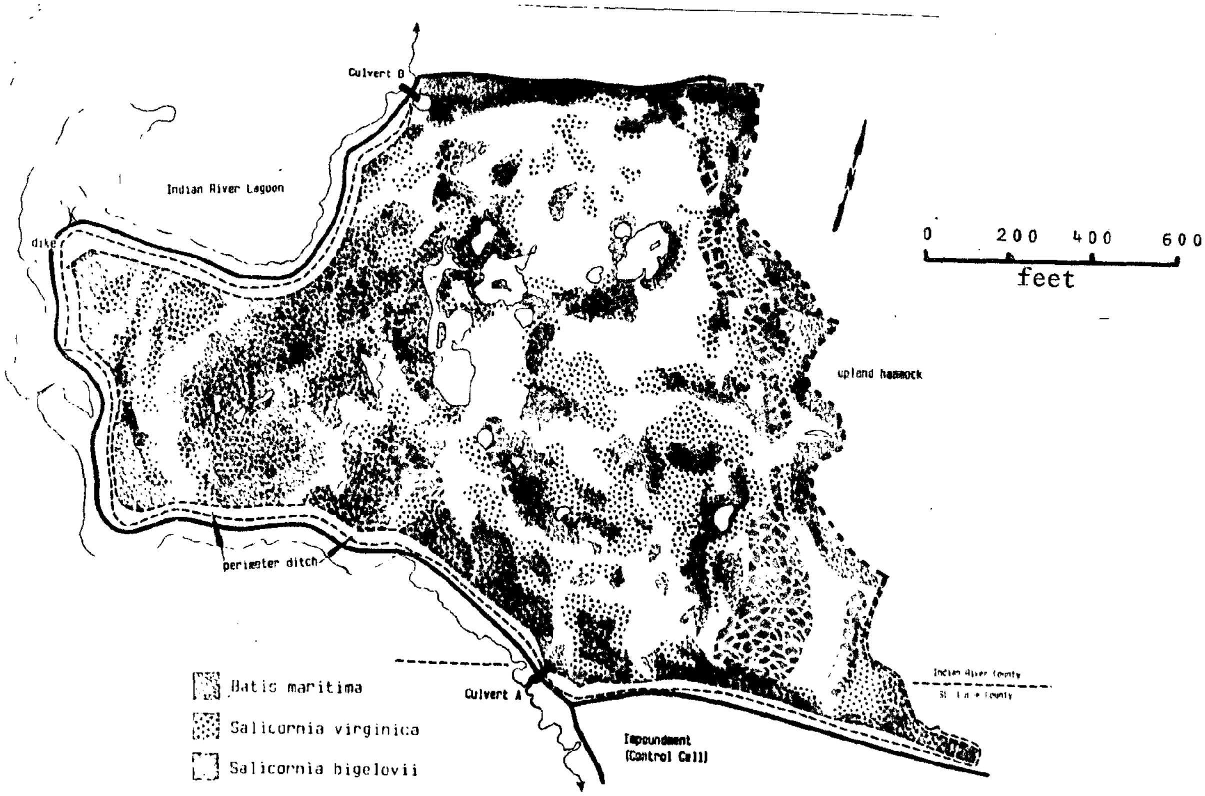

Figure 4. Approximate occurrence and location of marsh vegetation at Impoundment #12 in January 1984.

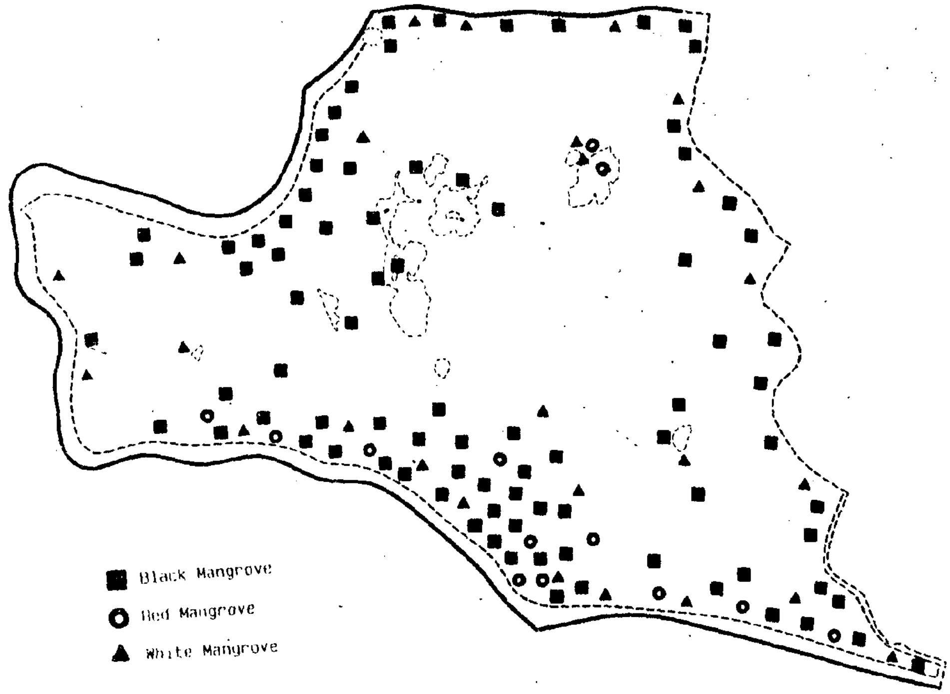

Figure 5. Approximate occurrence and location of marsh vegetation at Impoundment 12 in January 1984.

Figure 6. Extent of marsh flooding at sequential elevations (0.45 ft. NGVD).

Figure 7. Extent of marsh flooding at sequential elevat ons (0.55 ft. NGVD).

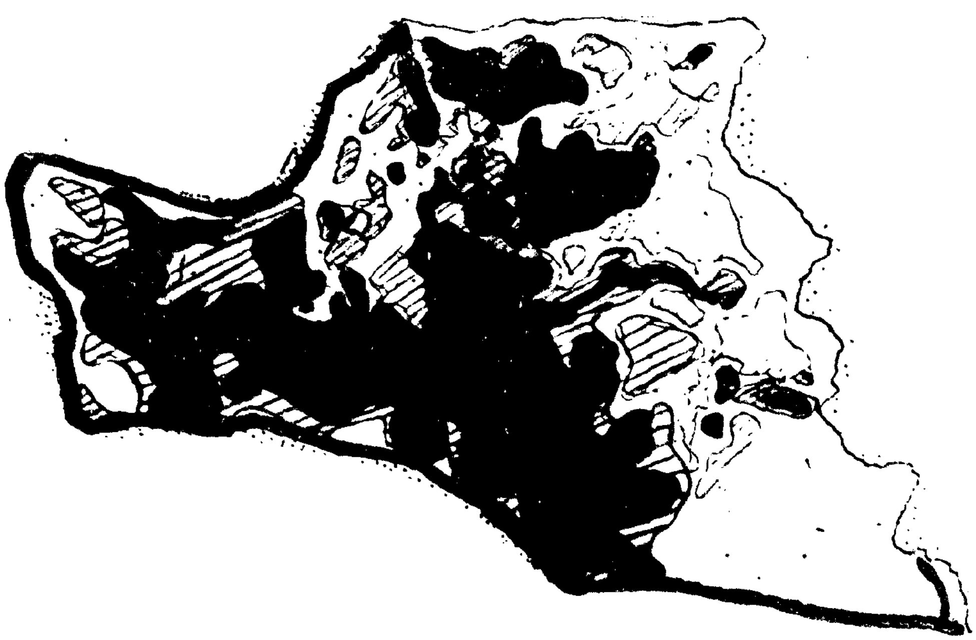

Figure 8. Extent of marsh flooding at sequential elevations (0.60 ft. NGVD).

Figure 9. Extent of marsh flooding at sequential elevations (0.75 ft. NGVD).

Figure 10. Extent of marsh flooding at sequential elevations (0.90 ft. NGVD).

Figure 11. Extent of marsh flooding at sequential elevations (1.0 ft. NGVD).

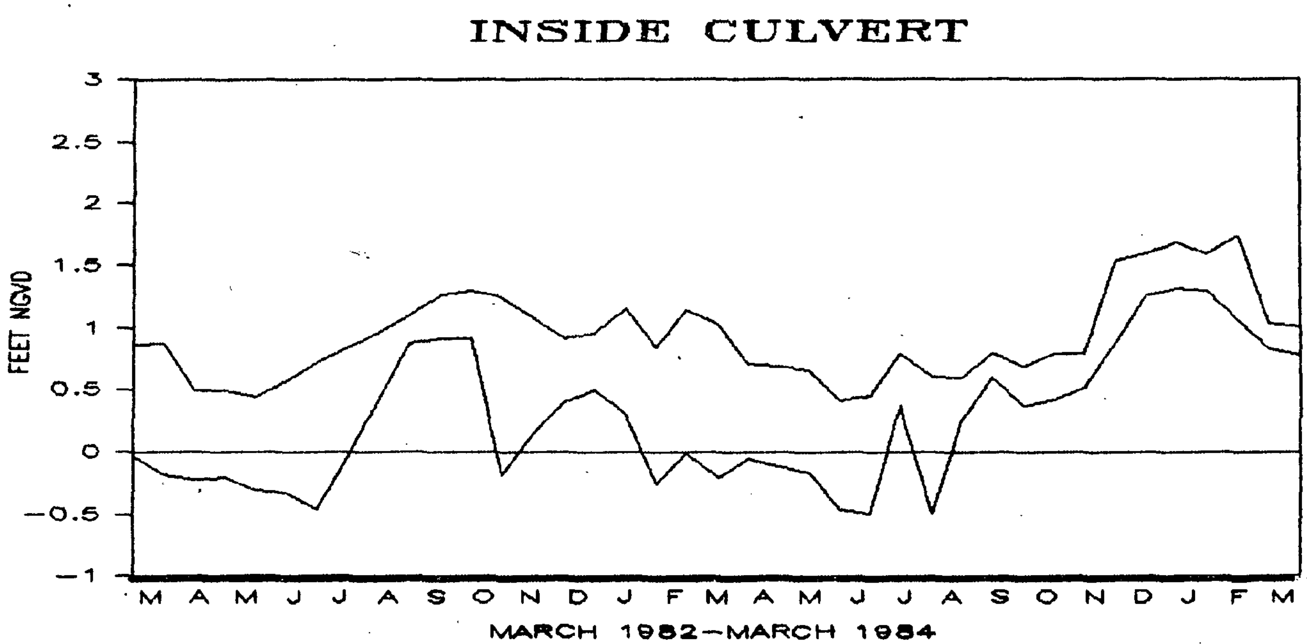

Figure 12. Water level fluctuations at Impoundment #12 during study.

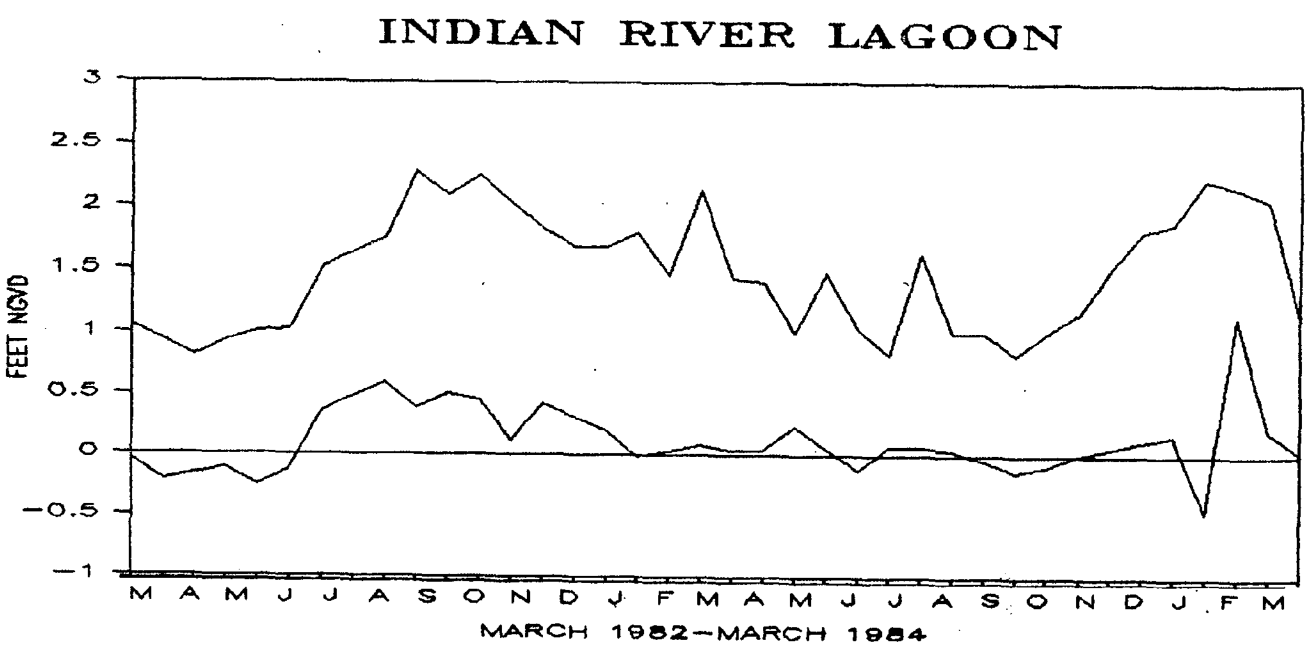

Figure 13. Water level fluctuations at Impoundment #12 during study.

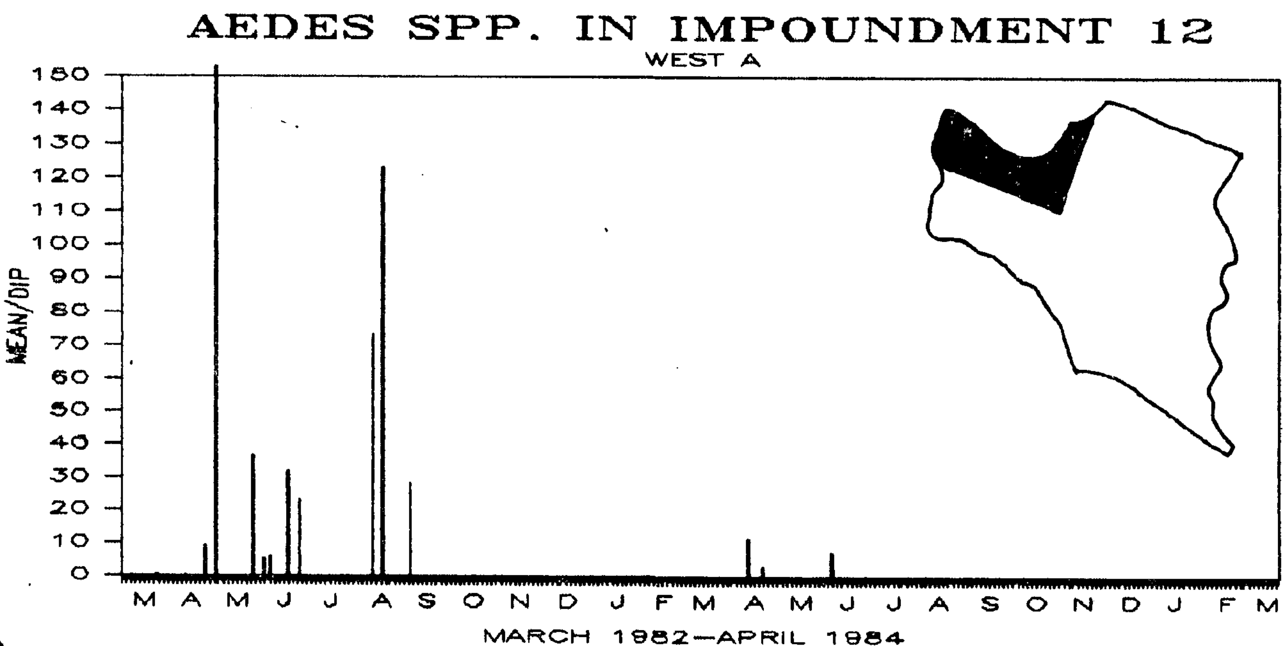

Figure 14. Mosquito production at Impoundment #12 during study.

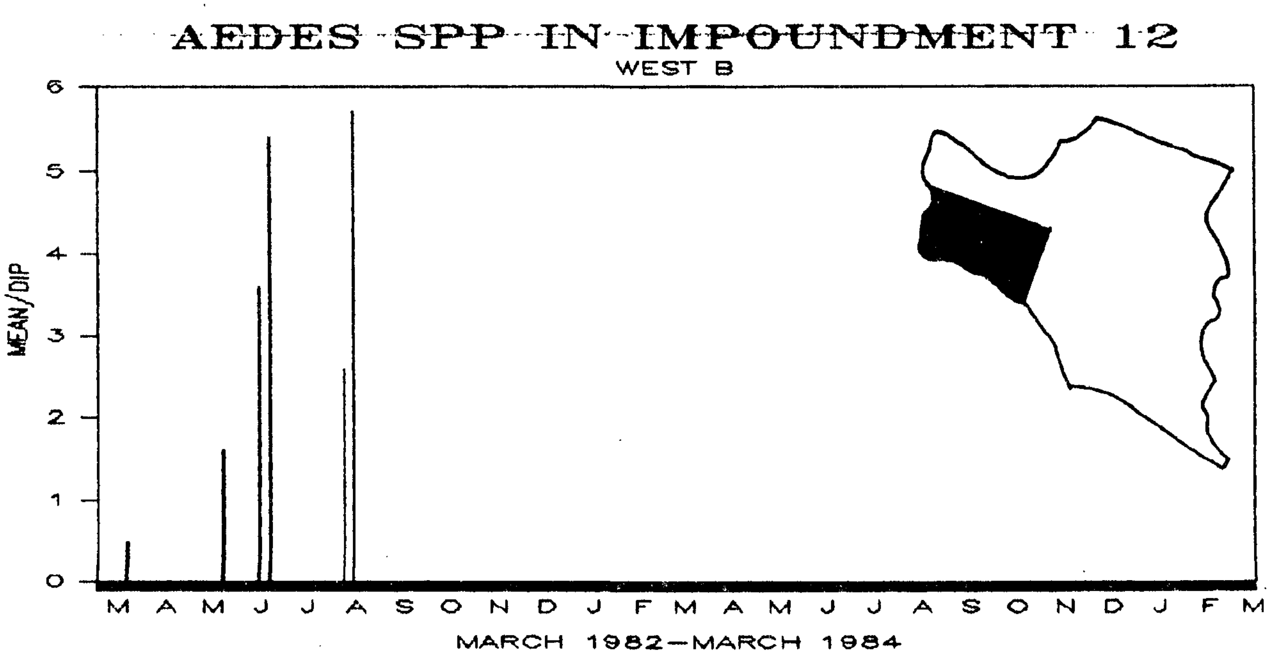

Figure 15. Mosquito production at Impoundment #12 during study.

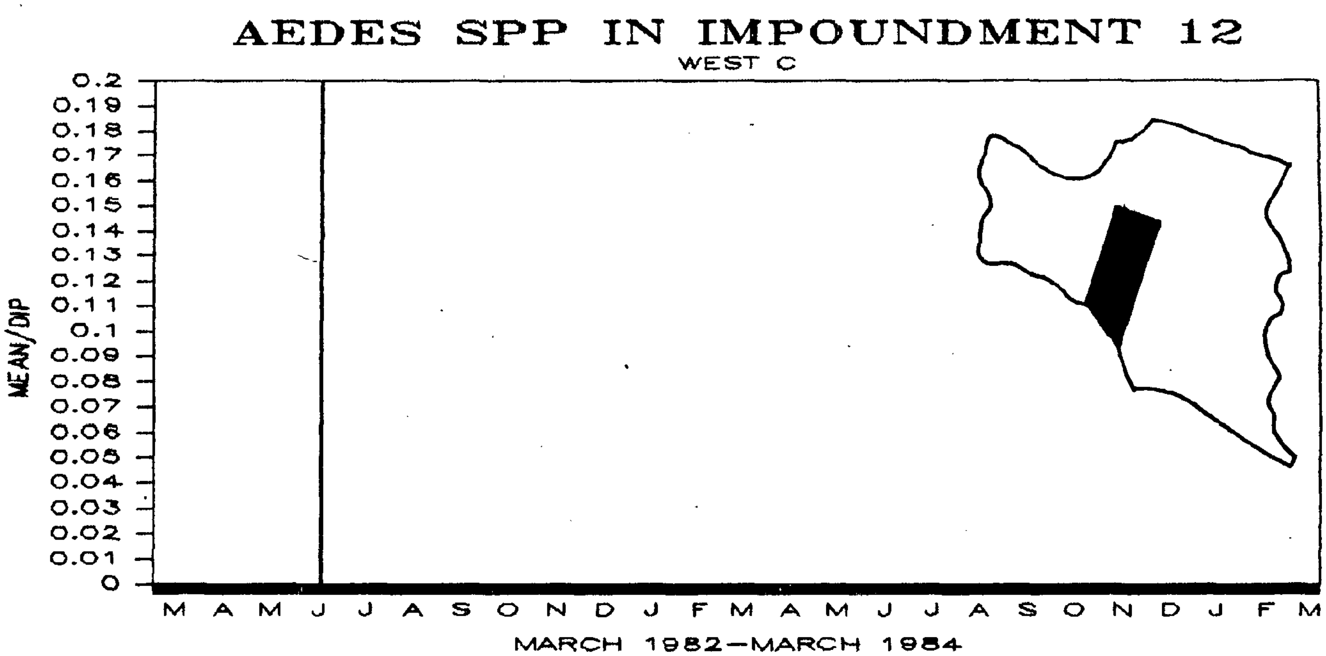

Figure 16. Mosquito production at Impoundment #12 during study.

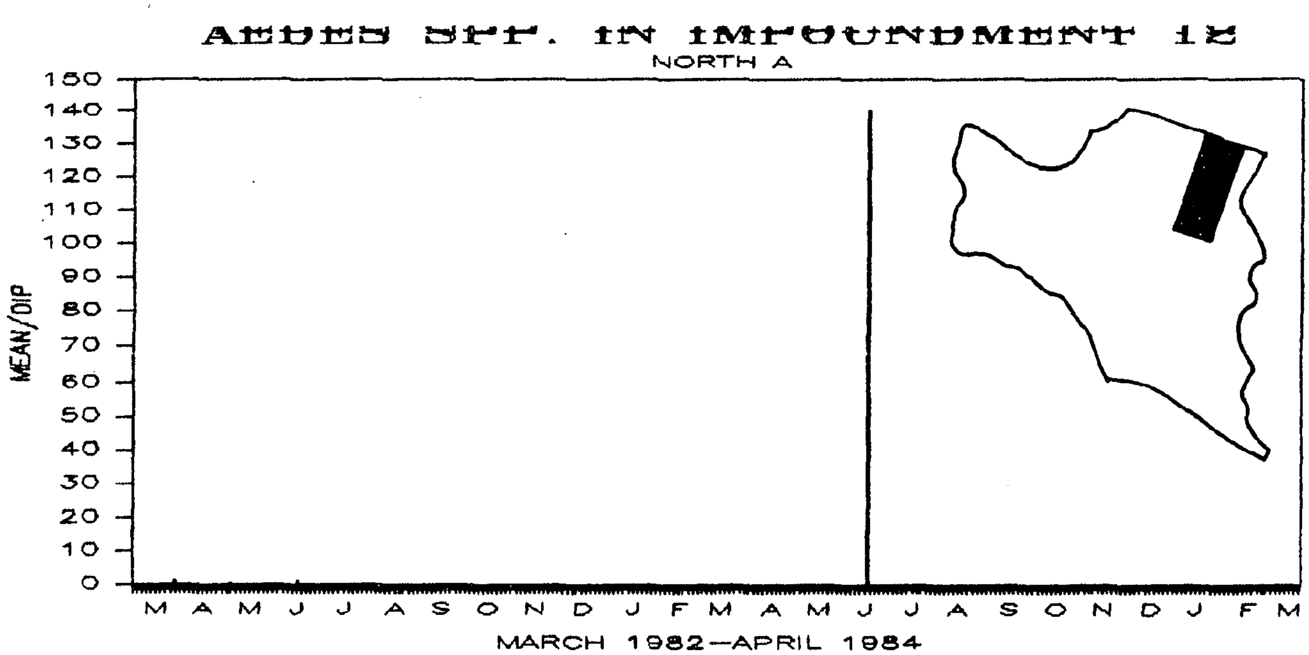

Figure 17. Mosquito production at Impoundment #12 during study.

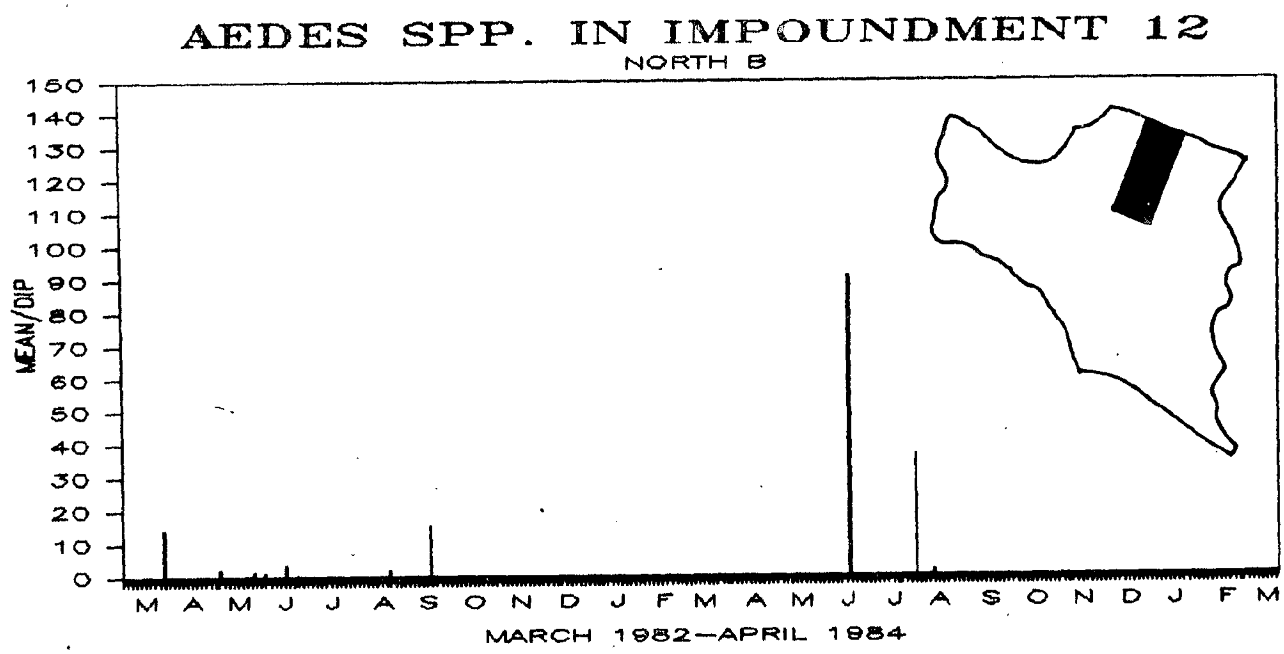

Figure 18. Mosquito production at Impoundment #12 during study.

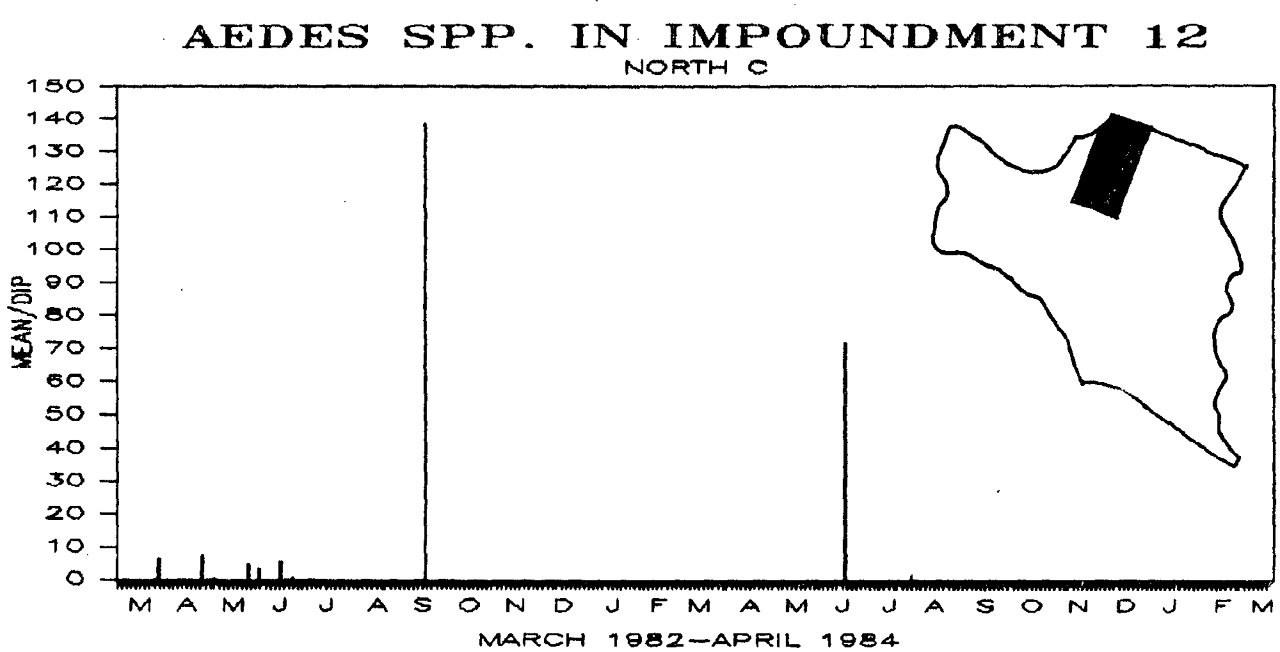

Figure 19. Mosquito production at Impoundment #12 during study.

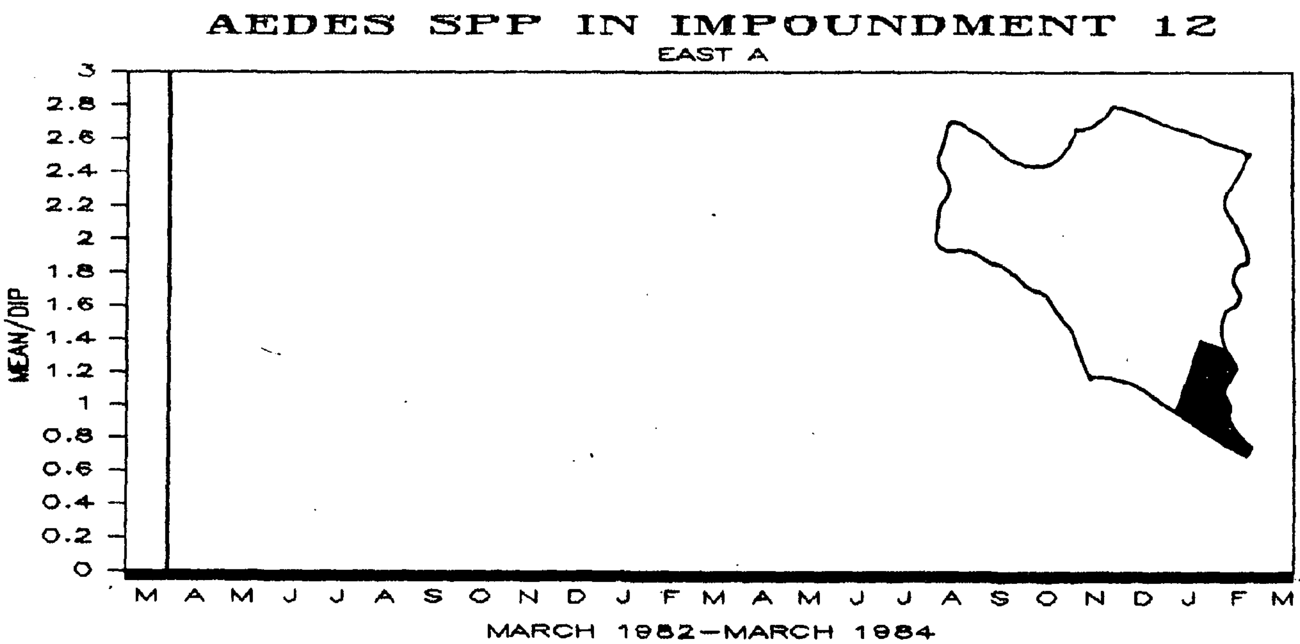

Figure 20. Mosquito production at Impoundment #12 during study.

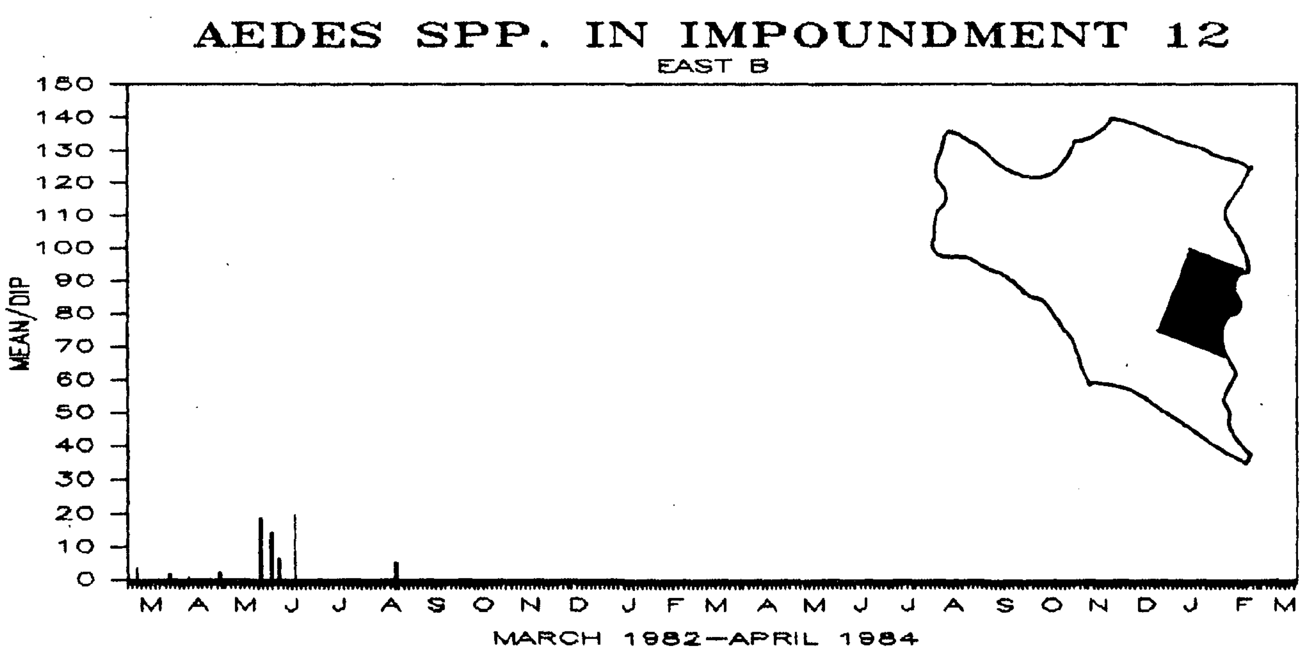

Figure 21. Mosquito production at Impoundment #12 during study.

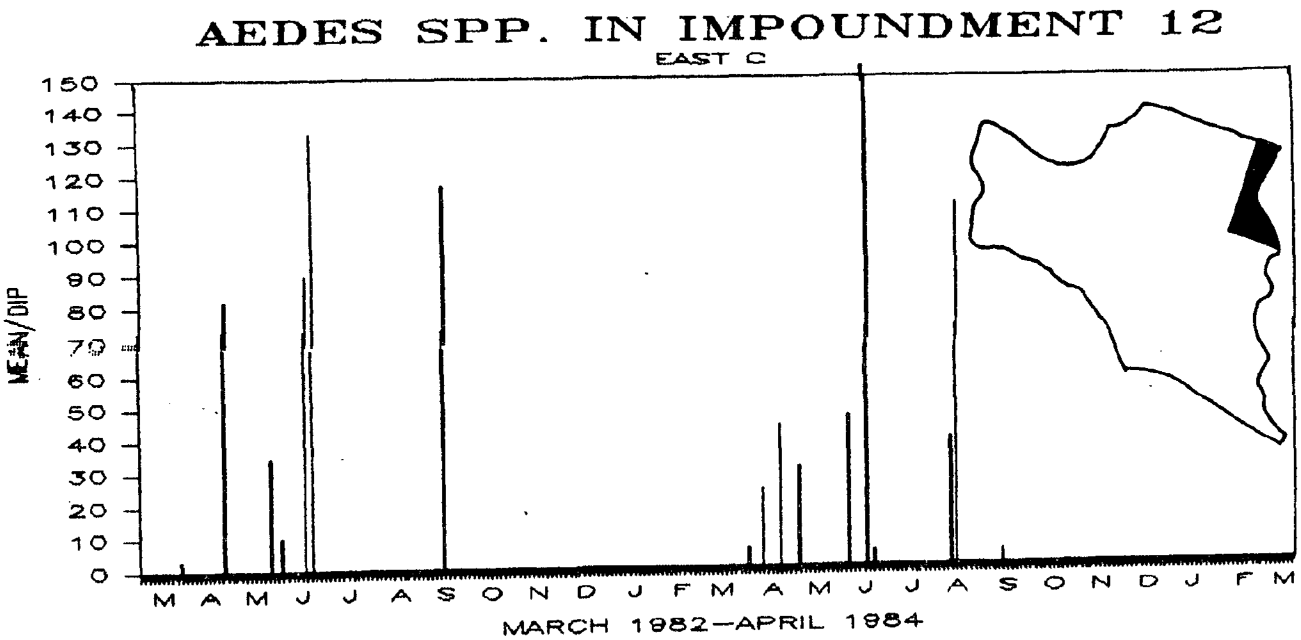

Figure 22. Mosquito production at Impoundment #12 during study.

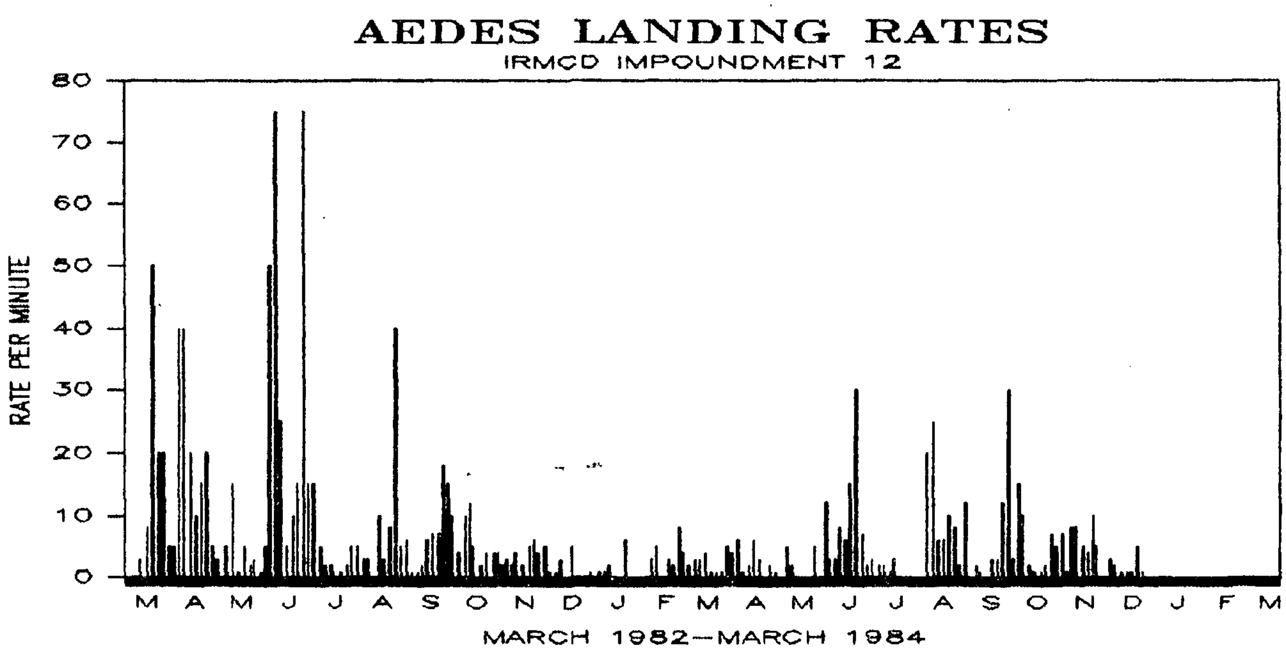

Figure 23. Maximum mosquito landing rates at Impoundment #12 during study.

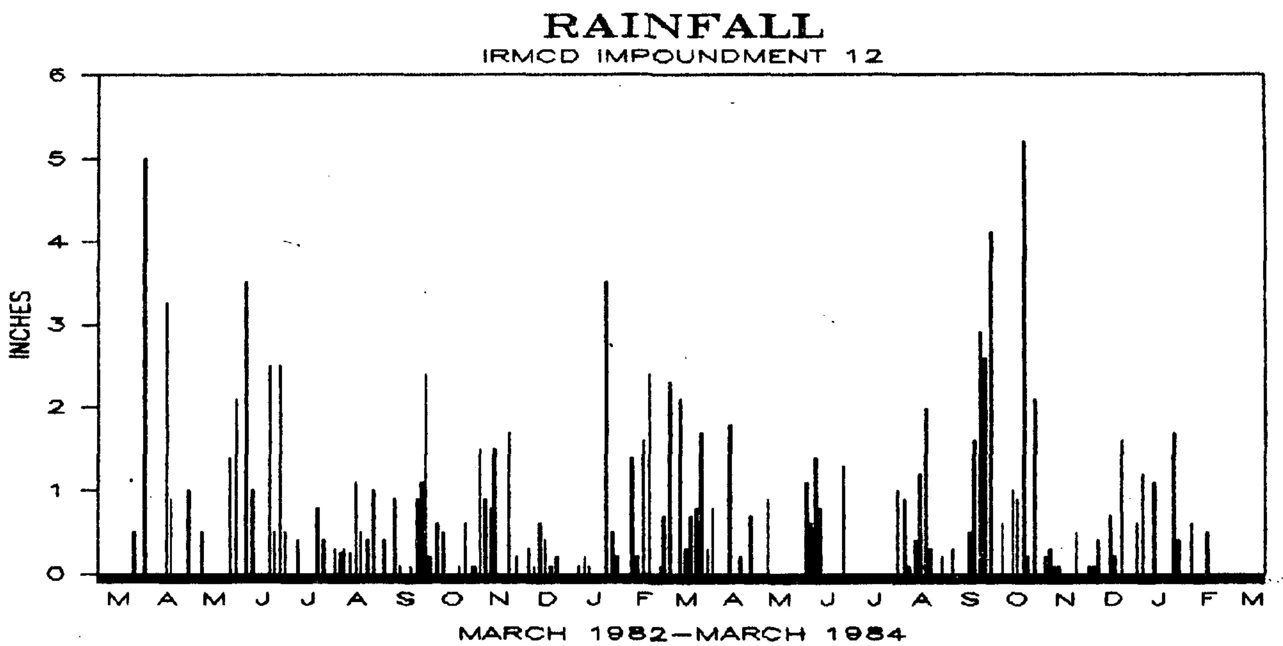

Figure 24. Rainfall at Impoundment #12 during study.

FISH AND MACROCRUSTACEAN POPULATION DYNAMICS IN A TIDALLY ~~TITALLY~~ INFLUENCED IMPOUNDED SUB-TROPICAL MARSH

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FISH AND MACROCRUSTACEAN POPULATION DYNAMICS IN A TIDALLY INFLUENCED IMPOUNDED SUB-TROPICAL MARSH

INTRODUCTION

Prior to the work of Harrington and Harrington (1961) subtropical high marsh fish populations had received little systematic study. The Harringtons were principally interested in trophic studies although repetitive sampling of fishes allowed species composition and temporal distribution in the high marsh to be determined during a single month (Sept. - Oct.). Their study site was subsequently impounded (Impoundment No. 12, Bidlingmeyer and McCoy 1978) to control salt marsh mosquito populations, *Aedes taeniorhychus* and *A. solicitans* (Harrington and Harrington, 1961). This method of mosquito control was very effective but eliminated much of the natural abiotic and biotic processes of the high marsh. Unfortunately, the study of natural fish movements and population dynamics was not conducted during this preimpoundment period.

During 1977 a neighboring impounded high marsh was opened to tidal influence. The ichthyofauna of this latter marsh site was subsequently compared with that of Impoundment No. 12 with some treatment of annual changes in species relative abundance during 197~~8~~9 and 1980 (Gilmore et al., 1982). This study demonstrated that minor tidal access allowed immigration of marsh transients from the adjacent estuary, and that these transients contributed a numerically significant portion of the marsh fauna on a seasonal basis. All commercial and sport fishery species which utilize marsh habitat were found to be members of this transient group while all were absent from the impounded marsh without tidal access (Gilmore et al., 1982; Harrington and Harrington, 1982).

Although the Gilmore et al. (1982) study presented limited temporal quantitative information, it and previous studies were essentially qualitative. Detailed quantitative study of fish movements between high marsh, low marsh and outer estuarine waters on diel, biweekly and seasonal bases within a tidally influenced impounded subtropical marsh had not been conducted. We therefore chose to conduct the first detailed quantitative study of the ichthyofauna of Impoundment No. 12 which had been previously studied by Harrington and Harrington (1961, 1982) and Gilmore et al. (1982). The 18.3 hectare (50.0 acre) marsh was reopened to tidal influence through a single 45.7 cm (18 inch) diameter culvert in February 1982. As detailed trophic analyses had also been conducted by Harrington and Harrington (1961, 1982), we continued the trophic dynamic studies of the ichthyofauna associated with this specific marsh site. This allows a comparative analysis of changes in energy sources before, during and after marsh impoundment had totally excluded high marsh-estuarine interchange of water and organisms (Harrington and Harrington 1961 and 1982).

Fish and macrocrustacean population dynamics and dynamics of physical parameters determined in this study are anticipated to present data allowing increased precision in management of impoundments for mosquito control and yet allow the optimum exchange and maintenance of estuarine organisms, many of which have a great economic impact on the fisheries of Florida. Impoundment closure periods will impact organism migration between the estuary and the impoundment (Gilmore et al. 1982). Timing closure and reopening periods carefully will minimize this impact. Use of devices which allow organism transport during closure periods will minimize migratory impact. Other management strategies such as installing additional culverts or overpumping may moderate potentially lethal physical parameters enhanced by management structures or closure periods. Determining the periods of major concern and the most effective means of moderating water quality parameters to reduce organism stress and mortality would be a major management asset.

COLLECTION SITE DESCRIPTIONS

Detailed descriptions of Impoundment 12 are presently in the published literature (Harrington and Harrington, 1961, 1982; Gilmore et al., 1982). Figure 1 illustrates the relative location of the collecting sites. Each site has a literal designation and a numerical designation to allow computer analysis of the data obtained from these locations.

Both are designated in the illustration and within Table 1. The upper marsh includes stations SP-1 (50), SP-2 (51), P-1 (52) and P-3 (53). Transitional stations located at the mouth of rivulets draining the upper marsh into the perimeter ditch are designated as DD-1 (40), DD-2 (41) and DD-3 (42). Perimeter ditch stations are regarded as lower marsh stations, Northwest Pond (30), Tarpon Hole (70), pull net transects (60 & 71), and the culvert stations, South Culvert (61) and North Culvert (72). The artificial perimeter ditch is considered to be lower marsh during this study and all references to the lower marsh are limited to stations located within the perimeter ditch. All stations within the Haeger Cove, seagrass bed (62), and sand bottom (63) are considered open estuarine or Indian River lagoon stations as is the Outside Pond station (31) situated in a tidal Rhizophora - Avicennia forest on the northwest corner of the western projection of the impoundment.

METHODS

A variety of gear types are necessary in order to obtain the appropriate qualitative and quantitative data on highly mobile and easily conditioned organisms. In addition, a range of microhabitats must be sampled throughout a 24 hr period(to account for the well documented diel movements of fishes and macrocrustaceans, over a variety of tidal cycles at periodic intervals throughout the year (e.g., two moon phases per month). Finally, several years of information should be obtained to differentiate seasonal variations in physical parameters which may affect fish and crustacean distribution patterns. To account for these considerations collections were made on all tidal cycles throughout the entire diurnal period at two week intervals at a variety of sites using multiple gear types from March 1982 to February 1983 (Fig. 1, Table 1). This covered the majority of microhabitats available to fishes within the study area. Complete diel (24 hr) collections were made at monthly intervals in the lower marsh and at culvert sites from August 1983 to January 1984. The examination of several annual cycles was out of the scope of this study.

GEAR TYPES:

Eight gear types were used for fish and crustacean collections (Table 2). Many of these were specifically designed to capture fishes in the microhabitats studied. Heart trap: An aluminum frame, adjustable aperture (to 35 mm), 3.2 mm ace weave mesh 0.62 x 0.78 m, 0.63 m deep heart trap was used to capture fishes moving through shallow depressions extending onto the upper marsh from the edge of the perimeter ditch (Fig. 2). The theoretical concept for this design requires that fishes contacting the trap from any direction will follow the heart shaped contour to the aperture. This same trap was used during the earlier Harrington surveys of this same marsh and the trap was assembled from rough drawings made by Harrington's colleagues at the Florida Medical Entomology Laboratory. The heart trap was used to obtain a qualitative sample of fishes moving between the perimeter ditch and the upper marsh. It was also used in paired synchronous sets made outside of the impoundment dike in two shallow tidal basins surrounded by mangrove forest (station 31). Sets were made overnight over an entire 24 hr cycle.

Culvert trap: A 1.52 m~~m~~ long trap was also designed specifically to collect organisms passing through the culvert. It is basically a 44 cm diameter aluminum cylinder wedged into the culvert with compressible tubing between the trap and the culvert. Two 3.2 mm mesh cones are inserted in either end and a central 3.2 mm mesh partition separates capture chambers on either side. This allows fishes swimming against currents, rheotaxic forms, and those moving with the current to be kept in separate chambers. The cylinder is cut along its longitudinal axis and hinged so that the trap could be easily opened to remove its contents. The culvert trap was set for one hour collections every two hours throughout a 24 hr period at monthly intervals at both culvert sites from September 1983 to January 1984.

Culvert net: In addition to the culvert traps a 1.7 x 1.0 x 1.3 m, 3.2 mm mesh bait box net was modified to fish the water exiting the culvert (Fig. 2). A 0.7 x 0.2 m cylindrical collar with a 0.5 m long, funnel was used to connect the net to the culvert with a metal clamp serving as a holding device. Wood stakes were used to support the net corners during the set. This system was used to capture organisms exiting the impoundment or entering by switching the net from one end of the culvert to the other when the tide changed. This was done at biweekly intervals from March 1982 to February 1983.

The following mobile fish capture techniques were used to determine fish density and biomass and to capture organisms that might not necessarily enter static traps:

Throw net: A 1.0 m^2 throw net (Kushlan 1981) was used to take density and biomass samples in the SP-1 and SP-2 upper marsh ponds. Three replicates were taken in SP-1 at flood to high tide while three replicates were taken both at flood-high and ebb-low in SP-2. Although the throw nets sampled a smaller area than the seines used, fish density and biomass estimates were much larger in the 1.0 m^2 samples (Table 3).

Seine nets: A tarred, 3.08 m, 3.2 mm ace mesh bag seine was pulled over measured set transects on all tidal cycles in both SP-1 and SP-2. The 3.08 m bag seine was also used to sample the P-1 and P-3 ponds at the ebb-low tide stage. The same net was used to sample 90 m^2 transects over a seagrass bed and open sand bottom adjacent to the impoundment. A 15.2 m, 3.2 mm ace mesh bag seine was used to sample 50 m transects in seagrass beds from August 1983 to January 1984.

Pull net: A tarred 2 m x 5.65 m, 3.2 mm ace weave pull net was specifically designed to sample the perimeter ditch microhabitat (Fig. 2). The net was designed to operate similar to a trawl. Lateral netting panels (1.3 x 2 m) replaced trawl doors and a double float line was installed to insure the cod end did not collapse and to aid in capture of aerial escapees (e.g. mullet, *Mugil cephalus*). A "many-ends" bottom line consisting of a lead line core within a multiple fiber cord bundle was used to insure that the bottom line did not bury into the soft mud when pulled. The net was fished along a set transect and pulled with handlines to a barrier net suspended across a foot bridge spanning the perimeter ditch. The pull net was fished biweekly on each tidal cycle during the diurnal sampling schedule of 1982-83. Pull net samples were taken adjacent to culvert sites, 60 and 72, once during the day and once at night on the same tidal cycle during the September 1983 - January 1984 sample period.

Cast net: A 2.8 m radius, 2.5 mm mesh cast net was used to sample the NW Pond site, a deep (to 2 m) circular pond well suited for this sampling strategy. Three throws were made during the morning flood-high tide and again during the afternoon ebb-low tide periods.

SPECIMEN TREATMENT AND DATA ANALYSIS

All specimens were fixed in 10% formalin, washed and preserved in 70% ethanol. Prior to preservation they were sorted to species and weighed and measured (standard length). Species with over 50 individuals were subsampled with a randomly picked sample of 50 used for length-weight distribution of the species. Total species sample weight of large collections was taken and mean weights of subsamples were used to calculate the total number of specimens, which in some cases reached in the tens of thousands in a single collection. All of these data were entered directly into a computer with a terminal located in the specimen processing center to eliminate key punch errors by second parties. Files of physical data and biological data were formatted similarly to allow for correlative analysis. Computer data entry forms were standardized and associated with programs to check species spelling and other erroneous data. This allowed several assistants to enter data even though they may not have extensive computer backgrounds.

All data was stored in a PRIME 750 (4 MB) computer system with INFO, BMD and MINITAB information processing and statistical analyses capabilities. In addition a battery of programs was written at the systems operating level and within INFO to produce reports, plots, etc. and to interact with statistical packages from a series of master menus.

PHYSICAL PARAMETER TECHNIQUES

Physical parameters monitored were water levels, dissolved oxygen, salinity, temperature and pH. Water levels were recorded with three electric and spring drive continuously recording meters permanently set in the upper marsh pond, P-1, in the perimeter ditch at the South Culvert, 61 and outside at the time of organism capture on calibrated stakes set in P-1, NW Pond, perimeter ditch at the South Culvert and outside the impoundment at the South Culvert. Dissolved oxygen was recorded at the time of organism capture on a temperature-salinity compensated meter and on recording meters set up to continuously record D.O. levels throughout a 24 hr period within the perimeter ditch at the South Culvert and the North Culvert. Salinities were recorded on a temperature compensated A.O. refractometer. Temperatures were recorded with hand held thermometers or with the temperature sensor of the portable D.O. meter. Hydrogen ion concentrations (pH) were measured with a portable field unit until probe failure and maintenance proved too costly. PH measurements were discontinued after 31 August 1982.

FEEDING ANALYSES

Feeding analyses were made as compatible with the previous work of Harrington and Harrington (1961, 1982) as possible. Their volumetric analysis with the use of grids was utilized with a seive sorting technique added (derived from Carr and Adams 1972). Observations of various species in the field greatly aided in determining the source of some of the more abundant food sources (e.g., detrital algal conglomerates). Five species were chosen for analysis based on their trophic standing and numerical abundance. The species examined were *Cyprinodon variegatus*, *Poecilia latipinna*, *Gambusia affinis*, *Elops saurus* and *Mugil cephalus*. Fishes examined were divided into size groups for ontogenetic comparisons and into spatial groups, e.g., upper and lower marsh and outside impoundment groups. Each month is to be examined for temporal transitions in diet. However, time only allowed several hundred specimens to be examined for the months of March and June, 1982. The multiple linear regression analysis included was produced from a INFO - MINITAB interactive program.

RESULTS

The Fish and Crustacean Community

A total of 242,729 specimens (134.87 kg) representing 50 species were captured during the survey, 14 of which could be considered marsh residents with the capability of reproducing within the confines of the marsh (230,105 individuals or 94.8% of the total catch; Tables 4,5,6,7). The 14 resident species belong to seven families three of which were found to dominate numerically, Cyprinodontidae, Poeciliidae and Palaemonidae. The atherinids, *Dormitator maculatus* and *Achirus lineatus* occur often enough in marsh samples to be considered residents although their reproductive strategies are not fully understood.

Of the 33 transient species captured, 15 are considered ephemeral migrators, while 9 are considered seagrass residents with no constant utilization of the marsh habitat. Seagrass residents are *Syngnathus scovelli*, *Lagodon rhomboides*, *Eucinostomus gula*, *E. argenteus*, *Gobiosoma robustum*, *Hippolyte pleurocanthus*, *Orchestia grillus*, *Eurytium limosum* and *Taphromysis bowmani*. Migrating planktivores that occurred in the marsh sporadically are *Brevoortia smithi*, *Sardinella achovia* and *Anchoa mitchilli*. Infrequently captured eurytopic migrators are *Anguilla rostrata*, *Myrophis punctatus*, *Strongylura marina*, *Lutjanus griseus*, *Gerres cinereus*, *Diapterus auratus*, *Diapterus plumieri*, *Archosargus probatocephalus*, *Pogonias cromis*, *Leiostomus xanthurus*, *Mugil curema* and *Sphyreana barracuda*.

Marsh transients that actually depend on the marsh as a habitat for a portion of their life cycle were *Elops saurus*, *Megalops atlanticus*, *Centropomus undecimalis*, *Mugil cephalus*, *Penaeus duorarum*, *Penaeus aztecus* and *Callinectes sapidus*. At this time we are not able to place *Microgobius gulosis* into a specific category, however, this species has a general occurrence in both seagrass beds and around mangrove prop roots, oyster beds, etc. in both fresh and saline water (Gilmore 1977; Gilmore et al. 1981). Twenty of the transient species captured are of commercial or sport fishery value and all of these spawn in open estuarine, neritic or pelagic habitats (Tables 4,5).

FISH AND MACROCRUSTACEAN POPULATION DYNAMICS

Figure 3 depicts spatial and temporal dynamics of total organism densities determined during the March 1982 - February 1983 sampling period.

Spatial distribution: These data indicate that the lower marsh (= perimeter ditch) contains the majority of organisms even though a larger sample area was collected in the upper marsh. Fish dispersal over the more extensive upper marsh and therefore lower densities accounts for much of this bias. Fish densities within seagrass beds were somewhat lower than the perimeter ditch but could undoubtedly be a partial artifact of the use of a single technique to monitor this site, i.e., a 3.1 m bag seine. The seine does not produce as high density estimates as the throw net as was demonstrated in the throw net-seine comparison for the upper marsh (Table 3). Seagrass bed fish density estimates did, however, surpass upper marsh densities even though better quantitative techniques were utilized at the latter site. Sand bottom habitats contained far fewer organisms throughout the year than any of the other microhabitats sampled. Very similar results can be seen in biomass distribution patterns (Fig. 4).

If we separate marsh transient species from residents we find differences in spatial utilization of the marsh (Figs. 5, 6, 7). The resident and transient fauna is typically more speciose in the lower marsh. The resident fauna is more speciose than the transient fauna on the upper marsh. More species of residents and transients occur outside the impoundment than on the upper marsh.

Temporal and spatial distribution: Resident richness (i.e., no. of species) remains nearly constant throughout the year in the upper marsh while transient species richness reaches a seasonal low from April to August peaking during the fall, in November. The transient fauna is more speciose than the resident fauna in the lower marsh from July to late November with a reversal of this trend from March to early July (Fig. 5). Outside of the confines of the impoundment, marsh residents were present in sufficient richness and numbers to make it difficult to determine temporal patterns in richness except that fewer resident species were found outside of the impoundment during the fall and during thermal depressions, 25 January 1983 (Figs. 5, 6).

The number of individuals for both residents and transients (Fig. 6) captured showed definite seasonal trends at all locations. Resident populations peaked in the upper marsh during March, May, July, late November-December and February. Transient species were most abundant on the upper marsh from November through May. A similar pattern was seen for both transients and residents in the lower marsh although a periodic peak in resident populations was seen from March through June. Outside the impoundment transient species again showed a basic fall-winter-spring series of peaks in abundance while resident populations showed periodic peaks throughout the year with greatest abundance during the winter and early spring.

Table 9 reveals the spatial-temporal distribution of the more abundant transient species based on a total number of individuals collected throughout the year. Typically the largest catch of these organisms took place in the culvert trap (60) as migration into or out of the marsh required passage at this location. The perimeter ditch adjacent to the culvert also showed larger concentrations of transients.

Movement up onto the upper marsh was most prevalent in *Elops saurus* and *Mugil cephalus*. *Centropomus undecimalis*, *Leiostomus xanthurus*, *Pogonias cromis*, *Callinectes sapidus*, *Penaeus* spp. and *Megalops atlanticus* also occurred in the upper marsh collections but in much lower numbers and tended to prefer the lower marsh, perimeter ditch microhabitat. *Anchoa mitchilli* and *Leiostomus xanthurus* were much more abundant outside of the impoundment, the former in seagrass beds (62), the latter over sand bottom (63). Penaeid shrimp were also more abundant in the adjacent seagrass bed.

Mean individual weight for transients is greater than that of resident species therefore reducing the bias in collection weight seen in the lower marsh, as both species groups contribute similar amounts to the lower marsh fish and crustacean collection weight (Fig. 7). Transient species show two major peaks in collection weight, first during the spring, May through early July, and then the late summer to winter, August to January. From late July to January transient collection weight remains rather stable, around 1 kg, in the lower marsh while the resident species drop significantly from late September through November. On the upper marsh transient weight is significantly greater than resident weight in July despite a much larger resident population in the collections. This is principally due to the abundance of larger *Elops saurus* on the upper marsh at this time.

PHYSICAL PARAMETERS

Physical parameters are particularly vital to biological activity in a transitional semi-aquatic habitat such as the subtropical high marsh under study. Relative to other aquatic ecosystems physical parameters in this habitat undergo extreme variation. This is due to the ephemeral water cover which is usually no more than a few centimeters over the greater expanse of the marsh. Variations in atmospheric parameters such as temperature, precipitation, ambient sunlight, wind and evaporation rates are all capable of producing greater change in the high marsh physical environment than in any other local aquatic habitat. The highest aquatic temperatures and salinities recorded from any estuarine habitat on the east coast of Florida were recorded from Impoundment 12 (43°C, Harrington and Harrington, 1961; 200+ ppt, Gilmore et al., 1982).

During the 1982-1984 study period, several thousand physical parameter measurements were made, sufficient to compare to long term norm records for the region, particularly with regard to temperature, salinity and precipitation patterns. During 1982 water temperatures peaked in April and September (Fig. 8, Table 10; 369 measurements between March 1982 and February 1983). Mean water temperatures only went below 20°C in March, late January and early February. Water salinities generally reach their annual minimum during the late summer and fall (Wilcox and Gilmore, 1976; Gilmore, 1977; Gilmore et al., 1981). However, during 1982-83 unusual rainfall patterns produced annual mean salinity minima in June and February although the absolute minimum salinity value of the year was measured during August. Figure 9 compares the 76 year mean precipitation pattern for the Fort Pierce, NOAA, EDS, recording station with the 1982-83 precipitation pattern recorded at the impoundment study site. The extreme lack of correlation of precipitation records with the norm was a regional phenomena and was not isolated to the study site.

Dissolved oxygen levels also fluctuated widely, particularly within the deeper perimeter ditch (Figs. 10, 11, 12). Mean oxygen minima occurred in April and late June to July. Although D.O. values ranged widely during the remainder of the year after July, the overall mean generally stayed above 5.0 ppm. Daily minima typically went below 3.0 ppm on 24 hr recordings made within the perimeter ditch at the entrance to the South Culvert (Figs. 13-15). PH values were below 7.0 throughout March and early April but went above 8.0 in May and remained above 7.0 for those records that were taken on into September after which the meter failed.

Water level meters recorded fluctuations at three locations, the upper marsh (pond, P-1), the lower marsh (perimeter ditch at the South Culvert site, 60-61) and outside the South Culvert in Haeger Cove, a finger of open estuary, the Indian River lagoon. These recordings provided detailed observations of coupling and uncoupling between tidal amplitude in the open estuary and within the impoundment, which in turn correlated well with the numerical catch of fishes and macrocrustaceans. Figures 9 and 17 show the recordings obtained from these meters, moon phase and rainfall records from the impoundment. As the sea level is at its maximum from September to late November the water level in the impoundment was virtually stored with little opportunity to leave on an ebb tide through a single 45.7 cm diameter culvert, thus uncoupling the tidal amplitudes between the marsh and the estuary until 30 November. The water level variation again uncoupled during the second week of December, coupled the last week in December, and uncoupled during all of January until early February. Neap tide coupling occurred in March and as the sea level reaches its minimum in late March and April the records reveal a coupling or synchronization in tidal amplitudes between the impoundment and the estuary. The periods of uncoupling are characterized by complete submergence of the upper marsh through both high and low lunar tidal cycles. Precipitation may have been a factor in keeping impoundment water levels high from 20-23 January and during late February and March as sea levels had come down during this period.

The upper marsh typically dries out during the low sea level and low rainfall periods of the late winter and spring (Figs. 8, 9, 10). During this period upper marsh ponds still containing water typically become hypersaline (Fig. 10; Gilmore et al., 1982). However, the 1982 dry season was wet with 14.7 in (37.3 cm) of rain measured at the impoundment site from March to May (Fig. 9). Rainfall depressed upper marsh salinities down to values between 30 and 35 ppt between March and May. Upper marsh dissolved oxygen values also dropped during March and early April as the water warms up within shallow ponds as photosynthetic activity increases. However, this D.O. reduction is not as great in the upper marsh as it is in the lower marsh perimeter ditch.

The lower marsh and estuarine salinity and temperature pattern was more moderate, as deeper more permanent water was always connected to the open estuary (Fig. 11). However, dissolved oxygen levels varied considerably in the perimeter ditch approaching lethal levels for resident and transient organisms during March and June-July (Figs. 11, 13-15).

ENVIRONMENTAL PARAMETERS AND POPULATION DYNAMICS

Water level fluctuation is the most obvious environmental parameter effecting the temporal distribution of fishes and crustaceans within the marsh. Due to the regional nature of the tidal amplitudes and sea level fluctuations, the subtropical high marsh in this portion of Florida is only seasonally inundated. The majority of the original high marsh was covered completely by water only during the highest tides on the highest sea level peak of the year, from September to November (Fig. 16). Along the

Florida east coast the most notable tidal amplitudes are caused by lunar phase (generally twice monthly) and lunar distance from the earth (perigean tides every 4 1/2 years). The largest lunar phase tides occur on every new and full moon throughout the year and are known as Spring tides. The new moon Spring tides are larger than full moon Spring tides from winter to spring. The opposite is true during the late summer and fall. Although there are seasonal fluctuations in Spring tide amplitudes, these tides have their greatest effect within the Indian River lagoon when they occur on the annual sea level rise during the late summer and fall. Therefore regional sea level rise has a greater overall effect on tidal amplitudes than does any other water level factor. Even though it is impounded, the majority of the marsh is still high marsh with the same inundation pattern. However, considerable low marsh has been created with the creation of the perimeter ditch during impoundment construction. This low marsh acts as a refugium during marsh exposure when sea level declines. Larger species (i.e., tarpon) that would normally migrate to deep estuarine habitats remain in the perimeter ditch after upper marsh exposure.

The seasonal population changes in resident fishes and crustaceans (Fig. 16, Table 11) reveal ~~there are~~ several important patterns. Early in the year, from January to June, when sea level is at its lowest, there is an obvious lunar periodicity with peak numerical abundance in the low marsh. On every new moon phase from January 9 to May 20 there is a peak in resident fish populations at this location, particularly C. variegatus, P. latipinna and F. confluentus. During every full moon from January 25 to June 3rd there is a lower resident population in the low marsh with an overall decline in populations through this five to six month period (winter - spring). It is also noteworthy that outside of the marsh during March and April resident populations reached a peak and low on the opposite lunar phase, high on full moon and low on new. Migration of individuals from the marsh through the culvert to the adjacent seagrass beds is a possibility and culvert data is analyzed for this movement below.

Another pattern which is directly associated with water level is the total decline in all organisms in our samples during sea level rise in June and the late summer and fall. Percent occurrence remains stable, increases or declines only slightly for C. variegatus, Gambusia affinis, Palaemonetes spp., Mugil cephalus, and Elops saurus during this period (Figs. 18-20; Table 11). This reveals that these organisms are dispersed between the stations even though a population reduction is seen at the specific collecting sites. Field observations show many of these species to be present across the entire inundated surface of the high marsh. Therefore extensive population decline at our upper marsh pond and perimeter ditch sites is due to the dispersal of previously clumped individuals over a much wider area within the impoundment. This dispersal phenomenon is confirmed when the sea level declines in November and large concentrations of both residents and transients are found in deeper upper marsh ponds and low marsh. This occurs when tidal amplitudes of the estuary couple or synchronize with the impoundment tidal amplitudes (Fig. 17). The lowest numerical catch of the year occurred on 27 October (407 individuals) during the highest water levels of the year; the highest numerical catch one month later on 29 November (59,581 individuals; Table) occurred when sea levels fell. The low marsh then acts as a low sea level - dry season refugium. The tidal amplitude coupling phenomena and the increase in overall catch can be seen in Figure 17. By February and March the majority of the marsh, the entire upper marsh except for the deeper ponds, is dry and a lunar coupling pattern takes place. The overall increase in catch with the decline in water levels causes the generally negative correlation of all major species with mean water level.

Although the catch of organisms that readily invade the high marsh declined with increased tide levels, those transient species that preferred low marsh (perimeter ditch microhabitats) increased in numbers with increasing water levels. This positive correlation was only statistically significant with Menidia spp. and Fundulus confluentus but was positive when the majority of high marsh species showed negative correlations with other parameters (Table 12). The two species that showed this recruitment pattern were the snook, Centropomus undecimalis and the tarpon, Megalops atlanticus. When recruitment of these latter two species was compared with long term water level and precipitation patterns, positive correlations were found with mean high water and weak negative correlations with precipitation (Fig. 21, Table 13).

An observation that cannot be completely explained by water level change is the drop in catch on January 25th, 1983 shown by populations of all species within the marsh. This population decline correlates well with the minimum recorded water temperatures, 13.5°C with an average of 16.6°C in addition to water level coupling (Figs. 8, 12; Table 9).

When mean dissolved oxygen levels for all stations combined reached their seasonal lows of 3.2 ppm, ranging to less than 1.0 ppm, during late June and early July, there was a decline in numerical catch of C. variegatus, P. latipinna, G. affinis and F. confluentus. All except for possibly F. confluentus showed an increase in occurrence in samples indicating a dispersal across the upper marsh where dissolved oxygen remained more stable (Figs. 18-20). The low marsh perimeter ditch typically produces the lowest dissolved oxygen levels during this period and in combination with a June sea level rise (Fig. 11; Appendix 1), causes a dispersal of organisms across the upper marsh, and decline in catch at the stations monitored. Mean salinities also decline during June due to tidal dilution of hypersaline upper marsh waters and increased rainfall.

Correlation coefficients determined for various physical parameters recorded at the time of capture demonstrated that dissolved oxygen has more significant correlations than the other parameters and precipitation the least (Table 12). Our pH records were limited to the first six months of the 1982-83 survey as the meter did not survive the intensive field work. As pH and salinity are highly correlated those species most greatly correlated with pH were also correlated with salinity (Table 12).

TIDE ANALYSIS

From March 1982 to February 1983 organisms were collected either on a daylight high to ebbing tide or from a low to flooding tide, the majority on either the ebb or flood. This allowed a tidal comparison of fish and crustaceans captured on the upper and lower marsh. The culvert net set during this period also allowed examination of fishes moving through the culvert on a 3 hr ebbing tide set and a 3 hr flooding tide set.

Of particular interest for management purposes is the movement of fishes and crustaceans through the culvert (South culvert, 61; Tables 14-15). *Cyprinodon variegatus* showed net movement into the impoundment through the culvert on flood tides from January to late April and May (Figs. 18,22,23,24). There was a net movement out in June and

July. Another net inward - flood tide movement occurred during August and September then a major movement out in November and December when the sea level receded (as it also did in late June and July). Overall totals of C. variegatus moving into and out of the impoundment during the various tidal cycles did not significantly favor one tide or the other although more fish were found to leave the impoundment. The early December mass of C. variegatus captured on the ebbing tide may have been just a minor portion of a major exodus from the marsh which was inadequately sampled on a biweekly schedule. It is likely, as seen in G. affinis and P. latipinna, that there is a large net movement of C. variegatus into the adjacent estuary when sea levels recede in the late fall and early winter (Table 14).

Poecilia latipinna, F. confluentus and G. affinis show a seasonal tidal movement pattern similar to C. variegatus. There is a major net movement of all species out of the marsh in June, November and December. Immigrations are most apparent from January to May and from July to September.

Major transient species were recruited around adult spawning seasons with major flood tide immigration of E. saurus and M. cephalus (leptocephalus and querimana larvae, respectively) during the fall and winter (Table 15). A similar trend was seen for Callinectes sapidus. Juvenile snook, Centropomus undecimalis, were most abundant during the fall, which is the peak spawning period for adult populations. However, more specimens of C. undecimalis were collected on ebbing tide in late November and December than on the flood tide. This indicates a net movement out of the marsh with the majority of the aquatic fauna when the sea level recedes. Apparently numbers collected earlier in September and October were not representative of the flood tide immigration that may have taken place during that period. It is also possible that the culvert net is collecting fish as they move back and forth through the culvert during immigration and due to the ebb tide collection always preceding the flood collection fish removed by earlier collection were not captured later showing a bias toward the ebb collections.

There was a major numerical difference in the tidal catch of all transient species with a strong bias toward flood tide captives. As large numbers of larvae and juveniles are collected on seasonal flooding tides and smaller numbers of larger juveniles are captured on ebbing tides mortality suffered during impoundment residency is probably responsible for the differential tidal collection.

Tables 16-18 reveal that there was no consistent difference between culvert sites 61 and 72 even though they were fitted with different water level control devices. These results are preliminary and further study is necessary to determine if flap-gate and flap-gate riser systems are in fact different in their ability to attract and transport aquatic organisms.

TROPHIC ANALYSIS

Qualitative distribution of stomach contents of the species examined for feeding studies are given in Tables 19-20. Although a variety of items were consumed several items dominated the diet of each species and an overall importance of certain food items to the marsh ecosystem was determined based on the relative abundance of the species consuming the item (Fig.31).

The most abundant fish on the high marsh is _C_. _variegatus_ making up 38% of the total numerical catch. Feeding in this species was observed on several occasions in the field. Upper marsh specimens were observed to take mouthfulls of cyanobacterial (blue-green algae) -fungal mats found throughout the marsh. These mats were found to consist of a wide variety of protozoans, algae (chrysophytes, chlorophytes), cyanobacteria and fungal myocelia with a varying amount of detrital material from decaying wood and other plant materials. Analysis of gut contents from _C_. _variegatus_ captured during March and June revealed that the majority of the material consumed consisted of this algal-fungal-detrital mat material (Figs. 25-26). We have called this material a detrital-algal conglomerate, or "D.A.C." Fresh vascular plant material was also found and consisted primarily of the marsh succulent, _Salicornia_ spp. Size class data demonstrates that consumption of DAC is prevalent throughout ontogeny. Diet diversity increased with fish length and from the upper marsh to outside the impoundment. There is a spatial variation in DAC consumption as lower marsh and outside marsh fish contained less DAC than upper marsh specimens. More vascular plant material and sand was consumed in the lower marsh and foraminiferans in the outer marsh. In June no C. variegatus were taken outside of the impoundment and DAC consumption within the marsh declined.

Poecilia latipinna consumed proportionately more DAC than C. variegatus with slightly more being consumed on the upper marsh than on the lower marsh (Fig. 27). Vascular plant material played a smaller dietary role when compared to C. variegatus. Major ontogenetic changes in diet in P. latipinna were not evident, although when the 8-13 mm SL size class was represented in June more copepods were consumed.

Gambusia affinis was a strict carnivore with distinct seasonal and spatial dietary variation (Fig. 28). During March the principal food item consumed were insects (including corixids), although at both upper and lower marsh locations copepods were the principal prey for specimens under 20 mm SL. Other arthropods such as spiders were also consumed. More corixids were consumed in the lower marsh while a more varied insect diet was seen in the upper marsh sample. Smaller size classes preyed principally upon copepods in March in both the upper and lower marsh. During June crustaceans dominated the diet with copepods and corixids more abundant in upper marsh fish and amphipods dominating the diet of lower marsh fish.

Mugil cephalus examined from both March and June contained mostly DAC and sand in all size classes (Fig. 29). Vascular plant material also made up a portion of the diet. Ostracods were evident in June samples but were not present in March. All specimens were from the lower marsh.

Elops saurus entered the marsh habitat as Stage II leptocephalus larva (40-20 mm SL). March and June specimens were found to prey upon copepods (Fig. 30). Larger size classes in the upper marsh preyed upon copepods during March but began to diversify their diet with fish and insects. During June upper marsh fish contained mostly insects, no fish. However, no specimens over 75 mm SL were captured. Lower marsh fish preyed principally upon fish in March switching to a more diverse diet in June of fish, amphipods, polychaetes and insects. Ladyfish were taken outside of the impoundment only in March and these contained mostly copepods although Stage II leptocephali contained DAC.

Using these numerically dominant species as indicators of the fish trophic analysis for the marsh we can get some indication of where the majority of energy is derived for this portion of the animal community. Detrital-algal-conglomerates form the majority of material consumed (Fig. 31). This is true for both March and June, however, DAC forms a far larger portion of the diet in March when water levels are low, populations reduced and hypersaline conditions exist. During June when water levels are higher and estuarine exchange is greater a more diverse diet is seen with more animal material being consumed. Consumption of fish increases slightly. However, amphipod, polychaete and ostracod consumption increases greatly. Corixid insect consumption declines considerably from March to June. Vascular plant consumption remains about the same.

DISCUSSION

Of the detrimental aspects of impoundment construction and management, destruction of marsh vegetation and displacement of transient fish and crustacean species (the majority of which support sport and commercial fisheries) are generally regarded as the most catastrophic. This study was conducted to determine management methodologies which would permit the latter organisms to utilize the impounded marsh much as they did prior to impoundment construction. As many of these organisms utilize the marsh as larval and juvenile refugia from predation and for the availability of abundant food resources during high growth rate periods, access during key seasonal recruitment periods is critical.

The seasons of maximum transient species recruitment have now been determined for the most abundant organisms (Fig. 5; Table 11). Although some emigration occurs in June, most emigration of these organisms takes place during the late fall and winter months as sea levels fall (Fig. 16; Table 11). Present mosquito management protocol requests for impoundment closure from May to September. Recruitment may take place during the closure period if organisms can find and enter a culvert fitted with water control apparatus which opens on a flooding tide. Egress would be virtually impossible until the fall opening. Our data now reveals that egress under more natural tidal conditions typically occurs during the late fall and winter months. It is at this time that the impoundment would be reopened to tidal circulation. Therefore, natural recruitment and emigration patterns of transient organisms which utilize the impounded marsh is basically compatible with a May - early September closure period, provided a means of impoundment entry is provided.

Comparison of closed flapgate systems and flapgate riser systems was inconclusive. Further study is necessary to determine whether water flow out of the impoundment is necessary for fish and crustaceans to find the culvert. More culvert trap data must be collected.

Trophic studies demonstrate that a detrital-fungal-algal substrate which covers much of the surface of the upper marsh is a primary source of nutrition for the numerically dominant resident species, *C. variegatus* and *P. latipinna* and the transient *M. cephalus*. A portion of this material is derived from decaying wood of *Avicennia nitida* which was killed during early flooding of the impoundment. A similar finding was made by Harrington and Harrington (1982) of fish diets examined after impoundment construction in 1966. Vascular plants are increasing readily in this impoundment and make up a portion of the fish diet. This indicates that a succession of plant communities from algal-fungal-bacterial to vascular may be evident and will be revealed in the fish diets as the upper marsh becomes more heavily vegetated with vascular plants such as *Salicornia* spp., *Batis maritima* and *Avicennia nitida*. Mosquito larvae were not an abundant food item for any of the carnivorous fishes examined.

The overall analysis of fish and macrocrustacean populations in Impoundment 12 reveals a community in succession with the restoration of tidal influence. Transient species previously excluded utilized the impoundment lower and upper marsh microhabitats. Food sources derived from the impoundment were consumed by transients as well as residents. Transient organisms were then found to transfer this energy derived from the impounded marsh to the estuary in the form of body protein etc., with their seasonal emigration to the open estuary.

With these observations several suggestions for impoundment management can be made.

1. Fish distribution and abundance is greatly effected by water level. Major immigration into the impoundment occurs with sea level rise, May - June and August - October; and emigration from the impoundment with sea level fall, June - July and October - December. The impoundment should be open as long as possible, with major concern for

emigration periods in June - July and October - December. The most significant transient fish and crustacean immigrations (including commercial and sport species) occurs during the fall, winter and early spring.

2. As water level is the major parameter effecting organism distribution in the impounded marsh, the influence of culverts on water level should be considered. The decoupling of tidal amplitudes between the marsh and open estuary due to a single 47.5 cm diameter culvert was observed as was the effect of coupling and decoupling on the distribution of organisms across the marsh. Organisms were not as dispersed when tidal amplitudes were coupled but dispersed across the upper marsh when the tidal amplitudes decoupled and overall impoundment water levels were higher. The significance of this observation needs further study by may greatly effect population changes due to predation, immigration and emigration.

3. Dissolved oxygen was found to be capable of showing significant correl~~l~~ation with numbers of fishes and crustaceans captured. Dissolved oxygen revealed major declines in March - April and June - July. These declines were most significant in the perimeter ditch. Concern for oxygen mortalities should be greatest during these periods and within the perimeter ditch. No study of techniques to increase dissolved oxygen levels was made and we therefore suggest that this be done.

4. Initial feeding study data indicate that although June was a significant mosquito breeding month, mosquito larvae did not play an important role in the diet of the most notorious marsh predator, *Gambusia affinis*. Although this species needs to be examined for the remainder of the year it is not a reliable predator on mosquito larvae, taking a wide variety of food organisms. Carnivorous marsh fishes examined continue to depend on algal-detrital materials for food which was found to be the case after impoundment construction. Vascular plants, eradicated during impoundment construction, have not yet become a major part of the fish diet, as they had been prior to impoundment construction.

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Table 1. Sampling sites.

Location and numerical Designation	Description
Upper Marsh	
SP-1; 50	240 m^2 pond, elev. 3.3 cm above NGVD, occasionally completely dries during dry season, March-April. Throw net & 3 m seine.
SP-2; 51	1,312 m^2 pond, elev. 6.1 cm above NGVD never found to be completely dry. Throw net & 3 m seine.
P-1; 52	916 m^2 pond, elev. 7.6 cm below NGVD, permanently wet. 3 m seine.
P-3; 53	2,612 m^2 pond, elev. 7.7 cm below NGVD, largest permanent pond on upper marsh. 3 m seine.
Transition Zone	
DD-1; 40	rivulet entering perimeter ditch on north side of western upper marsh extension. Heart trap set at mouth of rivulet.
DD-2; 41	rivulet entering perimeter ditch on south side of western upper marsh extension. Heart trap set at mouth of rivulet.
DD-3; 42	edge of upper marsh at rivulet entering perimeter ditch at southernmost east-west ditch. Heart trap set at mouth of rivulet.
Lower Marsh (Perimeter Ditch inside impoundment)	
Pull net site 1; 60	Net was pulled south along 200 m^2 transect from South Culvert (61) to foot bridge. Edges of transect vegetated with mangroves and succulents.
Pull net site 2; 71	Net was pulled north along 140 m^2 transect from perimeter ditch to west bank of NW Pond at North Culvert (72). Edges of transect vegetated with mangrove of west, succulents on east.
NW Pond; 30	100 m^2 hectares circular pond to 2 m deep, made by erosive force of water pumped into the impoundment from the adjacent lagoon (Indian River). Cast net sample.
Tarpon Hole; 70	Cove off north side of southern east-west ditch near junction with north-south western ditch. Cast net sample.

Table 1. Sampling sites. (Continued)

Location and numerical Designation	Description
Culvert sites	
South Culvert; 61	Original 6.8 m, 45.7 cm diameter culvert connecting southwestern north-south perimeter ditch with cove between impoundment and St. Lucie County Impoundment No. 24. Culvert was originally fitted with a riser board (on western end, outside of impoundment) to control impoundment water levels. Traps were set in the eastern end of the culvert, within the impoundment.
North Culvert; 72	This 12 m, 45.7 cm diameter culvert was installed at the NW Pond in September 1983. It is fitted with a flapgate riser system on the eastern (inside impoundment) end. Traps were set in the western end of the culvert.
Open Estuarine Sites	
Mangrove pond; 31	Two heart traps were set simultaneously in red mangrove lined ponds under direct tidal influence from the estuary. These small basins are located along the northeast shore of the impoundment dike.
Seagrass 1; 63	In the central portion of the Cove adjacent to the South Culvert is a large bed of Halodule wrightii. This was sampled using 3 m and 15.4 m seines along measured transects.
Sand bottom; 62	Sand shore along the mangrove fringe adjacent to the Seagrass 1 (63) transect was sampled with a 3 m seine.
Seagrass 2; 73	This <u>Halodule</u> <u>wrightii</u> bed is located along the north shore of the impoundment and was sampled with a 15.4 m seine.

Table 2. Gear types, sampling strategy for 17 stations where collections were made during the study period March 1982 - January 1984.

Gear	Station																
	30	31	40	41	42	50	51	52	53	60	61	62	63	70	71	72	73
10' SEINE						1	1	2	2		2	2	2				
50' SEINE												4					4
PULL NET										1,4					4		
CAST NET	1													5			
CULVERT NET											1						
CULVERT TRAP											4					4	
1 M THROW TRAP						1	1										
HEART TRAP		3	3	3	3												

1 = diurnal flood and/or ebb tide collections on biweekly interval, 1982-83.
2 = single diurnal collection on biweekly interval, 1982-83.
3 = diel collections, on biweekly interval, 1982-83.
4 = diel collections, on monthly interval, all tidal cycles, 1983-84.
5 = random periodic collections, 1982-83.

Table 3. Comparison of 3.4 m seine and 1 m^2 throw net data for two upper marsh stations.

	SP-1 (50)				SP-2 (51)			
	SEINE		THROW NET		SEINE		THROW NET	
	No/m^2	g/m^2	No/m^2	g/m^2	No/m^2	g/m^2	No/m^2	g/m^2
3-8	0.05	0.03	0	0	0.11	0.43	10.83	3.57
3-23	0	0	3.70	0.53	0.08	0.15	13.67	5.45
4-5	0	0	6.30	1.12	0.08	0.10	0	0
4-21	1.90	0.75	19.70	5.16	0.05	0.07	1.00	0.39
5-6	5.98	0.80	7.00	6.80	0.03	0.17	1.83	2.93
5-20	0	0	1.00	0.04	0.09	0.10	0	0
6-3	0.22	0.05	17.70	6.36	0.06	0.07	0.17	0.49
6-18	0.12	0.04	0.33	0.20	0.03	0.12	24.67	4.48
7-1	4.28	0.29	6.00	0.27	0.09	0.06	28.67	3.07
7-16	0.03	0.004	9.33	0.69	0.25	0.21	9.00	1.72
7-30	0.12	0.03	2.33	0.51	0.02	0.17	21.33	1.29
8-16	0.23	0.10	1.33	0.62	0.08	0.38	18.00	2.92
8-31	0.27	0.08	4.33	0.70	0.03	0.05	12.17	3.94
9-13	0.72	0.11	8.70	2.67	0.13	0.17	3.00	1.20
9-29	0.10	0.04	0	0	0.07	0.03	1.83	2.47
10-13	0.87	0.15	0	0	0.07	0.07	0	0
10-27	1.30	1.18	8.33	1.81	0.16	0.05	0	0
11-10	0.07	0.01	0	0	0.08	0.02	0	0
11-29	6.88	1.23	13.67	8.64	0.48	1.61	32.83	9.51
12-9	4.13	0.50	28.67	7.70	0.29	1.96	8.30	3.43
12-28	4.22	0.36	44.67	6.28	0.16	1.50	15.17	2.00
1-9	1.48	0.50	5.33	1.12	0.09	0.49	3.50	1.12
1-25	1.38	0.28	5.67	1.56	0.07	0.46	4.33	0.60
2-10	8.05	0.48	14.33	8.43	0.11	2.07	1.16	0.34
2-23	1.65	0.41	40.67	6.83	0.13	1.00	12.83	3.65

Table 4. Fish species captured in Impoundment No. 12 and vicinity from March 1982 to January 1984.

MARSH RESIDENTS	MARSH TRANSIENTS	
Teleosts	Teleosts	Lutjanidae
Cyprinodontidae	Clupeidae	Lutjanus griseus*
Cyprinodon variegatus	Brevoortia smithi*	Gerridae
Fundulus confluentus	Brevoortia spp.*	Diapterus auratus*
Fundulus grandis	Sardinella anchovia*	Diapterus plumeiri*
Fundulus spp.	Engraulidae	Diapterus spp.*
Lucania parva	Anchoa mitchilli	Eucinostomus gula
Rivulus marmoratus	Anguillidae	Eucinostomus argenteus
Poeciliidae	Anguilla rostrata*	Gerres cinereus*
Gambusia affinis	Ophichthidae	Sparidae
Poecilia latipinna	Myrophis punctatus	Archosargus probatrocephalus*
Atherinidae	Elopidae	Lagodon rhomboides*
Menidia beryllina	Elops saurus*	Sciaenidae
Menidia peninsulae	Megalops atlanticus	Leiostomus xanthurus*
Menidia spp.	Belonidae	Pogonias cromis*
Eleotridae	Strongylura marina	Mugiliidae
Dormitator maculatus	Cyprinodontidae	Mugil cephalus*
Soleidae	Fundulus similis	Mugil curema*
Achirus lineatus	Syngnathidae	Sphyreanidae
	Syngnathus scovelli	Sphyreana barracuda*
	Centropomidae	Gobiidae
	Centropomus undecimalis	Microgobius gulosus
		Gobiosoma robustum

* = species of commercial and/or sport fishery value.

Table 5. Crustacean species captured in Impoundment No. 12 and vicinity captured from March 1982 to January 1984.

MARSH RESIDENTS	MARSH TRANSIENTS
Palaemonidae	Talitridae
Palaemonetes spp.	_Orchestia grullus_
(_P. pugio_, _P. intermedius_)	Mysidae
Ocypodidae	_Taphromysis bowmani_
Uca pugilator	Hippolytidae
	Hippolyte pleurocanthus
	Penaeidae
	_Penaeus duorarum_*
	_Penaeus aztecus_*
	Penaeus spp.*
	Xanthidae
	Eurytium limosum
	Portunidae
	_Callinectes sapidus_*

* = species of commercial and/or sport fishery value.

Table 6. Total individuals collected, total species weight, % occurrence, all ranked by number of individuals for all stations and collections made between March 1982 and February 1983.

GENUS-SPECIES		TOTAL NUMBER	% OF GRAND NUMBER TOTAL	TOTAL WEIGHT	% OF GRAND WEIGHT TOTAL	SPECIFIC ABSOLUTE OCCURENCE	SPECIFIC RELATIVE OCCURENCE
CYPRINODON	VARIEGATUS	90,123	37.73 %	37,073.42	31.53 %	339: 506	67.00 %
GAMBUSIA	AFFINIS	61,879	25.90 %	10,802.54	9.19 %	320: 506	63.24 %
POECILIA	LATIPINNA	45,648	19.11 %	28,687.58	24.40 %	295: 506	58.30 %
PALAEMONETES	SPP	27,727	11.61 %	1,652.94	1.41 %	251: 506	49.60 %
ELOPS	SAURUS	4,285	1.79 %	4,132.58	3.52 %	174: 506	34.39 %
MUGIL	CEPHALUS	3,036	1.27 %	21,646.59	18.41 %	102: 506	20.16 %
CENTROPOMUS	UNDECIMALIS	2,233	0.93 %	1,129.11	0.96 %	58: 506	11.46 %
FUNDULUS	CONFLUENTUS	1,200	0.50 %	1,071.93	0.91 %	99: 506	19.57 %
MENIDIA	SPP	387	0.16 %	158.38	0.13 %	66: 506	13.04 %
ANCHOA	MITCHILLI	313	0.13 %	101.70	0.09 %	18: 506	3.56 %
LEIOSTOMUS	XANTHURUS	309	0.13 %	110.48	0.09 %	18: 506	3.56 %
MEGALOPS	ATLANTICUS	294	0.12 %	4,409.70	3.75 %	30: 506	5.93 %
LUCANIA	PARVA	258	0.11 %	36.47	0.03 %	29: 506	5.73 %
FUNDULUS	GRANDIS	222	0.09 %	433.37	0.37 %	36: 506	7.11 %
MUGIL	CUREMA	166	0.07 %	415.12	0.35 %	33: 506	6.52 %
POGONIAS	CROMIS	151	0.06 %	17.02	0.01 %	9: 506	1.78 %
CALLINECTES	SAPIDUS	132	0.06 %	2,508.93	2.13 %	42: 506	8.30 %
PENAEUS	SPP	91	0.04 %	91.80	0.08 %	25: 506	4.94 %
GERRES	CINEREUS	78	0.03 %	39.49	0.03 %	12: 506	2.37 %
FUNDULUS	SPP	77	0.03 %	5.41	0.00 %	26: 506	5.14 %
DIAPTERUS	AURATUS	54	0.02 %	91.90	0.08 %	21: 506	4.15 %
SYNGNATHUS	SCOVELLI	44	0.02 %	8.74	0.01 %	13: 506	2.57 %
BREVOORTIA	SPP	40	0.02 %	3.94	0.00 %	6: 506	1.19 %
DORMITATOR	MACULATUS	32	0.01 %	119.82	0.10 %	24: 506	4.74 %
EUCINOSTOMUS	ARGENTEUS	12	0.01 %	17.87	0.02 %	9: 506	1.78 %
MICROGOBIUS	GULOSUS	12	0.01 %	2.68	0.00 %	8: 506	1.58 %
ARCHOSARGUS	PROBATOCEPHALUS	8	0.00 %	456.52	0.39 %	5: 506	0.99 %
LUTJANUS	GRISEUS	8	0.00 %	659.85	0.56 %	5: 506	0.99 %
SPHYRAENA	BARRACUDA	8	0.00 %	4.54	0.00 %	5: 506	0.99 %
GOBIOSOMA	ROBUSTUM	7	0.00 %	1.97	0.00 %	5: 506	0.99 %
BREVOORTIA	SMITHI	7	0.00 %	0.57	0.00 %	2: 506	0.40 %
LAGODON	RHOMBOIDES	6	0.00 %	74.83	0.06 %	3: 506	0.59 %
HIPPOLYTE	PLUEROCANTHUS	6	0.00 %	0.02	0.00 %	1: 506	0.20 %
MYROPHIS	PUNCTATUS	5	0.00 %	4.35	0.00 %	3: 506	0.59 %
ACHIRUS	LINEATUS	4	0.00 %	0.96	0.00 %	2: 506	0.40 %
UCA	PUGILATOR	3	0.00 %	4.72	0.00 %	3: 506	0.59 %
ANGUILLA	ROSTRATA	3	0.00 %	1,570.45	1.34 %	2: 506	0.40 %
DIAPTERUS	SPP	2	0.00 %	0.26	0.00 %	2: 506	0.40 %
FUNDULUS	SIMILIS	2	0.00 %	2.90	0.00 %	2: 506	0.40 %
ORCHESTIA	GRILLUS	2	0.00 %	0.11	0.00 %	1: 506	0.20 %
EUCINOSTOMUS	GULA	1	0.00 %	3.54	0.00 %	1: 506	0.20 %
EURYTIUM	LIMOSUM	1	0.00 %	10.54	0.01 %	1: 506	0.20 %
PENAEUS	AZTECUS	1	0.00 %	0.19	0.00 %	1: 506	0.20 %
PENAEUS	DUORARUM	1	0.00 %	0.40	0.00 %	1: 506	0.20 %
RIVULUS	MARMORATUS	1	0.00 %	0.34	0.00 %	1: 506	0.20 %
SARDINELLA	ANCHOVIA	1	0.00 %	0.03	0.00 %	1: 506	0.20 %
STRONGYLURA	MARINA	1	0.00 %	1.91	0.00 %	1: 506	0.20 %
TAPHROMYSIS	BOWMANI	1	0.00 %	0.00	0.00 %	1: 506	0.20 %
GRAND NUMBER AND WEIGHT TOTALS:		238882		117,568.51			

Table 7. Total species weight , number to individuals and % occurrence, all ranked by total species weight for all stations and collections made between March 1982 and February 1983.

GENUS-SPECIES		TOTAL WEIGHT	% OF GRAND WEIGHT TOTAL	TOTAL NUMBER	% OF GRAND NUMBER TOTAL	SPECIFIC ABSOLUTE OCCURENCE	SPECIFIC RELATIVE OCCURENCE
CYPRINODON	VARIEGATUS	37,073.42	31.53 %	90,123	37.73 %	339: 506	67.00 %
POECILIA	LATIPINNA	28,687.58	24.40 %	45,648	19.11 %	[illegible]	58.30 %
MUGIL	CEPHALUS	21,646.59	18.41 %	3,036	1.27 %	102: 506	20.16 %
GAMBUSIA	AFFINIS	10,802.54	9.19 %	61,879	25.90 %	320: 506	63.24 %
MEGALOPS	ATLANTICUS	4,409.70	3.75 %	294	0.12 %	30: 506	5.93 %
ELOPS	SAURUS	4,132.58	3.52 %	4,285	1.79 %	174: 506	34.39 %
CALLINECTES	SAPIDUS	2,508.93	2.13 %	132	0.06 %	42: 506	8.30 %
PALAEMONETES	SPP	1,652.94	1.41 %	27,727	11.61 %	251: 506	49.60 %
ANGUILLA	ROSTRATA	1,570.45	1.34 %	3	0.00 %	2: 506	0.40 %
CENTROPOMUS	UNDECIMALIS	1,129.11	0.96 %	2,233	0.93 %	58: 506	11.46 %
FUNDULUS	CONFLUENTUS	1,071.93	0.91 %	1,200	0.50 %	99: 506	19.57 %
LUTJANUS	GRISEUS	659.85	0.56 %	8	0.00 %	5: 506	0.99 %
ARCHOSARGUS	PROBATOCEPHALUS	456.52	0.39 %	8	0.00 %	5: 506	0.99 %
FUNDULUS	GRANDIS	433.37	0.37 %	222	0.09 %	36: 506	7.11 %
MUGIL	CUREMA	415.12	0.35 %	166	0.07 %	33: 506	6.52 %
MENIDIA	SPP	158.38	0.13 %	387	0.16 %	66: 506	13.04 %
DORMITATOR	MACULATUS	119.82	0.10 %	32	0.01 %	24: 506	4.74 %
LEIOSTOMUS	XANTHURUS	110.48	0.09 %	309	0.13 %	18: 506	3.56 %
ANCHOA	MITCHILLI	101.70	0.09 %	313	0.13 %	18: 506	3.56 %
DIAPTERUS	AURATUS	91.90	0.08 %	54	0.02 %	21: 506	4.15 %
PENAEUS	SPP	91.80	0.08 %	91	0.04 %	25: 506	4.94 %
LAGODON	RHOMBOIDES	74.83	0.06 %	6	0.00 %	3: 506	0.59 %
GERRES	CINEREUS	39.49	0.03 %	78	0.03 %	12: 506	2.37 %
[illegible]UCANIA	PARVA	36.47	0.03 %	258	0.11 %	29: 506	5.73 %
[illegible]UCINOSTOMUS	ARGENTEUS	17.87	0.02 %	12	0.01 %	9: 506	1.78 %
POGONIAS	CROMIS	17.02	0.01 %	151	0.06 %	9: 506	1.78 %
EURYTIUM	LIMOSUM	10.54	0.01 %	1	0.00 %	1: 506	0.20 %
SYNGNATHUS	SCOVELLI	8.74	0.01 %	44	0.02 %	13: 506	2.57 %
FUNDULUS	SPP	5.41	0.00 %	77	0.03 %	26: 506	5.14 %
UCA	PUGILATOR	4.72	0.00 %	3	0.00 %	3: 506	0.59 %
SPHYRAENA	BARRACUDA	4.54	0.00 %	8	0.00 %	5: 506	0.99 %
MYROPHIS	PUNCTATUS	4.35	0.00 %	5	0.00 %	3: 506	0.59 %
BREVOORTIA	SPP	3.94	0.00 %	40	0.02 %	6: 506	1.19 %
EUCINOSTOMUS	GULA	3.54	0.00 %	1	0.00 %	1: 506	0.20 %
FUNDULUS	SIMILIS	2.90	0.00 %	2	0.00 %	2: 506	0.40 %
MICROGOBIUS	GULOSUS	2.68	0.00 %	12	0.01 %	8: 506	1.58 %
GOBIOSOMA	ROBUSTUM	1.97	0.00 %	7	0.00 %	5: 506	0.99 %
STRONGYLURA	MARINA	1.91	0.00 %	1	0.00 %	1: 506	0.20 %
ACHIRUS	LINEATUS	0.96	0.00 %	4	0.00 %	2: 506	0.40 %
BREVOORTIA	SMITHI	0.57	0.00 %	7	0.00 %	2: 506	0.40 %
PENAEUS	DUORARUM	0.40	0.00 %	1	0.00 %	1: 506	0.20 %
RIVULUS	MARMORATUS	0.34	0.00 %	1	0.00 %	1: 506	0.20 %
DIAPTERUS	SPP	0.26	0.00 %	2	0.00 %	2: 506	0.40 %
PENAEUS	AZTECUS	0.19	0.00 %	1	0.00 %	1: 506	0.20 %
ORCHESTIA	GRILLUS	0.11	0.00 %	2	0.00 %	1: 506	0.20 %
SARDINELLA	ANCHOVIA	0.03	0.00 %	1	0.00 %	1: 506	0.20 %
HIPPOLYTE	PLUEROCANTHUS	0.02	0.00 %	6	0.00 %	1: 506	0.20 %
TAPHROMYSIS	BOWMANI	0.00	0.00 %	1	0.00 %	1: 506	0.20 %
GRAND WEIGHT AND NUMBER TOTALS:		117,568.51		238882			

Table 8. Specific absolute occurrence, % occurrence, total number individuals, ranked by occurrence for all stations and collections made between March 1982 and February 1983.

TOTAL INDIVIDUALS COLLECTED, AND THEIR SUMMED WEIGHTS,
WITHIN THE CHOSEN RANGES OF THIS PARTICULAR REPORT.
DATA SORTED BY DECREASING OCCURENCE WITHIN RANGES OF THIS REPORT.

GENUS-SPECIES		SPECIFIC ABSOLUTE OCCURENCE	SPECIFIC RELATIVE OCCURENCE	TOTAL NUMBER	% OF GRAND NUMBER TOTAL	TOTAL WEIGHT	% OF GRAND WEIGHT TOTAL
CYPRINODON	VARIEGATUS	339: 506	67.00 %	90,123	37.73 %	37,073.42	31.53 %
GAMBUSIA	AFFINIS	320: 506	63.24 %	61,879	25.90 %	10,802.54	9.19 %
POECILIA	LATIPINNA	295: 506	58.30 %	45,648	19.11 %	28,687.58	24.40 %
PALAEMONETES	SPP	251: 506	49.60 %	27,727	11.61 %	1,652.94	1.41 %
ELOPS	SAURUS	174: 506	34.39 %	4,285	1.79 %	4,132.58	3.52 %
MUGIL	CEPHALUS	102: 506	20.16 %	3,036	1.27 %	21,646.59	18.41 %
FUNDULUS	CONFLUENTUS	99: 506	19.57 %	1,200	0.50 %	1,071.93	0.91 %
MENIDIA	SPP	66: 506	13.04 %	387	0.16 %	158.38	0.13 %
CENTROPOMUS	UNDECIMALIS	58: 506	11.46 %	2,233	0.93 %	1,129.11	0.96 %
CALLINECTES	SAPIDUS	42: 506	8.30 %	132	0.06 %	2,508.93	2.13 %
FUNDULUS	GRANDIS	36: 506	7.11 %	222	0.09 %	433.37	0.37 %
MUGIL	CUREMA	33: 506	6.52 %	166	0.07 %	415.12	0.35 %
MEGALOPS	ATLANTICUS	30: 506	5.93 %	294	0.12 %	4,409.70	3.75 %
LUCANIA	PARVA	29: 506	5.73 %	258	0.11 %	36.47	0.03 %
FUNDULUS	SPP	26: 506	5.14 %	77	0.03 %	5.41	0.00 %
PENAEUS	SPP	25: 506	4.94 %	91	0.04 %	91.80	0.08 %
DORMITATOR	MACULATUS	24: 506	4.74 %	32	0.01 %	119.82	0.10 %
DIAPTERUS	AURATUS	21: 506	4.15 %	54	0.02 %	91.90	0.08 %
ANCHOA	MITCHILLI	18: 506	3.56 %	313	0.13 %	101.70	0.09 %
LEIOSTOMUS	XANTHURUS	18: 506	3.56 %	309	0.13 %	110.48	0.09 %
SYNGNATHUS	SCOVELLI	13: 506	2.57 %	44	0.02 %	8.74	0.01 %
GERRES	CINEREUS	12: 506	2.37 %	78	0.03 %	39.49	0.03 %
POGONIAS	CROMIS	9: 506	1.78 %	151	0.06 %	17.02	0.01 %
EUCINOSTOMUS	ARGENTEUS	9: 506	1.78 %	12	0.01 %	17.87	0.02 %
MICROGOBIUS	GULOSUS	8: 506	1.58 %	12	0.01 %	2.68	0.00 %
BREVOORTIA	SPP	6: 506	1.19 %	40	0.02 %	3.94	0.00 %
LUTJANUS	GRISEUS	5: 506	0.99 %	8	0.00 %	659.85	0.56 %
ARCHOSARGUS	PROBATOCEPHALUS	5: 506	0.99 %	8	0.00 %	456.52	0.39 %
SPHYRAENA	BARRACUDA	5: 506	0.99 %	8	0.00 %	4.54	0.00 %
GOBIOSOMA	ROBUSTUM	5: 506	0.99 %	7	0.00 %	1.97	0.00 %
LAGODON	RHOMBOIDES	3: 506	0.59 %	6	0.00 %	74.83	0.06 %
MYROPHIS	PUNCTATUS	3: 506	0.59 %	5	0.00 %	4.35	0.00 %
UCA	PUGILATOR	3: 506	0.59 %	3	0.00 %	4.72	0.00 %
BREVOORTIA	SMITHI	2: 506	0.40 %	7	0.00 %	0.57	0.00 %
ACHIRUS	LINEATUS	2: 506	0.40 %	4	0.00 %	0.96	0.00 %
ANGUILLA	ROSTRATA	2: 506	0.40 %	3	0.00 %	1,570.45	1.34 %
FUNDULUS	SIMILIS	2: 506	0.40 %	2	0.00 %	2.90	0.00 %
DIAPTERUS	SPP	2: 506	0.40 %	2	0.00 %	0.26	0.00 %
HIPPOLYTE	PLUEROCANTHUS	1: 506	0.20 %	6	0.00 %	0.02	0.00 %
ORCHESTIA	GRILLUS	1: 506	0.20 %	2	0.00 %	0.11	0.00 %
EURYTIUM	LIMOSUM	1: 506	0.20 %	1	0.00 %	10.54	0.01 %
EUCINOSTOMUS	GULA	1: 506	0.20 %	1	0.00 %	3.54	0.00 %
STRONGYLURA	MARINA	1: 506	0.20 %	1	0.00 %	1.91	0.00 %
PENAEUS	DUORARUM	1: 506	0.20 %	1	0.00 %	0.40	0.00 %
RIVULUS	MARMORATUS	1: 506	0.20 %	1	0.00 %	0.34	0.00 %
PENAEUS	AZTECUS	1: 506	0.20 %	1	0.00 %	0.19	0.00 %
SARDINELLA	ANCHOVIA	1: 506	0.20 %	1	0.00 %	0.03	0.00 %
TAPHROMYSIS	BOWMANI	1: 506	0.20 %	1	0.00 %	0.00	0.00 %
GRAND NUMBER & WEIGHT TOTALS -->				238882		117,568.51	

Table 9. Spatial distribution of top ten transient species.

	Outer Estuary			Lower Marsh			Transition				Upper Marsh			
Species	62	63	31	61	60	30	70	40	41	42	53	52	51	50
E. saurus	47	18	2	2,247	927	27					385	241	217	172
M. cephalus				1,853	869	33		1	7	2	10	68	171	22
C. undecimalis	4		18	1,127	1,070				2	4	7			1
A. mitchilli	248	62		3										
L. xanthurus	46	147	1	48	66							1		
M. atlanticus				7	24	235	16			3			8	1
M. curema	1	7	2	69	86					1				
P. cromis	4			134	12						1			
C. sapidus	2		7	88	26						8			
Penaeus sp.	48	1	1	19	21						2		1	

Table 10. Mean environmental parameters from all stations.

PARAMETER

DATE	TID	STA	TIME	TEMP	SALIN	DO	PH
820308			1388	19.8	34.3	9.0	6.5
820323			1359	26.9	40.2	4.3	6.0
820405			1275	28.5	32.2	4.2	6.5
820421			1274	31.5	29.1	6.0	6.8
820506			1320	26.5	32.3	5.9	8.4
820520			1257	27.9	44.5	6.0	7.6
820603			1299	22.5	19.7	6.5	0.0
820618			1181	25.8	20.6	3.0	3.6
820701			1197	21.4	24.5	2.3	0.0
820716			1147	31.6	33.7	3.9	7.3
820730			1130	32.2	39.1	5.7	8.0
820816			1330	32.4	34.1	5.6	5.1
820831			1896	30.3	34.7	6.0	3.1
820912			1053	29.0	30.0	2.2	0.0
820913			1212	33.5	38.0	5.2	0.0
820928			1600	28.5	25.0	0.0	0.0
820929			1327	28.4	22.4	6.5	0.0
821013			1255	28.5	29.0	5.5	0.0
821026			1140	21.0	28.0	0.0	0.0
821027			1217	21.5	29.1	5.7	0.0
821109			1600	23.0	28.0	7.4	0.0
821110			1082	22.7	26.2	6.9	0.0
821128			1521	24.0	24.0	2.9	0.0
821129			1427	25.8	25.4	5.9	0.0
821208			1520	24.0	30.0	1.3	0.0
821209			1285	24.6	27.9	6.1	0.0
821227			1730	22.0	30.0	3.2	0.0
821228			1409	23.4	33.1	5.0	0.0
830109			1437	21.0	30.0	3.8	0.0
830110			1390	22.3	31.6	4.9	0.0
830124			1200	17.0	30.0	5.4	0.0
830125			1228	16.6	23.7	7.7	0.0
830209			1147	14.0	26.0	7.0	0.0
830210			1351	19.5	25.4	6.4	0.0
830222			1630	19.5	19.0	7.2	0.0
830223			1241	22.4	19.7	6.7	0.0
			AAAA	AAAA	AAAAA	AAAA	AAAA
			1304	25.8	30.0	5.6	2.7

Table 11. cont'd.

GENUS-SPECIES		JULY , 1982 DAY 1	JULY , 1982 DAY 2	JULY , 1982 DAY 3	AUGUST , 1982 DAY 1	AUGUST , 1982 DAY 2	AUGUST , 1982 DAY 3
ANCHOA	MITCHILLI	0	0	0	0	0	0
ARCHOSARGUS	PROBATOCEPHALUS	0	0	0	0	1	0
CALLINECTES	SAPIDUS	1	5	2	4	2	0
CENTROPOMUS	UNDECIMALIS	0	1	3	8	10	0
CYPRINODON	VARIEGATUS	14,748	8,758	5,850	981	494	0
DIAPTERUS	AURATUS	2	4	5	6	3	0
DORMITATOR	MACULATUS	0	1	2	1	2	0
ELOPS	SAURUS	19	69	88	26	28	0
EUCINOSTOMUS	ARGENTEUS	1	0	0	0	0	0
EURYTIUM	LIMOSUM	0	0	1	0	0	0
FUNDULUS	CONFLUENTUS	324	196	82	29	16	0
FUNDULUS	GRANDIS	0	8	6	0	5	0
FUNDULUS	SIMILIS	0	0	0	0	0	0
FUNDULUS	SPP	4	4	3	0	3	0
GAMBUSIA	AFFINIS	1,971	1,032	1,067	130	303	0
GERRES	CINEREUS	1	0	0	0	0	0
GOBIOSOMA	ROBUSTUM	1	0	0	0	0	0
HIPPOLYTE	PLUEROCANTHUS	0	6	0	0	0	0
LEIOSTOMUS	XANTHURUS	0	0	0	0	0	0
LUCANIA	PARVA	6	3	10	3	5	0
MEGALOPS	ATLANTICUS	0	1	18	9	6	0
MENIDIA	SPP	1	1	12	4	0	0
MICROGOBIUS	GULOSUS	0	2	1	0	0	0
MUGIL	CEPHALUS	0	0	2	3	2	0
MUGIL	CUREMA	2	0	1	0	1	0
MYROPHIS	PUNCTATUS	0	0	0	0	0	0
ORCHESTIA	GRILLUS	0	0	0	2	0	0
PALAEMONETES	SPP	22	52	37	59	143	0
PENAEUS	SPP	2	1	4	0	0	0
POECILIA	LATIPINNA	8,807	1,248	1,224	1,864	1,279	0
RIVULUS	MARMORATUS	0	0	0	0	0	0
SPHYRAENA	BARRACUDA	0	0	1	0	0	0
STRONGYLURA	MARINA	0	1	0	0	0	0
SYNGNATHUS	SCOVELLI	13	1	10	3	0	0
UCA	PUGILATOR	0	0	2	0	0	0
"TOTAL NUMBER" MONTHLY TOTALS		25,925	11,394	8,431	3,132	2,303	0

Table 11. cont'd

GENUS-SPECIES		SEPTEMB., 1982 DAY 1	SEPTEMB., 1982 DAY 2	OCTOBER , 1982 DAY 1	OCTOBER , 1982 DAY 2	NOVEMBER, 1982 DAY 1	NOVEMBER, 1982 DAY 2	DECEMBER, 1982 DAY 1	DECEMBER, 1982 DAY 2
ACHIRUS	LINEATUS	0	1	3	0	0	0	0	0
ANCHOA	MITCHILLI	0	0	12	0	36	36	69	1
ANGUILLA	ROSTRATA	0	0	0	1	2	0	0	0
ARCHOSARGUS	PROBATOCEPHALUS	2	0	3	1	0	0	0	1
BREVOORTIA	SPP	0	0	0	0	0	0	1	0
CALLINECTES	SAPIDUS	1	1	1	2	0	6	7	5
CENTROPOMUS	UNDECIMALIS	12	25	70	11	52	1,488	338	168
CYPRINODON	VARIEGATUS	161	15	10	21	21	1,518	5,488	7,596
DIAPTERUS	AURATUS	3	0	0	0	2	12	1	2
DIAPTERUS	SPP	0	0	0	1	0	1	0	0
DORMITATOR	MACULATUS	1	0	0	0	0	1	0	3
ELOPS	SAURUS	35	11	43	53	28	453	678	61
EUCINOSTOMUS	ARGENTEUS	0	0	0	0	1	5	0	0
EUCINOSTOMUS	GULA	1	0	0	0	0	0	0	0
FUNDULUS	CONFLUENTUS	1	0	0	0	0	7	51	70
FUNDULUS	GRANDIS	3	0	0	0	0	3	3	20
FUNDULUS	SIMILIS	0	0	0	0	0	0	0	1
GAMBUSIA	AFFINIS	66	13	60	125	140	40,432	3,626	3,053
GERRES	CINEREUS	0	1	1	0	4	66	2	3
GOBIOSOMA	ROBUSTUM	0	0	0	0	0	3	0	0
LAGODON	RHOMBOIDES	0	0	1	0	1	0	0	0
LUCANIA	PARVA	1	0	0	0	0	14	1	3
LUTJANUS	GRISEUS	0	1	0	2	0	0	0	3
MEGALOPS	ATLANTICUS	7	6	12	56	3	27	16	39
MENIDIA	SPP	0	0	0	1	0	29	45	64
MICROGOBIUS	GULOSUS	0	1	2	0	0	0	0	0
MUGIL	CEPHALUS	15	16	0	9	6	8	34	457
MUGIL	CUREMA	1	0	0	5	1	15	5	2
PALAEMONETES	SPP	170	899	5,026	33	849	3,503	1,729	3,357
PENAEUS	SPP	2	1	1	2	0	15	6	5
POECILIA	LATIPINNA	301	8	3	84	7	11,936	1,659	2,794
SPHYRAENA	BARRACUDA	0	5	0	0	0	2	0	0
TAPHROMYSIS	BOWMANI	0	0	0	0	0	1	0	0
"TOTAL NUMBER"	MONTHLY TOTALS	783	1,004	5,248	407	1,153	59,581	13,759	17,708

Table 11. cont'd

GENUS-SPECIES		JANUARY, 1983 DAY 1	DAY 2	FEBRUARY, 1983 DAY 1	DAY 2	MARCH, 1983 DAY 1	DAY 2	APRIL, 1983 DAY 1	DAY 2
ANCHOA	MITCHILLI	42	0	1	1	0	0	0	0
BREVOORTIA	SPP	3	2	0	22	0	0	0	0
CALLINECTES	SAPIDUS	6	5	2	3	0	0	0	0
CENTROPOMUS	UNDECIMALIS	15	0	2	26	0	0	0	0
CYPRINODON	VARIEGATUS	414	250	26,715	5,316	0	0	0	0
DORMITATOR	MACULATUS	0	0	1	2	0	0	0	0
ELOPS	SAURUS	45	73	326	115	0	0	0	0
FUNDULUS	CONFLUENTUS	30	4	110	29	0	0	0	0
FUNDULUS	GRANDIS	3	0	0	10	0	0	0	0
FUNDULUS	SPP	0	1	10	1	0	0	0	0
GAMBUSIA	AFFINIS	1,073	112	4,445	1,830	0	0	0	0
LAGODON	RHOMBOIDES	0	0	4	0	0	0	0	0
LEIOSTOMUS	XANTHURUS	0	0	7	243	0	0	0	0
LUCANIA	PARVA	1	2	2	1	0	0	0	0
LUTJANUS	GRISEUS	2	0	0	0	0	0	0	0
MEGALOPS	ATLANTICUS	34	15	38	7	0	0	0	0
MENIDIA	SPP	7	13	43	24	0	0	0	0
MUGIL	CEPHALUS	95	68	113	1,020	0	0	0	0
MUGIL	CUREMA	0	1	1	1	0	0	0	0
PALAEMONETES	SPP	107	340	2,622	965	0	0	0	0
PENAEUS	SPP	0	0	4	15	0	0	0	0
POECILIA	LATIPINNA	428	40	2,999	1,279	0	0	0	0
POGONIAS	CROMIS	0	0	1	0	0	0	0	0
UCA	PUGILATOR	0	1	0	0	0	0	0	0
'TOTAL NUMBER'	MONTHLY TOTALS	2,305	927	37,446	10,910	0	0	0	0

Table 12. Correlation coefficients from multiple linear regression analyses on number of individuals per collection and environmental parameters recorded at time of capture.

SPECIES	CORRELATION COEFFICIENT							
	N	Time	Temp.	Sal.	D.O.	pH	Water Level	Rain
		n=369	n=366	n=369	n=361	n=139	n=12	n=25
FISH								
Residents								
C. variegatus	232	0.090	-0.211*	-0.105	-0.105	-0.073	-0.560	-0.210
P. latipinna	193	0.158	-0.136	-0.145	-0.126	-0.117	-0.370	-0.260
G. affinis	209	0.020	-0.029*	-0.063	-0.047	-0.085	-0.230	-0.160
F. confluentus	56	0.086	-0.221	-0.098	-0.313*	-0.028	-0.690**	-0.230
F. grandis	31	-0.202**	-0.148	0.133	-0.241*	-0.192	-0.570	-0.150
L. parva	25	-0.029	0.051	0.269*	0.131	0.384*	-0.320	-0.160
Menidia spp.	60	-0.185**	-0.234	-0.047	-0.195**	-0.186	-0.760*	-0.110
Transients								
E. saurus	160	0.220*	-0.035	-0.005	-0.017	0.046	-0.340	-0.010
M. cephalus	90	0.108	-0.016	-0.108	0.102	-0.011	-0.460	-0.190
M. curema	27	-0.122	0.099	0.260*	-0.212*	0.409*	-0.070	-0.170
C. undecimalis	48	0.097*	-0.065	0.024	0.037	-0.122	-0.180	-0.140
M. atlanticus	27	-0.288*	-0.559	-0.063	-0.008	-0.230	-0.130	-0.320
CRUSTACEANS								
Residents								
Palaemonetes	147	0.174	0.033	0.015	0.032	0.029	-0.300	-0.230
Transients								
Penaeus spp.	24	0.058	-0.030	0.139	0.089	0.397*	-0.470	-0.270
C. sapidus	38	0.167	-0.054	0.180**	0.084	0.242	-0.520	0.050

* = significant at $\alpha = 0.01$
** = significant at $\alpha = 0.05$

Table 13. Long term precipitation means (1959-1970; Ft. Pierce, NOAA-EDS records) and monthly mean high water above sea level (1958-1970; Florida Medical Entomology, Vero Beach, Provost 1974) with total monthly numerical catch of the most abundant marsh transients.

Mean Rain (in)	High Water (ft)	Transient Species Snook	Tarpon	st. mullet	si. mullet	Ladyfish
3.50	0.49	0	0	459	2	1450
3.33	0.38	0	0	542	53	335
4.15	0.60	0	0	161	65	214
6.11	0.65	4	0	26	10	155
5.53	0.45	4	19	2	3	176
6.53	0.53	18	15	5	1	54
8.69	1.23	37	13	31	1	46
7.87	1.35	81	68	9	5	96
3.38	1.19	1540	30	14	16	481
4.70	0.78	506	55	591	7	739
2.01	0.60	15	49	163	1	118
2.77	0.52	28	45	1133	2	441
Correlation coefficients, r						
Rain		-0.20	-0.0014	-0.24	-0.26	-0.43
High water		0.49	0.45	-0.41	-0.22	-0.22

Table 14. Ebb-flood tidal movements at the Culvert Site, 61, March 1982 - February 1983.

DATE	C. VARIEGATUS EBB	C. VARIEGATUS FLOOD	G. AFFINIS EBB	G. AFFINIS FLOOD	P. LATIPINNA EBB	P. LATIPINNA FLOOD	F. CONFLUENTUS EBB	F. CONFLUENTUS FLOOD
3-08	10	56	25	7	30	90	1	
3-23	30	2,410	1	62	29	3,149	1	125
4-05	2	31	41	50	25	50	1	7
4-21	2	26	19	120	106	565	1	13
5-06	1	8	35	119	145	150		1
5-20	2	14	7	51	3	216		2
6-03	267		98		328		1	
6-18	16		47		45		2	
7-01	3		5	4	6	101		6
7-16	8	7	8	5	59	228	1	5
7-30	1			51	138	3		
8-16	13	159	9	2	529	1,103	5	21
8-31		41	4	25	105	920	2	2
9-13		2	2		53	189		1
9-29		3						
10-13		1						
10-27								
11-10					2			
11-29	192	3	31,011	182	7,447	38	3	1
12-09	4,286	351	2,286	14	1,496	9	35	4
12-28	28	3	106	94	357	507	12	
1-09	7	54	43	845	26	366		30
1-25			6	1	17		1	
2-10	5	759	655	392	300	2,239	7	35
2-23	14	184	440	534	734	375	2	16
Totals	4,887	4,076	34,848	2,558	11,980	10,298	74	270

Table 15. Ebb-flood tidal movements at the Culvert Site, 61, March 1982 - February 1983.

DATE	E. SAURUS EBB	E. SAURUS FLOOD	M. CEPHALUS EBB	M. CEPHALUS FLOOD	C. UNDECIMALIS EBB	C. UNDECIMALIS FLOOD	C. SAPIDUS EBB	C. SAPIDUS FLOOD
3-08	74	172	1	70				29
3-23	9	552	4	31				16
4-05	4	50		9				16
4-21	2	3	450	1				3
5-06		11	1	73				
5-20			5	1				
6-03	1		4					
6-18	1		10		3		7	
7-01								
7-16								
7-30				1	1	1	1	
8-16			2	1	1	7		
8-31			2			7		2
9-13		4		2		5		
9-29		10		4	5	18		1
10-13		29				67		1
10-27		8		3		8		
11-10	13	3		1	6	42		
11-29	2	356	3		518	8		3
12-09	15	639	5	9	294	34		5
12-28	2	33	3	414	55	25		2
1-09	6			2		1		
1-25	6		19	7				
2-10	8	171		9	1	1		
2-23	13	50	48	658	10	9		2
Totals	156	2,091	557	1,296	894	233	8	80

Table 16. Culvert trap collections from September 1983 to January 1984, number of organisms collected.

TIME	STATION 61		TOTAL	STATION 72		TOTAL
DAY	INSIDE	OUTSIDE		INSIDE	OUTSIDE	
AM LOW	4	9	13	4	3	7
AM FLOOD	3	21	24	61	35	96
AMPM HIGH	5		5		2	2
PM EBB	1	1	2	17	26	42
			44			148
NIGHT						
PM LOW	135	23	158	32	29	61
PM FLOOD	55	68	123	7		7
PMAM HIGH	11	61	72	3		3
AM EBB	32	6	38	55	31	86
			391			157
TOTALS	233	158		179	126	

Table 17. North Culvert (72) culvert trap collections 6 October 1983 to 6 January 1984.

		Oct. 6-7 in	Oct. 6-7 out	Nov. 6-7 in	Nov. 6-7 out	Dec. in	Dec. out	Jan. in	Jan. out	Totals in	Totals out	Totals
Day low	14		2	4	1					4	3	
flood	15	2				7		52	35	61	35	Day catch 148
high	13				2						2	
ebb	16	1	8			16	18			17	26	
total		3	10	4	3	23	18	52	35	82	66	
Night low	24					32	29			32	29	
flood	25			1		6				7		Night catch 157
high	23			3						3		
ebb	26					55	31			55	31	
total		0	0	4	0	93	60	0	0	97	60	
Total in, out		3	10	8	3	116	78	52	35	179	126	
Total/mo.		13		11		194		87				
Net movement												
in		7										
out				5		38		17				

Table 18. South Culvert (61) culvert trap collections, 8 August 1983 to 6 January 1984.

		Aug. 8-9		Sept. 8-9		Oct. 6-7		Nov. 6-7		Dec.		Jan.		Totals		Totals
		in	out	in	out	in	out	in	out	in	out	in	out	in	out	
Day low	14	12	30			4	9							4	9	Day catch
flood	15	3	1		1	3	21							3	21	44
high	13	8	7	3	54	3				2				5		
ebb	16	8		1	1				1	1				1	1	
total		31	38	4	56	10	30	0	1	3	0	0	0	13	31	
Night low	24			14			9		1	11	13	124		135	23	Night catch
flood	25	11	3	1				48	57	7	11			55	68	391
high	23					3	57	1	1	7	3			11	61	
ebb	26	14				19				13	6			32	6	
total		25	3	15	0	22	66	49	59	38	33	124	0	32	6	
Total in, out		56	41	19	56	32	96	49	60	41	33	124	0	233	158	
Total/mo.		97		75		128		109		74		124				
Net movement																
in				37		64		11								
out		15								8		124				

Table 19. Percentage frequency occurrence and percentages of aggregate volume of all organisms from fish examined from the impounded upper and lower marsh.

ITEM	% vol.	% freq.	ITEM	% vol.	% freq.
Detrital-Algal Conglomerate	29.28	89.83	Insect Fragments	0.55	22.03
Fungi	0.68	52.54	Unidentified insect pupae	0.07	5.08
Cyanophyta (=Cyanobacteria)	0.55	11.86	Collembola	0.01	3.39
Chrysophyta			Corixid adults	1.54	27.12
Bacillariophycea	0.01	5.08	Corixid eggs	0.25	10.17
Chlorophycea	0.71	13.56	Diptera	0.06	6.78
Tracheophyta	6.37	71.19	Aedes instars	0.07	8.47
Salicornia spp.	0.30	6.78	Chrysomelidae	0.22	6.78
Foraminifera	0.69	32.20	Formicidae	0.01	1.69
Nematoda	0.01	6.78	Arachnida	0.04	5.08
Annelida	1.01	1.69	Invertebrate eggs	0.14	22.03
Polychaeta	1.32	13.56	Fish material	28.14	37.29
Arthropod fragments	3.28	42.36	White amorphous material	0.0097	1.69
Crustacea fragments	0.21	1.69	Unidentified items	0.30	16.95
Nauplius larvae	0.02	1.69			
Ostracoda	5.66	30.51			
Copepoda	1.16	45.76			
Isopoda	0.02	1.69			
Amphipoda	16.42	18.64			
Mysidacea	0.01	1.69			
Palaemonidae	0.85	1.69			

Table 20. Percentage frequency of occurrence and percentage of aggregate volume of all organisms from fish examined from the open estuary, Indian River lagoon.

ITEM	% vol.	% freq.
Detrital-Algal conglomerates	29.41	83.33
Fungus	0.61	83.33
Chlorophycea	49.62	16.67
Tracheophyta	11.61	83.33
Foraminifera	7.28	83.33
Nematoda	0.03	16.67
Copepoda	0.03	16.67
Aedes instars	0.11	16.67
Invertebrate eggs	0.82	66.67
Fishes & fragments	0.47	50.00

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Figure 13. Dissolved oxygen trace for the 28 to 30 hour sampling day from March to May 1982. Asterix is the time of sunset and sunrise.

Figure 14. Dissolved oxygen trace for the 28 to 30 hour sampling day from June to September 1982. Asterix is approximate time of sunrise and sunset.

Figure 15. Dissolved oxygen trace for the 28 to 30 hour sampling day from September 1982 to February 1983. Last December and first January records are missing due to recorder failure. Asterix is approximate time of sunrise and sunset.

Figure 16. Spatial - temporal variation in number of individuals of residents (white) and transients (black) with moon phase and mean high water in feet above sea level (Provost 1974).

Figure 9. Water level records for: (A) Indian River lagoon in Haeger Cove at station 61; (B) Perimeter ditch inside South Culvert, station 61; (C) Upper marsh pond, P-1, with moon phase and rainfall measured on gauges at Impoundment No. 12.

Figure 17. Water level records for: (A) Indian River lagoon in Haeger Cove at station 61; (B) Perimeter ditch inside South Culvert, station 61; (C) Upper marsh pond, P-1, with moon phase, rainfall and number of marsh resident captured.

Figure 18. Spatial - temporal variation in number of individuals and % occurrence for the most abundant marsh residents, March 1982 to February 1983.

Figure 19. Spatial - temporal variation in number of individuals and % occurrence for the most abundant transient species, March 1982 to February 1983.

Figure 20. Spatial - temporal variation in number of individuals and % occurrence for the most abundant macrocrustaceans, March 1982 to February 1983.

Figure 21. Monthly mean of rainfall (dotted line; 76 yr mean, NOAA) and mean monthly high water (solid line; 12 yr means, Provost 1974) with number of individuals summed by month of snook, *Centropomus undecimalis* (solid line) and tarpon, *Megalops atlanticus* (dotted line), from March 1982 to February 1983.

Figure 22. Tidal comparison of number of individuals of sheepshead minnow, *Cyprinodon variegatus*, captured in the culvert net at the South Culvert (61). Black columns = flood tide, white columns = ebb tide.

Figure 23. Tidal comparison of number of individuals collected on the upper marsh (50 - 53). Black columns = flood tide, white columns = ebb tide.

Figure 24. Tidal comparison of number of individuals collected in the lower marsh (30, 60-61, 70). Black columns = flood tide, white columns = ebb tide.

Figure 25. Spatial and ontogenetic comparison of food consumption in the sheepshead minnow, *Cyprinodon variegatus* for the month of March.

Figure 26. Spatial and ontogenetic comparison of food consumption in the sheepshead minnow, *Cyprinodon variegatus* for the month of June.

Figure 27. Spatial, temporal and ontogenetic comparison of food consumption in the sailfin molly, *Poecilia latipinna*.

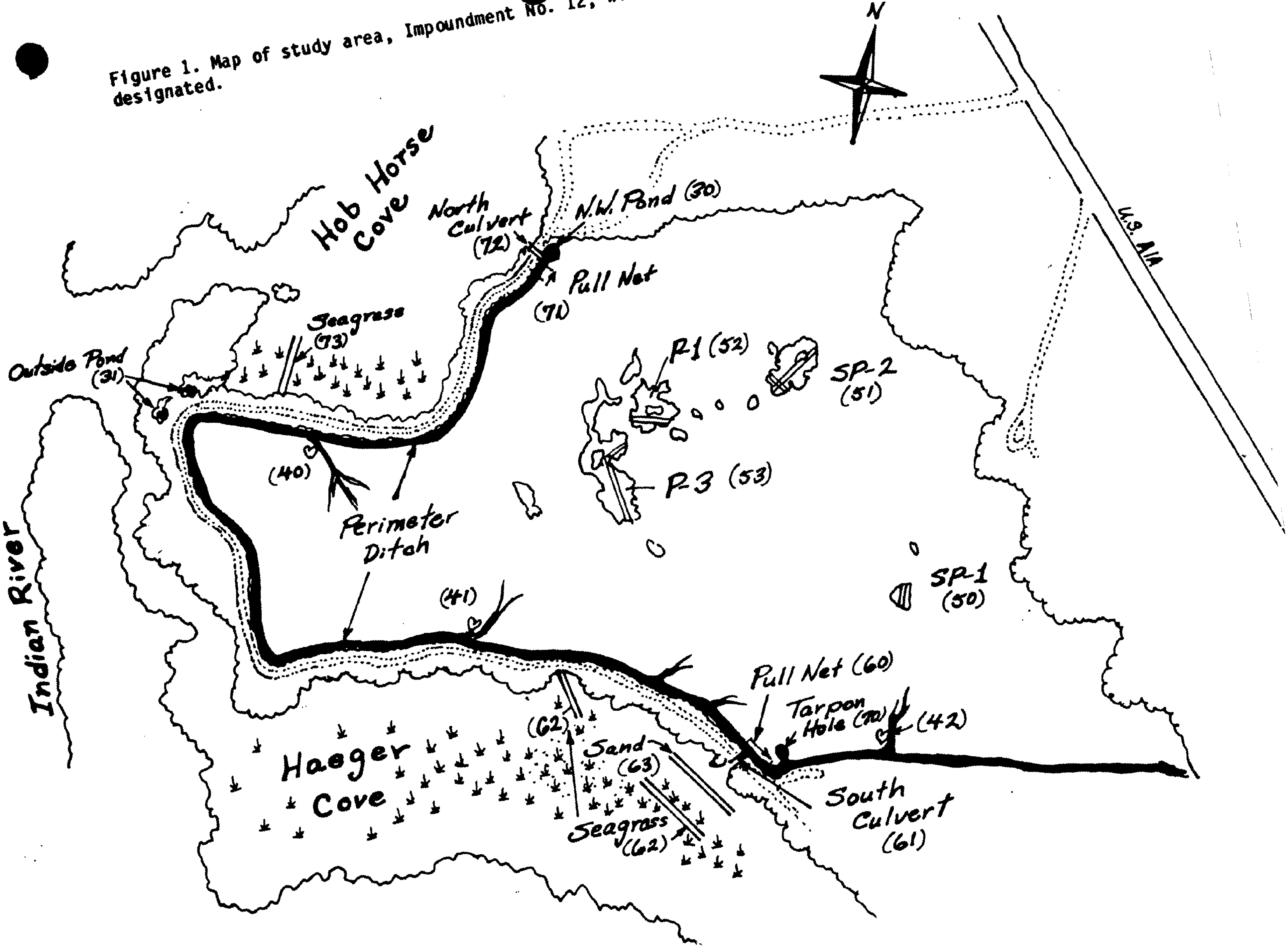
Figure 28. Spatial, temporal and ontogenetic comparison of food consumption in the mosquitofish, *Gambusia affinis*.

Figure 29. Spatial, temporal and ontogenetic comparison of food consumption in the striped mullet, *Mugil cephalus*.

Figure 30. Spatial, temporal and ontogenetic comparison of food consumption in the ladyfish, *Elops saurus*.

Figure 31. Temporal comparison of all species food consumption, % total food volume consumed, for all stations combined except the outer marsh.

Figure 1. Map of study area, Impoundment No. 12, with station locations designated.



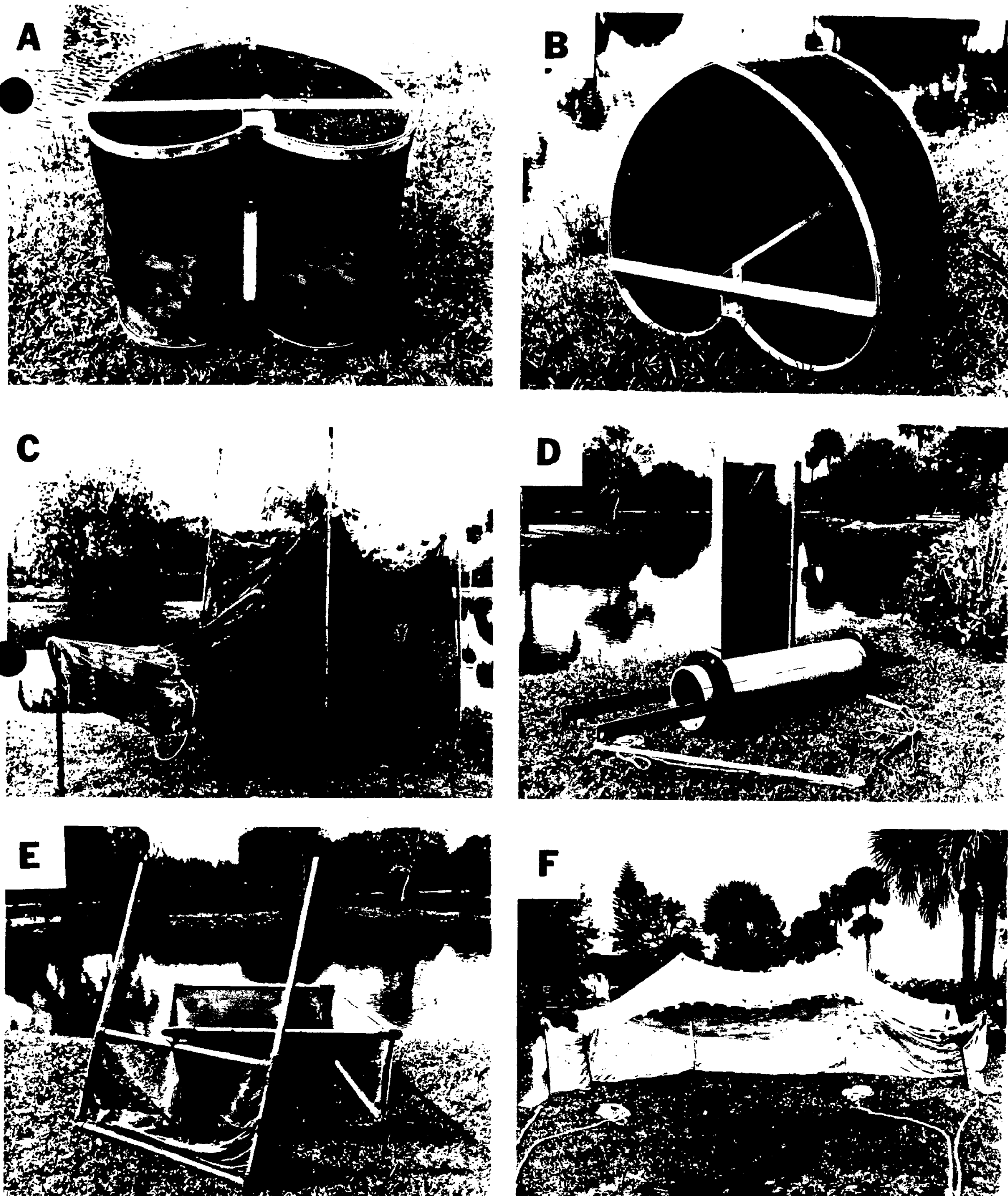


Figure 2. Gear types used: (A) Heart trap, front view; (B) Heart trap top angle view; (C) Culvert net; (D) Culvert traps, one aluminum shell (vertical and open), one PVC (horizontal and closed); (E) 1 m throw net; (F) Pull net.Pull net.

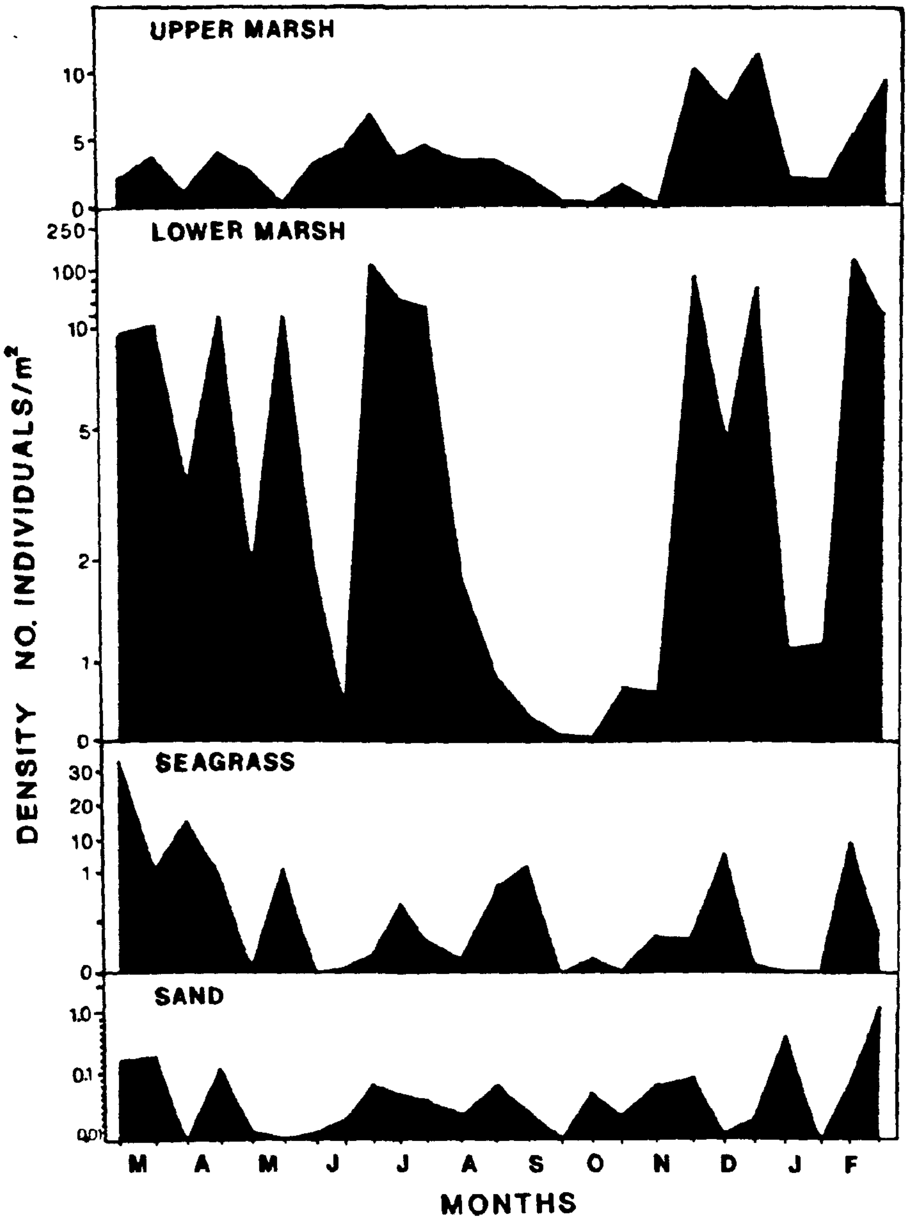


Figure 3. Spatial - temporal comparison of total fish densities from March 1982 to February 1983.

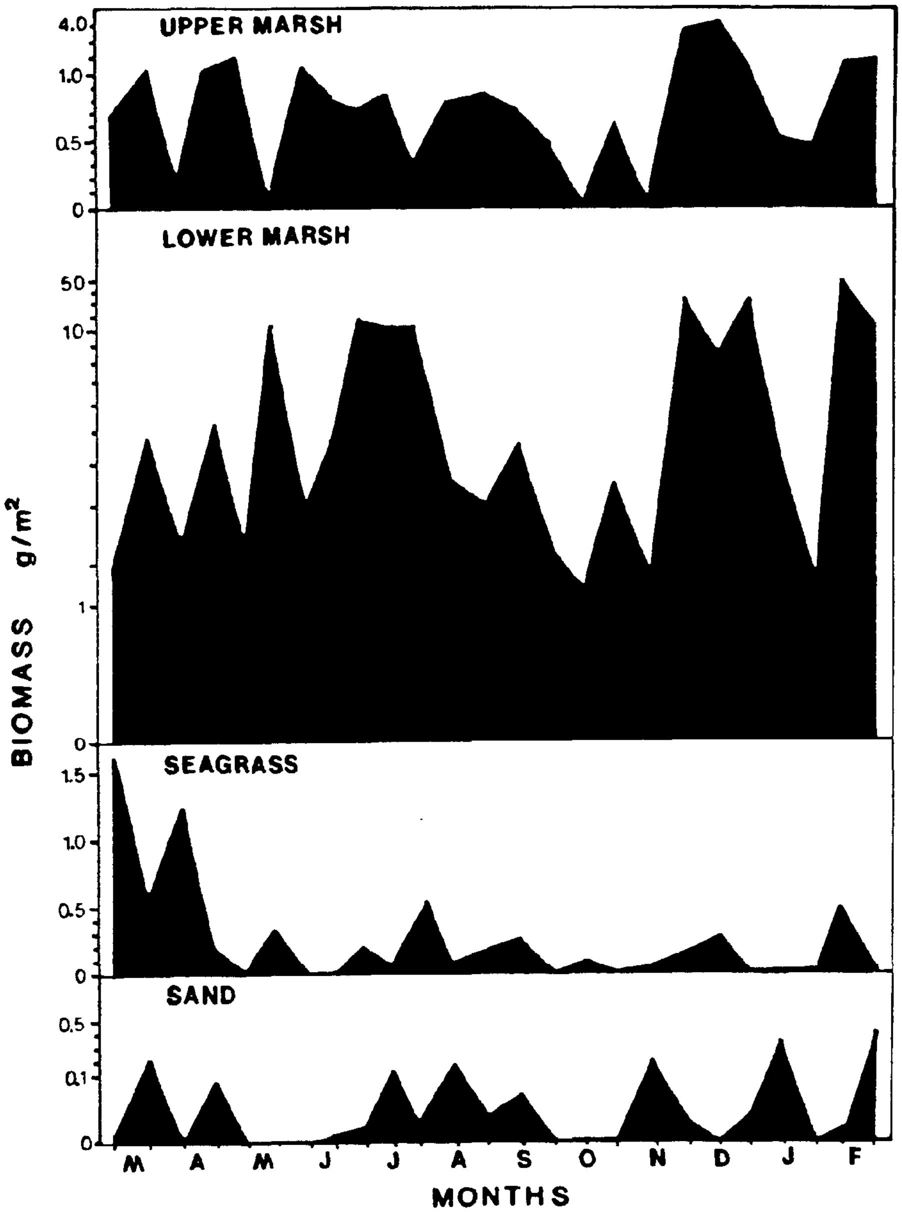


Figure 4. Spatial - temporal comparison of total fish biomass from March 1982 to February 1983.

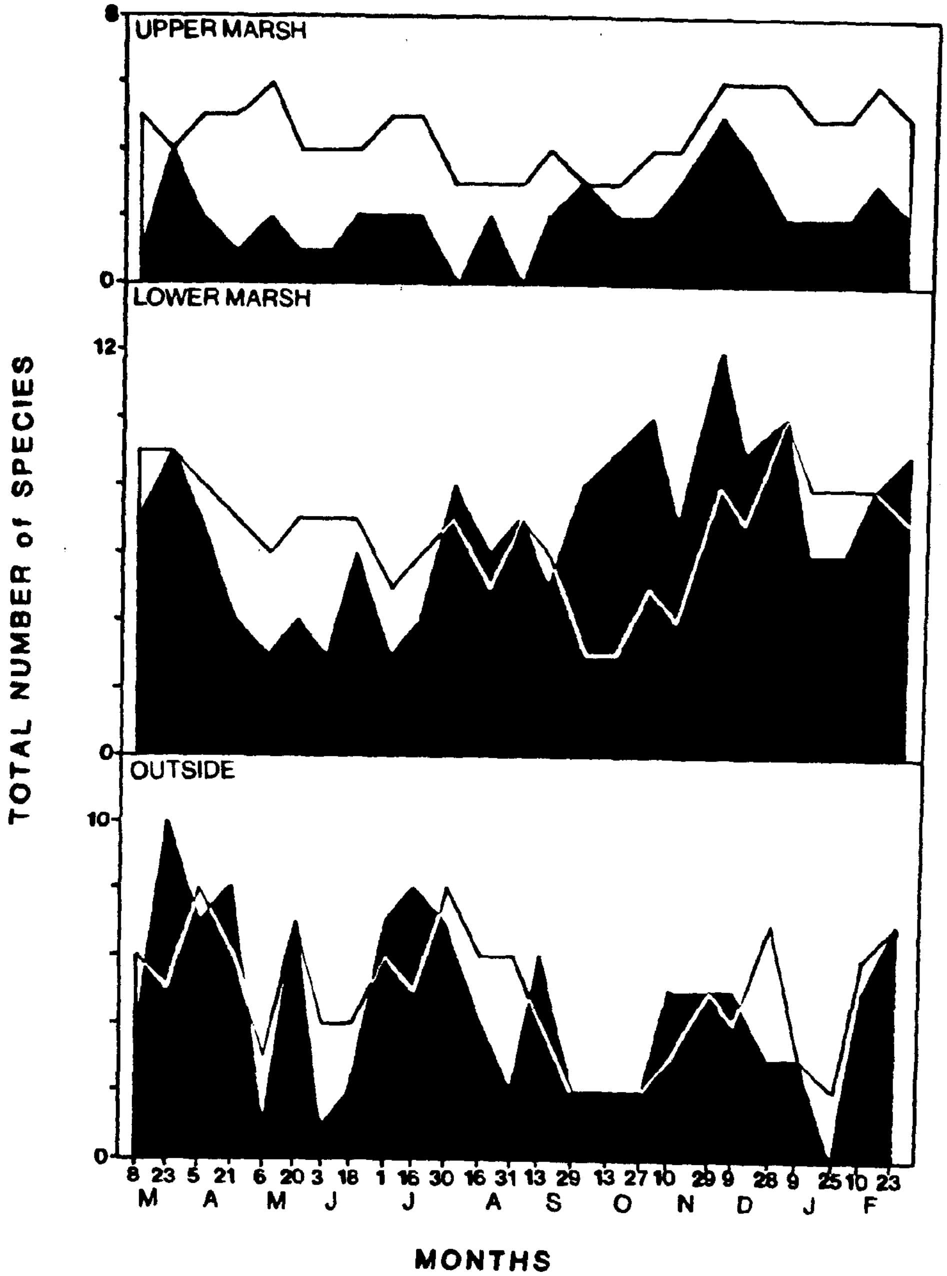


Figure 5. Spatial - temporal comparison of total number of species for transients (black) and residents (white), from March 1982 to February 1983.

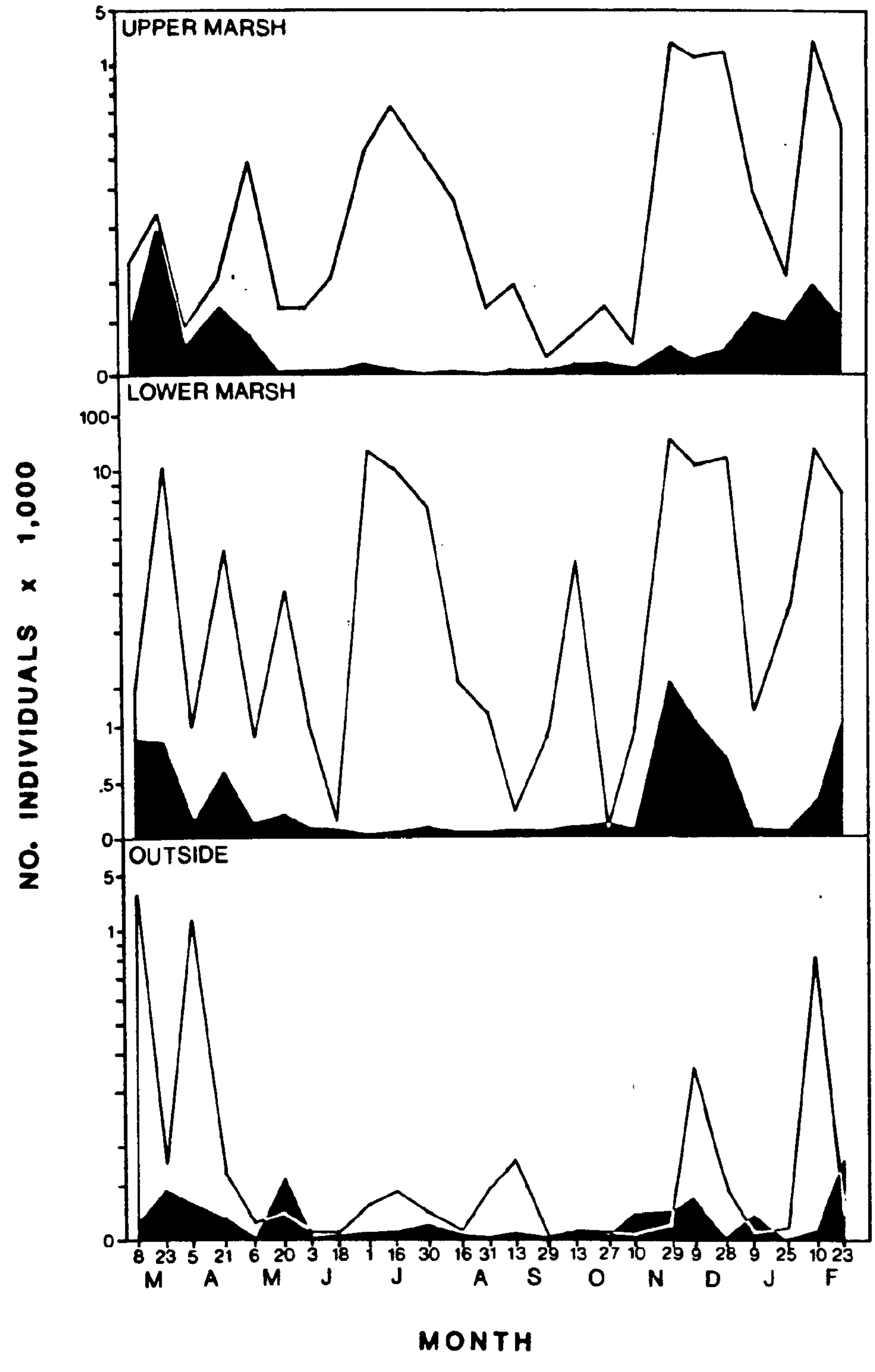


Figure 6. Spatial - temporal comparison of number of individuals for transients (black) and residents (white), from March 1982 to February 1983.

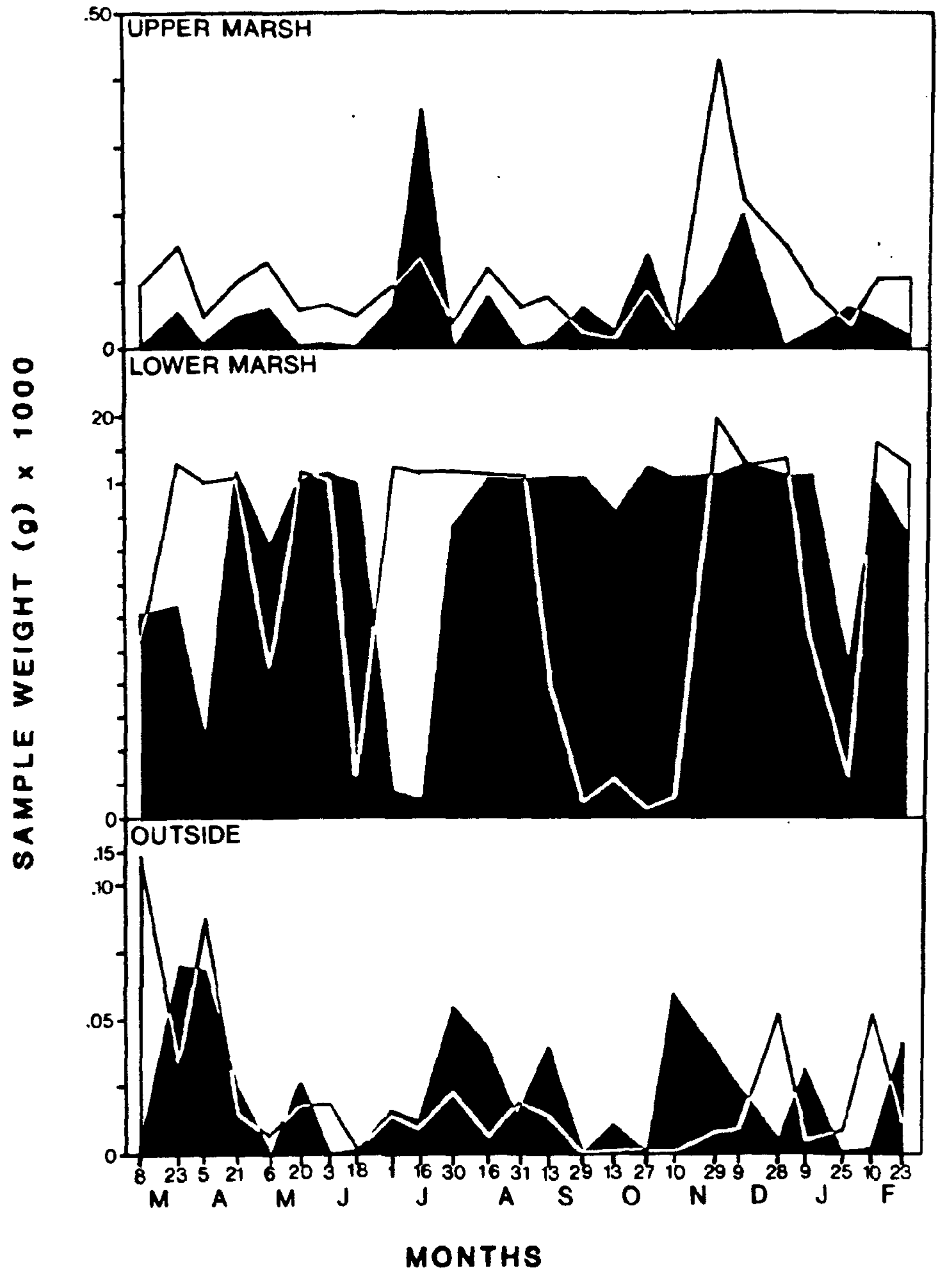


Figure 7. Spatial - temporal comparison of total sample weight for transients (black) and residents (white), from March 1982 to February 1983.

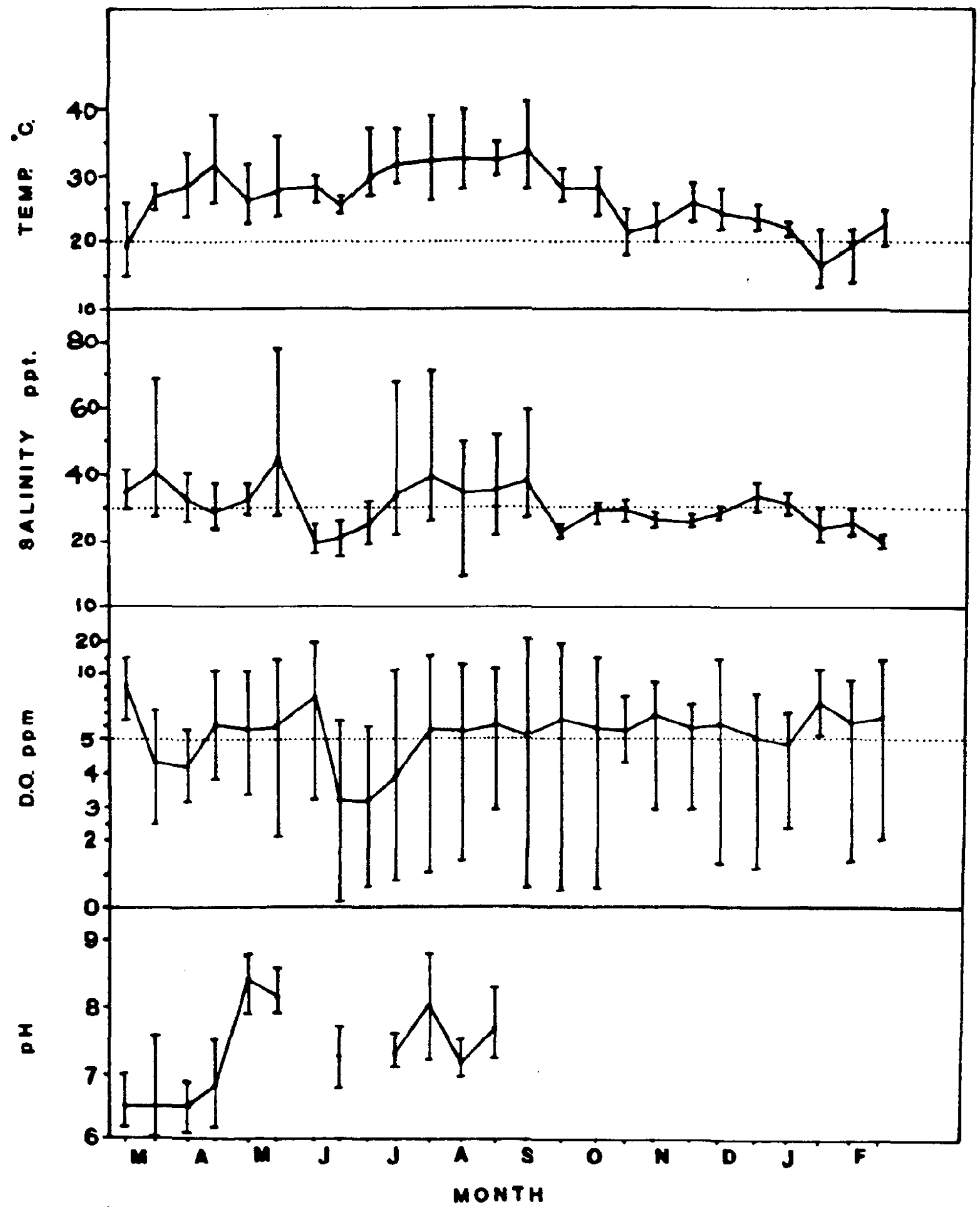


Figure 8. Temporal variation in means and range of temperature, salinity, dissolved oxygen and pH for all stations from March 1982 to February 1983.

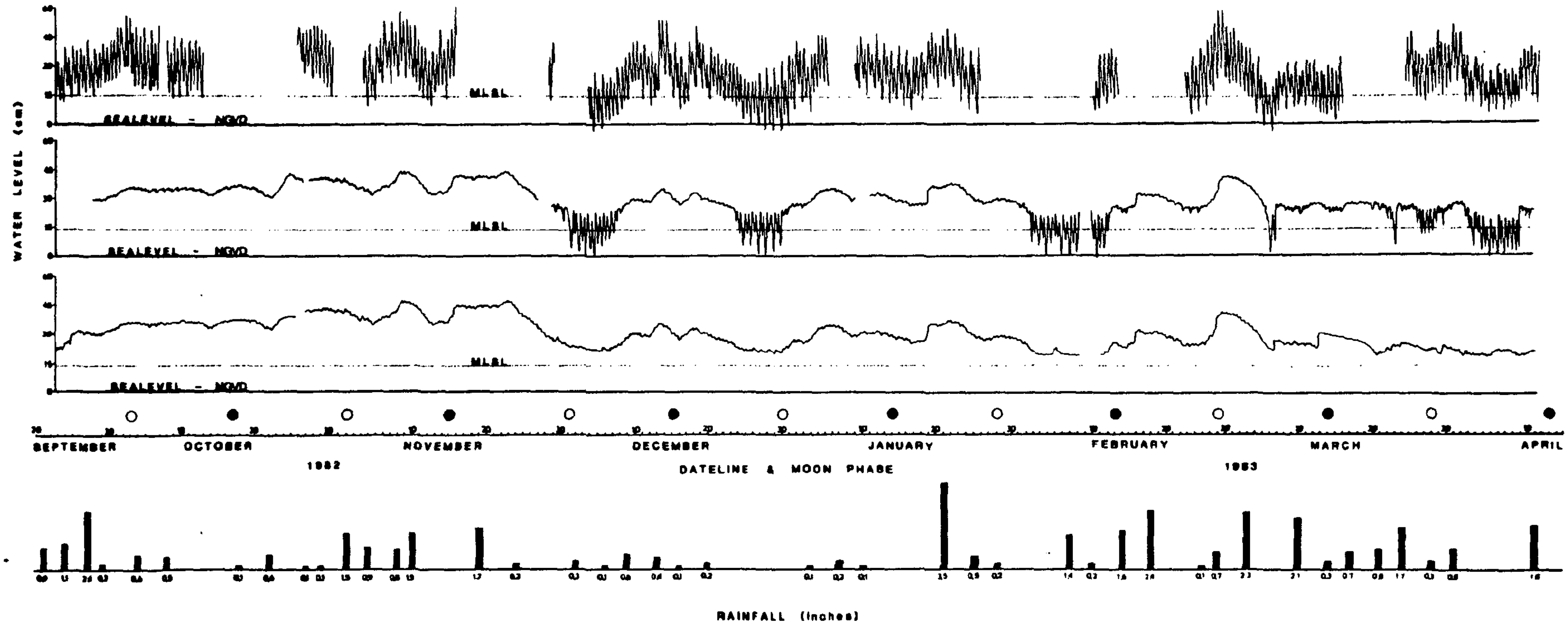


Figure 9. Water level records for: (A) Indian River lagoon in Haeger Cove at station 61; (B) Perimeter ditch inside South Culvert, station 61; (C) Upper marsh pond, P-1, with moon phase and rainfall measured on gauges at *Impoundment No. 12.*

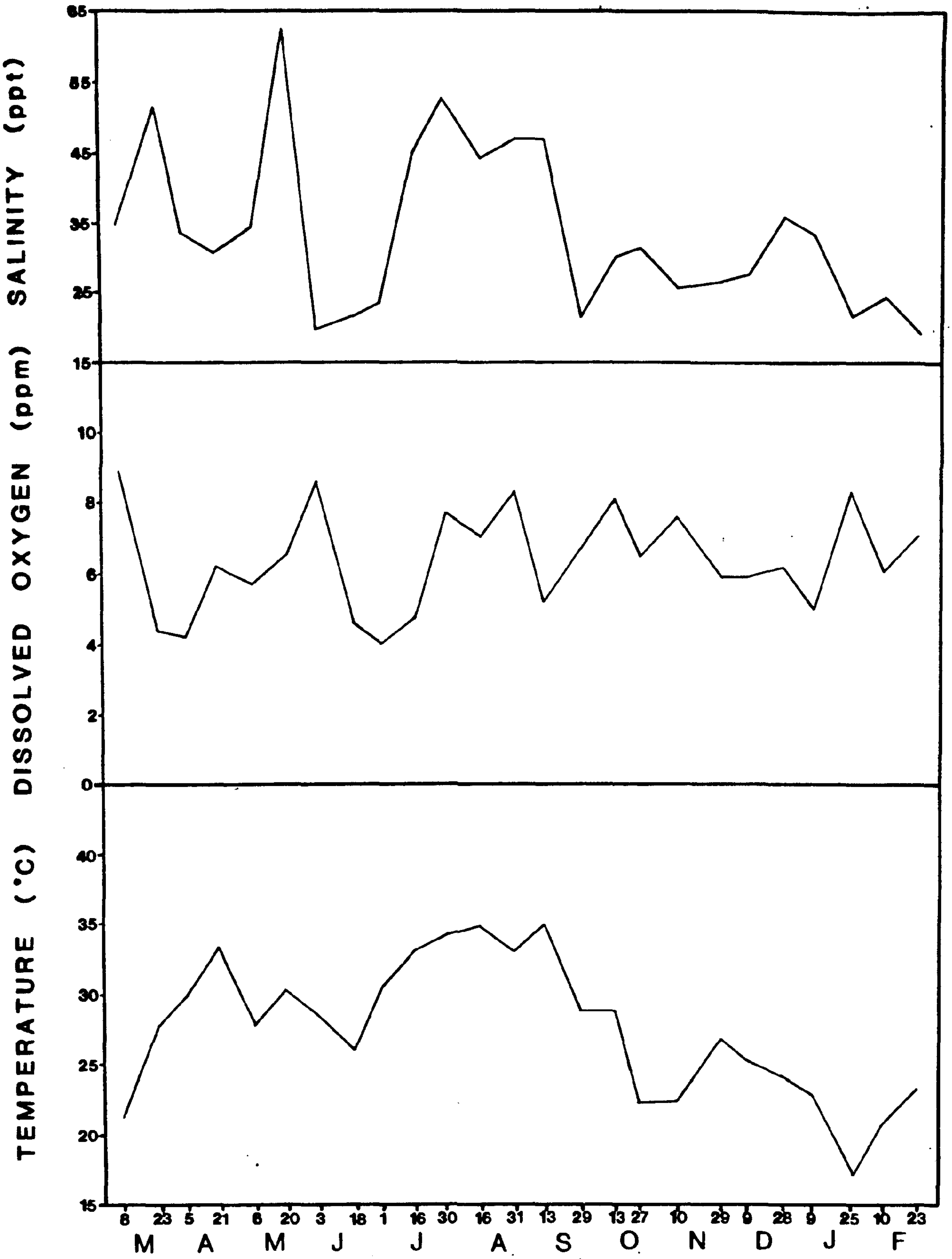


Figure 10. Means of physical parameters from upper marsh stations 50 - 53, from March 1982 to February 1983.

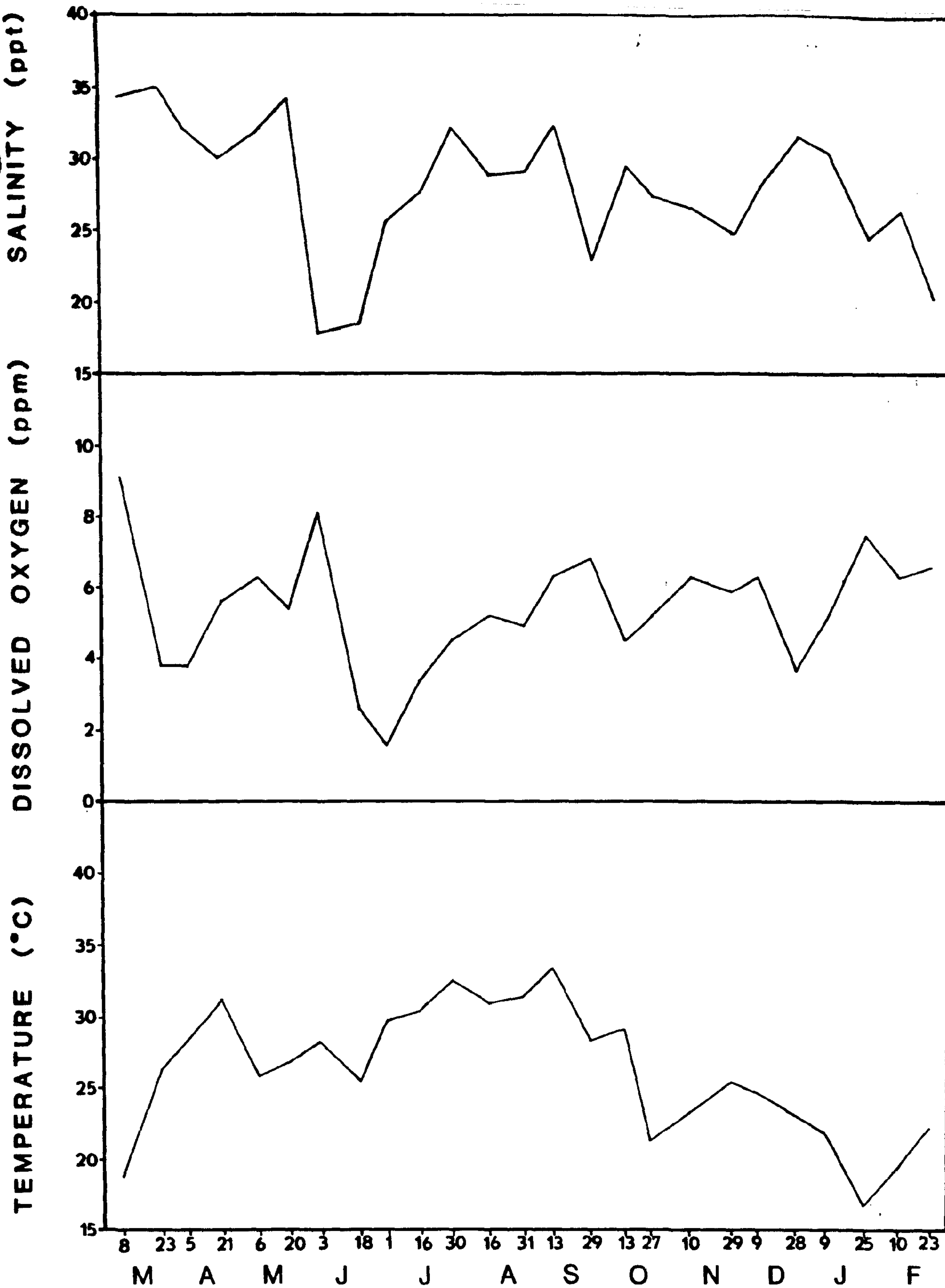


Figure 11. Means of physical paramters from lower marsh stations 30, 60 -61, from March 1982 to February 1983.

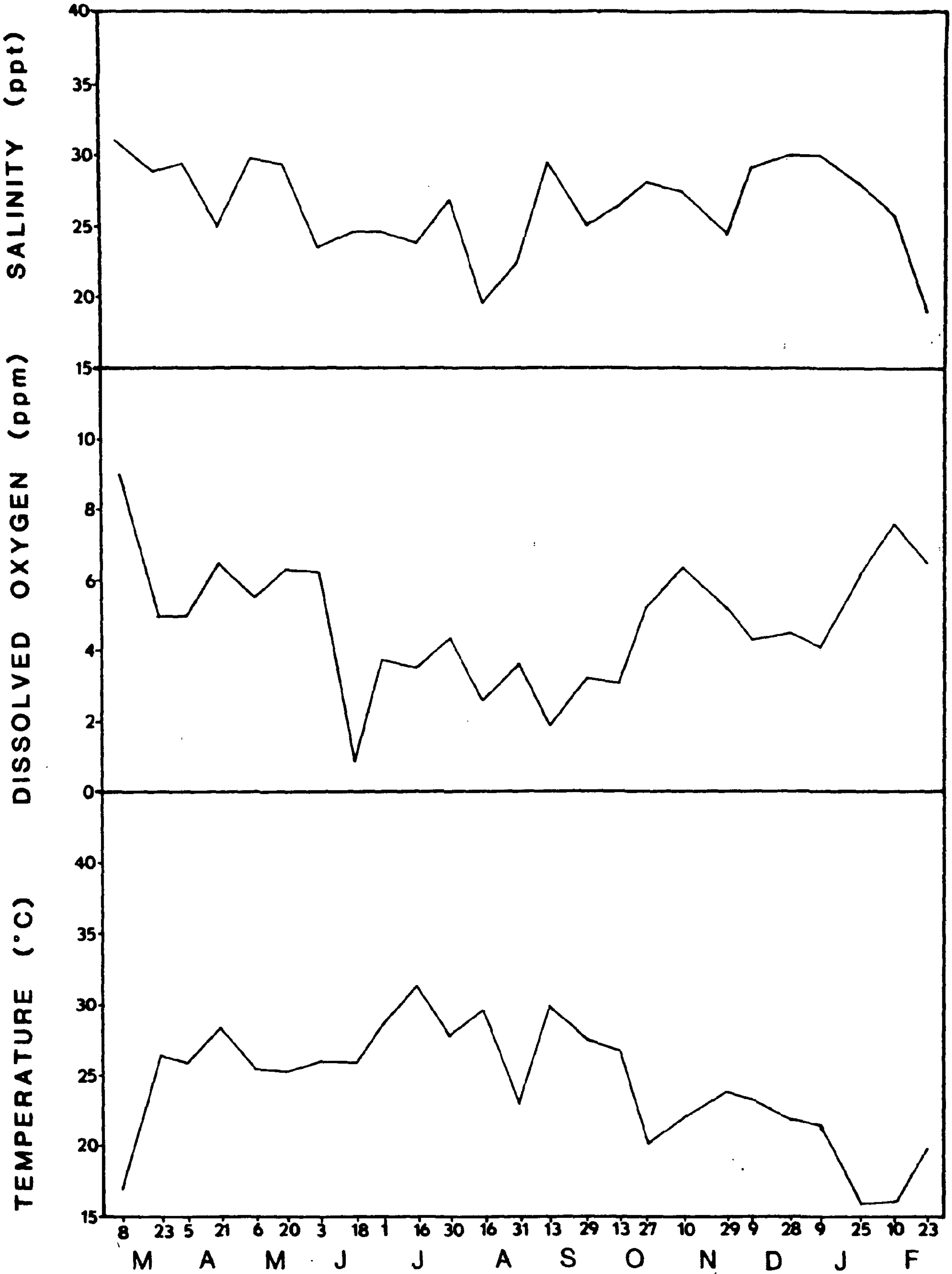


Figure 12. Means of physical parameters from Indian River lagoon stations, 31, 62, from March 1982 to February 1983.

Figure 13. Dissolved oxygen trace for the 28 to 30 hour sampling day from March to May 1982. Asterix is the time of sunset and sunrise.

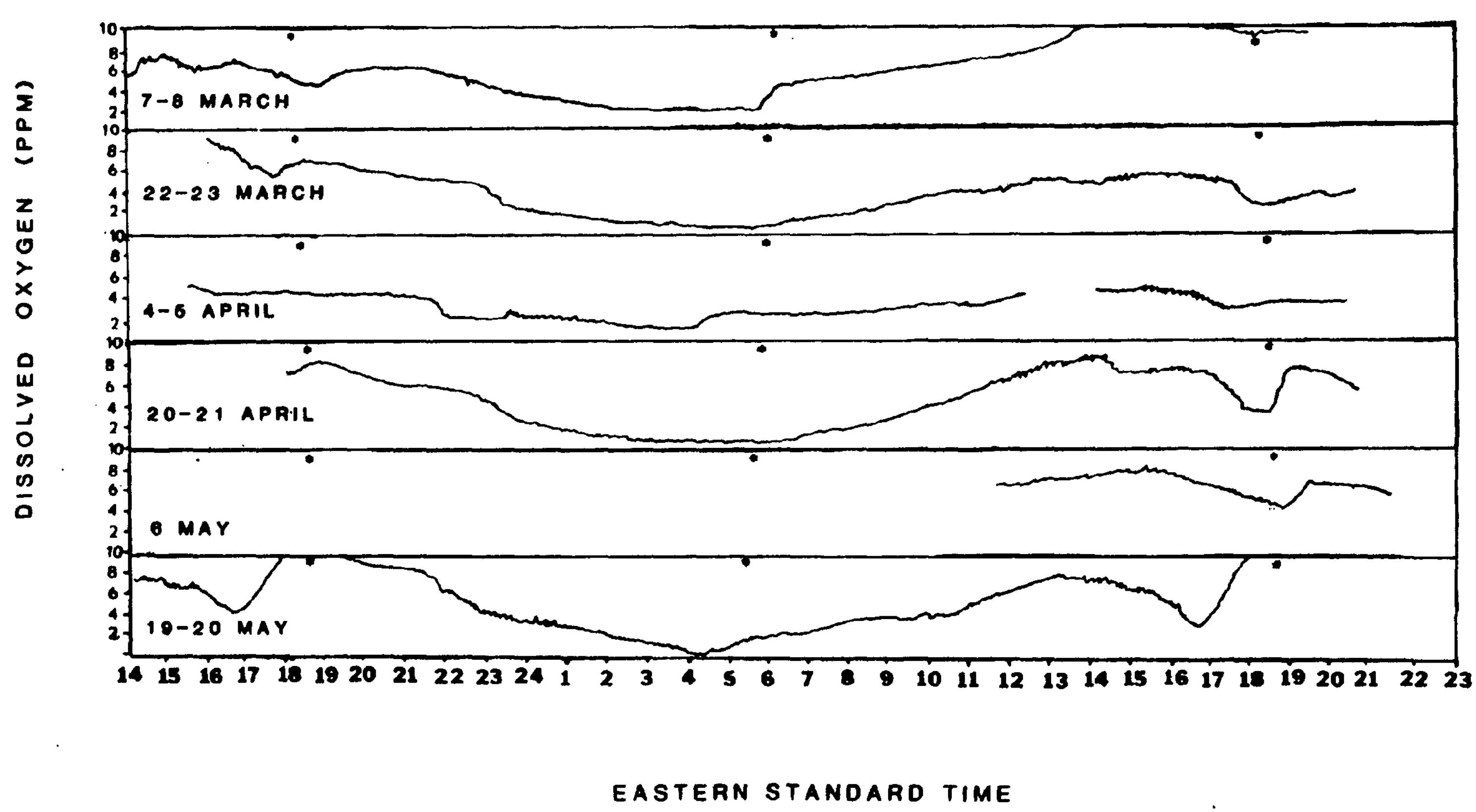


Figure 14. Dissolved oxygen trace for the 28 to 30 hour sampling day from June to September 1982. Asterix is approximate time of sunrise and sunset.

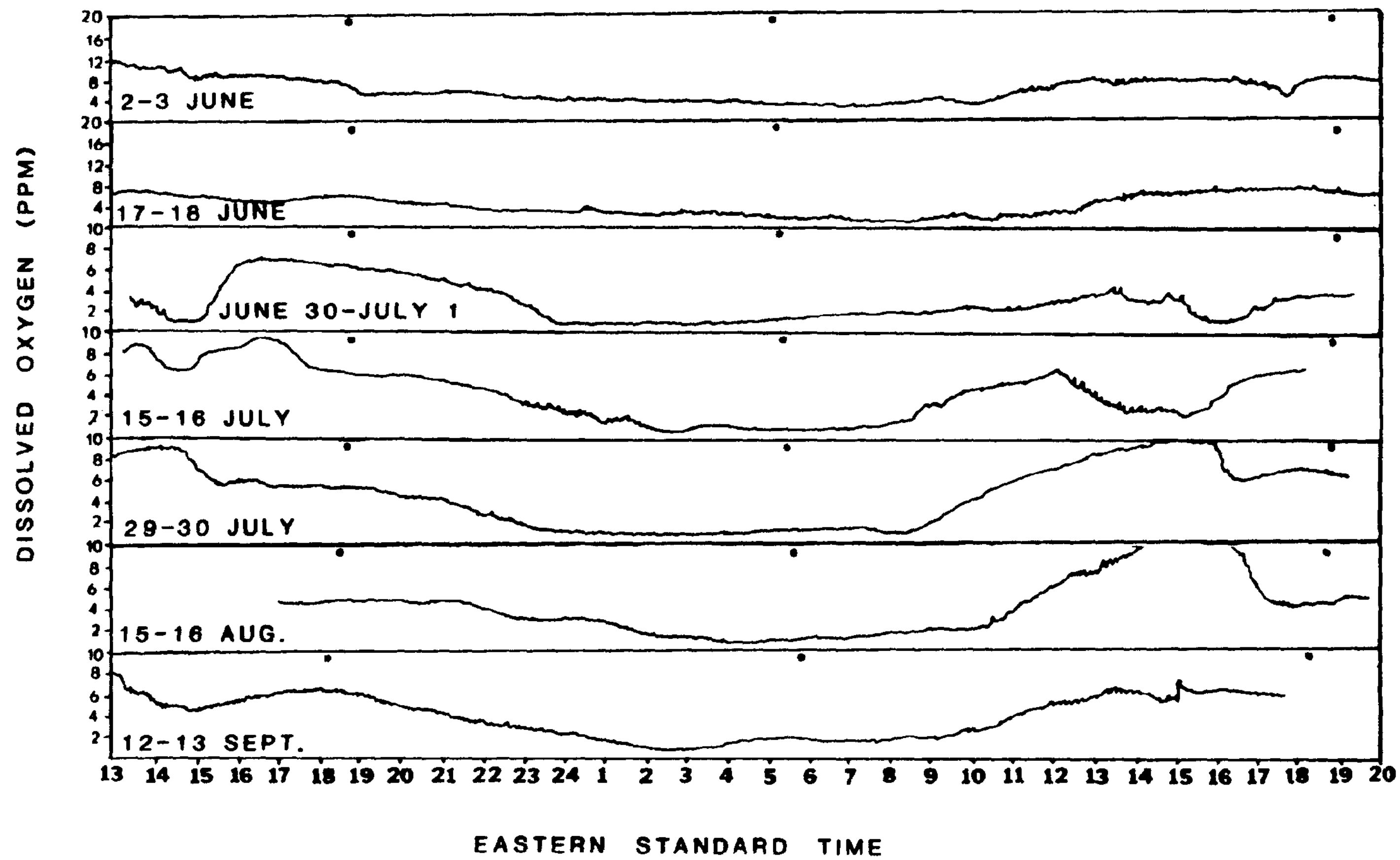


Figure 15. Dissolved oxygen trace for the 28 to 30 hour sampling day from September 1982 to February 1983. Last December and first January records are missing due to recorder failure. Asterix is approximate time of sunrise and sunset.

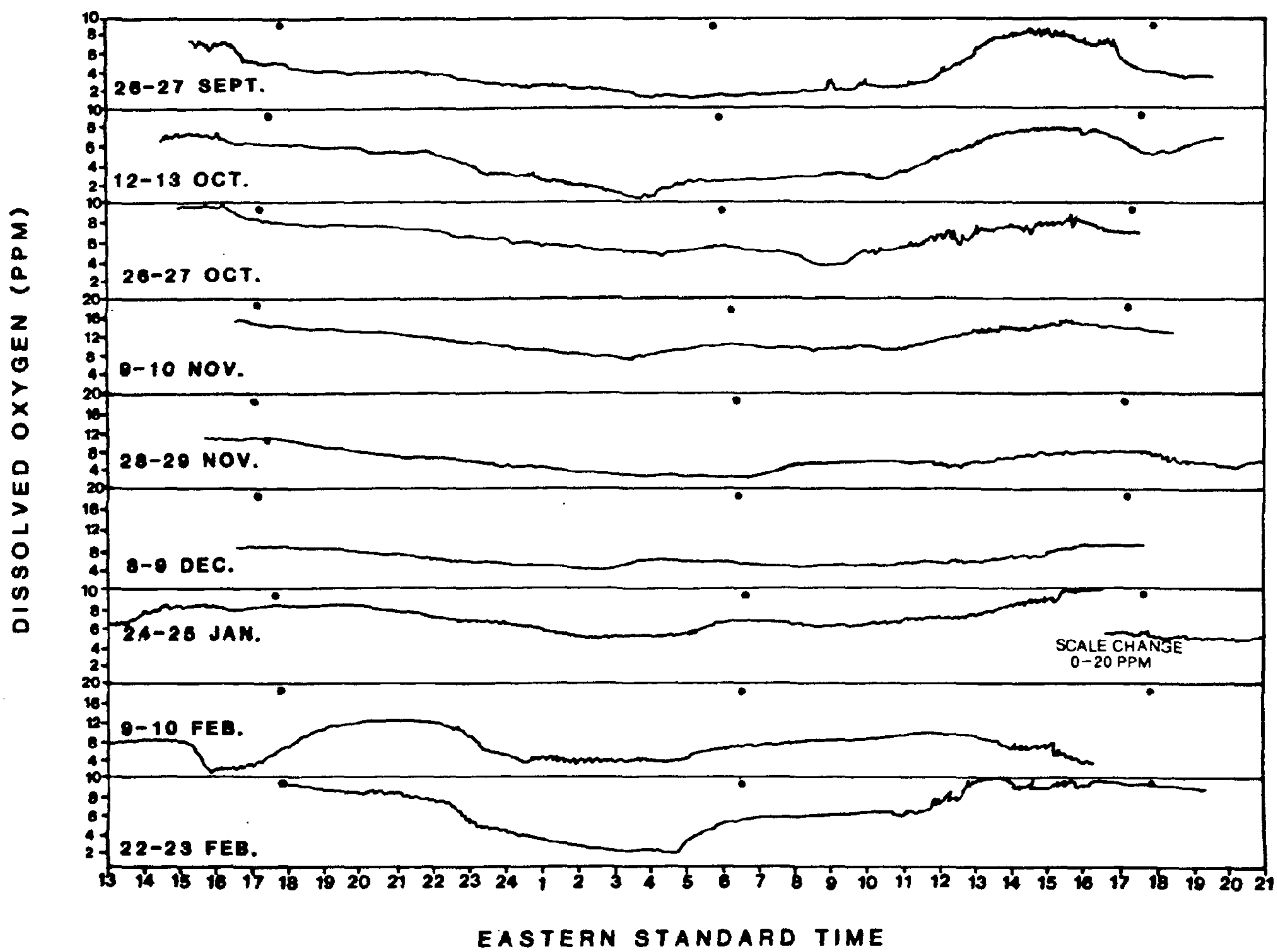
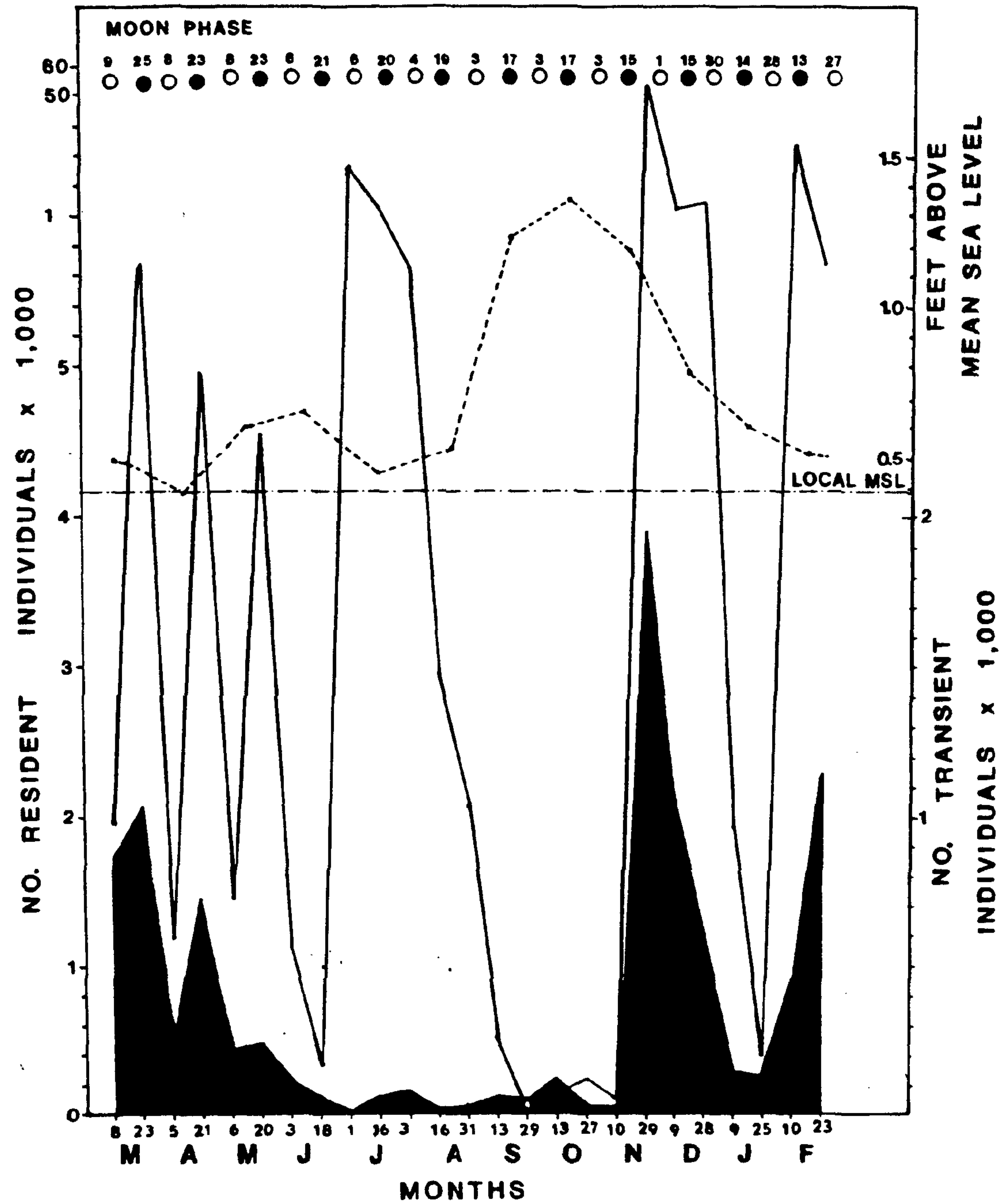


Figure 16. Spatial - temporal variation in number of individuals of residents (white) and transients (black) with moon phase and mean high water in feet above sea level (Provost 1974).



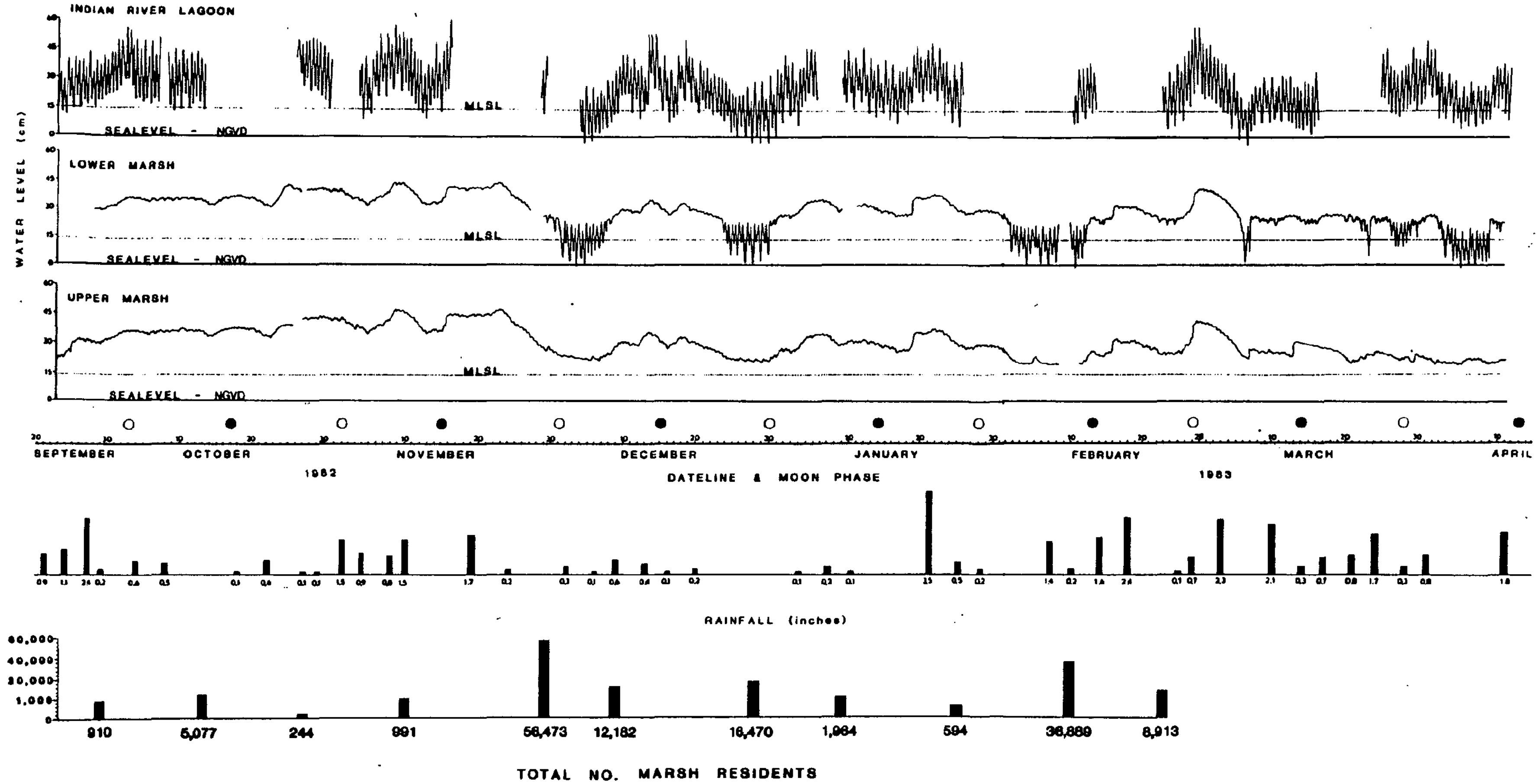


Figure 17. Water level records for: (A) Indian River lagoon in Haeger Cove at station 61; (B) Perimeter ditch inside South Culvert, station 61; (C) Upper marsh pond, P-1, with moon phase, rainfall and number of marsh resident captured.

Figure 18. Spatial - temporal variation in number of individuals and % occurrence for the most abundant marsh residents, March 1982 to February 1983.

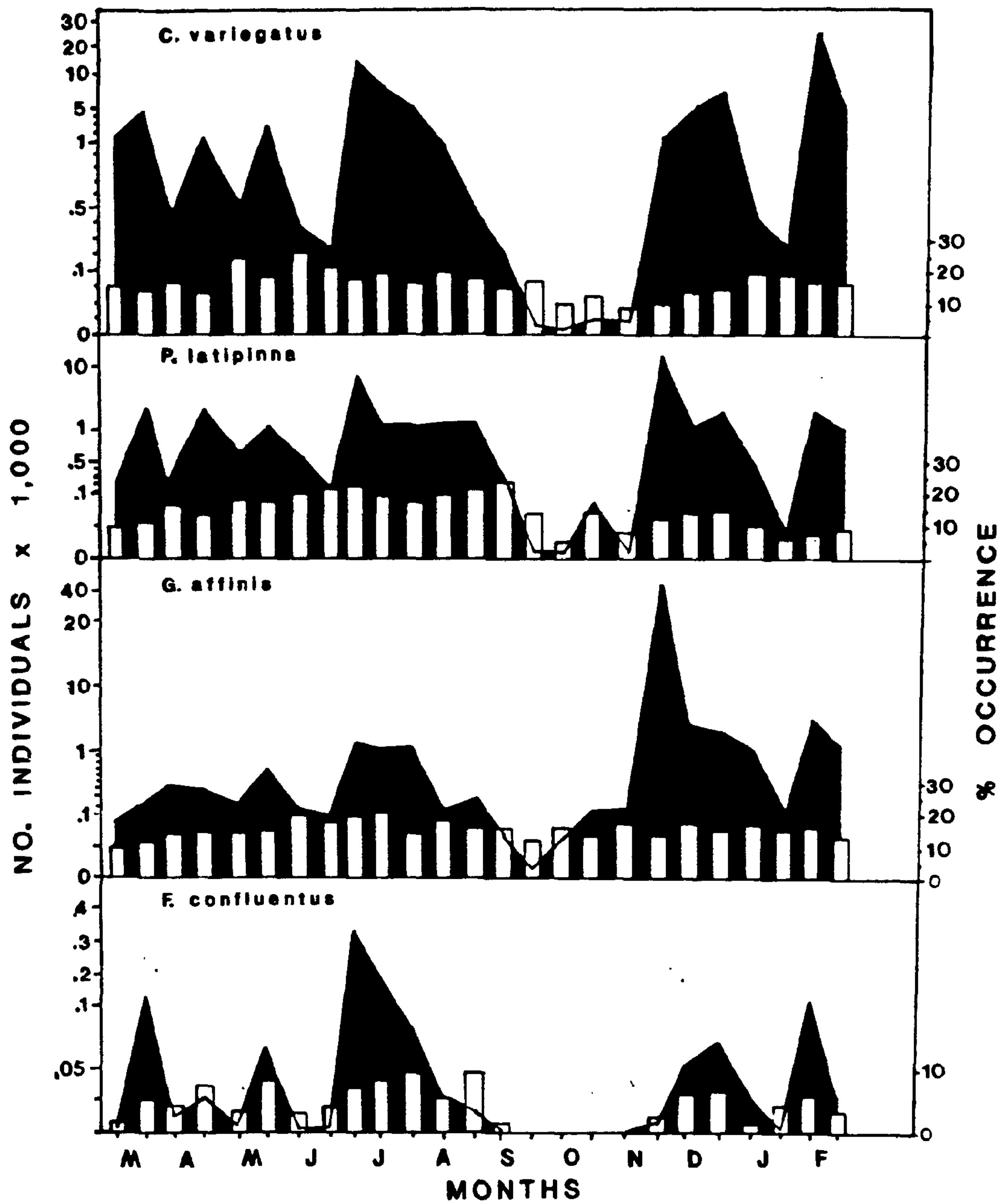


Figure 19. Spatial - temporal variation in number of individuals and % occurrence for the most abundant transient species, March 1982 to February 1983.

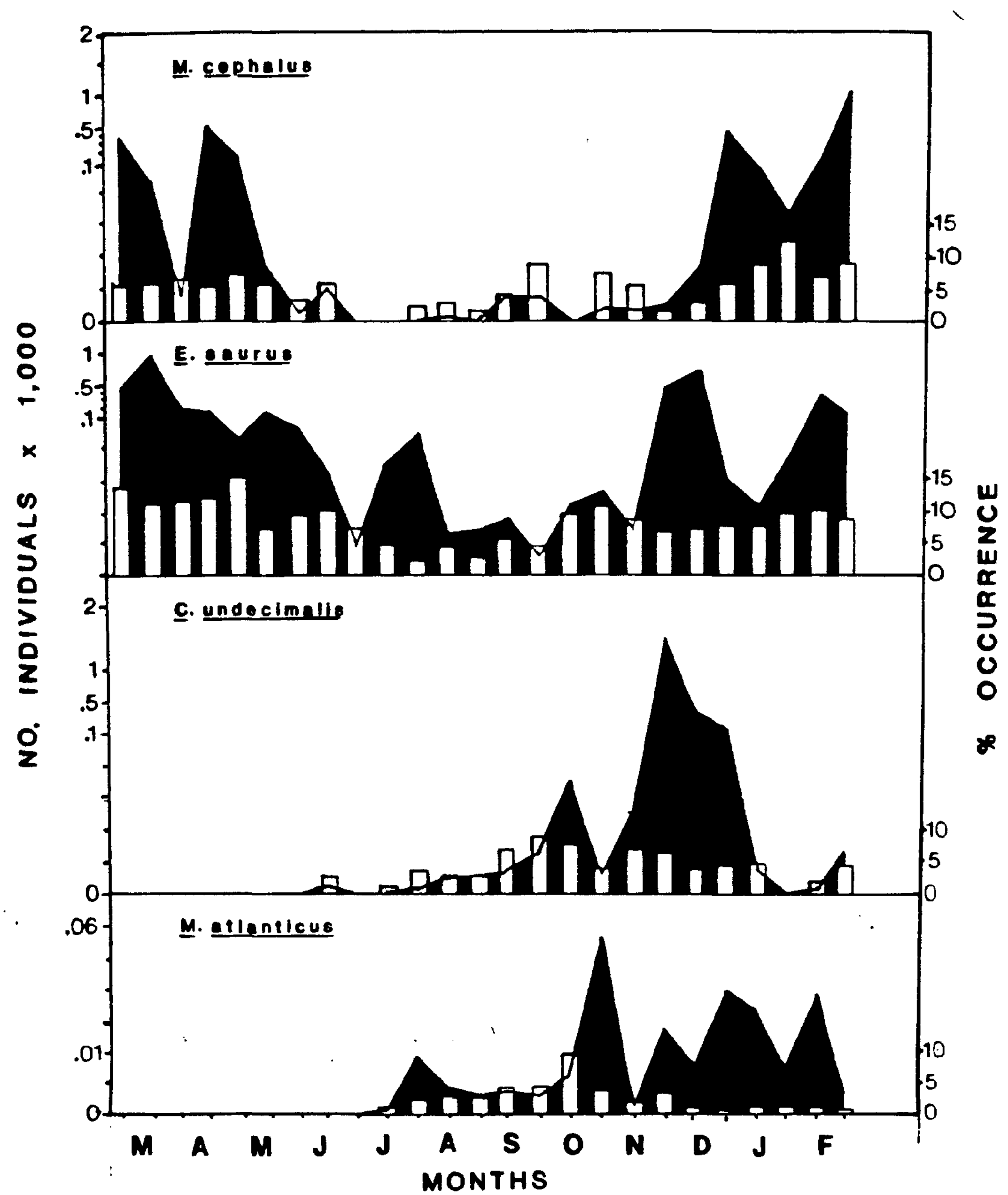
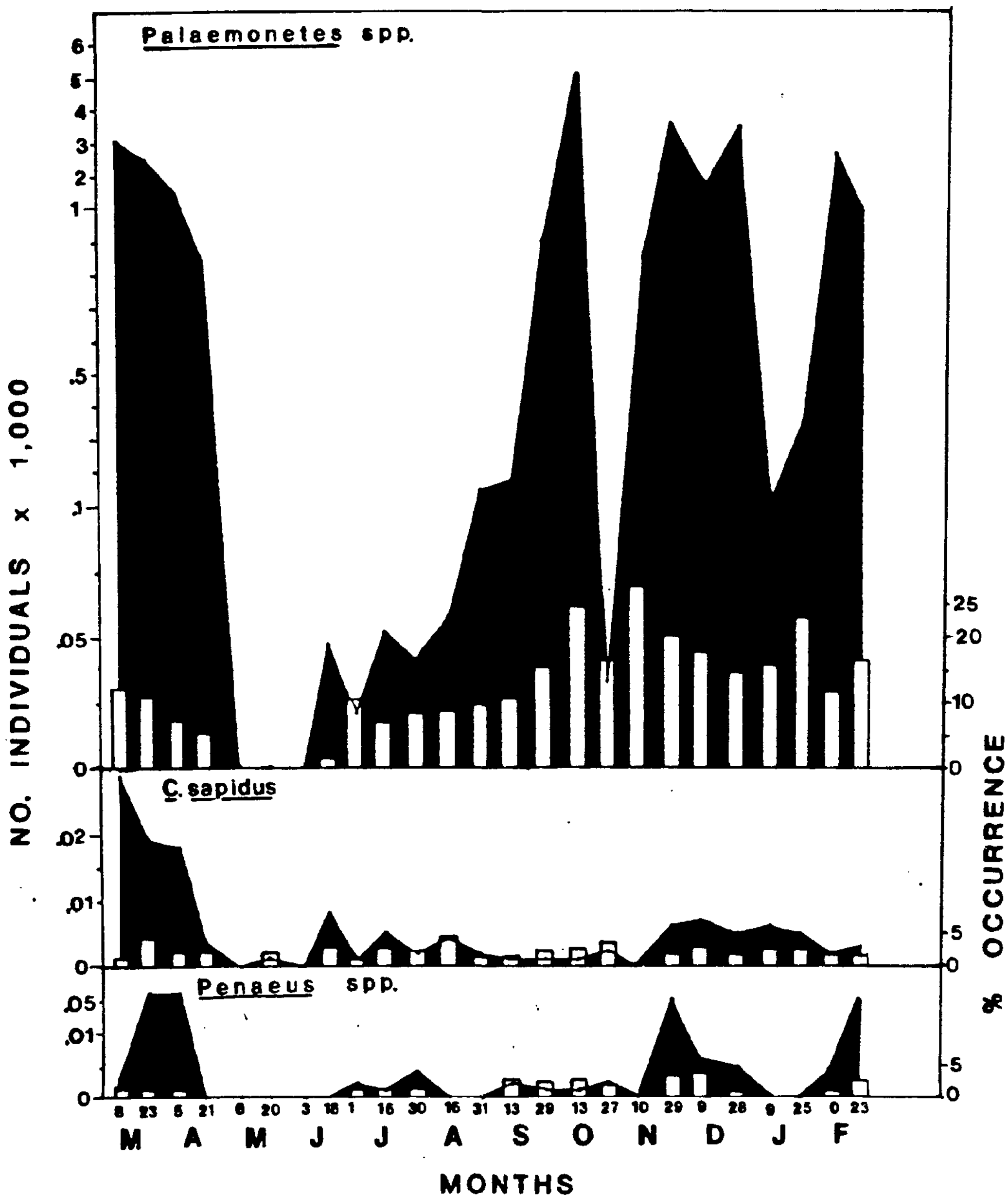


Figure 20. Spatial - temporal variation in number of individuals and % occurrence for the most abundant macrocrustaceans, March 1982 to February 1983.



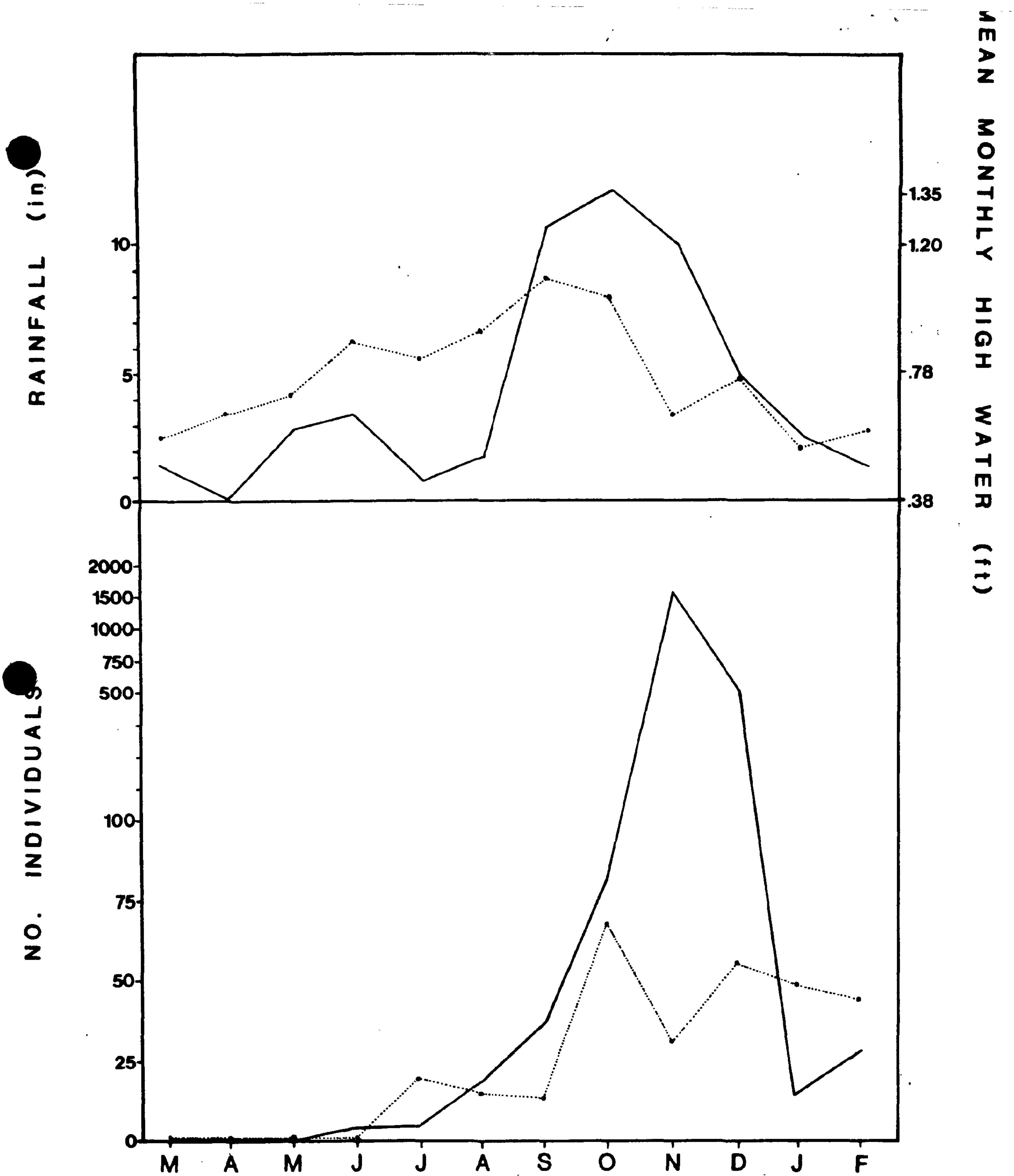


Figure 21. Monthly mean of rainfall (dotted line; 76 yr mean, NOAA) and mean monthly high water (solid line; 12 yr means, Provost 1974) with number of individuals summed by month of snook, Centropomus undecimalis (solid line) and tarpon, Megalops atlanticus (dotted line), from March 1982 to February 1983.

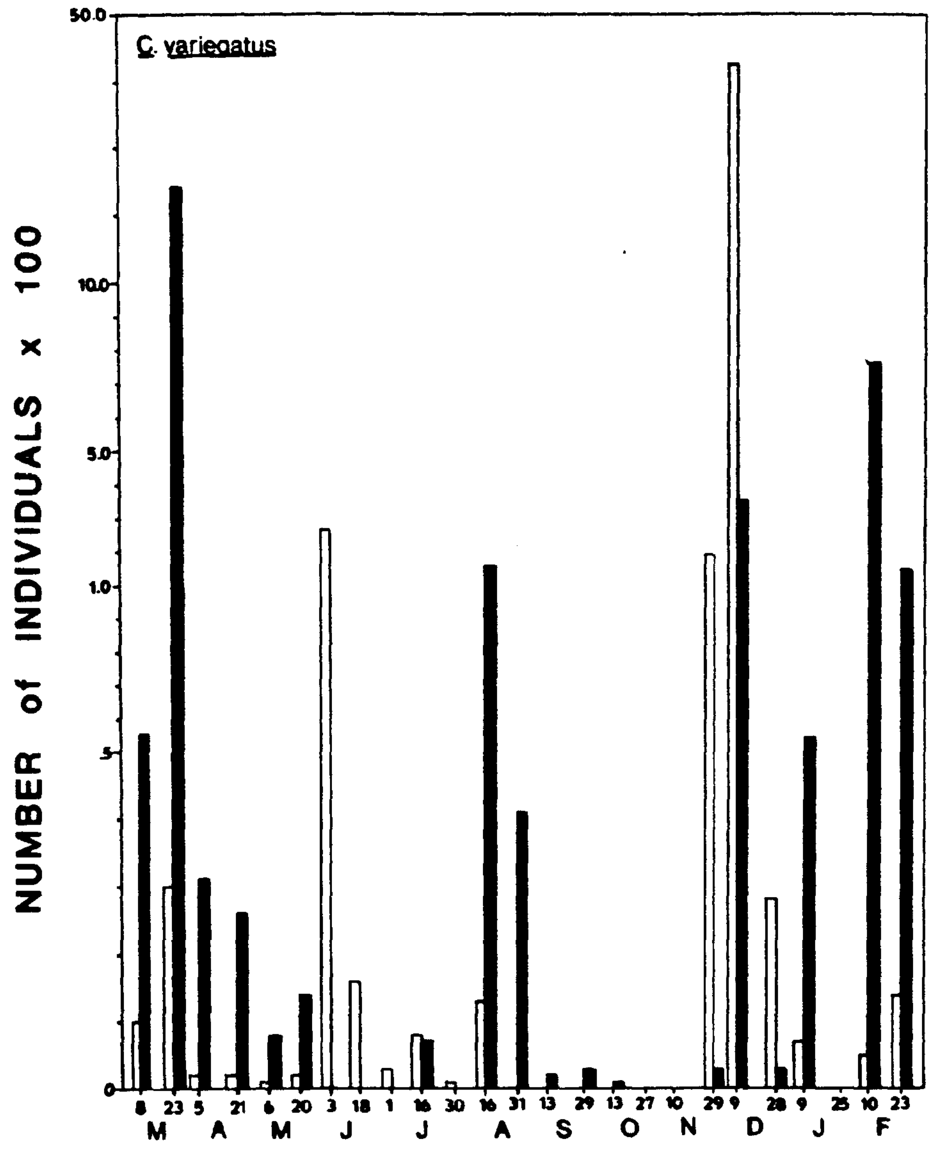


Figure 22. Tidal comparison of number of individuals of sheepshead minnow, Cyprinodon variegatus, captured in the culvert net at the South Culvert (61). Black columns = flood tide, white columns = ebb tide.

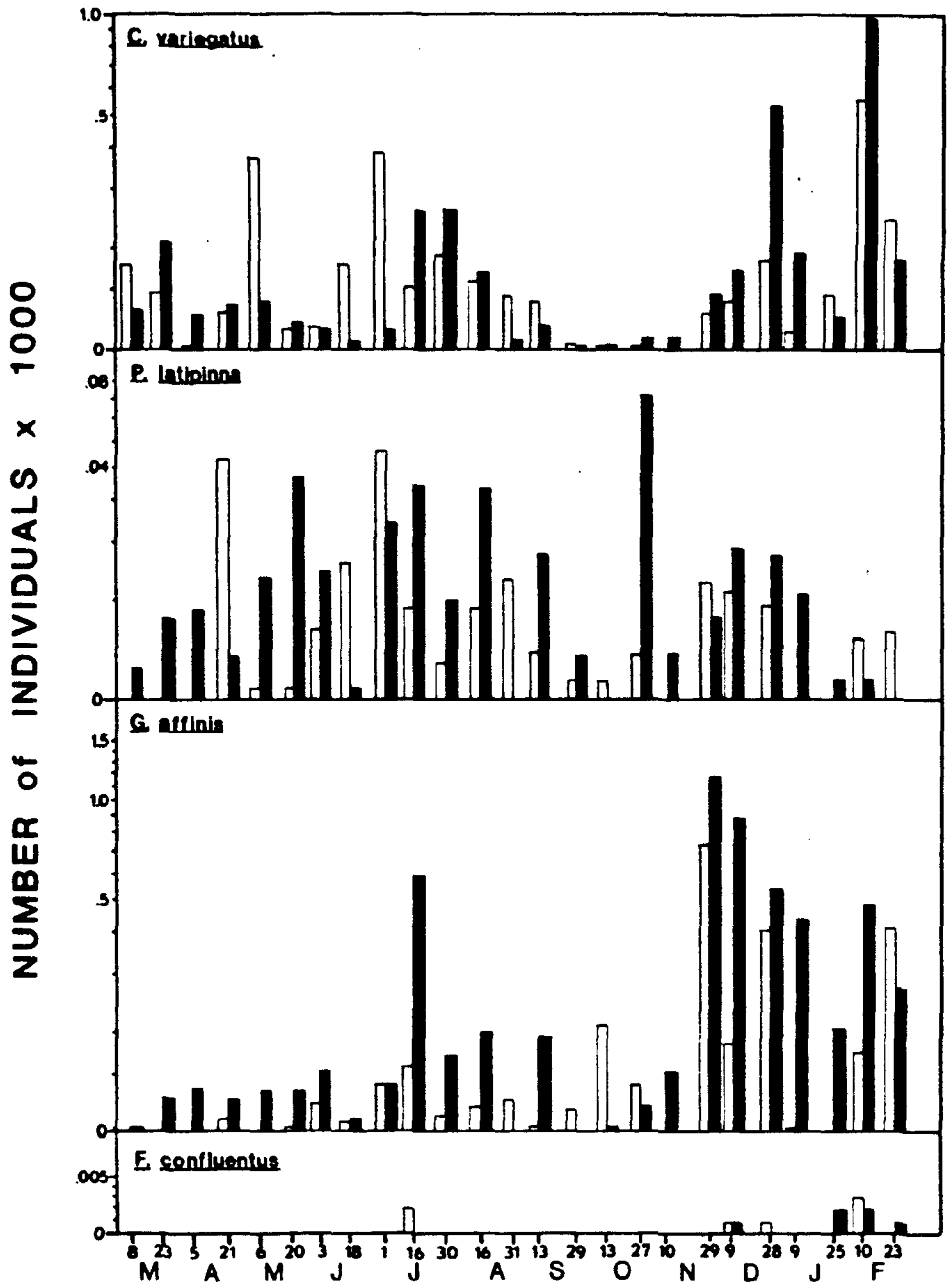


Figure 23. Tidal comparison of number of individuals collected on the upper marsh (50 - 53). Black columns = flood tide, white columns = ebb tide.

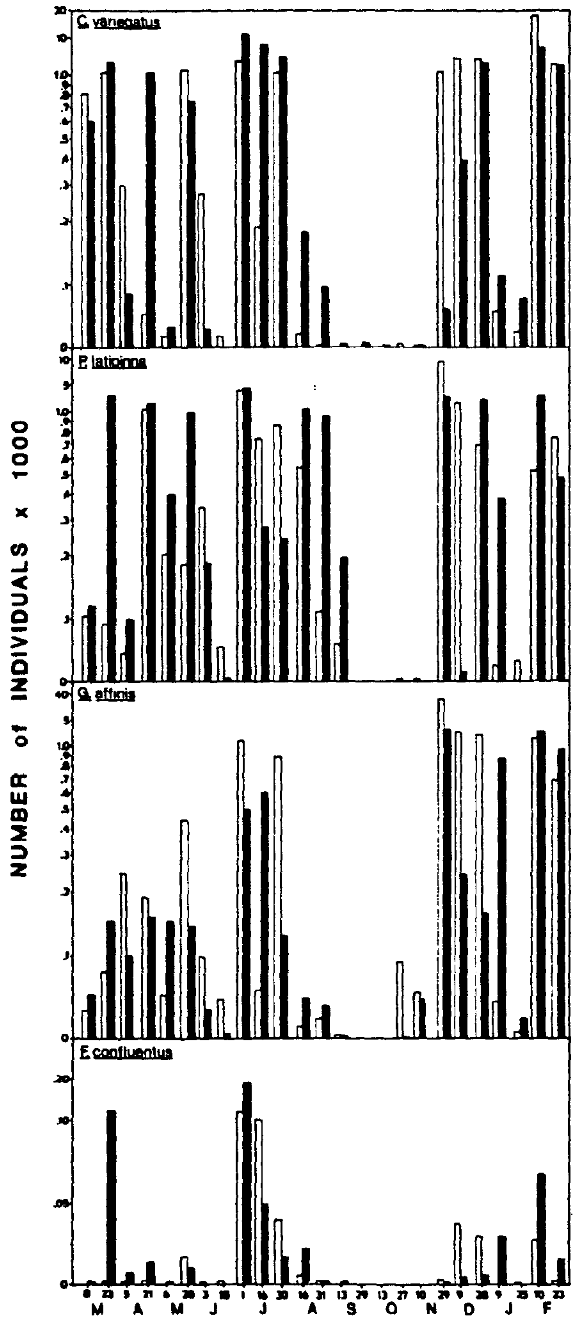
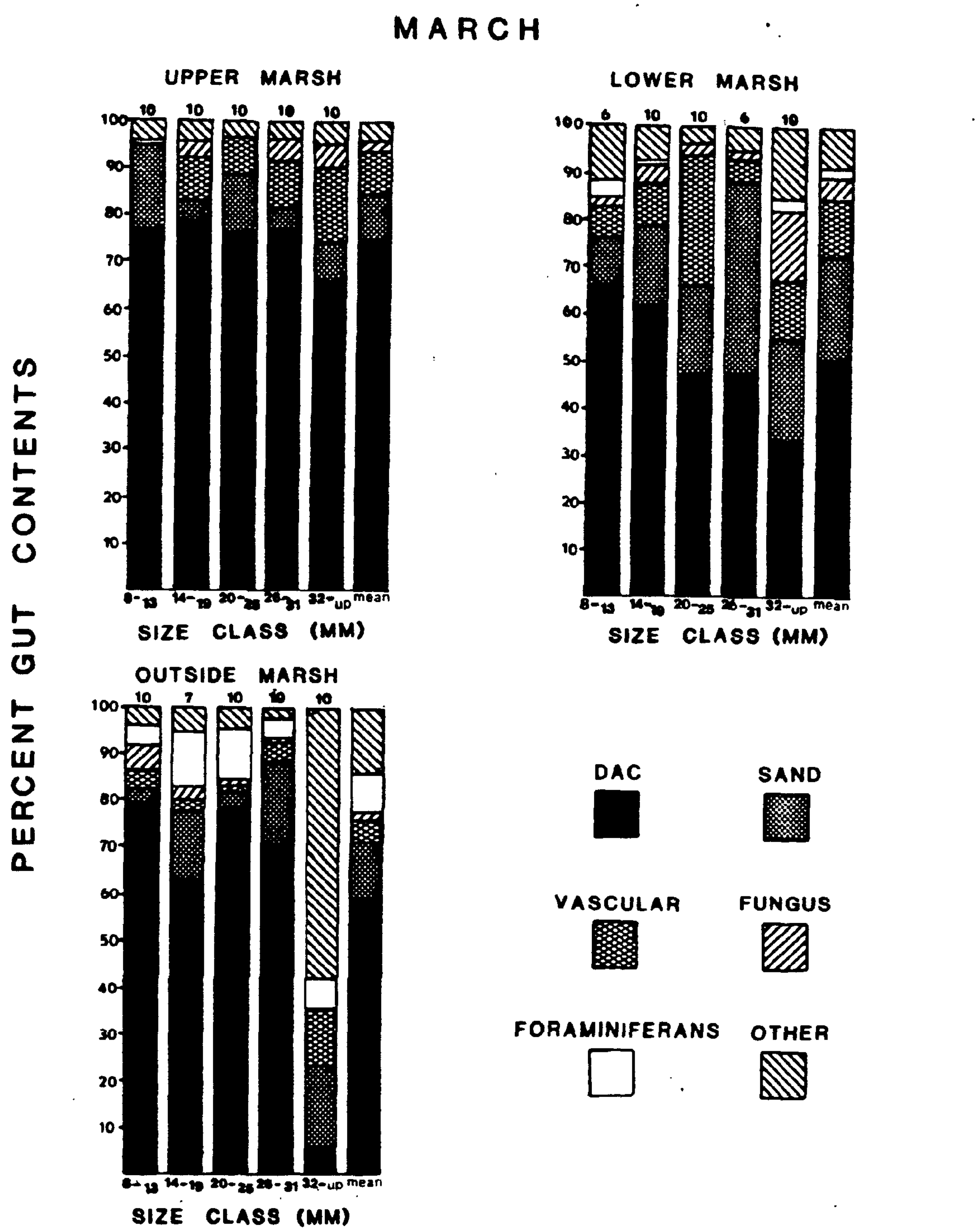


Figure 24. Tidal comparison of number of individuals collected in the lower marsh (30, 60-61, 70). Black columns = flood tide, white columns = ebb tide.

Figure 25. Spatial and ontogenetic comparison of food consumption in the sheepshead minnow, Cyprinodon variegatus for the month of March.



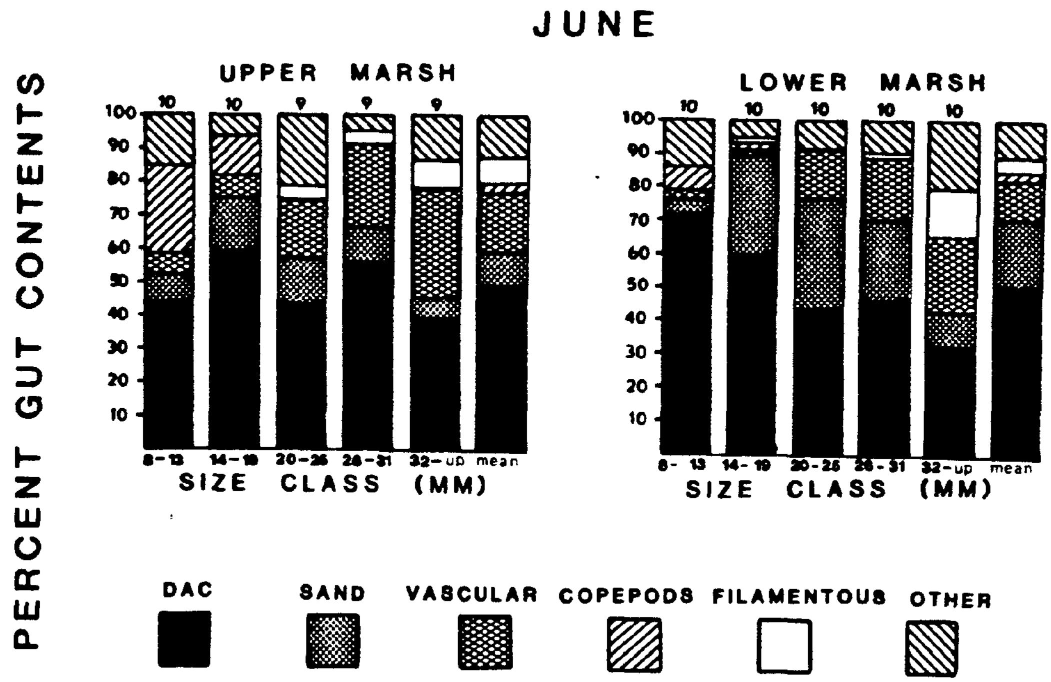


Figure 26. Spatial and ontogenetic comparison of food consumption in the sheepshead minnow, Cyprinodon variegatus for the month of June.

Figure 27. Spatial, temporal and ontogenetic comparison of food consumption in the sailfin molly, *Poecilia latipinna*.

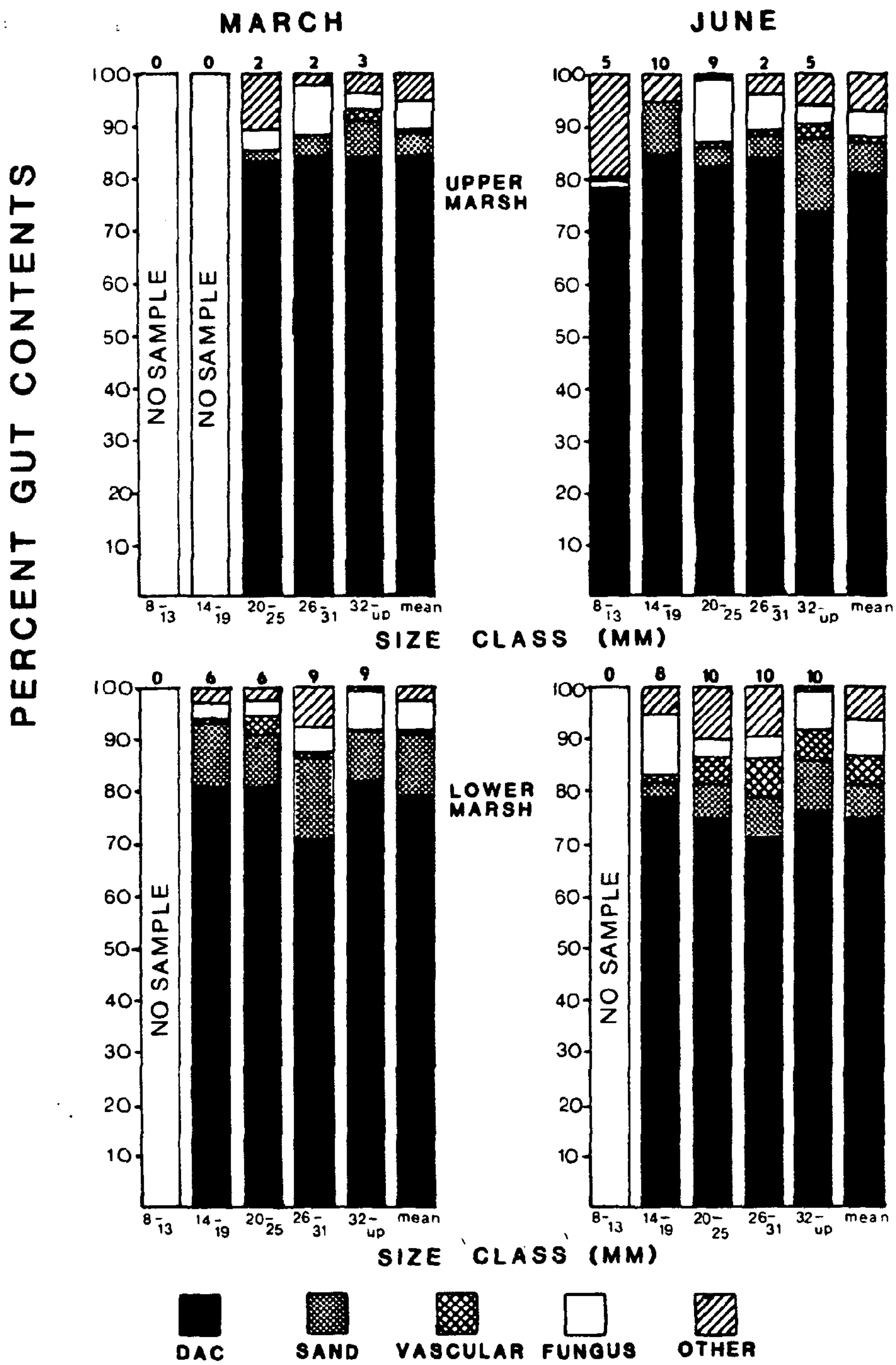


Figure 28. Spatial, temporal and ontogenetic comparison of food consumption in the mosquitofish, Gambusia affinis.

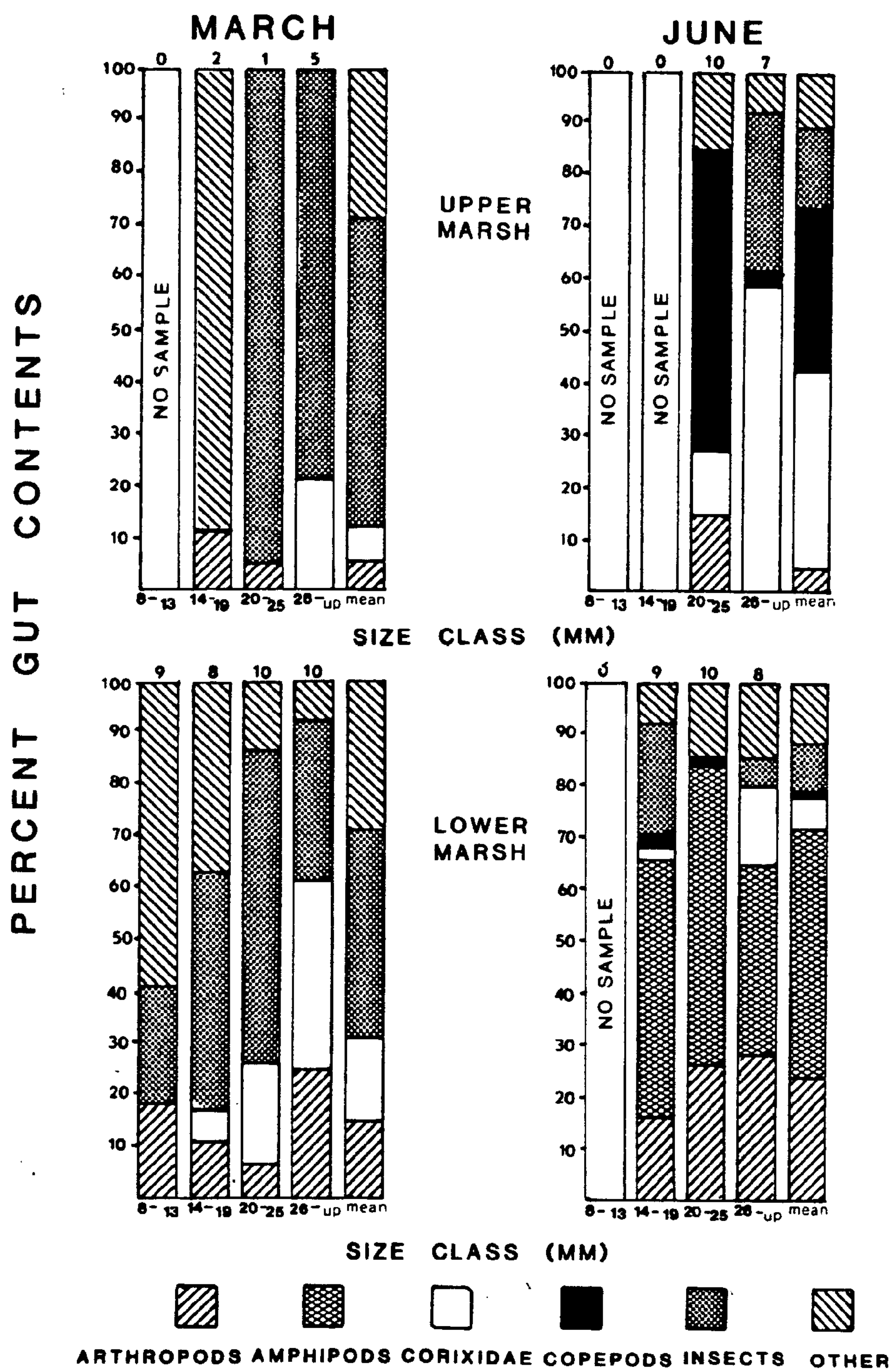


Figure 29. Spatial, temporal and ontogenetic comparison of food consumption in the striped mullet, *Mugil cephalus*.

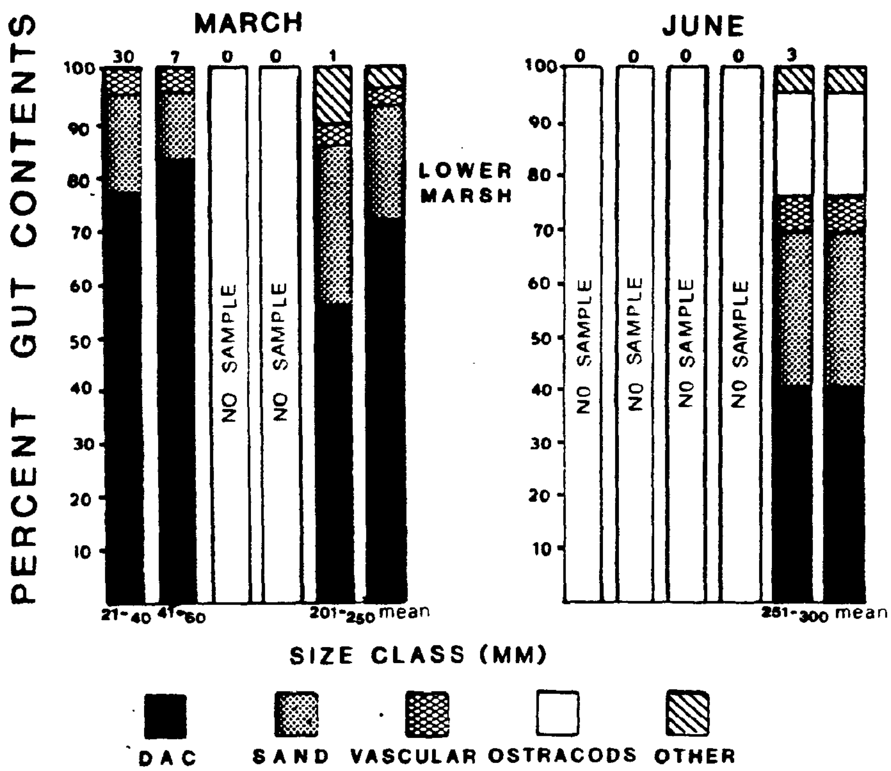


Figure 30. Spatial, temporal and ontogenetic comparison of food consumption in the ladyfish, <u>Elops</u> <u>saurus</u>.

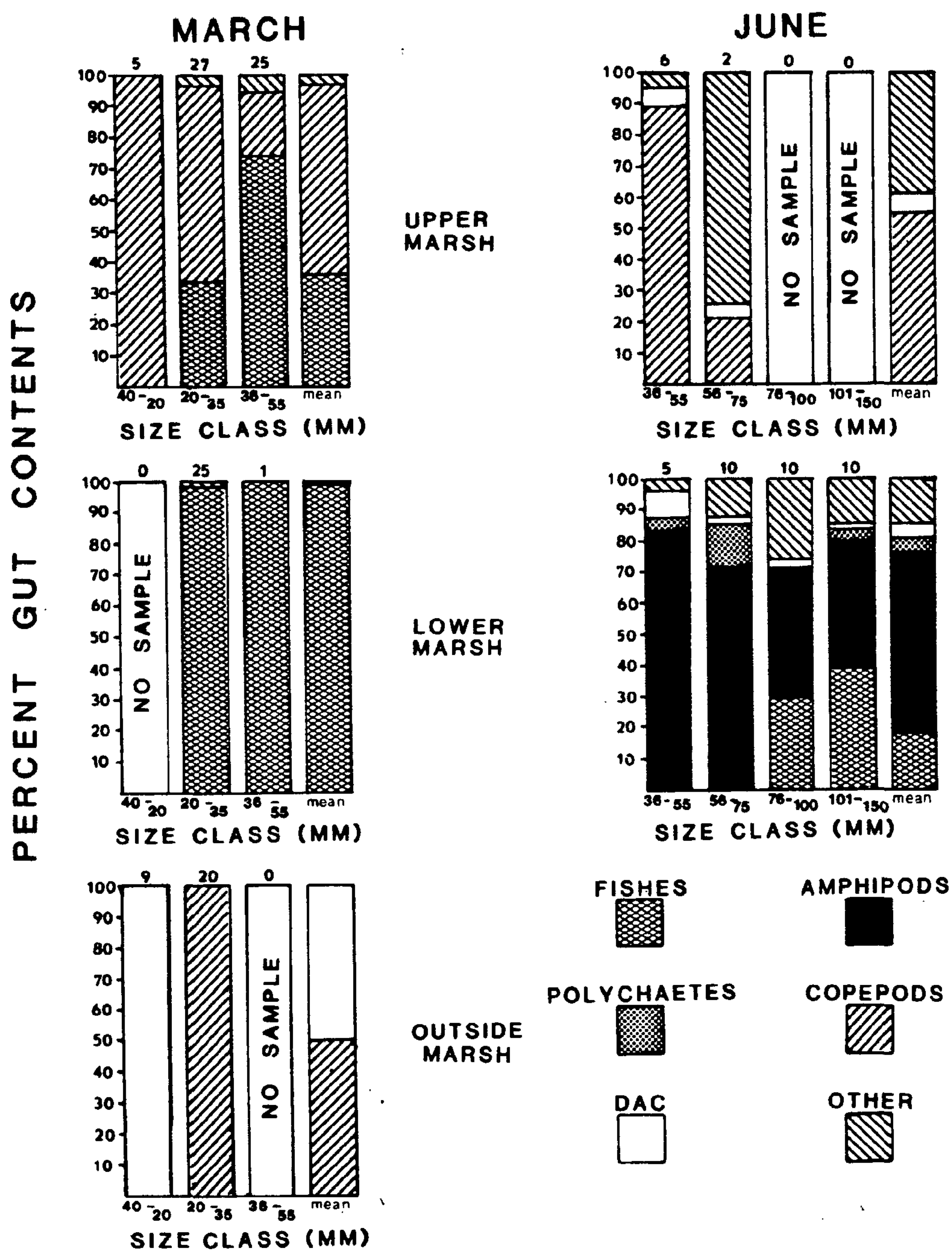
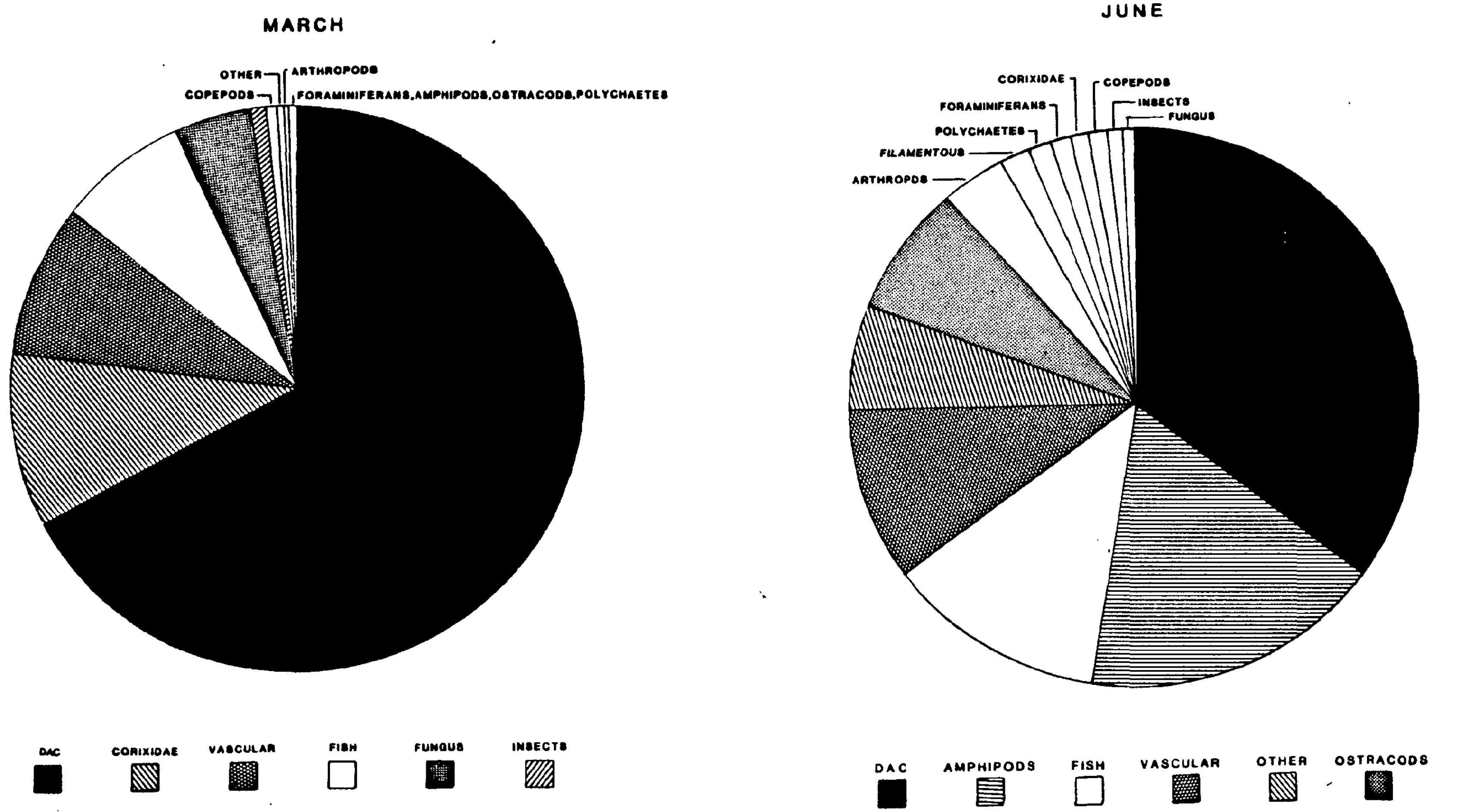


Figure 31. Temporal comparison of all species food consumption, % total food volume consumed, for all stations combined except the outer marsh.



APPENDIX I

PARAMETER2

DATE	TID	STA	TIME	TEMP	SALIN	DO	PH
820308	003	030	915	17.0	42.0	6.9	6.4
820308	004	030	1700	22.0	41.0	15.0	6.2
820308	003	050	1000	15.0	32.0	7.6	6.6
820308	004	050	1539	26.0	35.0	7.3	6.4
820308	003	051	1045	17.5	42.0	8.2	6.6
820308	004	051	1550	24.0	34.0	9.8	6.5
820308	004	052	1630	23.0	33.0	10.0	6.6
820308	004	053	1645	22.5	33.0	10.4	6.7
820308	003	060	1140	17.0	30.0	6.5	6.3
820308	004	060	1800	19.0	32.0	8.4	6.5
820308	003	061	1140	17.0	31.0	9.0	6.3
820308	004	061	1800	20.0	30.0	8.5	6.2
820308	003	062	1140	17.0	31.0	9.0	7.0
			AAAA	AAAA	AAAAA	AAAA	AAAA
820308			1388	19.8	34.3	9.0	6.5
820323	003	030	915	25.0	48.0	2.9	6.7
820323	004	030	1813	25.5	44.0	4.4	6.9
820323	003	031	1600	27.0	28.0	5.9	
820323	004	031	940	25.0	28.0	4.5	7.6
820323	003	050	1012	29.0	69.0	7.2	6.0
820323	004	050	1500	27.0	33.0	2.9	6.4
820323	003	051	1040	29.0	61.0	3.9	6.4
820323	004	051	1505	26.0	50.0	2.5	6.3
820323	004	052	1520	27.5	48.0	6.1	6.4
820323	004	053	1530	28.0	46.0	3.9	6.2
820323	003	060	1140	27.5	32.0	3.9	6.8
820323	004	060	1726	25.0	28.0	3.5	6.0
820323	003	061	1210	28.0	30.0	3.9	6.7
820323	004	061	1726	26.5	28.0	4.0	6.0
820323	003	062	1215	27.0	30.0	4.5	6.3
			AAAA	AAAA	AAAAA	AAAA	AAAA
820323			1359	26.9	40.2	4.3	6.48
820405	003	030	844	26.0	41.0	4.2	6.8
820405	004	030	1442	31.0	41.0	4.0	6.6
820405	003	031	905	24.0	28.0	4.2	6.6
820405	003	031	1521	26.5	30.0	5.7	6.6
820405	003	050	943	27.0	33.0	4.8	6.5
820405	004	050	1408	33.5	38.0	3.8	6.6
820405	003	051	1019	26.0	38.0	4.8	6.2
820405	004	051	1416	30.0	34.0	3.4	6.4
820405	004	052	1424	30.0	30.0	3.9	6.8
820405	004	053	1434	32.0	30.0	4.5	6.4
820405	003	060	1105	27.0	26.0	3.8	6.9
820405	004	060	1707	30.0	28.0	3.1	6.2
820405	003	061	1107	27.0	28.0	4.4	6.7
820405	004	061	1715	30.0	28.0	3.1	6.2
820405	003	062	1135	27.0	30.0	5.0	6.5
			AAAA	AAAA	AAAAA	AAAA	AAAA
820405			1275	28.5	32.2	4.2	6.5
820421	003	030	845	28.0	42.0	4.6	6.6

PARAMETER2

DATE	TID	STA	TIME	TEMP	SALIN	DO	PH
820421	004	030	1440	32.0	38.0	10.5	6.8
820421	003	031	855	26.0	26.0	4.6	6.8
820421	003	031	1600	30.0	24.0	9.0	7.5
820421	003	050	937	30.0	28.0	6.2	6.8
820421	004	050	1420	39.0	32.0	6.8	6.4
820421	003	051	1025	30.0	32.0	8.3	6.8
820421	004	051	1430	34.0	32.0	5.6	7.2
820421	004	052	1435	34.0	30.0	5.8	7.0
820421	004	053	1450	33.0	28.0	4.4	7.0
820421	003	060	1113	31.0	24.0	5.8	6.8
820421	004	060	1652	32.0	25.0	4.6	6.2
820421	003	061	1130	32.0	25.0	4.4	6.6
820421	004	061	1655	32.0	26.0	3.8	6.4
820421	003	062	1135	29.0	25.0	6.0	6.4
			AAAA	AAAA	AAAAA	AAAA	AAAA
820421			1274	31.5	29.1	6.0	6.8
820506	003	030	909	23.5	36.0	3.4	8.8
820506	004	030	1718	29.0	37.0	10.2	8.8
820506	003	031	925	23.0	28.0	4.2	7.9
820506	003	031	0	28.0	30.0	7.0	8.6
820506	003	050	1008	23.0	30.0	3.9	8.2
820506	004	050	1610	32.0	31.0	5.4	8.2
820506	003	051	1056	24.0	37.0	4.8	8.5
820506	004	051	1641	30.0	37.0	6.3	8.4
820506	004	052	1712	29.0	35.0	7.8	8.6
820506	004	053	1737	29.0	35.0	6.2	8.8
820506	003	060	1230	25.0	28.0	6.1	7.9
820506	004	060	1910	26.0	30.0	3.8	8.2
820506	003	061	1225	25.0	29.0	9.0	8.1
820506	004	061	1915	26.0	30.0	5.0	8.3
820506	003	062	1205	25.0	31.0	5.4	8.2
			AAAA	AAAA	AAAAA	AAAA	AAAA
820506			1320	26.5	32.3	5.9	8.4
820520	003	030	840	24.0	43.0	2.1	8.3
820520	004	030	1430	29.0	42.0	13.9	8.6
820520	003	031	905	24.0	28.0	4.8	8.0
820520	003	031	1520	26.5	30.0	9.3	7.9
820520	003	050	945	26.0	74.0	3.6	7.9
820520	004	050	1415	36.0	78.0	4.4	8.0
820520	003	051	1010	27.0	61.0	5.8	8.0
820520	004	051	1419	33.0	60.0	8.4	8.3
820520	004	052	1425	32.0	52.0	10.3	8.4
820520	004	053	1435	28.0	50.0	6.6	8.2
820520	003	060	1052	25.0	30.0	3.4	8.2
820520	004	060	1650	29.0	32.0	5.0	8.2
820520	003	061	1057	25.0	28.0	3.6	7.8
820520	004	061	1655	29.0	30.0	4.6	8.1
820520	003	062	1100	25.0	30.0	4.8	
			AAAA	AAAA	AAAAA	AAAA	AAAA
820520			1257	27.9	44.5	6.0	8.14

Appendix I

PARAMETER2

DATE	TID	STA	TIME	TEMP	SALIN	DO	PH
820603	003	030	830		18.0		
820603	004	030	1516	30.0	23.0	18.0	
820603	003	031	1412		25.0		
820603	004	031	913		23.0		
820603	003	050	945	26.5	18.0	6.7	
820603	004	050	1420	30.0	20.0	8.6	
820603	003	051	1015	27.0	22.0	3.2	
820603	004	051	1448	29.0	24.0	8.5	
820603	004	052	1510	30.0	18.0	14.4	
820603	004	053	1530	28.0	16.0	10.0	
820603	003	060	1110	26.0	16.0	4.0	
820603	004	060	1807	29.5	16.0	7.8	
820603	003	061	1115	26.0	18.0	3.8	
820603	004	061	1807	30.0	16.0	6.7	
820603	003	062	1118	26.0	22.0	6.2	
			AAAA	AAAA	AAAAA	AAAA	AAAA
820603			1299	28.2	19.7	8.16	0.0
820618	003	030	815	25.0	25.0	2.5	7.2
820618	004	030	1416	27.0	22.0	6.3	7.7
820618	003	031	1434	25.5	24.0	1.5	
820618	004	031	828	26.0	25.0	0.2	7.2
820618	003	050	900	25.0	21.0	0.8	7.5
820618	004	050	1330	26.5	21.0	5.0	
820618	003	051	930	26.0	26.0	3.0	7.4
820618	004	051	1342	27.0	24.0	6.1	
820618	004	052	1410	26.0	19.0	6.4	
820618	004	053	1425	26.0	18.0	6.4	
820618	003	060	1033	24.5	16.0	2.6	6.8
820618	004	060	1840	25.5	15.0	1.5	
820618	003	061	0	25.0	18.0		
820618	004	061	1836	26.0	15.0	0.2	7.2
			AAAA	AAAA	AAAAA	AAAA	AAAA
820618			1181	25.8	20.6	3.27	7.29
820701	003	030	745	29.0	32.0	1.4	
820701	004	030	1411		29.0		
820701	003	031	800	28.0	25.0	3.0	
820701	003	050	840	27.0	28.0	0.6	
820701	004	050	1345	37.0	25.0	5.9	
820701	003	051	925	28.0	25.0	2.7	
820701	004	051	1353	33.0	24.0	5.0	
820701	004	052	1400	28.0	20.0	6.0	
820701	004	053	1420		19.0		
820701	003	060	1040	30.0	23.0	1.8	
820701	004	060	1700		24.0		
820701	003	061	1043	30.0	23.0	1.6	
820701	004	061	1700		22.0		
820701	003	062	1045	29.0	24.0	4.4	
			AAAA	AAAA	AAAAA	AAAA	AAAA
820701			1197	29.9	24.5	3.24	0.0
820716	003	030	742	28.0	36.0	0.8	7.2

PARAMETER2

DATE	TID	STA	TIME	TEMP	SALIN	DO	PH
820716	004	030	1245	31.5	36.0	4.3	7.1
820716	003	031	830	29.0	24.0	1.4	7.1
820716	003	031	1434	34.0	22.0	4.1	7.7
820716	003	050	900	29.0	68.0	2.4	7.3
820716	004	050	1225	37.0	57.0	0.8	7.2
820716	003	051	942	30.0	40.0	3.3	7.2
820716	004	051	1232	34.5	38.0	4.2	7.3
820716	004	052	1235	34.0	34.0	10.2	7.3
820716	004	053	1240	34.0	32.0	7.4	7.3
820716	003	060	1035	30.0	22.0	3.2	7.4
820716	004	060	1535	30.0	25.0	4.4	7.2
820716	003	061	1038	31.0	22.0	3.9	7.6
820716	004	061	1540	31.0	24.0	3.7	7.2
820716	003	062	1040	31.0	25.0	5.1	7.6
			^^^^	^^^^	^^^^^	^^^^	^^^^
820716			1147	31.6	33.7	3.9	7.3
820730	003	030	753	28.0	40.0	1.0	7.8
820730	004	030	1338	34.0	39.0	6.9	8.0
820730	003	031	805	27.0	26.0	1.9	7.2
820730	003	031	805	27.0	26.0	7.9	7.2
820730	003	050	833	28.0	62.0	1.6	8.0
820730	004	050	1311	39.0	71.0	3.6	8.2
820730	003	051	905	26.5	44.0	1.2	8.4
820730	004	051	1320	37.0	52.0	13.6	8.5
820730	004	052	1328	37.5	47.0	13.6	8.6
820730	004	053	1332	37.0	38.0	12.5	8.8
820730	003	060	1000	30.0	27.0	3.5	7.8
820730	004	060	1610	36.0	30.0	7.0	8.0
820730	003	061	1003	30.0	28.0	2.3	7.7
820730	004	061	1605	37.0	28.0	6.2	8.0
820730	003	062	1006	29.0	28.0	3.2	8.1
			^^^^	^^^^	^^^^^	^^^^	^^^^
820730			1130	32.2	39.1	5.7	8.0
820816	003	030	911	29.0	38.0	1.4	7.0
820816	004	030	1606	35.0	34.0	11.9	
820816	003	031	930	28.0	14.0	2.2	7.0
820816	003	050	1014	28.0	48.0	2.2	7.2
820816	004	050	1527	38.5	49.0	5.3	7.0
820816	003	051	1028	28.0	50.0	3.0	6.9
820816	004	051	1538	40.0	50.0	11.6	7.0
820816	004	052	1600	37.0	38.0	10.6	7.2
820816	004	053	1615	37.0	30.0	9.5	
820816	003	060	1123	30.0	26.0	2.4	7.5
820816	004	060	1737	31.0	25.0	7.6	
820816	003	061	1128	29.5	25.0	1.6	7.4
820816	004	061	1740	31.0	25.0	6.4	
820816	003	062	1132	31.0	25.0	3.0	7.3
			^^^^	^^^^	^^^^^	^^^^	^^^^
820816			1330	32.4	34.1	5.6	7.15
820831	003	030	913	28.0	40.0	1.2	7.6

PARAMETER2

DATE	TID	STA	TIME	TEMP	SALIN	DO	PH
820831	004	030	1613	32.0	38.0	8.6	
820831	003	031	9302		22.0	2.9	7.4
820831	003	031	1404	30.0	23.0	4.8	
820831	003	050	1008	30.0	51.0	8.2	8.1
820831	004	050	1534	35.0	50.0	9.4	
820831	003	051	1036	30.0	52.0	5.4	8.3
820831	004	051	1542	35.0	50.0	7.6	
820831	004	052	1600	34.5	40.0	8.6	
820831	004	053	1617	34.0	37.0	10.5	
820831	003	060	1132	31.0	24.0	3.4	7.2
820831	004	060	1735	32.5	25.0	6.8	
820831	003	061	1140	31.0	22.0	3.0	7.4
820831	004	061	1730	33.0	25.0	6.7	
820831	003	062	1143	31.0	22.0	3.0	
			^^^^	^^^^	^^^^^	^^^^	^^^^
820831			1896	32.2	34.7	6.0	7.69
820912	003	031	1053	29.0	30.0	2.2	
820913	003	030	825	28.0	40.0	0.6	
820913	004	030	1445	37.0	40.0	20.0	
820913	003	031	835	28.0	30.0	1.2	
820913	003	050	900	28.0	53.0	0.9	
820913	004	050	1402	41.0	60.0	9.2	
820913	003	051	930	29.5	49.0	1.5	
820913	004	051	1411	37.0	50.0	6.2	
820913	004	052	1440	37.0	36.0	6.8	
820913	004	053	1454	37.0	33.0	6.5	
820913	003	060	1012	31.0	28.0	1.8	
820913	004	060	1635	36.0	30.0	7.2	
820913	003	061	1020	31.0	28.0	1.6	
820913	004	061	1640	36.5	27.0	6.7	
820913	003	062	1024	32.0	28.0	2.2	
			^^^^	^^^^	^^^^^	^^^^	^^^^
820913			1212	33.5	38.0	5.2	0.0
820928	004	031	1600	28.5	25.0		
820929	003	030	905	26.0	25.0	0.5	
820929	004	030	1555	30.0	21.0	18.0	
820929	003	031	920	26.5	25.0	3.2	
820929	003	050	951	27.0	22.0	3.4	
820929	004	050	1514	31.0	21.0	5.6	
820929	003	051	1012	26.5	22.0	1.7	
820929	004	051	1525	30.0	21.0	6.2	
820929	004	052	1547	30.0	21.0	8.6	
820929	004	053	1600	29.0	21.0	14.7	
820929	003	060	1124	27.0	25.0	2.2	
820929	004	060	1755	29.5	21.0	9.0	
820929	003	061	1100	27.5	25.0	2.6	
820929	004	061	1753	29.5	21.0	8.6	
			^^^^	^^^^	^^^^^	^^^^	^^^^
820929			1327	28.4	22.4	6.5	0.0

PARAMETER2

DATE	TID	STA	TIME	TEMP	SALIN	DO	PH
821013	003	030	845	28.5	30.0	0.6	
821013	004	030	1550	31.0	28.0	6.1	
821013	003	031	1430	28.0	26.0		
821013	003	031	905	25.0	25.0	2.6	
821013	003	050	936	24.0	30.0	1.4	
821013	004	050	1517	32.0	30.0	7.6	
821013	003	051	1005	24.5	31.0	3.5	
821013	004	051	1525	31.0	30.0	14.0	
821013	004	052	1545	31.5	30.0	12.6	
821013	004	053	1600	30.5	29.0	9.4	
821013	003	060	1151	27.0	30.0	2.7	
821013	004	060	804	31.0	30.0	7.5	
821013	003	061	1155	27.0	30.0	3.5	
821013	004	061	1806	30.0	28.0	6.8	
821013	003	062	1051	27.0	28.0	3.6	
			^^^^	^^^^	^^^^^	^^^^	^^^^
821013			1255	28.5	29.0	5.55	0.0
821026	004	031	1440	21.0	28.0		
821027	003	030	805	19.0	26.0	2.6	
821027	004	030	1447	25.0	28.0	4.8	
821027	003	031	826	19.5	26.0	4.6	
821027	003	050	858	18.0	30.0	4.5	
821027	004	050	1430	25.0	32.0	6.7	
821027	003	051	928	18.0	32.0	5.2	
821027	004	051	1440	24.0	32.0	7.3	
821027	004	052	1507	25.0	32.0	8.2	
821027	004	053	1513	24.0	30.0	7.1	
821027	003	060	1002	19.0	28.0	4.3	
821027	004	060	1620	23.0	28.0	7.2	
821027	003	061	1005	19.0	26.0	5.2	
821027	004	061	1619	23.0	28.0	6.8	
821027	003	062	1045	20.0	30.0	5.8	
			^^^^	^^^^	^^^^^	^^^^	^^^^
821027			1217	21.5	29.1	5.7	0.0
821109	004	031	1600	23.0	28.0	7.4	
821110	003	030	655	21.0	25.0	4.3	
821110	004	030	1315	26.0	24.0	5.8	
821110	003	031	710	21.0	27.0	6.6	
821110	003	050	800	20.0	25.0	5.3	
821110	004	050	1222	24.5	28.0	8.1	
821110	003	051	810	20.0	26.0	8.7	
821110	004	051	1235	23.0	25.0	6.6	
821110	004	052	1256	24.0	25.0	8.5	
821110	004	053	1305	23.0	25.0	8.1	
821110	003	060	911	22.0	28.0	5.3	
821110	004	060	1546	25.0	28.0	9.1	
821110	003	061	914	22.0	28.0	5.6	
821110	004	061	1550	24.0	26.0	7.9	
821110	003	062	922	22.0	27.0	6.3	
			^^^^	^^^^	^^^^^	^^^^	^^^^
821110			1082	22.7	26.2	6.9	0.0

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PARAMETER2

DATE	TID	STA	TIME	TEMP	SALIN	DO	PH
821128	004	031	1521	24.0	24.0	2.9	
821129	003	030	1010	23.5	25.0	4.4	
821129	004	030	1700	26.0	25.0	6.9	
821129	003	031	1028	23.0	25.0	5.2	
821129	003	050	1110	25.5	28.0	5.4	
821129	004	050	1600	29.0	26.0	6.1	
821129	003	051	1140	25.0	28.0	4.8	
821129	004	051	1617	27.0	26.0	6.3	
821129	004	052	1647	27.0	26.0	6.6	
821129	004	053	1708	28.0	25.0	6.3	
821129	003	060	1300	26.0	24.0	5.2	
821129	004	060	1754	27.0	25.0	7.1	
821129	003	061	1305	24.0	24.0	4.0	
821129	004	061	1750	26.0	25.0	7.6	
821129	003	062	1312	24.5	24.0	7.4	
			AAAA	AAAA	AAAAA	AAAA	AAAA
821129			1427	25.8	25.4	5.9	0.0
821208	004	031	1520	24.0	30.0	1.3	
821209	003	030	810	23.0	28.0	2.0	
821209	004	030	1621	26.5	28.0	14.4	
821209	003	031	838	22.0	29.0	5.4	
821209	003	050	915	22.0	26.0	5.8	
821209	004	050	1445	28.0	26.0	10.7	
821209	003	051	952	22.0	29.0	3.8	
821209	004	051	1500	28.0	30.0	2.6	
821209	004	052	1553	26.0	27.0	6.0	
821209	004	053	1612	26.0	27.0	6.5	
821209	003	060	1108	24.0	28.0	3.7	
821209	004	060	1700	25.0	28.0	6.8	
821209	003	061	1113	23.5	28.0	4.4	
821209	004	061	1705	25.0	28.0	6.6	
821209	003	062	1118	24.0	28.0	6.3	
			AAAA	AAAA	AAAAA	AAAA	AAAA
821209			1285	24.6	27.9	6.1	0.0
821227	004	031	1730	22.0	30.0	3.2	
821228	003	030	1037	22.0	34.0	1.2	
821228	004	030	1610	24.0	33.0	6.2	
821228	003	031	1050	21.0	30.0	3.1	
821228	003	050	1130	23.0	36.0	5.2	
821228	004	050	1539	25.5	36.0	5.7	
821228	003	051	1152	23.0	38.0	5.4	
821228	004	051	1553	25.0	36.0	6.6	
821228	004	052	1603	24.0	35.0	5.9	
821228	004	053	1618	24.5	34.0	8.3	
821228	003	060	1334	24.0	32.0	4.0	
821228	004	060	1711	23.0	29.0	2.6	
821228	003	061	1340	23.0	31.0	4.9	
821228	004	061	1714	23.0	30.0	3.5	

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PARAMETER2

DATE	TID	STA	TIME	TEMP	SALIN	DO	PH
821228	003	062	1345	22.0	30.0	7.1	
			AAAA	AAAA	AAAAA	AAAA	AAAA
821228			1409	23.4	33.1	5.0	0.0
830109	004	031	1437	21.0	30.0	3.8	
830110	003	030	935	21.5	34.0	2.4	
830110	004	030	1728	22.0	32.0	7.9	
830110	003	031	955	21.0	30.0	3.8	
830110	003	050	1030	22.5	31.0	4.0	
830110	004	050	1620	23.0	32.0	4.4	
830110	003	051	1100	23.0	35.0	3.6	
830110	004	051	1632	23.0	34.0	5.2	
830110	004	052	1705	23.0	34.0	7.1	
830110	004	053	1715	23.0	33.0	5.6	
830110	003	060	1150	22.0	28.0	4.7	
830110	004	060	1800	22.0	31.0	6.1	
830110	003	061	1150	21.5	30.0	4.6	
830110	004	061	1804	22.0	28.0	4.7	
830110	003	062	1145	22.0	30.0	4.6	
			AAAA	AAAA	AAAAA	AAAA	AAAA
830110			1390	22.3	31.6	4.9	0.0
830124	004	031	1200	17.0	30.0	5.4	
830125	003	030	853	15.0	22.0	5.6	
830125	004	030	1405	18.0	23.0	6.9	
830125	003	031	905	14.5	26.0	6.5	
830125	003	050	930	13.5	22.0	6.1	
830125	004	050	1338	22.0	24.0	7.2	
830125	003	051	953	14.0	20.0	6.5	
830125	004	051	1345	17.0	21.0	8.8	
830125	004	052	1355	18.0	21.0	11.6	
830125	004	053	1413	18.0	23.0	9.4	
830125	003	060	1020	15.0	24.0	6.0	
830125	004	060	1755	18.0	25.0	11.0	
830125	003	061	1027	16.0	27.0	5.5	
830125	004	061	1800	18.0	26.0	10.0	
830125	003	062	1100	16.0	28.0	6.5	
			AAAA	AAAA	AAAAA	AAAA	AAAA
830125			1228	16.6	23.7	7.7	0.0
830209	003	031	1147	14.0	26.0	7.0	
830210	003	030	945	18.0	30.0	8.8	
830210	004	030	1612	20.0	30.0	9.5	
830210	003	031	957	16.0	26.0	7.0	
830210	003	050	1030	19.0	26.0	6.2	
830210	004	050	1540	22.0	25.0	5.9	
830210	003	051	1058	19.0	26.0	5.9	
830210	004	051	1548	21.5	24.0	6.4	
830210	004	052	1605	21.0	22.0	6.7	
830210	004	053	1622	21.0	23.0	5.3	

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PARAMETER2

DATE	TID	STA	TIME	TEMP	SALIN	DO	PH
830210	003	060	1157	19.0	25.0	7.0	
830210	004	060	1734	20.5	24.0	1.4	
830210	003	061	1157	18.0	25.0	8.0	
830210	004	061	1740	20.0	24.0	3.1	
830210	003	062	1210	18.0	25.0	8.6	
			AAAA	AAAA	AAAAA	AAAA	AAAA
830210			1351	19.5	25.4	6.4	0.0
830222	004	031	1630	19.5	19.0	7.2	
830223	003	030	830	20.5	22.0	2.0	
830223	004	030	1453	24.0	22.0	9.1	
830223	003	031	842	19.5	18.0	5.5	
830223	003	050	916	21.0	20.0	2.5	
830223	004	050	1430	25.0	22.0	5.3	
830223	003	051	945	20.5	18.0	3.7	
830223	004	051	1440	24.0	20.0	7.5	
830223	004	052	1517	25.0	18.0	13.3	
830223	004	053	1505	25.0	19.0	10.2	
830223	003	060	1100	20.5	18.0	4.9	
830223	004	060	1620	25.0	20.0	8.8	
830223	003	061	1117	20.5	20.0	5.6	
830223	004	061	1624	22.5	19.0	9.3	
830223	003	062	1040	20.5	20.0	6.7	
			AAAA	AAAA	AAAAA	AAAA	AAAA
830223			1241	22.4	19.7	6.7	0.0
			AAAA	AAAA	AAAAA	AAAA	AAAA
			1304	25.8	30.0	5.6	2.7

REPORT 11 (MONTHLY TOTALS), ON: ======= MOS01 ========
TOTAL WEIGHT OF INDIVIDUALS COLLECTED, AND GRAND TOTALS, BY MONTH. ZERO COLUMNS INDICATE PERIODS WITHOUT COLLECTIONS.

GENUS-SPECIES		JANUARY, 1982 DAY 1	JANUARY, 1982 DAY 2	FEBRUARY, 1982 DAY 1	FEBRUARY, 1982 DAY 2	MARCH, 1982 DAY 1	MARCH, 1982 DAY 2	APRIL, 1982 DAY 1	APRIL, 1982 DAY 2
ANCHOA	MITCHILLI	0.00	0.00	0.00	0.00	0.00	6.21	0.71	5.10
BREVOORTIA	SMITHI	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.33
BREVOORTIA	SPP	0.00	0.00	0.00	0.00	0.00	1.02	0.00	0.00
CALLINECTES	SAPIDUS	0.00	0.00	0.00	0.00	378.16	291.33	181.82	54.99
CYPRINODON	VARIEGATUS	0.00	0.00	0.00	0.00	374.99	2,131.55	461.41	228.89
DORMITATOR	MACULATUS	0.00	0.00	0.00	0.00	0.20	0.34	4.26	0.89
ELOPS	SAURUS	0.00	0.00	0.00	0.00	39.71	91.92	83.47	139.25
EUCINOSTOMUS	ARGENTEUS	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.54
FUNDULUS	CONFLUENTUS	0.00	0.00	0.00	0.00	1.71	353.93	33.62	20.76
FUNDULUS	GRANDIS	0.00	0.00	0.00	0.00	4.04	2.64	7.47	4.02
FUNDULUS	SPP	0.00	0.00	0.00	0.00	0.33	0.00	0.84	1.78
GAMBUSIA	AFFINIS	0.00	0.00	0.00	0.00	15.79	56.52	97.80	84.34
GOBIOSOMA	ROBUSTUM	0.00	0.00	0.00	0.00	0.00	0.81	0.00	0.00
LEIOSTOMUS	XANTHURUS	0.00	0.00	0.00	0.00	4.60	25.70	10.94	13.86
LUCANIA	PARVA	0.00	0.00	0.00	0.00	2.95	3.48	3.55	6.10
MENIDIA	SPP	0.00	0.00	0.00	0.00	7.69	0.97	3.13	4.28
MICROGOBIUS	GULOSUS	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.56
MUGIL	CEPHALUS	0.00	0.00	0.00	0.00	114.22	310.48	2.22	2,062.25
MUGIL	CUREMA	0.00	0.00	0.00	0.00	80.48	0.00	2.29	43.40
MYROPHIS	PUNCTATUS	0.00	0.00	0.00	0.00	0.00	2.11	1.09	0.00
PALAEMONETES	SPP	0.00	0.00	0.00	0.00	141.62	298.31	77.10	74.09
PENAEUS	AZTECUS	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00
PENAEUS	DUORARUM	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00
PENAEUS	SPP	0.00	0.00	0.00	0.00	2.74	5.46	24.88	0.00
POECILIA	LATIPINNA	0.00	0.00	0.00	0.00	215.68	3,265.17	550.83	1,138.87
POGONIAS	CROMIS	0.00	0.00	0.00	0.00	2.63	13.53	0.72	0.00
SARDINELLA	ANCHOVIA	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
SYNGNATHUS	SCOVELLI	0.00	0.00	0.00	0.00	0.00	1.35	0.76	0.43
TOTAL WEIGHT	MONTHLY TOTALS	0.00	0.00	0.00	0.00	1,387.57	6,864.02	1,549.15	3,884.73

REPORT 11 (MONTHLY TOTALS), ON: ======= MOSQ1 ========

TOTAL WEIGHT OF INDIVIDUALS COLLECTED, AND GRAND TOTALS, BY MONTH. ZERO COLUMNS INDICATE PERIODS WITHOUT COLLECTIONS.

GENUS-SPECIES		MAY, 1982 DAY 1	MAY, 1982 DAY 2	MAY, 1982 DAY 3	JUNE, 1982 DAY 1	JUNE, 1982 DAY 2	JUNE, 1982 DAY 3
ANCHOA	MITCHILLI	0.00	14.28	0.00	0.00	0.00	0.00
ARCHOSARGUS	PROBATOCEPHALUS	0.00	0.00		0.00	0.00	
CALLINECTES	SAPIDUS	0.00	19.37	0.00	0.00	163.26	0.00
CENTROPOMUS	UNDECIMALIS	0.00	0.00		0.00	1.09	
CYPRINODON	VARIEGATUS	140.57	1,818.37	0.00	520.72	84.27	0.00
DIAPTERUS	AURATUS	0.00	3.40		0.00	0.87	
DORMITATOR	MACULATUS	1.33	0.77	0.00	30.48	1.20	0.00
ELOPS	SAURUS	117.75	212.27	0.00	453.26	752.56	0.00
EUCINOSTOMUS	ARGENTEUS	0.00	0.18	0.00	0.00	0.00	0.00
EURYTIUM	LIMOSUM	0.00	0.00		0.00	0.00	
FUNDULUS	CONFLUENTUS	1.16	37.33	0.00	1.96	4.35	0.00
FUNDULUS	GRANDIS	11.07	161.71	0.00	53.04	0.00	0.00
FUNDULUS	SIMILIS	0.00	0.65		0.00	0.00	
FUNDULUS	SPP	0.12	0.99	0.00	0.00	0.00	0.00
GAMBUSIA	AFFINIS	58.07	116.22	0.00	51.02	21.37	0.00
GERRES	CINEREUS	0.00	0.00		0.00	0.00	
GOBIOSOMA	ROBUSTUM	0.00	0.00	0.00	0.00	0.00	0.00
HIPPOLYTE	PLUEROCANTHUS	0.00	0.00		0.00	0.00	
LEIOSTOMUS	XANTHURUS	0.00	4.61	0.00	0.00	0.00	0.00
LUCANIA	PARVA	0.00	1.78	0.00	0.00	0.71	0.00
MEGALOPS	ATLANTICUS	0.00	0.00		0.00	0.00	
MENIDIA	SPP	16.11	27.83	0.00	12.75	3.12	0.00
MICROGOBIUS	GULOSUS	0.00	0.12	0.00	0.00	0.00	0.00
MUGIL	CEPHALUS	756.69	1,599.07	0.00	1,576.70	84.21	0.00
MUGIL	CUREMA	0.00	73.06	0.00	2.49	11.41	0.00
MYROPHIS	PUNCTATUS	1.15	0.00	0.00	0.00	0.00	0.00
ORCHESTIA	GRILLUS	0.00	0.00		0.00	0.00	
PALAEMONETES	SPP	0.00	0.00	0.00	0.00	5.37	0.00
PENAEUS	SPP	0.00	0.00	0.00	0.00	0.00	0.00
POECILIA	LATIPINNA	374.93	863.92	0.00	733.53	113.92	0.00
RIVULUS	MARMORATUS	0.00	0.00		0.34	0.00	
SPHYRAENA	BARRACUDA	0.00	0.00		0.00	0.00	
STRONGYLURA	MARINA	0.00	0.00		0.00	0.00	
SYNGNATHUS	SCOVELLI	0.00	1.02	0.00	0.00	0.23	0.00
UCA	PUGILATOR	0.00	0.00		0.00	0.00	
'TOTAL WEIGHT' MONTHLY TOTALS		1,478.95	4,956.95	0.00	3,436.29	1,247.94	0.00

Appendix 2

REPORT 11 (MONTHLY TOTALS), ON: ====== MOSQ1 ========

TOTAL WEIGHT OF INDIVIDUALS COLLECTED, AND GRAND TOTALS, BY MONTH. ZERO COLUMNS INDICATE PERIODS WITHOUT COLLECTIONS.

GENUS-SPECIES		JULY , 1982 DAY 1	JULY , 1982 DAY 2	JULY , 1982 DAY 3	AUGUST , 1982 DAY 1	AUGUST , 1982 DAY 2	AUGUST , 1982 DAY 3
ANCHOA	MITCHILLI	0.00	0.00	0.00	0.00	0.00	0.00
ARCHOSARGUS	PROBATOCEPHALUS	0.00	0.00	0.00	0.00	41.98	
CALLINECTES	SAPIDUS	40.92	378.41	123.08	212.28	153.48	0.00
CENTROPOMUS	UNDECIMALIS	0.00	0.81	0.30	0.33	5.13	0.00
CYPRINODON	VARIEGATUS	2,390.44	1,809.83	2,189.20	688.95	347.98	0.00
DIAPTERUS	AURATUS	1.49	7.81	8.56	24.68	9.36	
DORMITATOR	MACULATUS	0.00	0.18	8.06	4.92	4.06	0.00
ELOPS	SAURUS	95.13	20.83	70.35	144.44	190.76	0.00
EUCINOSTOMUS	ARGENTEUS	1.48	0.00	0.00	0.00	0.00	
EURYTIUM	LIMOSUM	0.00	0.00	10.54	0.00		
FUNDULUS	CONFLUENTUS	63.80	173.85	63.06	36.27	10.80	0.00
FUNDULUS	GRANDIS	0.00	18.73	5.59	0.00	3.36	0.00
FUNDULUS	SIMILIS	0.00	0.00	0.00	0.00	0.00	
FUNDULUS	SPP	0.21	0.24	0.10	0.00	0.10	0.00
GAMBUSIA	AFFINIS	314.92	143.92	167.90	19.39	44.13	0.00
GERRES	CINEREUS	3.29	0.00	0.00	0.00	0.00	
GOBIOSOMA	ROBUSTUM	0.43	0.00	0.00	0.00	0.00	
HIPPOLYTE	PLUEROCANTHUS	0.00	0.02	0.00	0.00	0.00	
LEIOSTOMUS	XANTHURUS	0.00	0.00	0.00	0.00	0.00	0.00
LUCANIA	PARVA	2.09	0.89	2.90	0.14	1.92	0.00
MEGALOPS	ATLANTICUS	0.00	0.31	133.96	385.61	308.70	0.00
MENIDIA	SPP	1.68	0.58	6.77	0.71	0.00	0.00
MICROGOBIUS	GULOSUS	0.00	0.61	0.52	0.00	0.00	
MUGIL	CEPHALUS	0.00	0.00	568.45	673.71	390.74	0.00
MUGIL	CUREMA	0.29	0.00	0.16	0.00	0.09	0.00
MYROPHIS	PUNCTATUS	0.00	0.00	0.00	0.00	0.00	
ORCHESTIA	GRILLUS	0.00	0.00	0.00	0.11	0.00	
PALAEMONETES	SPP	3.15	3.91	4.89	3.18	14.28	0.00
PENAEUS	SPP	8.86	0.65	6.90	0.00	0.00	0.00
POECILIA	LATIPINNA	1,466.48	820.66	573.46	1,763.46	1,693.03	0.00
RIVULUS	MARMORATUS	0.00	0.00	0.00	0.00	0.00	
SPHYRAENA	BARRACUDA	0.00	0.00	0.44	0.00	0.00	
STRONGYLURA	MARINA	0.00	1.91	0.00	0.00	0.00	
SYNGNATHUS	SCOVELLI	1.92	0.20	2.22	0.61	0.00	
UCA	PUGILATOR	0.00	0.00	4.48	0.00	0.00	0.00
'TOTAL WEIGHT' MONTHLY TOTALS		4,396.58	3,384.35	3,951.89	3,958.79	3,219.90	0.00

Appendix 2

REPORT 11 (MONTHLY TOTALS), ON: ======= MOSQ1 ========
TOTAL WEIGHT OF INDIVIDUALS COLLECTED, AND GRAND TOTALS, BY MONTH. ZERO COLUMNS INDICATE PERIODS WITHOUT COLLECTIONS.

GENUS-SPECIES		SEPTEMB., 1982 DAY 1	SEPTEMB., 1982 DAY 2	OCTOBER , 1982 DAY 1	OCTOBER , 1982 DAY 2	NOVEMBER, 1982 DAY 1	NOVEMBER, 1982 DAY 2	DECEMBER, 1982 DAY 1	DECEMBER, 1982 DAY 2
ACHIRUS	LINEATUS	0.00	0.12	0.84	0.00	0.00	0.00	0.00	0.00
ANCHOA	MITCHILLI	0.00	0.00	7.67	0.00	7.32	10.02	17.98	1.19
ANGUILLA	ROSTRATA	0.00	0.00	0.00	818.49	751.96	0.00	0.00	0.00
ARCHOSARGUS	PROBATOCEPHALUS	87.20	0.00	183.52	120.58	0.00	0.00	0.00	23.24
BREVOORTIA	SPP	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
CALLINECTES	SAPIDUS	19.01	2.81	103.25	96.71	0.00	31.22	193.86	7.58
CENTROPOMUS	UNDECIMALIS	16.02	9.30	8.92	15.84	5.00	870.10	137.00	48.41
CYPRINODON	VARIEGATUS	72.97	12.32	6.14	13.49	19.71	982.97	4,406.80	4,655.08
DIAPTERUS	AURATUS	14.69	0.00	0.00	0.00	0.34	12.69	5.99	2.02
DIAPTERUS	SPP	0.00	0.00	0.00	0.05	0.00	0.21	0.00	0.00
DORMITATOR	MACULATUS	3.30	0.00	0.00	0.00	0.00	0.52	0.00	17.63
ELOPS	SAURUS	476.91	0.97	46.97	366.83	83.74	468.62	63.17	38.63
EUCINOSTOMUS	ARGENTEUS	0.00	0.00	0.00	0.00	14.79	0.75	0.00	0.00
EUCINOSTOMUS	GULA	3.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FUNDULUS	CONFLUENTUS	1.71	0.00	0.00	0.00	0.00	7.13	75.28	81.63
FUNDULUS	GRANDIS	8.85	0.00	0.00	0.00	0.00	15.54	16.15	98.13
FUNDULUS	SIMILIS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25
GAMBUSIA	*AFFINIS*	15.56	2.93	5.62	26.13	31.49	7,329.10	635.69	439.84
GERRES	CINEREUS	0.00	0.05	0.02	0.00	0.28	35.10	0.28	0.47
GOBIOSOMA	ROBUSTUM	0.00	0.00	0.00	0.00	0.00	0.73	0.00	0.00
LAGODON	RHOMBOIDES	0.00	0.00	47.44	0.00	27.28	0.00	0.00	0.00
LUCANIA	PARVA	0.06	0.00	0.00	0.00	0.00	8.70	0.07	0.17
LUTJANUS	GRISEUS	0.00	185.53	0.00	287.63	0.00	0.00	0.00	74.48
MEGALOPS	ATLANTICUS	10.09	150.07	542.25	1,022.34	65.44	251.10	117.63	424.08
MENIDIA	SPP	0.00	0.00	0.00	0.04	0.00	7.82	16.93	27.11
MICROGOBIUS	GULOSUS	0.00	0.26	0.14	0.00	0.00	0.00	0.00	0.00
MUGIL	CEPHALUS	845.35	1,246.32	0.00	1,239.32	573.84	371.55	5,229.15	1,178.58
MUGIL	CUREMA	0.09	0.00	0.00	0.49	34.72	42.50	76.54	34.02
PALAEMONETES	SPP	9.55	45.03	112.05	2.98	29.35	273.86	89.80	174.91
PENAEUS	SPP	1.10	0.14	0.13	6.40	0.00	16.93	10.39	3.21
POECILIA	LATIPINNA	438.84	16.78	2.15	70.45	1.06	10,556.29	443.20	1,190.36
SPHYRAENA	BARRACUDA	0.00	1.07	0.00	0.00	0.00	3.03	0.00	0.00
TAPHROMYSIS	BOWMANI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		==========	==========	==========	==========	==========	==========	==========	==========
TOTAL WEIGHT MONTHLY TOTALS		2,024.84	1,673.70	1,067.11	4,087.77	1,646.32	21,296.48	11,535.94	8,523.02

REPORT 11 (MONTHLY TOTALS), ON: ======= MOSQ1 ========

TOTAL WEIGHT OF INDIVIDUALS COLLECTED, AND GRAND TOTALS, BY MONTH. ZERO COLUMNS INDICATE PERIODS WITHOUT COLLECTIONS.

GENUS-SPECIES		JANUARY, 1983 DAY 1	JANUARY, 1983 DAY 2	FEBRUARY, 1983 DAY 1	FEBRUARY, 1983 DAY 2	MARCH, 1983 DAY 1	MARCH, 1983 DAY 2	APRIL, 1983 DAY 1	APRIL, 1983 DAY 2
ANCHOA	MITCHILLI	30.39	0.00	0.63	0.20	0.00	0.00	0.00	0.00
BREVOORTIA	SPP	0.12	0.15	0.00	2.62	0.00	0.00	0.00	0.00
CALLINECTES	SAPIDUS	16.70	16.25	19.55	4.89	0.00	0.00	0.00	0.00
CENTROPOMUS	UNDECIMALIS	4.21	0.00	0.16	6.49	0.00	0.00	0.00	0.00
CYPRINODON	VARIEGATUS	310.36	125.56	9,726.56	3,554.29	0.00	0.00	0.00	0.00
DORMITATOR	MACULATUS	0.00	0.00	1.41	40.27	0.00	0.00	0.00	0.00
ELOPS	SAURUS	2.46	5.55	43.49	123.54	0.00	0.00	0.00	0.00
FUNDULUS	CONFLUENTUS	18.47	4.88	50.40	29.83	0.00	0.00	0.00	0.00
FUNDULUS	GRANDIS	15.04	0.00	0.00	7.99	0.00	0.00	0.00	0.00
FUNDULUS	SPP	0.00	0.05	0.58	0.07	0.00	0.00	0.00	0.00
GAMBUSIA	AFFINIS	157.66	21.36	663.57	282.20	0.00	0.00	0.00	0.00
LAGODON	RHOMBOIDES	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00
LEIOSTOMUS	XANTHURUS	0.00	0.00	0.81	49.96	0.00	0.00	0.00	0.00
LUCANIA	PARVA	0.09	0.32	0.53	0.02	0.00	0.00	0.00	0.00
LUTJANUS	GRISEUS	112.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MEGALOPS	ATLANTICUS	384.69	175.94	360.35	77.14	0.00	0.00	0.00	0.00
MENIDIA	SPP	1.91	2.75	8.00	8.20	0.00	0.00	0.00	0.00
MUGIL	CEPHALUS	1,313.01	316.25	578.67	615.81	0.00	0.00	0.00	0.00
MUGIL	CUREMA	0.00	0.32	0.13	12.64	0.00	0.00	0.00	0.00
PALAEMONETES	SPP	8.99	27.04	172.69	80.79	0.00	0.00	0.00	0.00
PENAEUS	SPP	0.00	0.00	0.59	3.42	0.00	0.00	0.00	0.00
POECILIA	LATIPINNA	125.14	25.56	1,191.52	1,052.29	0.00	0.00	0.00	0.00
POGONIAS	CROMIS	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00
UCA	PUGILATOR	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00
'TOTAL WEIGHT'	MONTHLY TOTALS	2,501.45	722.22	12,819.89	5,952.66	0.00	0.00	0.00	0.00

ZOOPLANKTON AND MARSH VEGETATION IN A RECENTLY RE-OPENED MOSQUITO CONTROL IMPOUNDMENT

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ZOOPLANKTON AND MARSH VEGETATION IN A RECENTLY RE-OPENED MOSQUITO CONTROL IMPOUNDMENT

INTRODUCTION

From 1955 to 1963, 33,518 acres of salt marshes bordering the Indian River, the Banana River and Mosquito Lagoon in east-central Florida were impounded for mosquito control. These marshes were oviposition sites for the salt marsh mosquitoes _Aedes taeniorhynchus_ and _A. sollicitans_. In Florida, salt marsh mosquito impoundments are usually managed by local mosquito control organizations, and impoundment management practices as well as chemical treatment of mosquito populations, vary from district to district.

Although there is a great deal of information available on salt marshes and mangrove swamps, there are huge gaps in our knowledge of the biology of these areas (Clewell 1979), and very scant data on the biology and ecology of salt marsh impoundments.

Marsh Vegetation.

The prime mosquito-producing portion of a salt marsh is that area of the marsh above the influence of daily tidal innundation, the high marsh, (Provost 1974). Frequent tidal flooding of the low marsh does not provide the opportunity for salt marsh mosquitoes to oviposit since they will not lay their eggs upon standing water or overly-moist soil. In south Florida, the low marsh is usually dominated by the red mangrove, _Rhizophora mangle_ and a number of halophytic grasses such as smooth cordgrass (Spartina alterniflora), whereas in the high marsh black mangroves (Avicennia germinans), white mangroves (Laguncularia racemosa) saltwort (Batis maritima) and glasswort (Salicornia spp.) predominate. Further north, Spartina alterniflora predominates in the low marsh and S. patens, Distichlis spicata and Juncus roemerianus in the high marsh.

It is not at all clear what physical-chemical factors affect the zonation of species in salt marshes. Clearly, the frequency and extent of tidal innundation has to be important, but there is a plethora of direct and indirect effects associated with different tidal regimes that need to be separated so that their interaction with plant physiology and ecology can be identified. Bordeau and Adams (1956) list micro-relief, soil texture, and soil salinity as the major factors influencing zonation in North Carolina. Other factors that have been considered important in this respect are: submergence-emergence ratios (Johnson and York 1915), tide-elevation influences (Adams 1963), water quality (Odum et al. (1982), nutrient levels (McCoy 1969), propagule availability (Rabinowitz 1978), and catastrophic events (Ball 1980). These factors obviously overlap and the list barely scratches the surface of the possible interactions among physical-chemical factors, plant physiology, and plant ecology. The list has been presented mainly to illustrate the complexities and subtleties involved in study of salt marsh plant communities.

It has now become evident that in most cases salt marsh species zonation does not represent seral stages of succession, but are the result of geomorphological and hydrological processes (Thom 1967, Chapman 1970), local conditions (Odum et al. 1982), chance events (Ball 1980), catastrophic events (Craighead and Gilbert 1962), and historical factors (van der Valk 1981).

There have been a number of studies on the effects on high marsh vegetation of activities related to mosquito control. Most of these, however, have dealt with ditching, rather than impounding, and their results are contradictory. Some studies report a shift to drier conditions with a concomitant invasion of the high marsh by upland species (Daigh et al. 1938, Daigh and Stearns 1939, Miller and Egler 1950). Other studies report a shift towards conditions more typical of the low marsh (Travis et al. 1954, Shisler and Jobbins 1977). A third group of studies report no significant change due to these activities (Taylor 1937, Headlee 1939, Ferrigno 1961). Ball (1980) reports an increase in red mangrove cover in areas ditched for mosquito control in Biscayne Bay, while several authors have reported various degrees of damage to mangroves due to improper diking and impounding (Breen and Hill 1969, Odum and Johannes 1975, Patterson-Zucca 1978, Lugo 1981). In Florida, the general consensus appears to be that impounding in mangrove areas favors the spread of red mangroves at the expense of black mangroves, white mangroves and other high marsh species (McCoy 1969).

The importance of the low marsh in the overall dynamics of the coastal zone has been recognized for a long time. The high marsh, however, was once considered by many (particularly by those wishing to develop it) as real estate with little ecological value. Recent studies, have demonstrated that the high marsh provides many of the same services as the low marsh, as well as many others that are qualitatively and/or quantitatively different and just as important to the overall health of the estuarine ecosystem (Heald 1969, Lugo and Snedaker 1974).

Marsh Zooplankton.

Zooplankton communities form the base of a large number of marine and estuarine food chains. We have all been exposed to one form or another of the above statment, from grade-school science texts to advanced volumes in marine ecology and invertebrate biology. The importance of plankton populations, however, is not restricted to their role in the feeding dynamics of other organisms. Many benthic and nektonic organisms spend part of their life as planktonts (meroplankton), and thus, zooplankton dynamics are often indicative of patterns and processes affecting the benthos and the nekton (Jeffries 1977); zooplankton communities can be extremely important in regulating water quality, phytoplankton communities, and undesirable algal blooms (Jeffries 1977); finally, many planktonic organisms are excellent indicators of water quality, of pollution and of overall physical conditions in bodies of water such as lakes, lagoons, estuaries and impoundments (Thomas et al.

1976).

In spite of the recognized importance of zooplankton dynamics, there is very little information on the biology and ecology of plankton in salt marshes and mangrove swamps, let alone on its dynamics in mosquito control impoundments. Part of the problem has been the significant logistic problems involved in studying the plankton communities in these habitats (see Methods). This study represents a first attempt to characterize the zooplankton fauna of salt marsh impoundments under different management regimes.

PROJECT RATIONALE

This study attempts to evaluate the changes that occur in a salt marsh impoundment (Indian River County # 12) after re-establishing a tidal connection between the impoundment and the adjoining Indian River lagoon. This impoundment is of particular interest because of the background data available from this site. Both Harrington and Harrington (1982) from the Florida Medical Entomology Laboratory and Gilmore and co-workers from the Harbor Branch Foundation have conducted research on the fish communities at this site, both pre-and post-impounding. Gilmore et al. (1981) showed a significant increase in the utilization of the marsh by transient fish species after reestablishment of a connection (through culverts) between the marsh and the Indian River lagoon. Activities in the salt marsh will have direct effects on many organisms such as those that migrate between these two habitat during some or all stages of their life histories.

STUDY AREA

A description of impoundment IRC # 12 is given in the first part of this report by Carlson and Vigliano. The impoundment adjoining IRC # 12 (Control Cell) is similar in nature to the experimental marsh except that it has remained closed to the Indian River during the study. We established sampling stations for plankton and physical-chemical parameters at the following locations: Mole Hole (N.W. Pond), a small, shallow pond formed at the N.W. terminus of the perimeter ditch; Culvert Station, at the perimeter ditch near culvert A; River Station; in the Indian River across from culvert A; Control Station, at the perimeter ditch in the control cell; SP-2 and P-3 Stations, in shallow semi-permanent ponds in the interior of the impoundment. The growth of mangrove seedlings was monitored in the experimental and control cell, and transects for the study of vegetation were also established in both cells. All sampling stations and vegetation transects are shown in Figure 1.

METHODS

One of the main reasons for the lack of information about the plankton communities of coastal marshes (Odum _et al_. 1982) is the difficulty in obtaining adequate samples from these communities. The major problem encountered is the shallow water usually existing in these areas. This makes it impossible to use standard, unsupported circular nets without dragging the nets through the substrate, thus contaminating the samples and creating severe clogging problems. Clogging has also been a problem when using other sampling methods. For example, pumping is often ineffective because only a small volume of water can usually pass through standard sieves before these become clogged and overflow.

For this study, we developed several techniques that have proven to be satisfactory for sampling zooplankton from shallow areas with soft substrates. Brief descriptions of these are included below:

<u>Floating Nets</u>.

The configuration of the plankton nets minimizes their vertical profile while maintaining an adequate filtering surface. We found that a net with a rectangular mouth tapering to a conical cod-end was best for these purposes (Figure 2). Such a net (36" x 8" mouth, 66" long) was attached to a PVC frame supported by styrofoam floats in so that under tow, the upper edge of the mouth floats just below the water surface (Figure 3). A flowmeter (General Oceanics) was attached inside the mouth of each net . We installed a plastic ring at the cod-end of each net (Figure 4) and machined it to accept a collecting vessel with a screen of the appropriate mesh size (Figure 5). Material remaining in the net after a tow could thus be washed into the collecting vessel and the latter could then be easily removed to transfer its contents to glass jars for preservation and storage. Two nets, one of 63u mesh and one of 202u mesh were used at each site during each sampling. A sample consisted of a straight-line tow over a distance of 200 feet. We accomplished this as follows: One person hand-carried the net out of the water and away from the sampling location to a pre-measured 200-foot marker while a second person carried the net-end of the tow rope. A third person held the other end of the rope at the 0-foot marker. At the 200-foot marker, the tow rope was attached to the towing bridle and the net was placed in the water. The net was then pulled-in through the complete transect without stopping. Upon arrival at the 0-foot. marker, the net was immediately taken out of the water, the sides of the nets were rinsed from the outside, and the catch removed from the collection bucket and rinsed with distilled water into a glass storage jar (see below).

Pump Samples.

The pump sampling apparatus was designed to maximize filtering area and to provide temporary storage for relatively large volumes of water to prevent overflowing while the sample was being collected and filtered.

The filtering apparatus consists of two PVC cylinders, 4 feet high and 10 inches in diameter (Figure 6). The walls of the cylinders were perforated with numerous holes of various sizes, and these were covered with 63u-mesh plankton screening (Figure 7). This allowed excess water to escape through the holes while the plankton was retained inside the cylinders. A conical splashguard was fitted on the top edge of each cylinder to prevent sample spillage (Figure 9). Two baffles inside the splashguards broke up the water stream to prevent damage to the lower collecting screens.

Samples were collected with a 2-inch pump driven by a 2-hp gasoline engine. The intake hose was attached to a pole with a float near the end (Figure 8). This arrangement allowed the operator to keep the nozzle in constant vertical and horizontal motion without disturbing the substrate. The outflow hose was inserted at the top of the splashguards (Figure 9) and maintained in place for the duration of the sampling interval (samples were timed). We collected the sample at the bottom of the cylinders in removable screens of the appropriate mesh size (63u or 202u, Figure 10).

The flow rate of the pump was measured immediately before and after each sample by recording the amount of time necessesary to fill a container of known volume. We used the mean of these two measurements (which varied very little during the course of the study, see Results) to calculate the flow rate for the sample, the volume of water filtered, and the density of the organisms captured. After collection, and prior to removal of the collecting screens, the walls of the cylinders were rinsed with the water that filtered through the 63u-mesh screens on the sides of the cylinders. This filtered water was collected in buckets placed adjacent to the cylinders while the sample was being collected. Two pump samples were taken at each site during each collection date; one with a 63u-mesh bottom collecting screen and the other with a 202u-mesh collecting screen. Each 202u sample was of 10 minutes duration. The 63u samples had to be limited to 2 minutes. Even with the large filtering surface the filtering apparatus became clogged with 63u samples of longer duration.

All samples with the same type of gear (net or pump) were collected on the same day, but at least 24 hours were allowed to elapse between pump and net samples at the same site.

<u>Hand Nets</u>.

Qualitative samples from the temporary ponds in the study area were collected using a 63u-mesh net attached to a wooden handle and pushed just under the water surface along a predetermined route (Figure 11).

<u>Processing of the Plankton Samples</u>.

Immediately after collection, each sample was preserved in a glass jar with a 10% buffered formalin-rose bengal solution. In the laboratory, the sample was washed with distilled water through a 63u-mesh sieve. Any large organisms present in the sample (adult fish, large insects, etc.) were removed, washed with 70% ethanol to remove any planktonts that may have adhered to them, and stored in 70% ethanol. The rest of the sample was placed in a glass graduated cylinder and diluted in steps to 0.100-2.00 l. The diluted sample was then aereated and mixed, taking care not to create currents that could bias the subsampling procedure by sorting the organisms according to size.

Subsampling was carried out immediately after mixing. A 1 ml or 2 ml subsample was obtained from the diluted sample with a Hensen-Stempel pipette. The size of the subsample, as well as the final dilution was dependent upon the richness of the sample (Newell and Newell 1963, Carter and Dadswell 1983). The subsample was then placed in a Bogorov counting tray and spread evenly throughout the tray with 70% ethanol. All the organisms in the subsample were counted and identified to the lowest taxonomic group possible.

After counting, the subsample was returned to the original sample and the volume brought back to the original level with 70% ethanol. The process of mixing and subsampling was then repeated 4 more times for a total of 5 subsamples for each sample. The density of each taxon per cubic meter was then calculated for each subsample (see Appendix A) and the mean from the five subsamples was used as the density of each taxon for that particular sample.

Identification of organisms captured in plankton samples is an extremely difficult task. A large fraction of the organisms, particularly the numerous immature forms, can usually only be identified to major taxonomic groups. During initial sorting and compilation of our reference collection, we used liberal criteria in separating specimens to different taxa. For our original determinations we used standard reference works (e.g. Davis 1949, Davis and

Williams 1950, Grice 1960, Gonzalez and Bowman 1965, Menzies and Frankenberg 1966, Wells 1976, Newell and Newell 1979, Fox 1983, and others). Specimens from all the taxa were then sent to specialists (particularly to Dr. Marsh Youngbluth of the Harbor Branch Foundation) for confirmation and/or further identification. Taxa were then lumped or split as appropriate.

There has been considerable debate over the advantages and disadvantages of different techniques for sampling zooplankton (UNESCO 1968). In the final analysis, no single method is 100% effective in obtaining quantitative estimates of plankton diversity and abundance (Newell and Newell 1963). A combination of methods, such as were used in this study (nets of various mesh sizes, and pumps) represent the best possible compromise. Rectangular nets have been used successfully before (Zaitsev 1959, Ellertsen 1977, Schram 1981), and represented the only workable configuration for the conditions existing in our study area.

Physical-chemical Variables.

The following variables were measured at the Mole Hole, Culvert, River and Control stations on a bi-weekly basis: Salinity, dissolved oxygen, pH, water and air temperatures, and water levels (maximum, minimum and existing). Water temperature, salinity and water levels were measured at ponds SP-2 and P-3 during each sampling

Vegetation Sampling.

Vegetation cover on the experimental and control marshes was monitored along 1200-foot transects established at each location (Figure 1). Each transect was divided into 12 100-foot sections and five quadrat locations were chosen along each section. The distance along a section and the distance and direction from the transect line of each quadrat were determined using a random number generator. At each location, an estimate of percent coverage by each plant species on a 1/4 $meter^2$ area was obtained with the help of a 1/2 square-meter frame that was subdivided with heavy wire into 16 equal sections. A total of 60 such estimates were obtained along each transect every 3 months.

We also measured the growth and establishment of mangroves in the experimental and control marshes. At each location, 100 mangrove seedlings were tagged and mapped, and the growth of each (length) was measured every three months. A majority of these seedlings were located along the perimeter of the experimental and control cells (Figure 1).

A summary of the sampling routine is shown in Table 1 and the sample records are shown in Table 2.

RESULTS

<u>Physical-chemical</u> <u>Data</u>.

Figures 12 - 26 show the values of the physical-chemical variables measured every two weeks at the study sites. The patterns of these variables in time are typical of the seasonal patterns of the area.

Descriptive statistics for air and water temperatures, dissolved oxygen, salinity, pH, and water levels at the study stations are given in Table 3. In general, the values are in agreement with those found in similar habitats elsewhere. Tables 4 and 5 show the correlations between the same variable at the different stations, and the correlations among the different variables at the same station. The most consistent within-station patterns (Table 5) are the negative correlations between water level and temperature, salinity, and pH. Temperature and salinity were significantly correlated only in the shallow, semi-isolated stations (Mole Hole, SP-2 and P-3), whereas temperature and D.O. were negatively correlated only at the more open and deeper stations (Culvert and Indian River).

Water temperature, salinity, and water level were significantly correlated throughout the study sites. The only exceptions were temperature and water level at SP-2 and P-3, where the correlations were only significant between these two sites. Dissolved oxygen was only correlated between the Culvert and River stations, whereas significant correlations in pH values were evident between Mole Hole and River, Culvert and River, and Culvert and Control (Table 4).

Additional correlations between Carlson and Vigliano's rainfall data and these physical-chemical variables are presented in Table 6. The most obvious pattern discernible from this table is the significant negative correlation between rainfall and salinity at all the stations.

Dissolved oxygen, salinity, pH and water levels were most variable at Mole Hole, followed, in descending order, by the Control, Culvert, and River stations (Hollander's Test for Ordered Alternatives (Hollander and Wolfe 1973); variance:mean Mole Hole > Control > Culvert > River, Y" = 2.651, p. < 0.004). Sites SP-2 and P-3 were not included in the above analysis because D.O and pH were not measured at these stations.

There were similarities as well as significant differences in the mean values of water temperature, D.O, salinity, pH, and water level range recorded at the different stations during the course of the study (Figure 27). Dissolved oxygen and pH were the most consistent variables, with no significant differences evident between any of the sites at which they were measured (not measured at SP-2 and P-3). As expected, water temperatures were significantly higher at the two shallow ponds (SP-2 and P-3) than at any other site. Likewise, salinities were significantly higher in the small, shallow, and isolated stations (SP-2, P-3, and Mole Hole) than at the Culvert and Indian River Stations. Also as expected, the Control station was the least saline. The pattern of mean water level range (difference between maximum and minimum levels during each two-week period) was one of increasing amplitude with decreasing isolation (River > Culvert > SP-2 / P-3 / Mole Hole > Control).

<u>Mangrove</u> <u>Data</u>.

A total of 108 mangrove seedlings were marked initially at the experimental site and 100 at the control. In the experimental cell, 22 red mangroves, 73 black mangroves and 13 white mangroves were marked. The corresponding numbers for the control are: 28 reds, 47 blacks and 25 whites. These proportions correspond approximately to the frequency of the species at each location. Descriptive statistics for growth of the seedlings at the two sites are shown in Table 7.

There was considerable mortality of mangrove seedlings during the study (Table 8). Mortality of mangroves was significantly higher at the experimental (open) cell than at the control (closed). 59% of the red mangrove seedlings marked at the experimental cell were dead by November, 1983, but only 7.1% died at the control (Table 8). The corresponding figures for black mangroves and white mangroves are: blacks, experimental = 26%, control = 2.1%; whites, experimental = 23%, control = 0%. We tested the significance of these differences using a G-test with William's correction and one degree of freedom (Sokal and Rohlf 1981) and found them to be highly significant (Reds: $G = 19.95$, $p. \ll 0.01$; Blacks, $G = 14.75$, $p. \ll 0.01$; Whites, $G = 5.75$, $p. < 0.02$). Descriptive statistics for seedlings surviving to November, 1983 are shown in Table 9.

Red mangroves surviving to November, 1983 showed significantly greater growth at the control than at the experimental site during all sampling intervals. Total growth (3/82 - 11/83) was also significantly higher at the control site (Table 10). The pattern for black mangroves was similar except that there were no significant differences in growth between the two sites during the periods 8/82-11/82 and 11/82-3/83; Total growth, however was still significantly higher at the control. Total growth of white mangroves was also higher at the control site, but the pattern during the individual sampling periods was much less clear-cut than for the other two species (Table 10).

Since the seedlings monitored for growth were of different sizes at the start of the study, we examined proportional growth (growth as a function of initial size) to control for possible inherent differences in growth rates of seedlings of different sizes. Red mangroves and white mangroves still exhibited significantly greater growth at the control cell, but there was no significant difference in proportional growth of black mangroves between the two cells (Table 11).

Transect Data.

The following species were found along the transects in the experimental and control cells: *Rhizophora mangle*, *Laguncularia racemosa*, *Avicennia germinans*, *Salicornia virginica*, *S.bigelovii*, *Batis maritima*, *Ruppia maritima*, *Sueda linearis*, *Philoxerus vermicularis*, and *Conocarpus erectus*. The last three species were extremely infrequent and will not be considered in any of the analyses that follow.

The most frequent species in the control cell quadrats was *S. virginica* followed by *S.bigelovii* (except in winter), and B. maritima. In the experimental cell S. bigelovii occurred in a greater proportion of the quadrats than S. virginica during 1982, except during the winter samples, but this pattern was reversed in 1983 (Table 12). R. maritima was frequent at times in both cells. No red mangroves were found in any of the 60 quadrats at the experimental cell whereas this species occurred in 1 - 3% of the quadrats in the control. Descriptive statistics for frequency of occurrence by all species during the quadrat surveys are given in Table 13.

Except for an apparent decrease in the frequency of S. bigelovii at the experimental cell from 1982 to 1983 there appears to be no significant pattern in relative frequency changes by the different species from 1982 to 1983 (Table 12).

Data on percent coverage by the different species are given in Table 14. During every survey from February, 1982 to November, 1983 A. germinans had higher coverage in the control cell than in the experimental. Differences in percent coverage by the other species, however, were not as clear-cut. There were no significant differences in coverage at the two sites by L. racemosa, S. virginica, or B. maritima. Coverage by S. bigelovii was significantly higher at the experimental site during the April, 1982 and July, 1982 sampling and the opposite situation was true for R. maritima during the February, 1983 sampling.

If we compare the changes in percent coverage between years (differences in percent cover by each species at approximately the same months in 1982 and 1983), the patterns are even less distinct (Table 15). There are some significant differences between the experimental and control cells for some species during some months, but none of the patterns are consistent among the different dates.

With one exception, changes in percent cover from 1982 to 1983 at each site were small (less than 10% increase or decrease). The exception was R.maritima at the control cell which in 1983 showed 34% and 28% increases over the 1982 values during the summer and winter comparisons (Figure 28).

Plankton Data.

Efficiencies for the 202u and 63u plankton nets varied considerably. The 202u nets filtered at close to 100% efficiency, but the corresponding value for the 63u nets was only about 6%. (Table 16). Clogging of the fine mesh of the 63u nets was probably responsible for these low values. Volumes filtered per sample varied from approximately 10.5 m^3 for the 202u nets to 0.64 m^3 for the 63u pumps. Within-method variability in volume of water filtered per sample, however, was very low overall (standard errors from 0.007 to 0.280) (Table 16).

Four taxa were collected only with the 63u gear and 8 with the 202u. There were 3 taxa collected exclusively with the nets, and 12 exclusively with the pumps.

Sorting, identifying and tabulating the catch from the plankton samples have proven to be an extremely tedious and time-consuming task. As a result, we have been able to completely process only the samples through September 1982. Because of the short time span encompassed by the processed samples (May '82 - September '82), more thorough analysis of the plankton data will be postponed until the complete data set is compiled. Nevertheless, certain patterns can be discerned from the data available at this time, and these will be examined below. One should keep in mind, however, that the overall picture may change considerably as new data become incorporated into the analyses.

A total of 59 taxa were separated from our samples (Table 17). Copepods, ostracods, foraminiferans and crustacean larvae predominated in both 63u and 202u samples. Different taxa tended to dominate the samples collected with the different mesh-size gear but some of the more common species, such as the copepods *Acartia tonsa*, *Oithona nana*, and *Tortanus setacaudatus*, were abundant in both (Table 21). Very few taxa were collected exclusively at one station (1 at Mole Hole, 3 at the Culvert, 2 at the River, and 0 at the Control). None of these taxa were abundant at the sites were they were collected. A total of 11 taxa, however, were collected only at the River and Control stations, while only 1, an unidentified beetle, was collected exclusively at Mole Hole and Control.

Individual collections from Mole Hole appear to be the least diverse, followed in ascending order by the Control station, the Culvert station, and the Indian River station

The differences are statistically significant for collections with some of the sampling gear used, but not for all (Figure 29). Overall, the River station was the most diverse, yielding a total of 47 taxa, followed by the Culvert Station (44 taxa), the Control station (33), Mole Hole (29), P3 (21), and SP-2 (18). If we consider only pump samples, the order remains the same: River (45), Culvert (36), Control (33), and Mole Hole (29).

The patterns of total density / sample, do not follow those of diversity, and vary depending upon the type of gear being used (Table 19). Although it is difficult to achieve statistical significance because of the large variances involved, it appears that the densities of organisms are higher at the Mole Hole and Control stations than at the River and Culvert stations (Figure 30). The only exceptions are the samples obtained with the 202u nets where total densities follow the pattern: River > Culvert > Control (no net samples were taken at Mole Hole).

The average densities of each taxon collected with 202u gear at the different stations were not significantly correlated except between the Control station and Mole Hole, but those from 63u gear collections were significantly correlated (Table 20). Cross-correlations between 202u and 63u gear were significant only for the River 202u-River 63u, River 63u-Culvert 202u, and Culvert 63u-Control 202u comparisons. There was a negative correlation between the densities of taxa collected with the 202u and 63u gears between Mole Hole and the Control station (Table 20).

A total of 22 taxa were collected at P-3 and SP-2. Of these, ostracods, copepods (O. nana, A. tonsa, Harpacticoid sp. C, Cyclopoid spp. D & E, and misc nauplii), polychaete larvae, and corixids were collected with the greatest frequency (Table 21). These taxa, with the exception of the corixids, are also among the most frequent and abundant collected at the other stations (Table 18).

DISCUSSION

Phvsical-chemical Variables.

The observed negative correlations between water level and temperature, salinity, and pH are simply a result of rainfall and evaporation. Likewise, the positive correlation between water temperature and salinity at the shallow ponds simply reflect the effects of evaporation on salinity and water temperature, through its effect on water levels. A positive correlation between pH and salinity, such as was evident between these variable at the Culvert and River stations, has been previously reported from other systems (de Mora 1983), and has been attributed to a number of different processes such as the increase with salinity of the first and second apparent dissociation constant of carbonic acid (Mook and Koene 1975), increases in bacterial populations (Morris et al. 1978), and tidal mixing processes (de Mora 1983).

The study sites seemed to segregate into three groups based upon their relative isolation (primarily) and size (secondarily): Open stations (Culvert and Indian River), an isolated station (Control), and small semi-isolated stations (P3, SP-2 and Mole Hole). The smallest sites (P3 and SP-2), had significantly higher water temperatures than any of the other sites. Salinity was also higher at the semi-isolated sites than at the more open Culvert and River stations, with the lowest values recorded at the Control station (Figure 27). Water temperature, salinity and water levels were correlated among all stations except P3-and SP-2 (Table 4). Range in water level also followed an isolation gradient (River > Culvert > SP2, P3, Mole Hole > Control), whereas variability in certain physical-chemical variables followed approximately the opposite order (Mole Hole > Control > Culvert > River). Relative isolation and small size tend to foster greater variability in physical conditions, higher water temperatures, and greater extremes of salinity.

<u>Marsh</u> <u>Vegetation</u>.

Initial come-back of vegetation after catastrophic defloration (e.g. by overflooding) often occurs quickly, whereas change in vegetation caused by more discrete alteration of physical conditions (e.g. temporary changes in hydroperiod, small salinity or elevation changes, etc.) can be quite a slow process (van der Valk 1981).

The vegetation at the experimental cell recovered considerably after the marsh was reopened to the Indian River. (Figures 31 and 32). Initial re-vegetation proceeded quickly, and a significant amount of regrowth had taken place by the time that our first vegetation samples were taken in April. 1982. Although it is clear that the changes in physical conditions after re-connection were responsible for the increase in vegetative cover of the marsh. historical factors may have played an important role in determining the exact nature of the initial plant colonization. What we are witnessing now is a "second stage", were slow accommodation to changing physical conditions is taking place.

The greatest differences in vegetation between the open and closed marshes can be found at the periphery of the two cells, around their perimeter ditches. Spread of mangroves from the periphery of tidal ditches and creeks has been reported previously (Ball 1980). Higher growth of mangroves, particularly <u>R</u>. <u>mangle</u> is evident at the control station. starting from the perimeter ditch inward (Table 10). Density of mangroves appears to also be higher at the control station than at the experimental, with the difference being less pronounced as one moves away from the ditch. Nevertheless there is significant colonization and growth of mangroves in the interior of the control cell. but very little in the interior of the experimental (pers. observation). Red mangroves have become established at the periphery of the open cell. but they are suffering significantly higher mortality than at the closed cell, and their growth rates are significantly slower (Tables 8 and 10). Growth of black mangroves at the open cell. however. is keeping pace with growth at the closed cell: Even though the overall growth of black mangroves was higher at the control, growth as a function of initial size was not significantly different between the two sites (Table 11).

Lowered salinities (such as exist in the control cell) are known to favor the growth of mangroves (Ball 1980). Red mangroves are usually more sensitive to salinity increases than blacks, conversely, reds are usually able to tolerate high water levels better, and for longer periods than blacks (Provost 1974). Thus the combination of lower salinities and prolonged inundation at the control cell appear to foster the growth of the red mangrove, a plant typical of the low marsh. Differences in other physical-chemical variables such as pH, D.O., and nutrient levels could certainly interact with salinity and water levels to influence the zonation and growth of mangroves, but their effects in the present situation are unknown.

There was very little change in relative frequency and percent coverage by the species found along the interior of both cells (Tables 12-15). The 1983 increase in coverage at the control cell by R. maritima clearly correlate with increases in standing water and decreases in salinity due to the high precipitation recorded during 1983. Differences in percent coverage, and in changes in percent coverage, and relative frequency of the species along the transect did not reveal any real pattern; significant differences were observed during some times of the year, but these were not consistent in time nor in space.

It is difficult to predict what the frequency and abundance of the different mangrove species will be in the two cells in the future. Nevertheless, based upon the patterns observed to date, and on observations on similar impoundments elsewhere, certain educated guesses can be made at this time. Red mangroves will continue to spread and grow at the control cell as long as the water level and salinity remain close to the current values. This could result in the exclusion of black mangroves, which are relatively intolerant of these conditions and which are prone to displacement by shading from reds (Ball 1980). A few blacks, and some white mangroves may persist in this cell as pockets or fringes in the higher elevations, such as the upland border, and the impoundment dikes.

The "marsh-floor vegetation" (Salicornia, Batis, etc.) may continue to spread in the interior of the control cell, or it may remain at the present levels, but it is unlikely that it will be totally displaced by red mangroves since the interior of this marsh dries-up periodically thus creating unfavorable conditions for the spread of R. mangle (high salinities and dry substrates). This situation may change, however, if pumping is resumed, or if the marsh is connected through culverts to the Indian River and kept flooded during the summer. If conditions existing at the experimental cell during the first part of this study were to persist (i.e. culverts open during the whole year) there would probably be an increase in the coverage of the marsh by black mangroves, Batis, and Salicornia. It is difficult to predict what effects the new scheme of maintaining the marsh flooded during the summer breeding season (see Carson and Vigliano, this report) will have on these species. It is already apparent that some of the Salicornia stands at this site are showing signs of stress due to the seasonal flooding (pers.observation). Whether these species can recover and continue to spread during the times when the marsh is not artificially flooded, or whether this scheme will again favor the spread of red mangroves remains to be seen. We are continuing our monitoring of the vegetation at the two sites, and will be better able to define the correct alternative after further data are examined.

Zooplankton.

The plankton sampling methods developed and used during the present study circumvent many of the obstacles often encountered when attempting to sample the plankton of shallow marsh habitats (see Methods). The 202u gear was highly efficient in filtering the water at the study sites, and allowed us to obtain sufficiently large sample volumes to make the resulting data meaningful (Table 16). Unfortunately, the same can not be said for the 63u gear. Clogging of the meshes was still a problem. This resulted in very low filtering efficiencies for the plankton nets, and limited us to processing much smaller volumes of water than with the 202u apparatus. Thus, the results obtained with the 63u gear are best considered to be qualitative rather than quantitative. The sample-to-sample variablity in efficiencies and volumes filtered was highly reproducible within a given type of sampling gear (Table 16).

The clogging problem and the mesh sizes influenced the types of organisms captured with the different gear. The relative abundance of some taxa were clearly different in the 63u and 202u collections (Table 21, see also Youngbluth 1982). In addition, four taxa were collected only with the 63u gear, and 8 exclusively with the 202u. The former were small forms (small copepods, fish eggs, etc) that could pass through the 202u meshes. The latter, were mostly larger, fast-swimming taxa (insects, fish larvae, isopods) that were able to avoid capture with the 63u nets, possibly because of considerable turbulence, acceleration fronts, pressure differentials, and cyclic displacement patterns that can precede a heavily clogged plankton net (Clutter and Anraku 1968). Similar processes may be responsible for the fact that 10 taxa (again mostly large fast-swimming forms) were collected exclusively with the pump samplers, but only 1 exclusively with the nets (four taxa that only occurred in a single sample are not included in the above figures).

Plankton communities are characterized by large and rapid population fluctuations on a seasonal basis. The system, however, is an involved one, with many positive and negative feedbacks such as: complex predator-prey interactions; nutrient re-cycling in which planktonic plants use the dissolved wastes of animals and thus mitigate severe nutrient limitation, at least in shallow waters; and complementing life cycles among large groups of species

(Jeffries 1977). These feedbacks give the system a degree of predictability in the long term, so that often the more interesting process in planktonic communities are the timing and magnitude of the seasonal patterns in abundance of the various groups of organisms comprising the phytoplankton and the zooplankton. Obviously, we do not have enough data at this time to examine these patterns and processes in detail, but we can characterize the composition of the collections processed to date, and explore a few similarities and differences in plankton abundance and diversity between our study sites.

As in most estuarine plankton communities, copepods were the numerically-dominant group of organisms in the salt marsh plankton (Tables 18 and 21). The dominant species within the copepods were *Acartia tonsa*, *Tortatanus setacaudatus* and *Oithona nana*. These species, particularly *A. tonsa*, have been reported as the dominant summer species in macrozooplankton samples from a wide variety of regions (Davis 1949, Barlow 1955, Newell and Newell 1963, Hopkins 1977, Carter and Dadswell 1983).

The overall density of organisms from the collections processed to date (Table 19) are in line with those reported by Youngbluth (1976) from the Indian River . Differences between the Indian River and the study marsh in the relative abundance of some taxa (particularly tintinnids) are evident (see Youngbluth 1976), but we can not determine at this time whether these are real differences between the two communities or simply a result of slightly different timing in the plankton cycles at the two locations, between years, or both.

Some differences between the study sites are evident in spite of the few samples processed to date. As with the physical-chemical variables, the sites seem to segregate into groups depending upon their size and relative isolation. The diversity of taxa per sample was greater at the Indian River station, followed by the Culvert, Control and Mole Hole, whereas the total density per sample follows approximately the opposite pattern (Figures 29 and 30). These inequalities are partly a result of differences in relative abundance of the different taxa at the different stations. If one examines the average density per taxa across all samples processed to date, it becomes apparent that there is a much greater degree of dominance at Mole Hole and the Control stations than at the Culvert and River stations. Even though the mean densities are usually greater at the former stations (Figure 30), the medians of the distribution are much lower (Figure 33). Total diversity also follows the pattern: River > Culvert > Control > Mole Hole.

The above patterns may be the result of zooplankton responses to differences in physical conditions existing at the different stations. The patterns certainly seem to emulate those exhibited by many of the physical variables measured concurrently. Significant changes in abundance and diversity of zooplankton faunas have often been attributed to rapid responses to changing environmental conditions (e.g. Carter and Dadswell 1983). On the other hand, these patterns may simply be examples of the species-area, species-isolation relations, which are two of the most widespread patterns observed in biotic communities everywhere (Arrhenius 1921; Preston 1960, 1962; Connor and McCoy 1979; Gilpin 1980; Rey 1979, 1984).

It is interesting to note that the total densities of the different taxa are not significantly correlated among sites when only the 202u collections are considered, but the opposite is true when densities in collections with 63u gear are compared (Table 20). Differences in relative abundance of the various taxa, and in the numbers and types of species collected with the two types of gear are probably responsible for the difference.

It is apparent from the data analyzed to date, that increased isolation tends to decrease the diversity of the plankton fauna, but isolation may also correlate with higher overall densities. Interspecific competition and predator-prey relations among planktonts have been postulated as important mechanisms regulating the diversity and abundance of these organisms (Youngbluth 1976, Jeffries 1977). It may be that reduction of interspecific interactions at the less diverse sites may facilitate an increase in densities of the taxa inhabiting these sites, at least in the short term, but it will take carefully controlled experiments to determine the importance of this factor as a density-regulating mechanism (Connell 1980).

CONCLUSIONS

There were some important differences as well as similarities in vegetation dynamics, physical chemical patterns, and plankton abundance and diversity both between marshes and between stations within marshes. In general, the experimental marsh showed signs of returning to pre-impoundment, high marsh conditions, but the duration and final extent of the process are yet to be determined. It is probable that the new management schedule for this marsh will modify the patterns and process that were taking place, but it is unlikely that they will be totally reversed. Continued study of this marsh will provide some of the answers to the above questions.

Relative isolation and size appear to be important variables in the dynamics of the zooplankton, marsh vegetation and physical-chemical variables. Many of the patterns observed during this study were consistent with respect to the above variables, but an exact cause-effect relationship can not be established from the data at hand. For example, we do not know if the relationship between plankton abundance and diversity and site isolation and/or size is a result of physiological processes (i.e. responses to different environmental conditions), of population processes (i.e. differential immigration and extinction rates), or combinations of both.

In spite of the uncertainties, the possible effects of these variables should be considered when formulating management schemes for salt marsh impoundments, but it would be a gross oversimplification to always try to maximize area and minimize isolation regardless of the management objectives. To do so, will only lead to problems such as those associated with the recent controversy over the size and shapes of wildlife refuges (Diamond 1975, Simberloff and Abele 1976, Simberloff 1982). At our present level of knowledge, every management objective has to be examined individually, and schemes designed to achieve particular objectives must be evaluated separately. Only after many such tests will we be able to develop reliable sets of criteria that will help us design ecologically-sound management plans for salt marsh impoundments. The results of this study will provide important information upon which to base and evaluate future management strategies for salt marsh impoundments.

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FIGURE LEGENDS

Figure 1. Map of the study area showing the sampling locations. Stippled areas within the impoundments indicate the general location of the mangrove seedlings measured for growth.

Figure 2. Floating plankton net.

Figure 3. Plankton net in operation.

Figure 4. Cod-end and collecting vessel of a plankton net.

Figure 5. Plankton collecting vessel in place.

Figure 6. Filtering cylinders for the pump samples.

Figure 7. Side of filtering cylinders showing perforations.

Figure 8. Pump intake hose and float assembly.

Figure 9. Pump sampling apparatus in operation.

Figure 10. Bottom collecting screen for filtering cylinder.

Figure 11. Hand net collection at pond P-3.

Figures 12-26. Plots of the values of physical-chemical variables at the various stations during the course of the study.

Figure 27. Comparison of mean values of various physical variables at the different stations. The means for stations above a common line do not differ significantly (t-test, $p > 0.05$).

Figure 28. Changes in mean % cover by various plant species along the transects. The numbers on the x-axis represent the time intervals for the comparisons: 1 = 4/82 - 5/83, 2 = 7/82 - 8/83, 3 = 11/82 - 11/83.

Figure 29. Comparison of mean number of taxa per sample for zooplankton collected at the different stations. The means for stations under a common line do not differ significantly (t-test, $p > 0.05$).

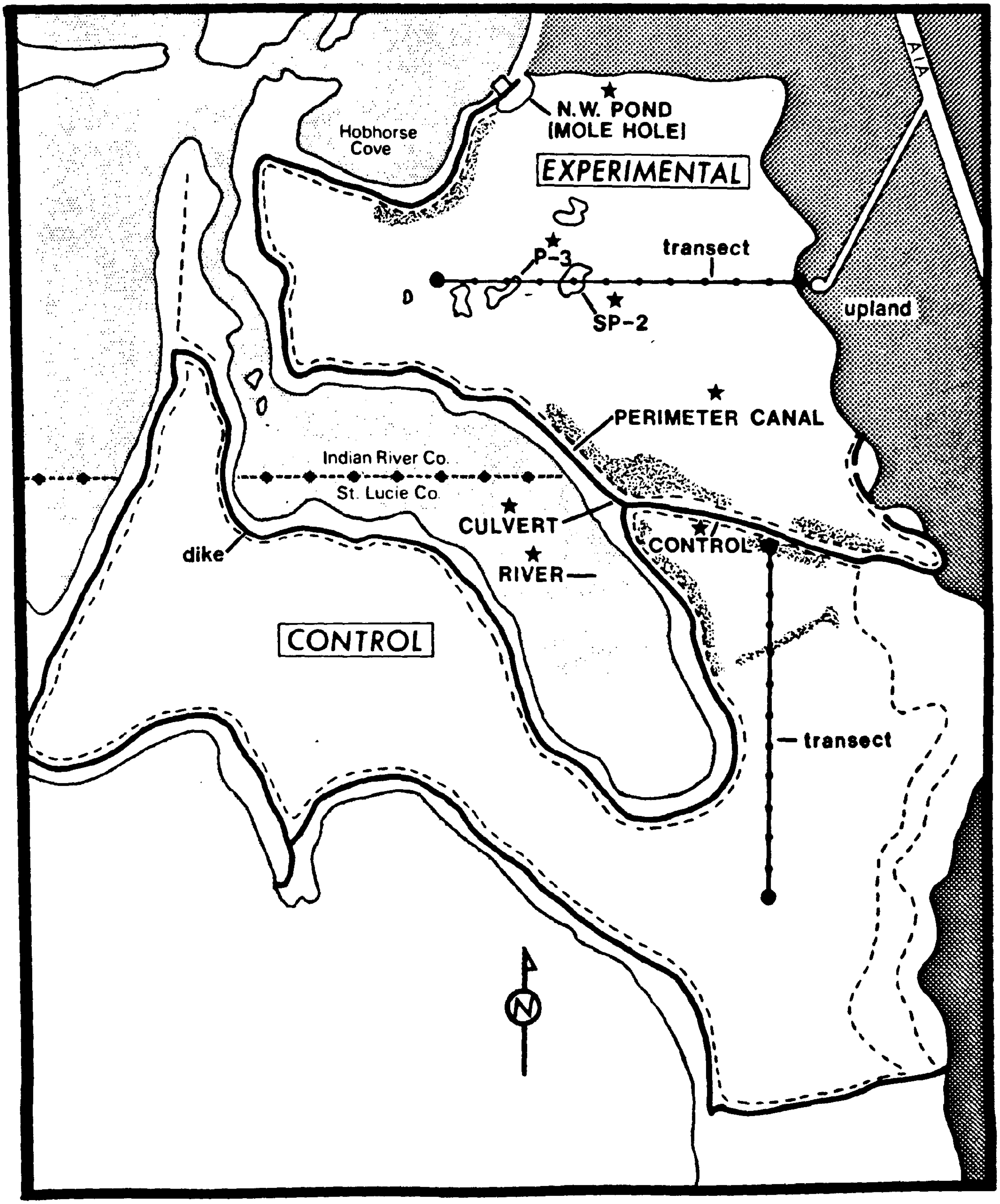
Figure 30. Comparison of mean density per sample for zooplankton collected at the different stations. The means for stations under a common line do not differ significantly (t-test, $p > 0.05$).

Figure 31. Schematic vegetation map of the experimental marsh prior to reopening Culvert A.

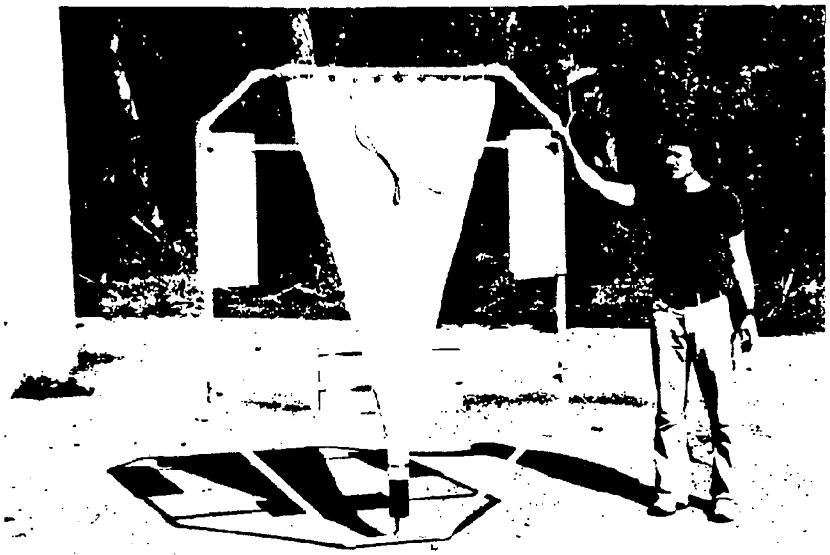
Figure 32. Schematic vegetation map of the experimental cell circa 1983. (Figs. 31 & 32 compiled by B. Vigliano).

Figure 33. Comparisons of the distributions of average density per taxon per plankton sample for the 202u- and the 63u - mesh gear. The distribution medians for stations above a common line do not differ significantly (Mann-Whitney Test, $p > 0.05$).

FIGURE 1.


A1A
N.W. POND
(MOLE HOLE)
Hobhorse
Cove
EXPERIMENTAL
transect
P-3
SP-2
upland
PERIMETER CANAL
Indian River Co.
St. Lucie Co.
CULVERT
CONTROL
dike
RIVER
CONTROL
transect
N

2



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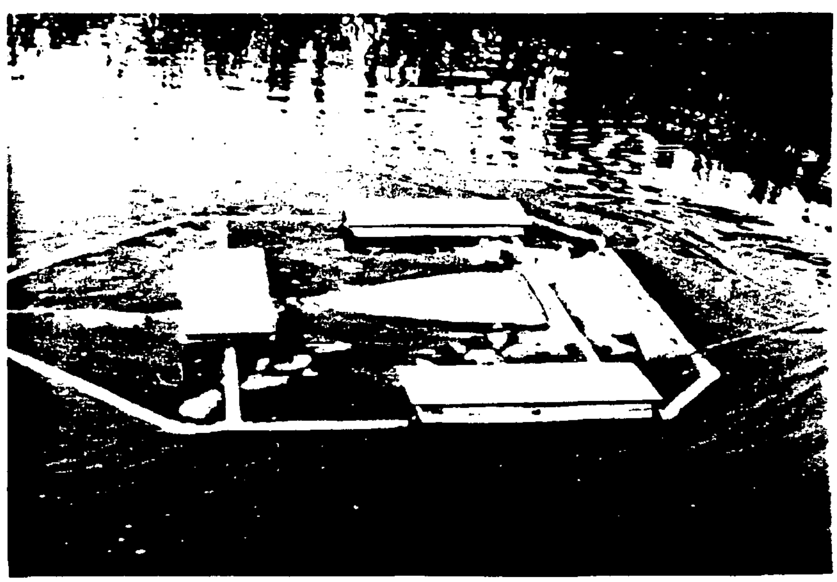

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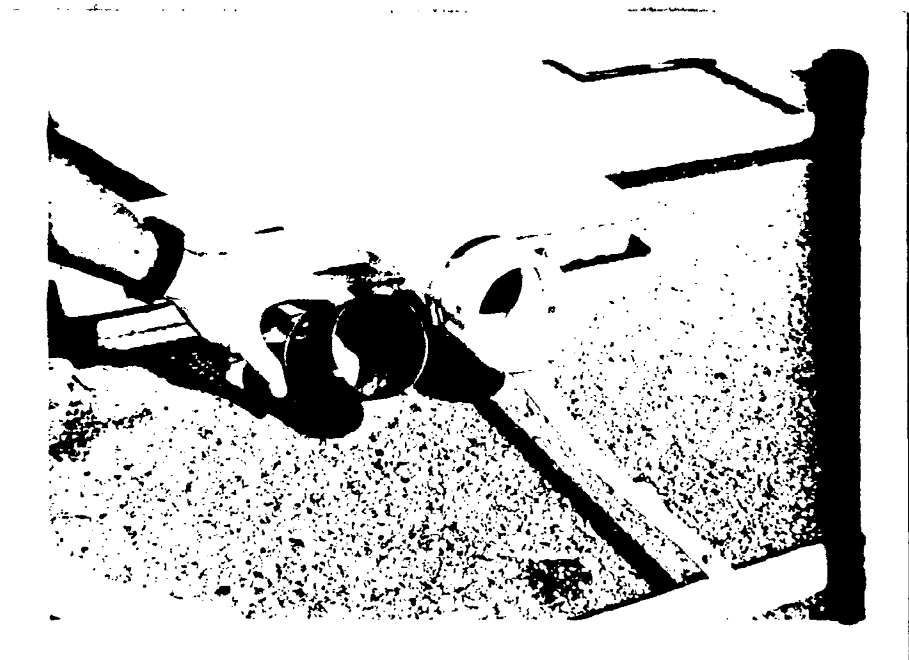

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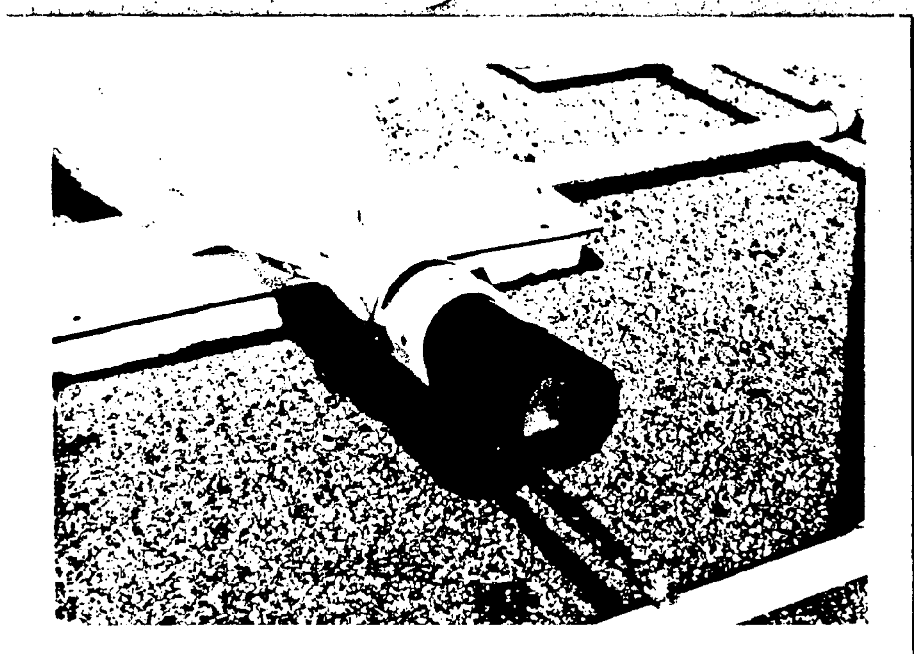

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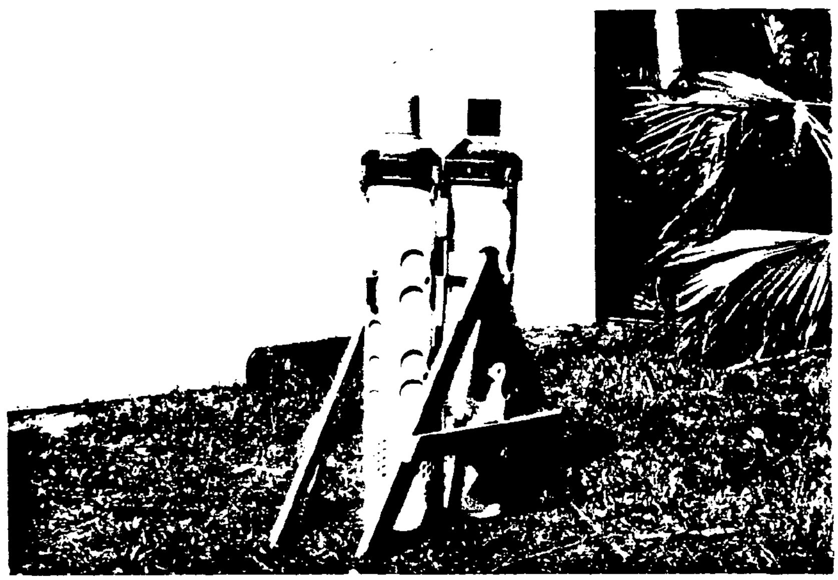

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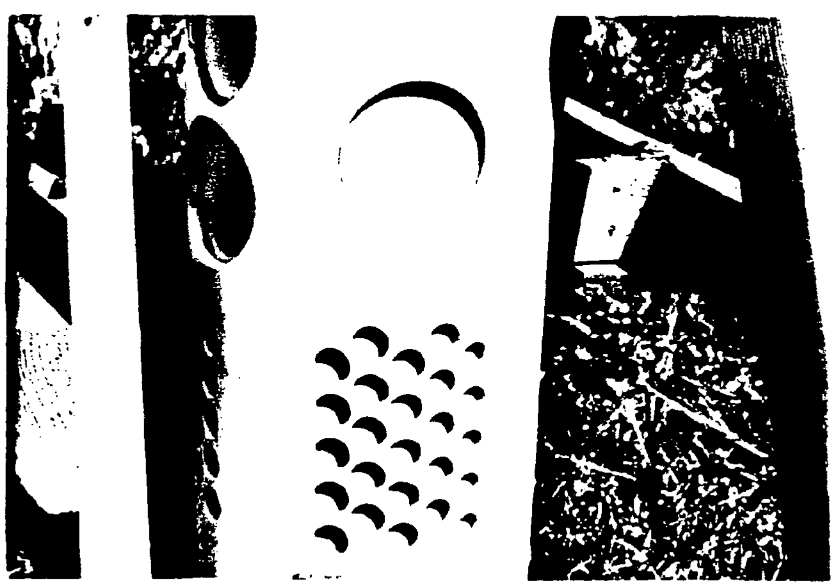

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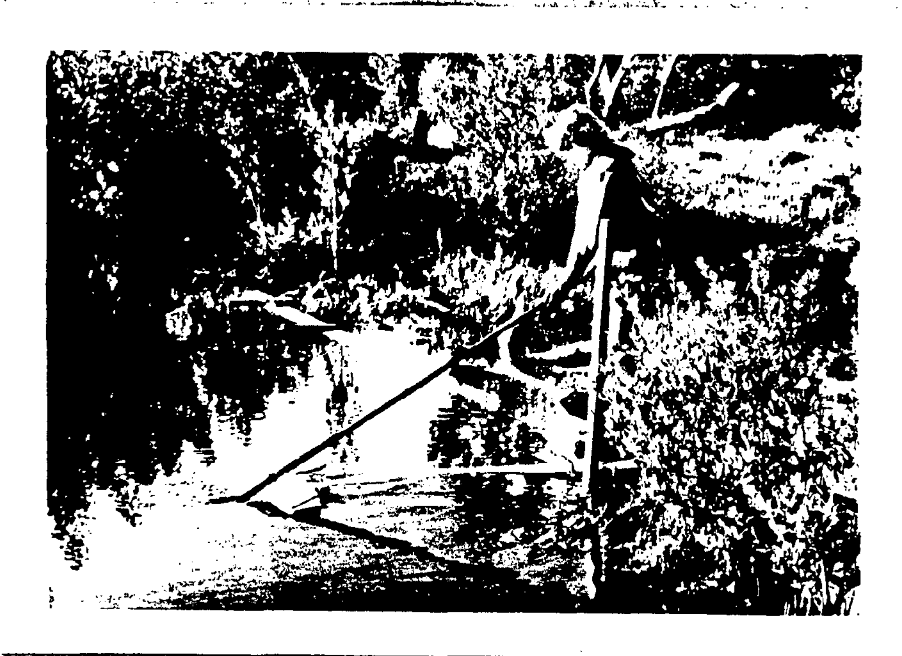
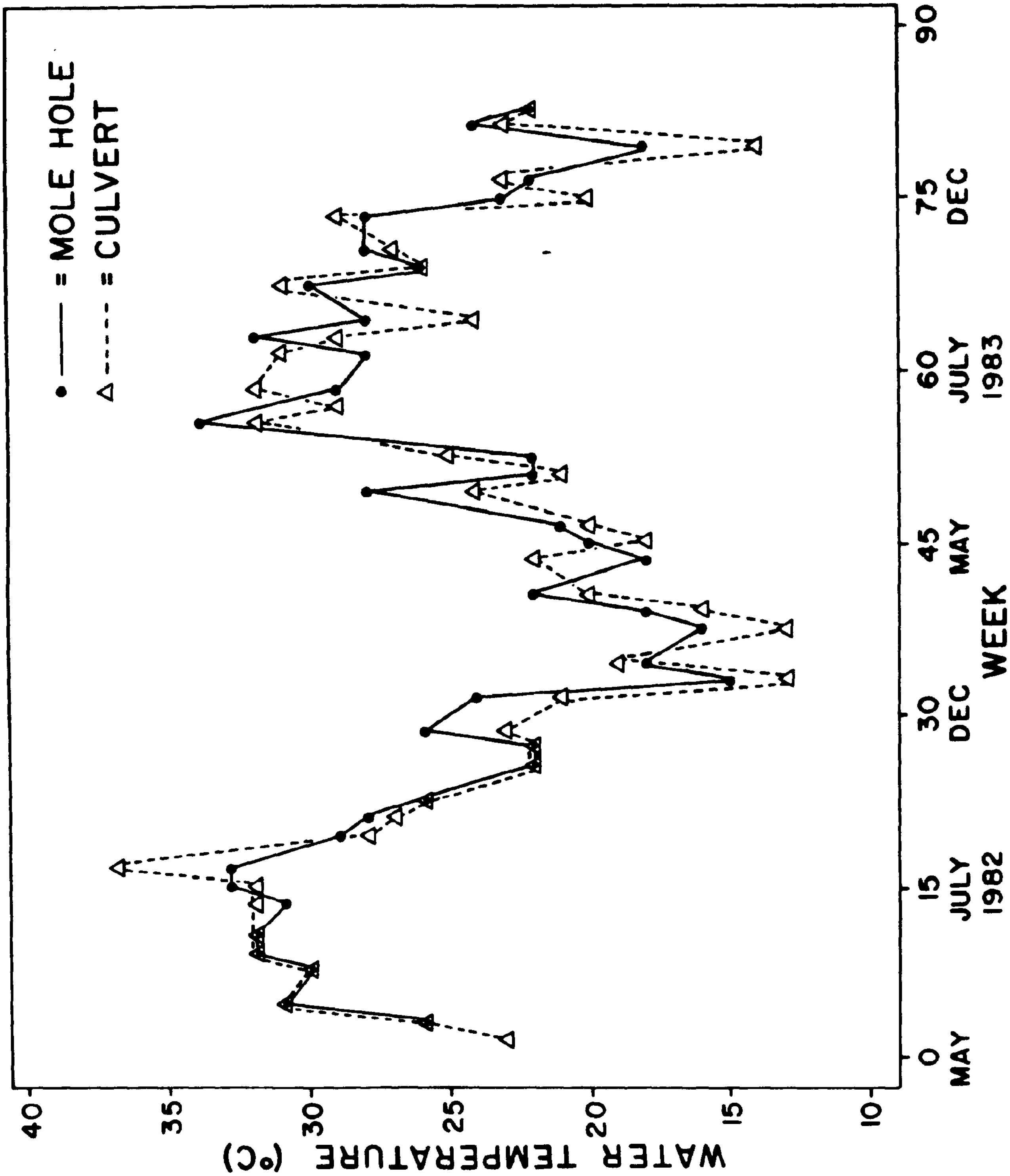


9

10

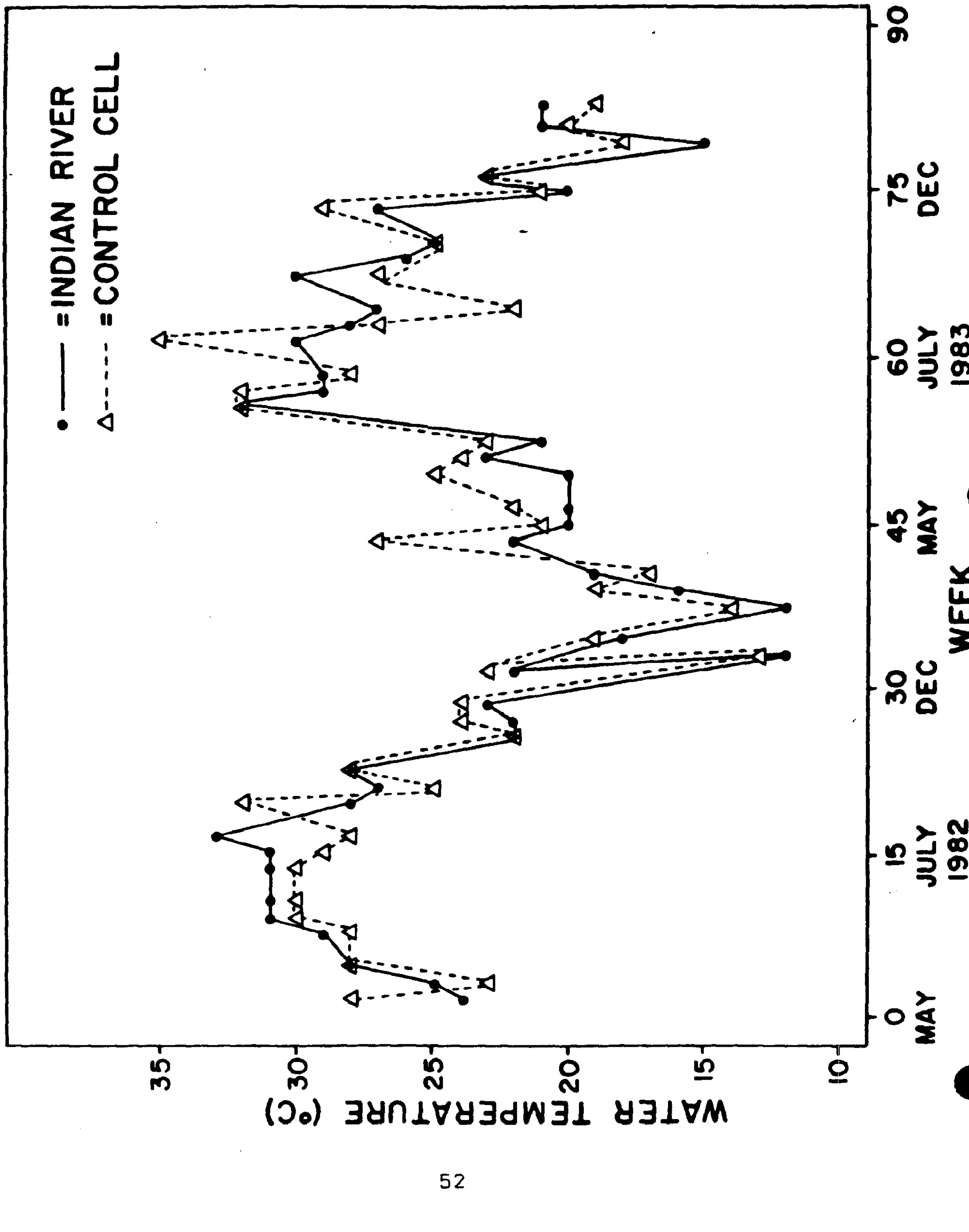
11

FIGURE 12.



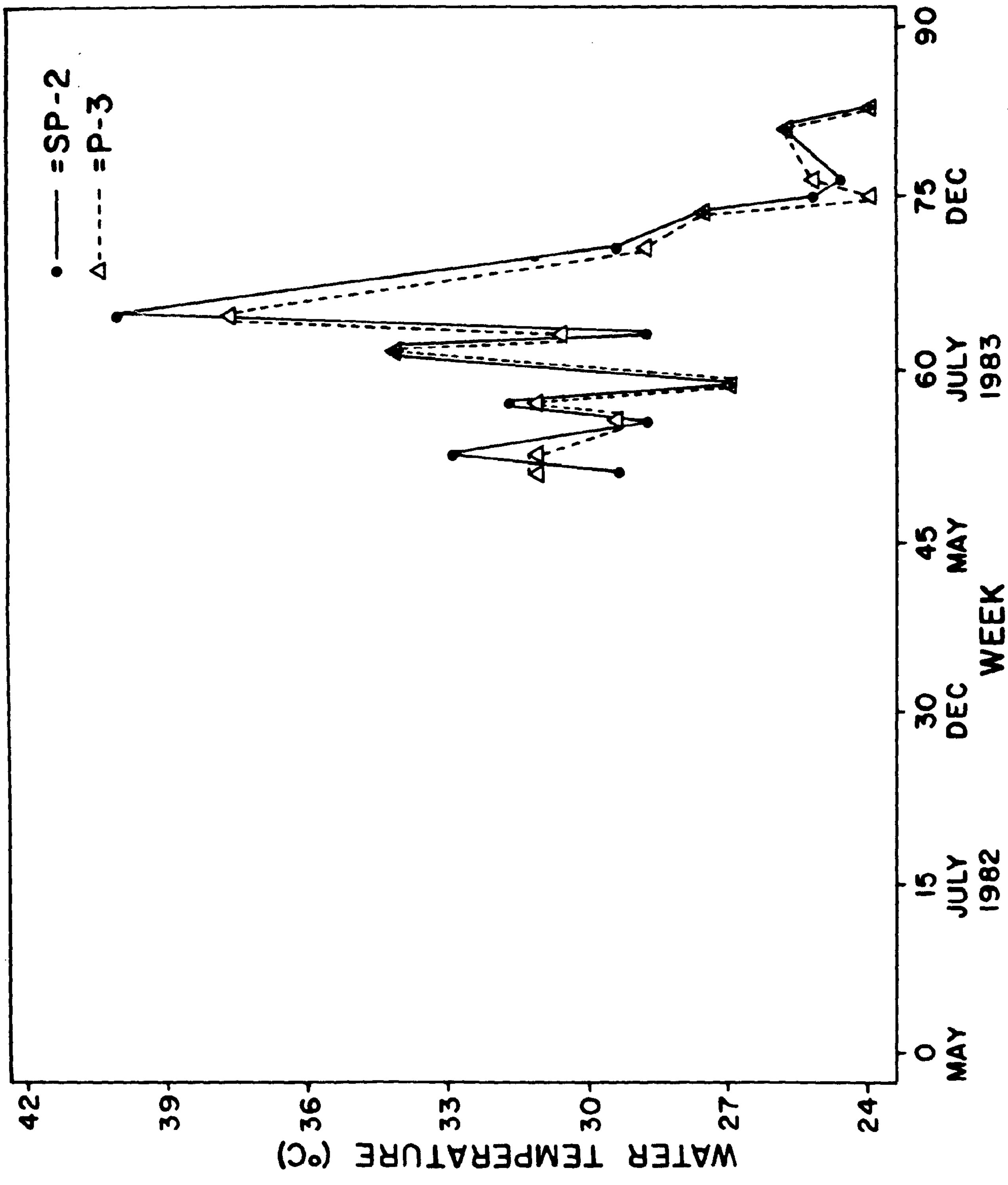
• —— = MOLE HOLE
△ - - - = CULVERT
WATER TEMPERATURE (°C)
40
35
30
25
20
15
10
WEEK
0 MAY
15 JULY 1982
30 DEC
45 MAY
60 JULY 1983
75 DEC
90

FIGURE 13.



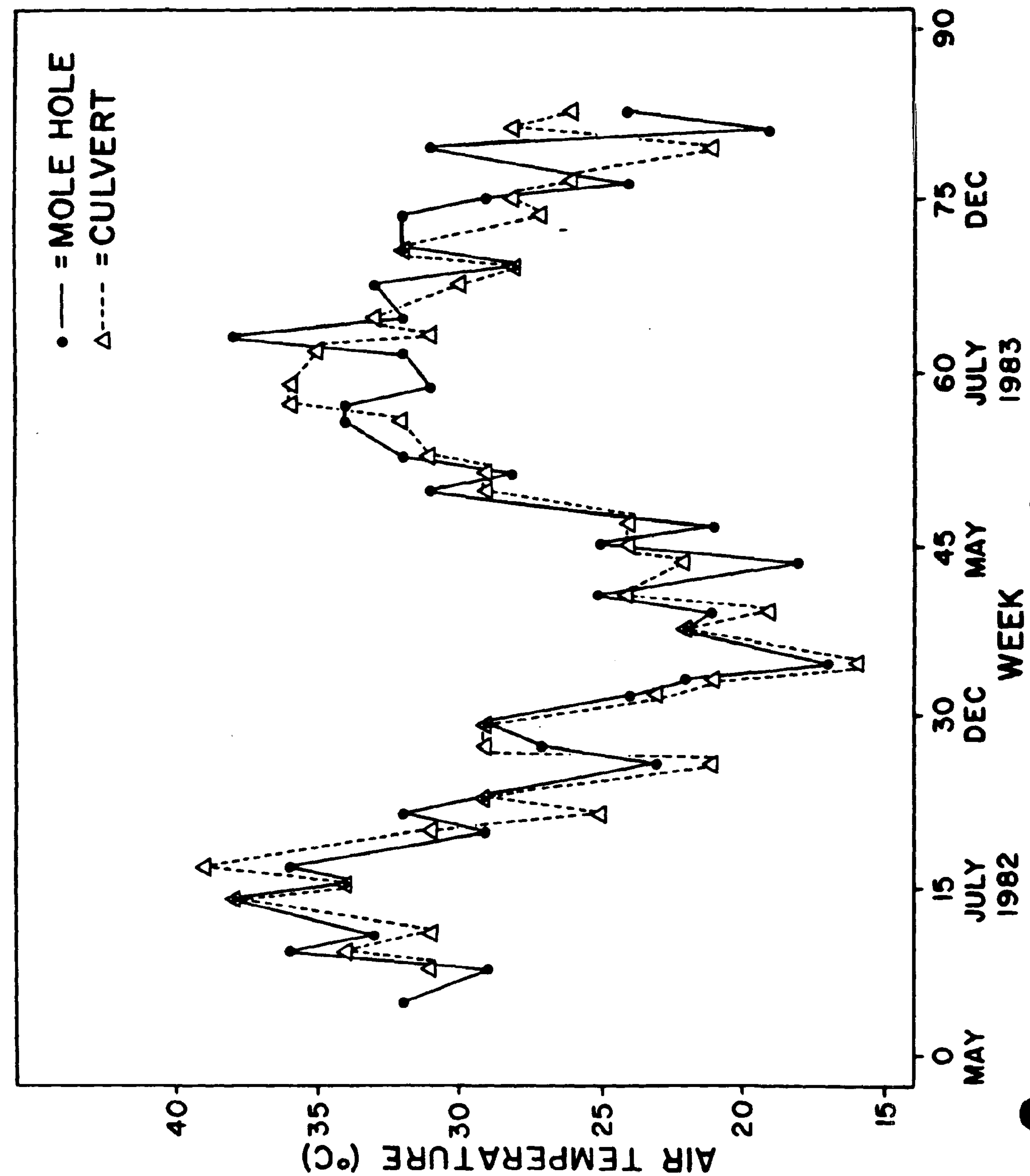
= INDIAN RIVER
= CONTROL CELL
WATER TEMPERATURE (°C)
35
30
25
20
15
10
WEEK
0
MAY
15
JULY
1982
30
DEC
45
MAY
60
JULY
1983
75
DEC
90

FIGURE 14.



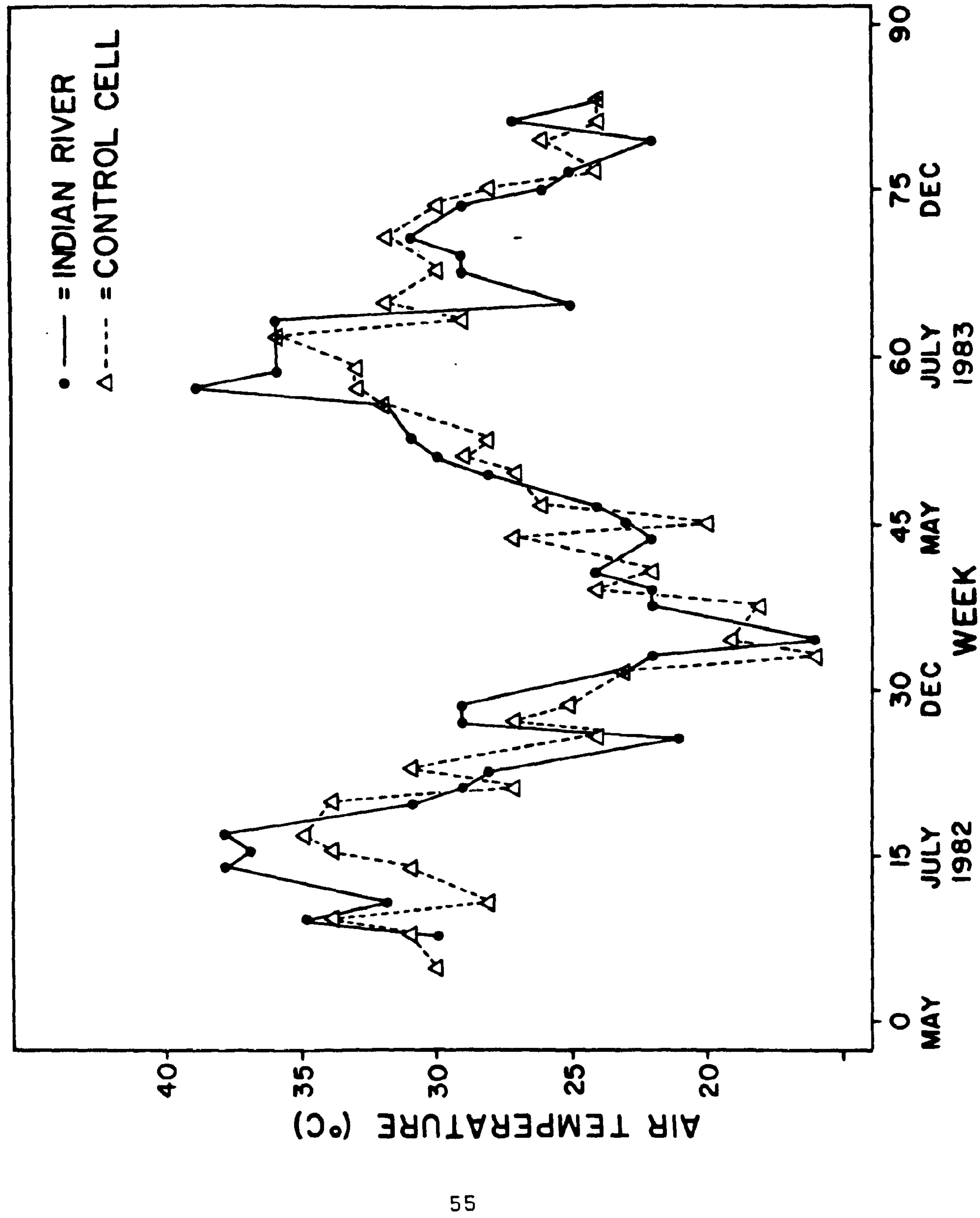
=SP-2
=P-3
WATER TEMPERATURE (°C)
42
39
36
33
30
27
24
WEEK
0 MAY
15 JULY 1982
30 DEC
45 MAY
60 JULY 1983
75 DEC
90

FIGURE 15.



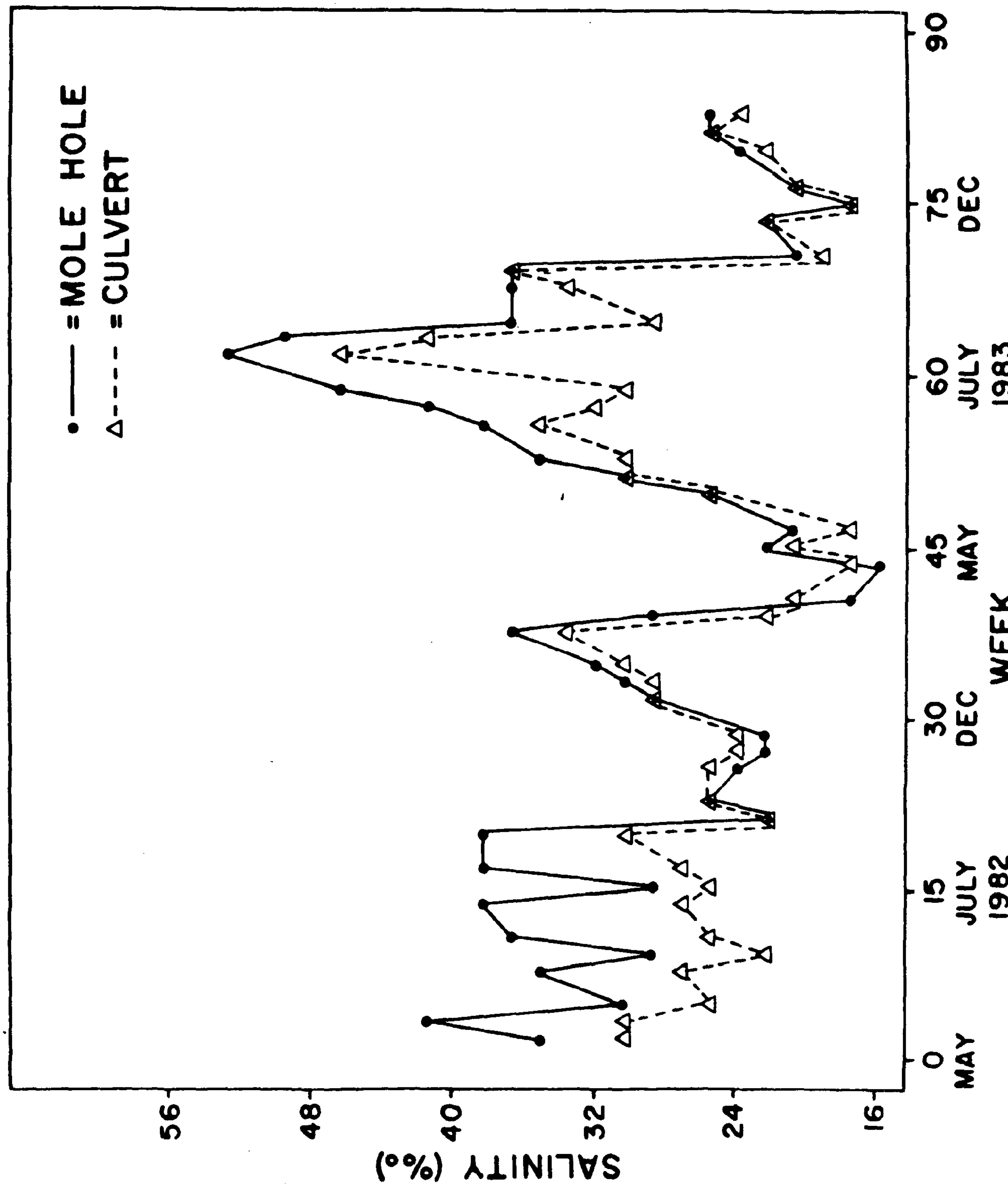
=MOLE HOLE
=CULVERT
AIR TEMPERATURE (°C)
40
35
30
25
20
15
WEEK
0
MAY
15
JULY
1982
30
DEC
45
MAY
60
JULY
1983
75
DEC
90

FIGURE 16.



= INDIAN RIVER
= CONTROL CELL
AIR TEMPERATURE (°C)
40
35
30
25
20
WEEK
0
MAY
15
JULY
1982
30
DEC
45
MAY
60
JULY
1983
75
DEC
90

FIGURE 17.



• —— = MOLE HOLE
Δ - - - = CULVERT
SALINITY (‰)
56
48
40
32
24
16
WEEK
0
MAY
15
JULY
1982
30
DEC
45
MAY
60
JULY
1983
75
DEC
90

FIGURE 18.

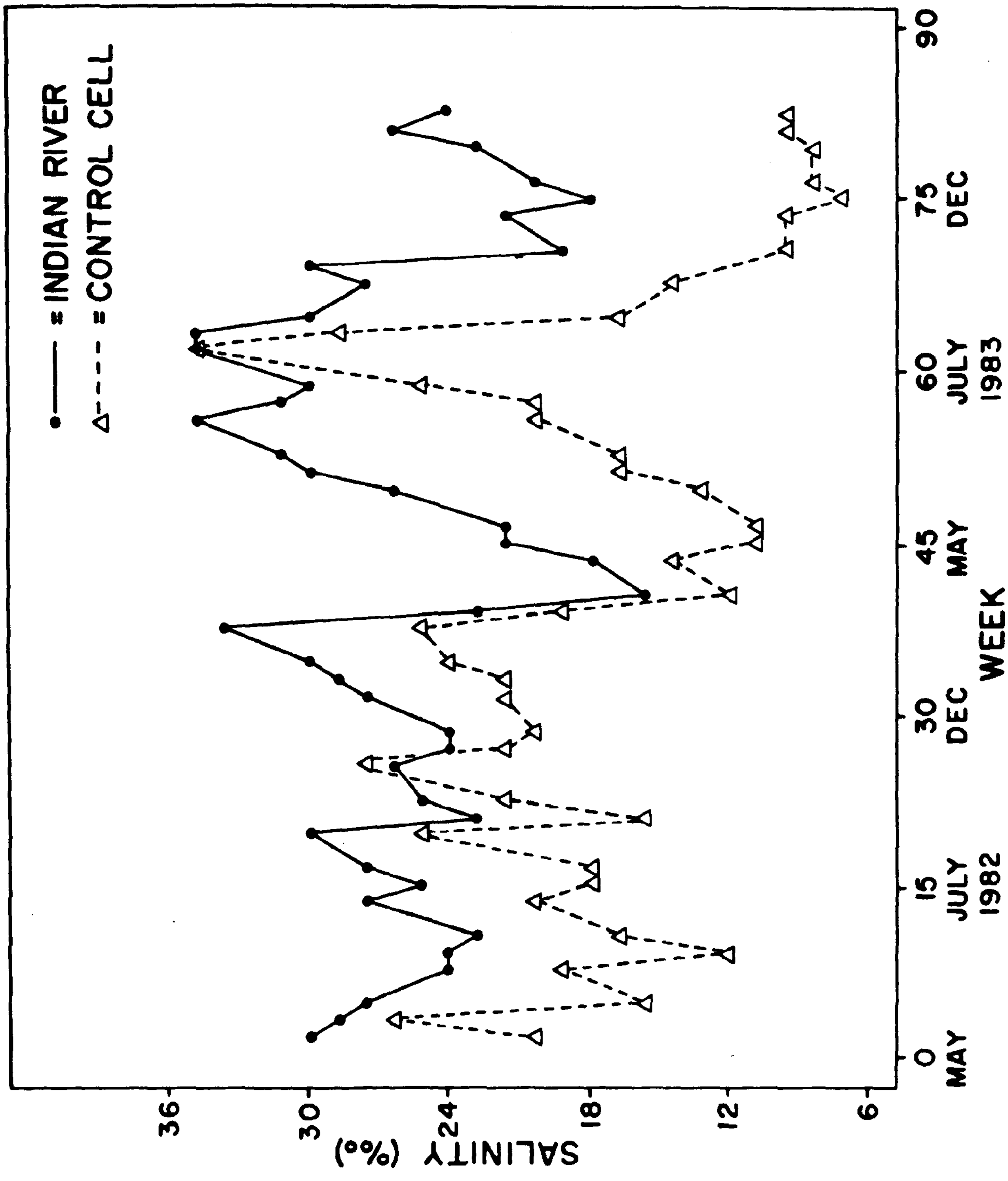
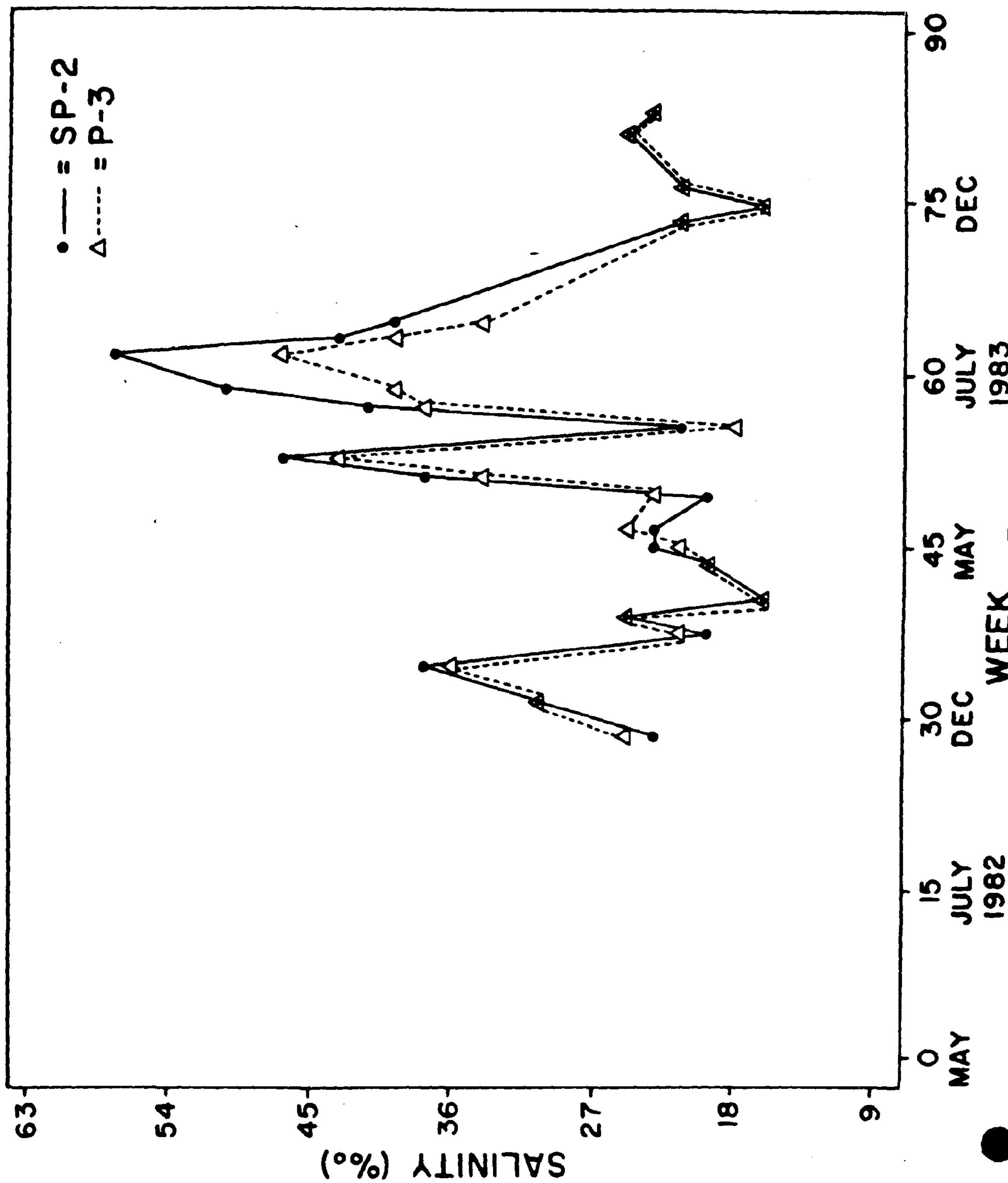

= INDIAN RIVER
= CONTROL CELL
SALINITY (‰)
36
30
24
18
12
6
WEEK
0 MAY
15 JULY 1982
30 DEC
45 MAY
60 JULY 1983
75 DEC
90

FIGURE 19.



• —— = SP-2
Δ ----- = P-3
SALINITY (‰)
63
54
45
36
27
18
9
WEEK
0 MAY
15 JULY 1982
30 DEC
45 MAY
60 JULY 1983
75 DEC
90

FIGURE 20.

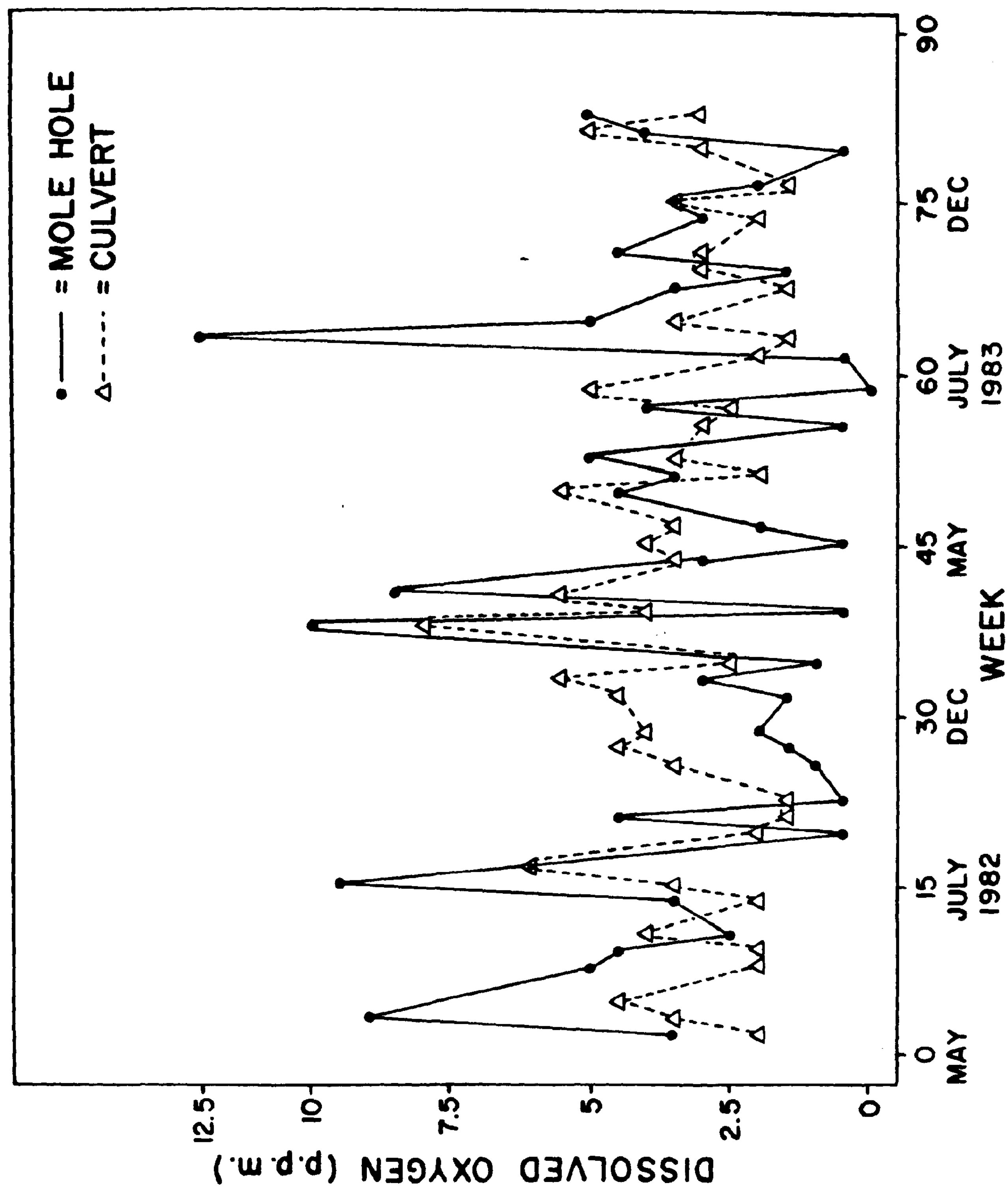

= MOLE HOLE
= CULVERT
0
MAY
15
JULY
1982
30
DEC
45
MAY
60
JULY
1983
75
DEC
90
WEEK
0
2.5
5
7.5
10
12.5
DISSOLVED OXYGEN (p.p.m.)

FIGURE 21.

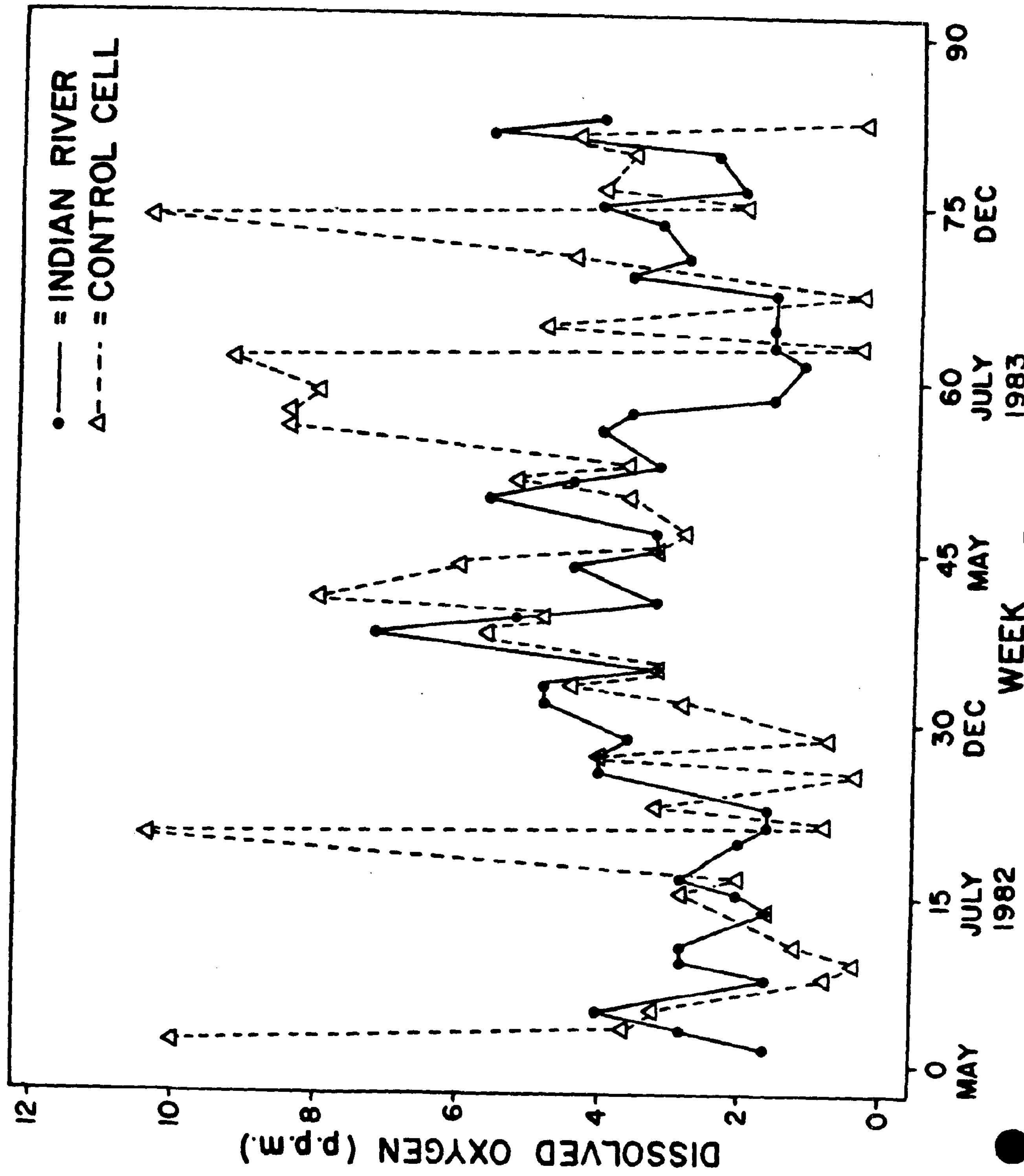

= INDIAN RIVER
= CONTROL CELL
DISSOLVED OXYGEN (p.p.m.)
0
2
4
6
8
10
12
WEEK
0
MAY
15
JULY
1982
30
DEC
45
MAY
60
JULY
1983
75
DEC
90

FIGURE 22.

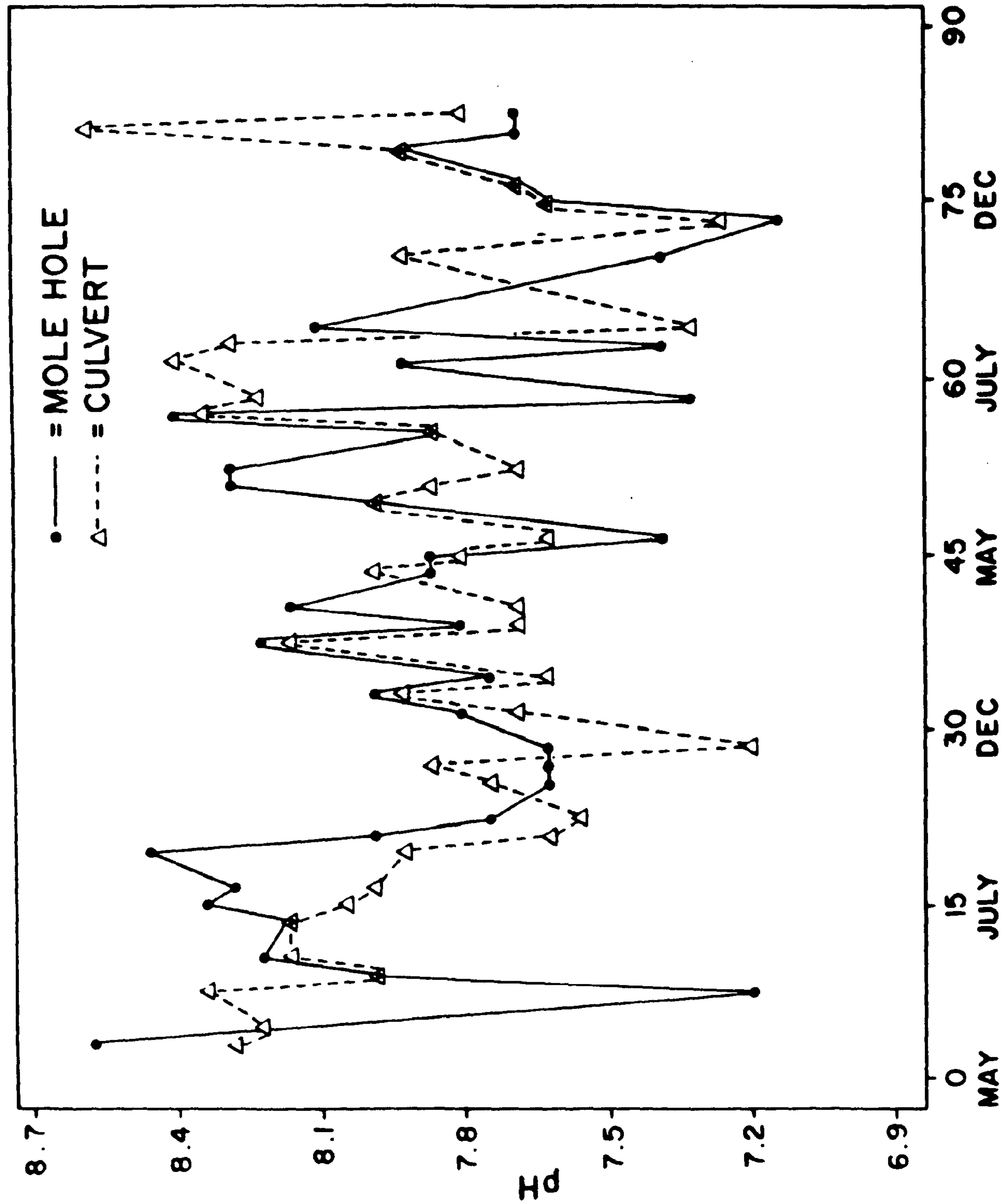
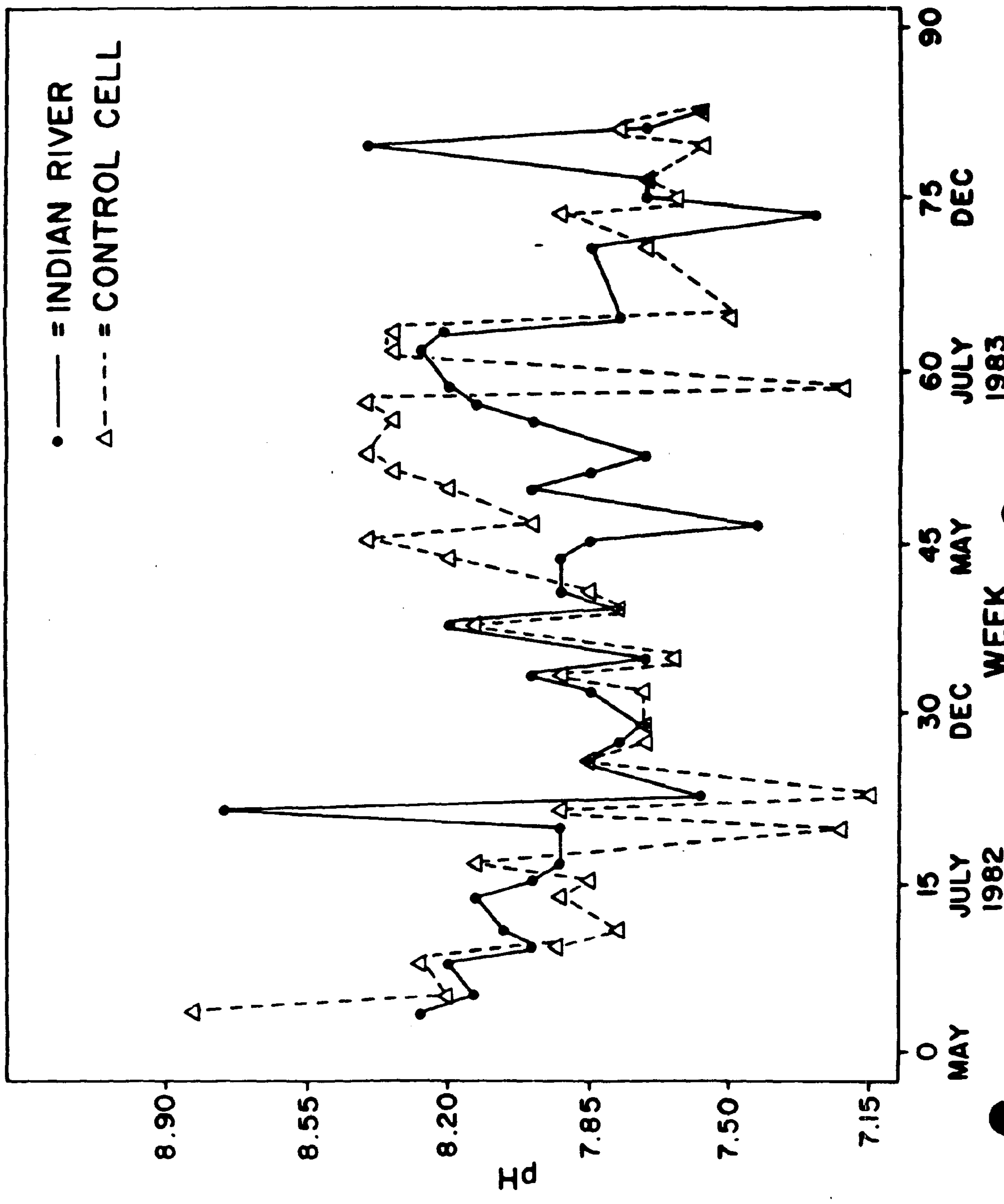

= MOLE HOLE
= CULVERT
pH
8.7
8.4
8.1
7.8
7.5
7.2
6.9
WEEK
0 MAY
15 JULY 1982
30 DEC
45 MAY
60 JULY 1983
75 DEC
90

FIGURE 23.



= INDIAN RIVER
= CONTROL CELL
pH
8.90
8.55
8.20
7.85
7.50
7.15
WEEK
0
MAY
15
JULY
1982
30
DEC
45
MAY
60
JULY
1983
75
DEC
90

FIGURE 24A.

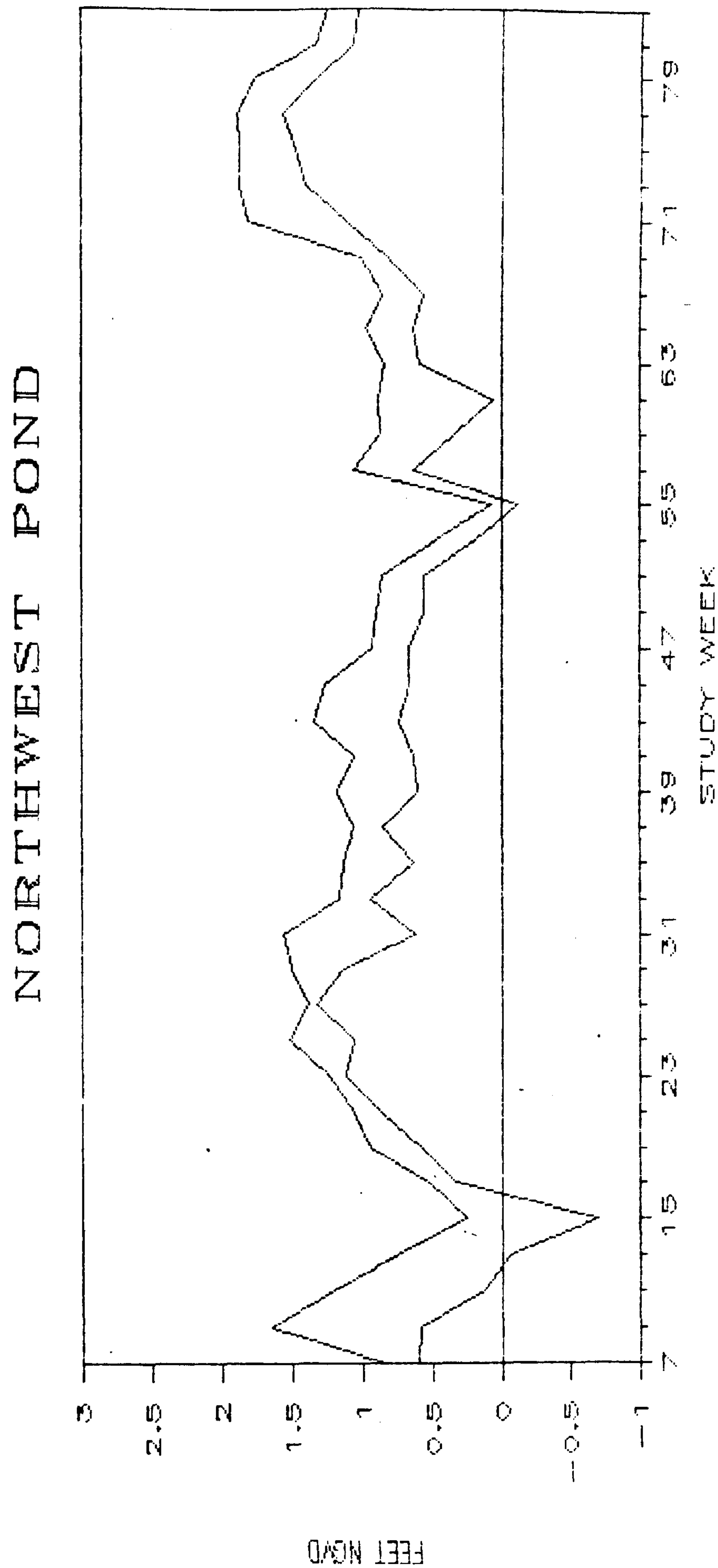

NORTHWEST POND
STUDY WEEK
7
15
23
31
39
47
55
63
71
79
FEET NGVD
3
2.5
2
1.5
1
0.5
0
-0.5
-1

FIGURE 24B

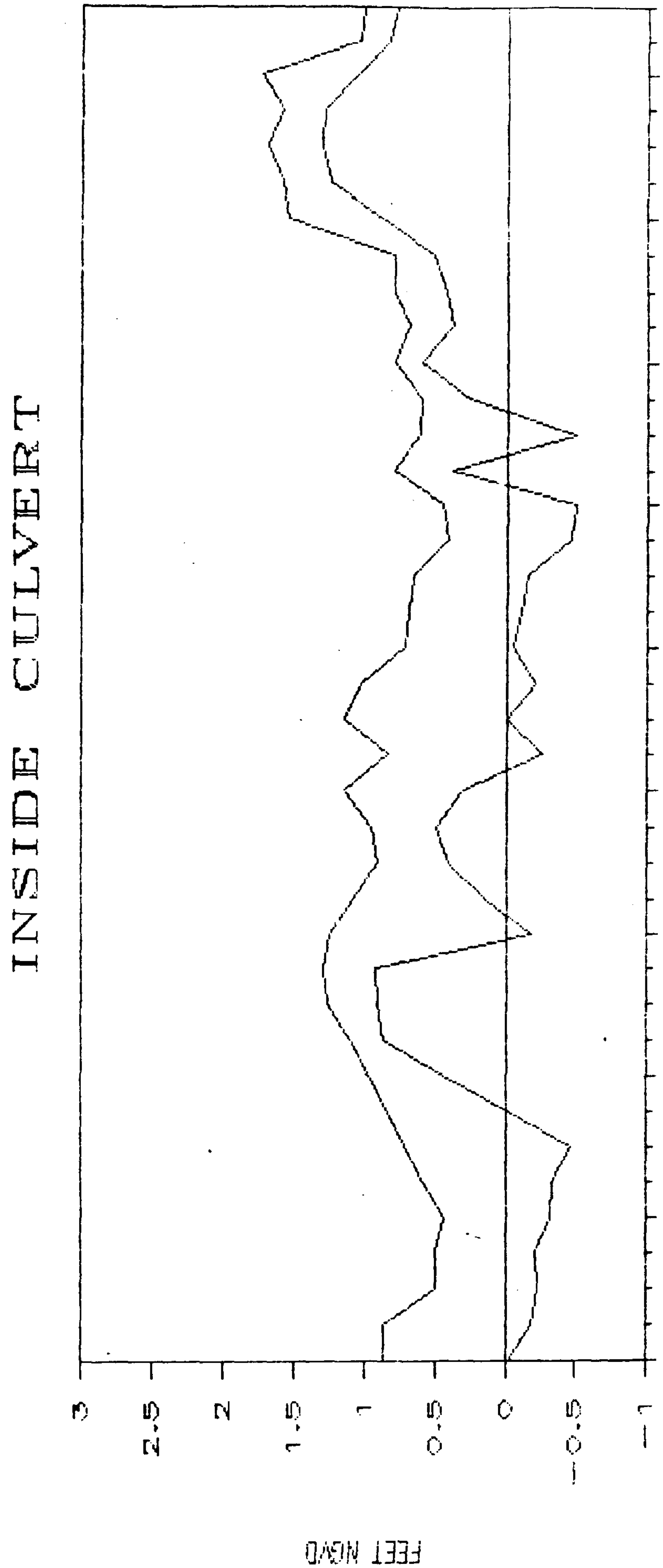

INSIDE CULVERT
STUDY WEEK
FEET NGVD
7
15
23
31
39
47
55
63
71
79
3
2.5
2
1.5
1
0.5
0
-0.5
-1

FIGURE 25A.

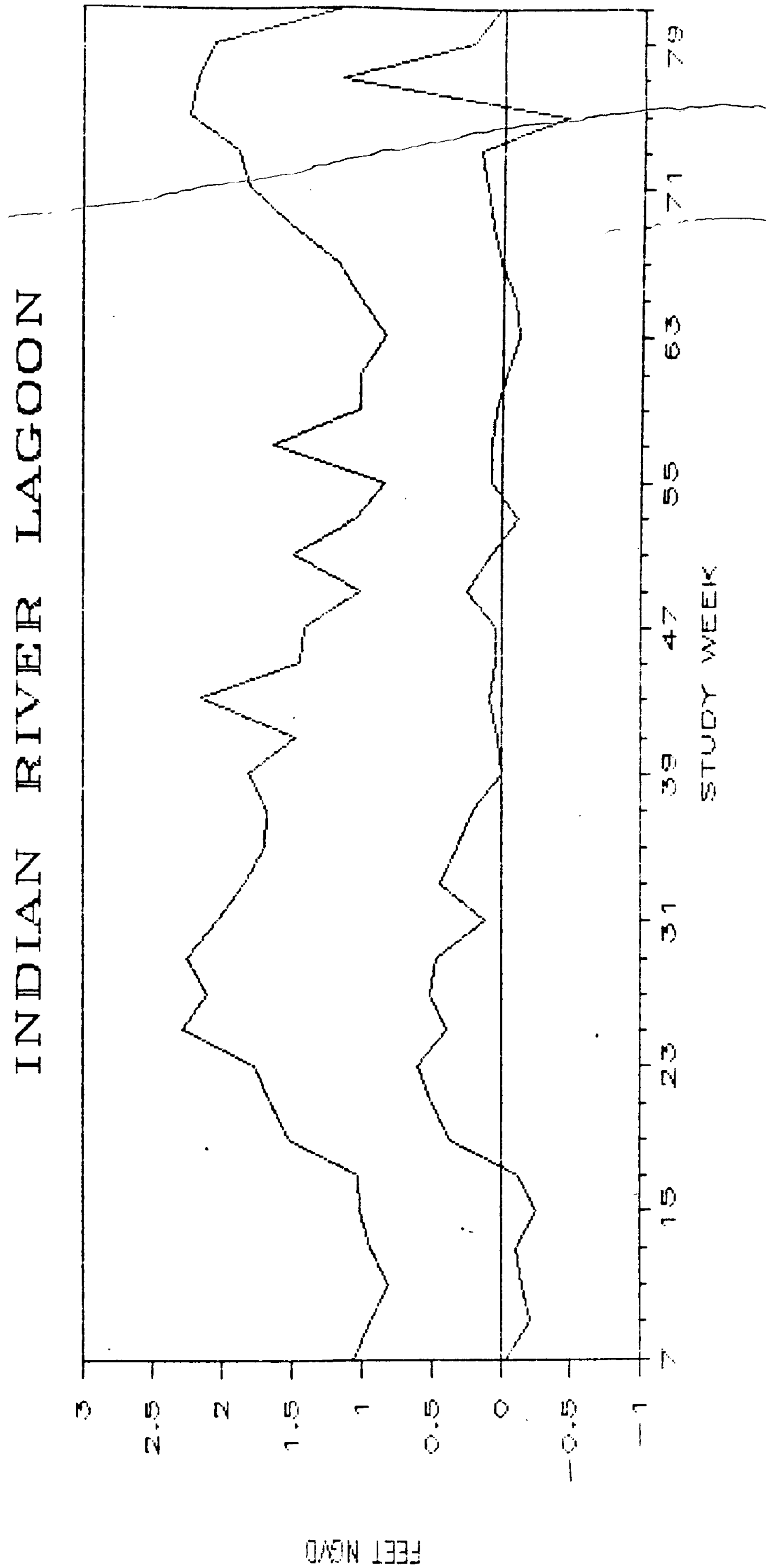

INDIAN RIVER LAGOON
STUDY WEEK
7 15 23 31 39 47 55 63 71 79
FEET NGVD
3 2.5 2 1.5 1 0.5 0 -0.5 -1

FIGURE 25B.

CONTROL CELL

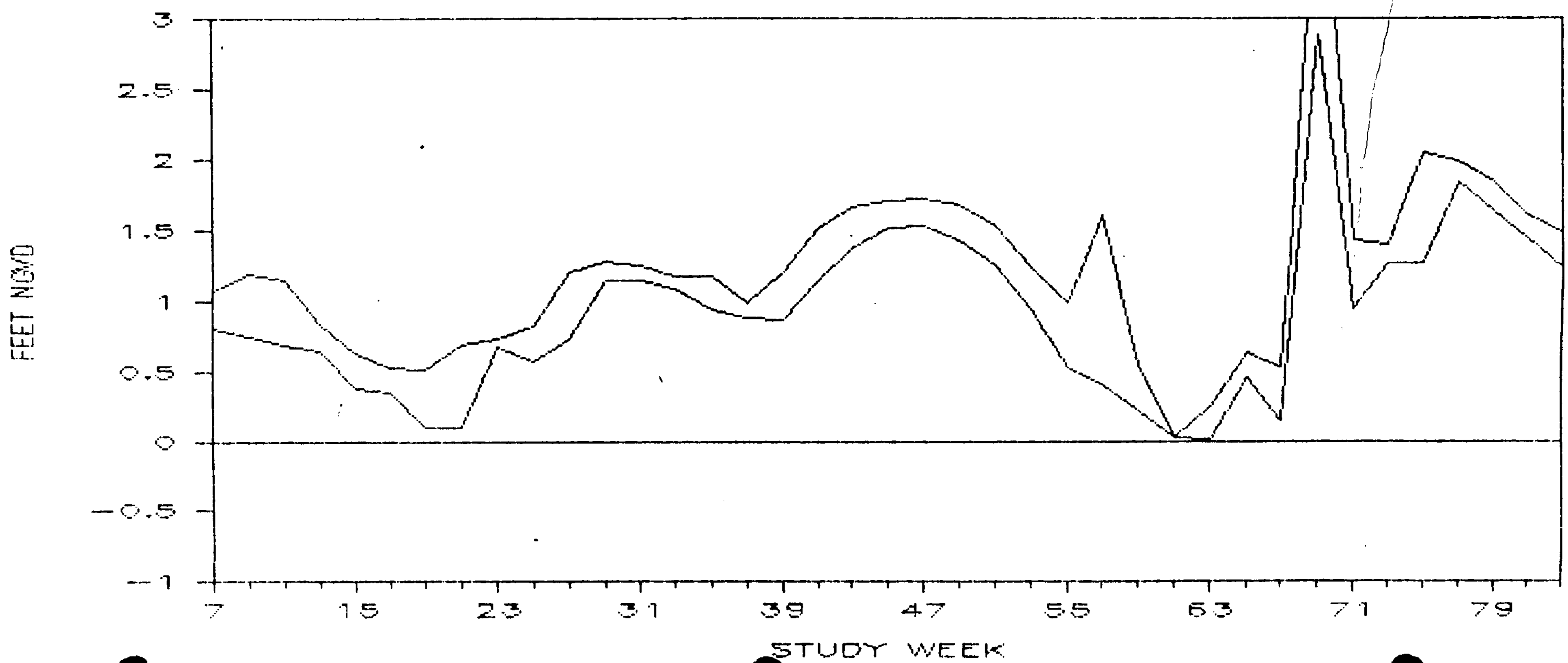


FIGURE 26.

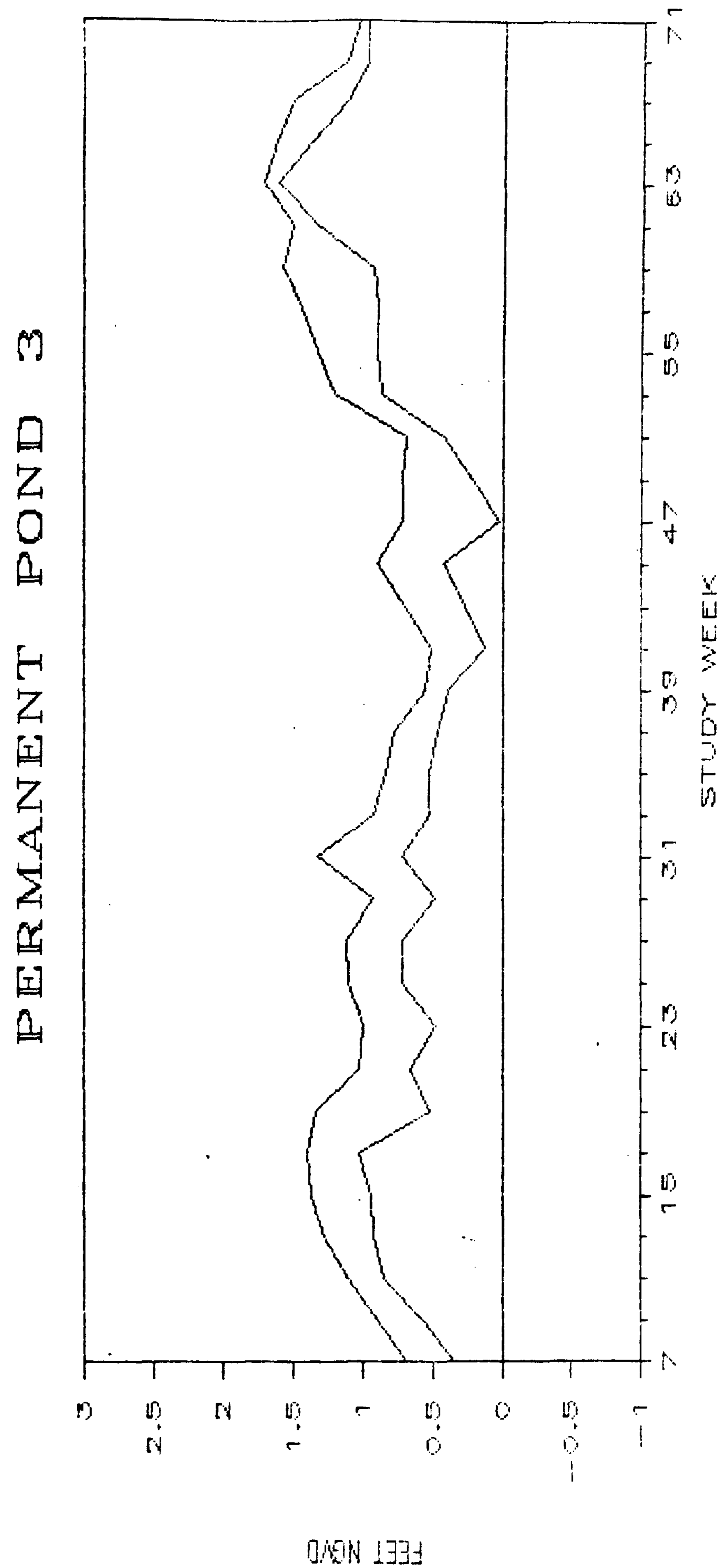

PERMANENT POND 3
STUDY WEEK
7
15
23
31
39
47
55
63
71
FEET NGVD
3
2.5
2
1.5
1
0.5
0
-0.5
-1

Figure 27. Comparison of mean values of various physical variables at the different stations. The mean for stations above a common line do not differ significantly (t-test, $p > 0.05$).

```
TEMP.   25.4     24.9      24.2      24.7        29.2     28.1
C       MOLE     CULVERT   INDIAN    CONTROL     SP-2     P-3
        HOLE               RIVER
        +-------------------------------------+
                                                 +------------+

D.O.    3.54     3.38      3.18      4.06
PPM     MOLE     CULVERT   INDIAN    CONTROL
        HOLE               RIVER
        +-------------------------------------+

SAL.    30.5    29.8    28.1    27.0      26.2      17.7
PPT     MOLE    SP-2    P-3     CULVERT   INDIAN    CONTROL
        HOLE                              RIVER
        +------------------+
                                +------------------+
                                                    +--------+

PH      7.87     7.89      7.93      7.92
        MOLE     CULVERT   INDIAN    CONTROL
        HOLE               RIVER
        +-------------------------------------+

WATER   0.32       0.43     0.37    0.43     0.65       1.38
LEVEL   CONTROL    MOLE     P-3     SP-2     CULVERT    INDIAN
RANGE              HOLE                                 RIVER
FT.     +-----------------------+
                   +-------------------+
                                          +--------+
                                                       +-------+
```

FIGURE 28.

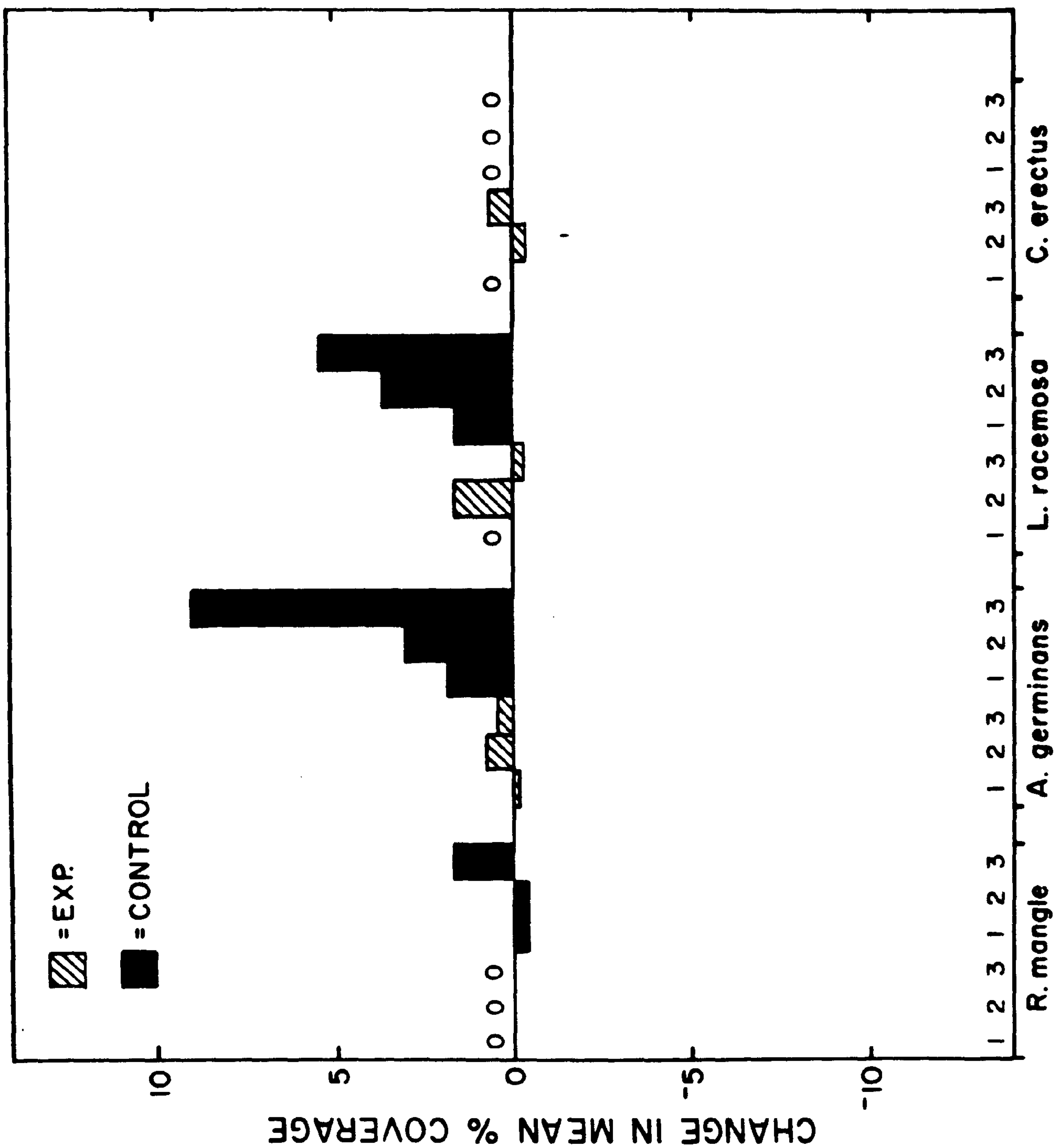

=EXP.
=CONTROL
R. mangle
A. germinans
L. racemosa
C. erectus
CHANGE IN MEAN % COVERAGE

FIGURE 28 (Continued).

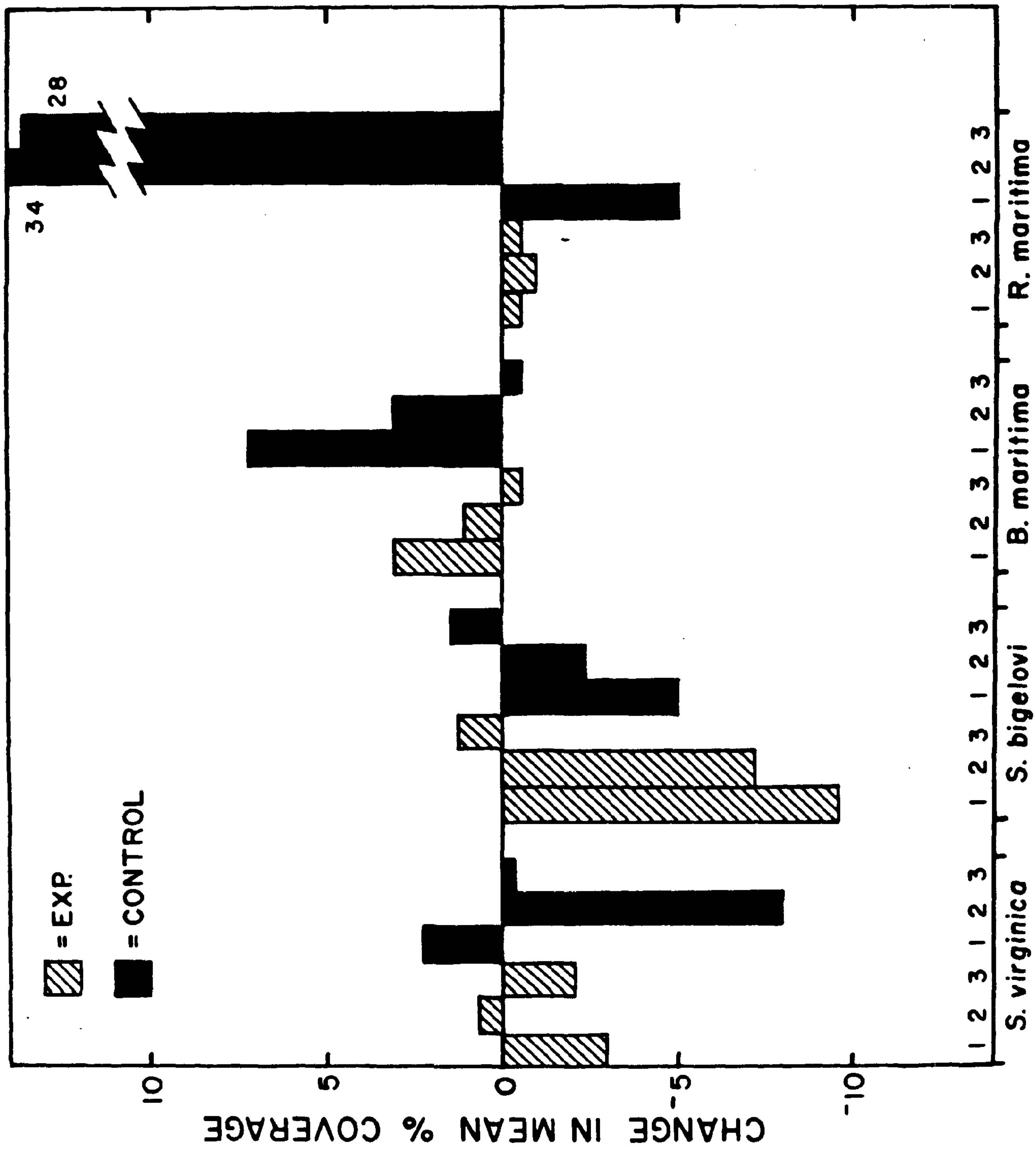


Figure 29. Comparisons of mean no. of taxa per sample for zooplankton collected at the different stations. The means for stations under a common line do not differ significantly (t-test, p > 0.05).

```
202u PUMP:    (13.0)       (13.0)        (10.6)        (8.4)
              RIVER        CULVERT       CONTROL       MOLE HOLE
             +----------------------------------+
                                                     +----------+

202u NET:     (16.0)       (10.7)        (5.6)
              CULVERT      RIVER         CONTROL
             +-------------------+
                                        +---------+

 63u PUMP:    (18.9)       (17.9)        (12.4)        (5.9)
              RIVER        CULVERT       CONTROL       MOLE HOLE
             +---------------------+
                                        +----------+
                                                     +----------+

 63u NET:     (16.0)       (16.0)        (10.3)
              RIVER        CULVERT       CONTROL
             +----------------------------------+
```

Figure 30. Comparison of mean density per sample for zooplankton collected at the different stations. The means of stations under a common line do not differ significantly (t-test, $p > 0.05$).

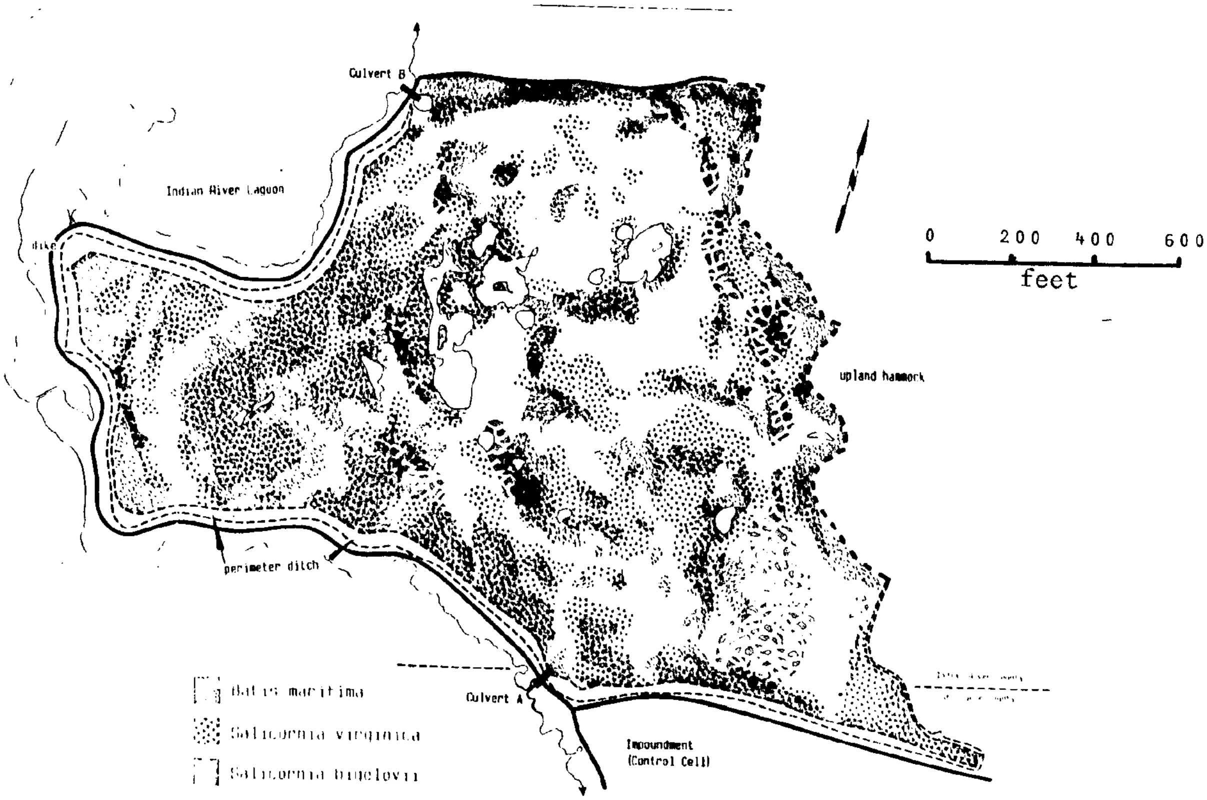
```
202u PUMP:   (3153)      (6282)       (2746)       (418)
             CULVERT     MOLE HOLE    RIVER        CONTROL
            +------------------------------------+
                                                   +----------+

202u NET:    (44526)     (11643)      (198)
             RIVER       CULVERT      CONTROL
            +---------+
                        +---------+
                                     +---------+

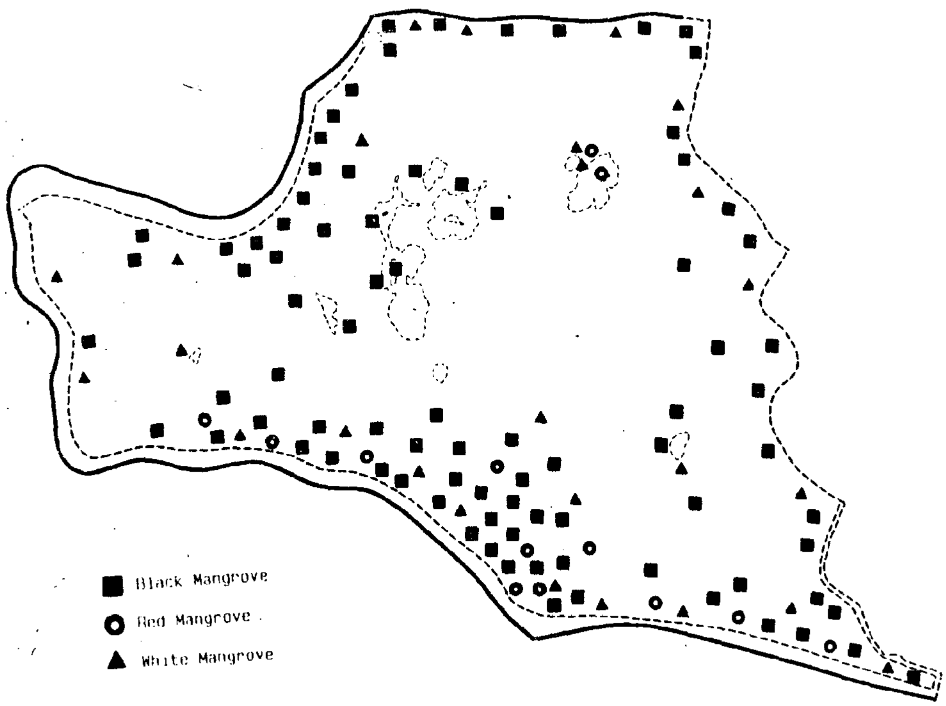
63u PUMP:    (18923247)  (212105)     (113579)     (96684)
             MOLE HOLE   CONTROL      CULVERT      RIVER
            +-----------+
                          +------------------------------------+

63u NET:     (1191533)   (1106239)    (674486)
             CONTROL     RIVER        CULVERT
            +--------------------------------------+
```

Approximate occurrence and location of marsh vegetati n at Impoundment #12 in 1980.



Approximate c currence and location of marsh vegetation at Imp undment #12 in January 1984.



Approximate occurrence nd location of marsh vegetation at Impoundment 12 in January 1984.

Figure 33. Comparisons of the distributions of average density per taxon per plankton sample for the 202u- and 63u-mesh gear. The distribution median for stations above a common line do not differ significantly (Mann-Whitney Test, p > 0.05).

```
          (99)              (22)              (1)          (0)
202u:   CULVERT            RIVER            CONTROL     MOLE HOLE
       +------------------------+
                                      +--------------------------+


           (83)             (41)             (15)           (0)
 63u:     RIVER            CULVERT          CONTROL      MOLE HOLE
        +----------------------------------------+
                                                   +------------+
```

Table 1. Summary of sampling routines.

METHOD	SITES	FREQUENCY
Plankton	Mole Hole	Bi-weekly
202μ net	Culvert	
	River	
	Control	
64μ net	Mole Hole	Bi-weekly
	Culvert	
	River	
	Control	
202μ pump	Mole Hole	Bi-weekly
	Culvert	
	River	
	Control	
64μ pump	Mole Hole	Bi-weekly
	Culvert	
	River	
	Control	
Dip nets	Pond P-1	Bi-weekly
	Pond SP-2	
Vegetation		
Veg. cover (transects)	IRC # 12	Quarterly
	Control	
Mangrove establishment	IRC # 12	Quarterly
	Control	
Physical Parameters	Mole Hole	Bi-weekly
	Culvert	
	River	
	Control	
	SP-2	
	P-1	

Table 2. Summary of plankton samples collected between 5/82 and 12/83.

Table 2.

DATE	PUMP								NETS						DIP NET	
	M. HOLE		CULVERT		RIVER		CONTROL		CONTROL		RIVER		CULVERT		SP-2	P-3
	63 µ	202 µ	63 µ	202 µ	63 µ	202 µ	63 µ	202 µ	63 µ	202 µ	63 µ	202 µ	63 µ	202 µ	63 µ	63 µ
5 May 82	5	5	-	-	-	-	1	1	-	-	-	-	-	-	-	-
10 May 82	-	-	1	1	1	1	-	-	-	-	-	-	-	-	-	-
19 May 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
1 June 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
15 June 82	-	-	-	-	-	-	-	-	1	1	1	1	1	1	-	-
16 June 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
29 June 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
2 July 82	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
15 July 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
16 July 82	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
26 July 82	-	-	-	-	-	-	-	-	+	+	1	1	1	1	1	1
27 July 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
10 August 82	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+
12 August 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
25 August 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
27 August 82	-	-	-	-	-	-	-	-	+	+	+	+	+	+	1	1
14 Sept 82	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
15 Sept 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
28 Sept 82	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
29 Sept 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
11 Oct 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
12 Oct 82	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
27 Oct 82	-	-	-	-	-	-	-	-	+	1	1	1	1	1	1	1
29 Oct 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
10 Nov 82	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
12 Nov 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
23 Nov 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
24 Nov 82	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
9 Dec 82	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
10 Dec 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
21 Dec 82	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
22 Dec 82	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
6 Jan 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
7 Jan 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
19 Jan 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-

Table 2 (Continued).

DATE	PUMP								NETS						DIP NETS	
	M. HOLE		CULVERT		RIVER		CONTROL		CONTROL		RIVER		CULVERT		SP-2	P-3
	63 µ	202 µ	63 µ	202 µ	63 µ	202 µ	63 µ	202 µ	63 µ	202 µ	63 µ	202 µ	63 µ	202 µ	63 µ	63 µ
21 Jan 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
3 Feb 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
4 Feb 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
17 Feb 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
18 Feb 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
3 March 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
4 March 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
16 March 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
18 March 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
30 March 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
31 March 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
11 April 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
13 April 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
27 April 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
28 April 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
10 May 83	-	-	-	-	-	-	-	-	1	1	1	1	+	+	1	1
11 May 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
23 May 83	-	-	-	-	-	-	-	-	+	+	+	+	+	+	1	1
25 May 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
6 June 83	-	-	-	-	-	-	-	-	+	+	+	+	+	+	1	1
13 June 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
22 June 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
24 June 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
7 July 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
20 July 83	-	-	-	-	-	-	-	-	+	+	1	1	1	1	1	1
22 July 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
1 August 83	-	-	-	-	-	-	-	-	+	+	+	+	1	1	1	1
3 August 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
19 August 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
22 August 83	-	-	-	-	-	-	-	-	+	+	1	1	1	1	1	1
30 August 83	-	-	-	-	-	-	-	-	+	+	1	1	1	1	1	1
31 August 83	1	1	1	1	1	1	+	+	-	-	-	-	-	-	-	-
14 Sept 83	-	-	-	-	-	-	-	-	+	+	1	1	1	1	1	1
15 Sept 83	1	1	1	1	1	1	+	+	-	-	-	-	-	-	-	-
30 Sept 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-

Table 2 (Continued).

DATE	PUMP								NETS						DIP NETS	
	M. HOLE		CULVERT		RIVER		CONTROL		CONTROL		RIVER		CULVERT		SP-2	P-3
	63 μ	202 μ	63 μ	202 μ	63 μ	202 μ	63 μ	202 μ	63 μ	202 μ	63 μ	202 μ	63 μ	202 μ	63 μ	63 μ
5 Oct 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
13 Oct 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
14 Oct 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
27 Oct 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
28 Oct 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
8 Nov 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
10 Nov 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
22 Nov 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
23 Nov 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
6 Dec 83	-	-	-	-	-	-	-	-	1	1	+	+	1	1	1	1
8 Dec 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
19 Dec 83	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
20 Dec 83	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
TOTALS	47	47	43	43	43	43	41	41	28	29	33	33	34	34	37	37
TOTAL # OF SAMPLE AT EACH SITE	94		86		86		82		57		66		68		64	
TOTAL # OF SAMPLE FOR EACH SAMPLING APPARATUS	348								255							
TOTAL # OF SAMPLES COLLECTED FOR PROJECT	603															

+ - WATER LEVEL TOO LOW TO OBTAIN REPRESENTATIVE SAMPLE

Table 3. Descriptive statistics for physical data measured at the different stations. N= sample size, TMEAN = 5% trimmed mean, SEMEAN = standard error, Q3 = third quartile, Q1 = first quartile. Site abbreviations are as follows: MH = Mole Hole, CU = Culvert, IR = Indian River, C= Control, SP= Sp-2, P = P-3. Variable abbreviations following site names are as follows: AIR = air temperature, WATER = water temperature, DO = dissolved oxygen, SAL = salinity, LEVEL = water level at the time of the sample.

Table 3.

$ type phy.des;2
*****************************IRC # 12: PHYSICAL DATA****************************

Descriptive Statistics

	MHAIR	CUAIR	IRAIR	CAIR	MHWATER	CUWATER	IRWATER	CWATER
N	40	39	39	39	41	42	42	41
NMISS	2	3	3	3	1	0	0	1
MEAN	28.41	28.19	28.26	27.59	25.40	24.90	24.23	24.71
MEDIAN	28.80	28.50	28.80	27.50	26.00	24.50	24.15	24.80
TMEAN	28.53	28.24	28.26	27.77	25.52	25.00	24.45	24.84
STDEV	5.61	5.32	5.51	4.91	5.12	5.77	5.29	5.03
SEMEAN	0.89	0.85	0.88	0.79	0.80	0.89	0.82	0.79
MAX	38.00	38.50	38.50	35.50	34.00	37.30	32.50	35.30
MIN	16.50	16.20	16.30	15.50	15.30	13.00	12.30	13.30
Q3	32.22	32.00	31.50	31.50	29.25	29.75	28.62	28.30
Q1	23.85	24.00	23.50	24.00	21.65	21.17	20.45	21.25

	SPWATER	P3WATER	MHDO	CUDO	IRDO	CDO	MHSAL	CUSAL
N	15	15	41	42	42	41	42	42
NMISS	27	27	1	0	0	1	0	0
MEAN	29.10	28.92	3.54	3.38	3.18	4.06	30.57	27.01
MEDIAN	29.00	29.00	3.30	3.35	3.05	3.40	29.50	26.00
TMEAN	28.65	28.60	3.31	3.31	3.10	3.91	30.24	26.61
STDEV	4.23	3.88	2.93	1.41	1.39	2.95	8.93	6.13
SEMEAN	1.09	1.00	0.46	0.22	0.21	0.46	1.38	0.95
MAX	40.00	38.00	12.40	7.80	7.20	10.50	52.00	47.00
MIN	24.00	24.00	0.20	1.40	1.30	0.40	16.00	17.00
Q3	32.00	31.10	4.75	4.25	4.13	5.35	37.12	30.00
Q1	26.00	26.00	1.15	2.10	1.93	1.75	23.00	23.00

	IRSAL	CSAL	SPSAL	P3SAL	MHpH	CUpH	IRpH	CpH
N	42	41	23	23	39	39	39	39
NMISS	0	1	19	19	3	3	3	3
MEAN	26.23	17.69	29.8	28.09	7.879	7.894	7.931	7.922
MEDIAN	26.00	18.00	24.0	25.00	7.850	7.900	7.900	7.900
TMEAN	26.28	17.47	29.2	27.81	7.884	7.899	7.927	7.925
STDEV	4.78	6.41	11.8	9.01	0.362	0.318	0.278	0.362
SEMEAN	0.74	1.00	2.5	1.88	0.058	0.051	0.044	0.058
MAX	35.00	35.00	57.0	46.00	8.550	8.600	8.750	8.800
MIN	15.00	7.00	16.0	16.00	7.130	7.200	7.300	7.180
Q3	30.00	21.00	39.0	36.00	8.200	8.150	8.100	8.200
Q1	23.00	12.00	21.0	21.00	7.630	7.700	7.720	7.680

	MHLEVEL	CULEVEL	IRLEVEL	CLEVEL	SPLEVEL	P3LEVEL
N	38	38	38	39	33	32
NMISS	4	4	4	3	9	10
MEAN	0.365	1.480	3.223	0.534	1.641	1.631
MEDIAN	0.390	1.515	3.300	0.590	1.630	1.630
TMEAN	0.388	1.484	3.214	0.508	1.726	1.717
STDEV	0.508	0.467	0.479	0.626	0.610	0.617
SEMEAN	0.082	0.076	0.078	0.100	0.106	0.109
MAX	1.300	2.350	4.350	2.500	2.390	2.390
MIN	-1.200	0.480	2.370	-0.480	-0.330	-0.330
Q3	0.730	1.833	3.570	0.970	1.965	1.950
Q1	0.110	1.165	2.810	0.020	1.510	1.505

TABLE 4. Pearson correlation coefficients among physical variables measured at the different stations. * = P⩽0.05, ** = P⩽0.01, *** = P⩽0.001, NS = P>0.05, NM = variable not measured at that station.

		N	MOLE HOLE	P.	CULVERT	P.	I. RIVER	P.	CONTROL	P.	SP-2	P.	P-3	P.
TEMPERATURE	MOLE HOLE	(41)	-		0.935	***	0.924	***	0.804	***	0.342	NS	0.401	NS
	CULVERT	(42)			-		0.957	***	0.859	***	0.309	NS	0.358	NS
	I.RIVER	(42)					-		0.892	***	0.436	NS	0.509	NS
	CONTROL	(41)							-		0.373	NS	0.447	NS
	SP-2	(15)									-		0.970	***
	P-3	(15)											-	
D.O.	MOLE HOLE	(41)	-		0.169	NS	-0.033	NS	-0.199	NS	NM		NM	
	CULVERT	(42)			-		0.690	***	0.011	NS	NM		NM	
	I. RIVER	(42)					-		-0.001	NS	NM		NM	
	CONTROL	(41)							-		NM		NM	
SALINITY	MOLE HOLE	(42)	-		0.881	***	0.851	***	0.721	***	0.847	***	0.802	***
	CULVERT	(42)			-		0.899	***	0.768	***	0.753	***	0.722	***
	I. RIVER	(42)					-		0.725	***	0.694	***	0.685	***
	CONTROL	(42)							-		0.714	***	0.686	***
	SP-2	(23)									-		0.981	***
	P-3	(23)											-	
pH	MOLE HOLE	(39)	-		0.266	NS	0.328	*	0.277	NS	NM		NM	
	CULVERT	(39)			-		0.675	***	0.375	*	NM		NM	
	I. RIVER	(39)					-		0.297	NS	NM		NM	
	CONTROL	(39)							-		NM		NM	
LEVEL	MOLE HOLE	(38)	-		0.931	***	0.670	***	0.372	*	0.533	**	0.182	NS
	CULVERT	(38)			-		0.729	***	0.459	**	0.572	***	0.233	NS
	I. RIVER	(38)					-		0.391	*	0.600	***	0.125	NS
	CONTROL	(39)							-		0.052	NS	-0.082	NS
	SP-2	(33)									-		0.492	**
	P-3	(32)											-	

TABLE 5: Pearson correlation coefficients among physical variables measured at each station. * = P≤ 0.05, **P≤ 0.01, ***P≤ 0.001, NS = P>0.05, NM = variable not measured at that station.

Station		N	TEMP	P.	DO	P.	SAL	P.	pH	P.	LEVEL	P.
MOLE HOLE	TEMP	(41)	-		0.188	NS	0.447	**	0.065	NS	-0.428	**
	DO	(41)			-		0.158	NS	0.264	NS	-0.263	NS
	SAL	(42)					-		0.270	NS	-0.460	**
	pH	(39)							-		-0.551	***
	LEVEL	(38)									-	
CULVERT	TEMP	(42)	-		-0.367	*	0.277	NS	0.215	NS	-0.475	**
	DO	(42)			-		-0.146	NS	0.164	NS	-0.106	NS
	SAL	(42)					-		0.444	**	-0.415	**
	pH	(39)							-		-0.439	**
	LEVEL	(38)									-	
INDIAN RIVER	TEMP	(42)	-		-0.691	***	0.190	NS	0.209	NS	-0.333	*
	DO	(42)			-		-0.040	NS	-0.086	NS	-0.176	NS
	SAL	(42)					-		0.353	*	-0.385	*
	pH	(39)							-		-0.297	NS
	LEVEL	(38)									-	
CONTROL CELL	TEMP	(41)	-		-0.243	NS	0.266	NS	0.118	NS	-0.560	***
	DO	(41)			-		0.177	NS	-0.012	NS	-0.141	NS
	SAL	(42)					-		0.134	NS	-0.758	***
	pH	(39)							-		-0.004	NS
	LEVEL	(39)									-	
SP-2	TEMP	(15)	-		NM		0.585	*	NM		-0.498	*
	SAL	(23)					-		NM		-0.545	**
	LEVEL	(33)							NM		-	
P-3	TEMP	(15)	-		NM		0.640	*	NM		-0.396	NS
	SAL	(23)					-		NM		-0.408	NS
	LEVEL	(32)							NM		-	

TABLE 6. Correlation (Pearson) between precipitation and other physical variables. * = $P \leq 0.05$, ** = $P \leq 0.01$, NS = $P \leq 0.05$

	γ	P.		γ	P.
Mole Hole			Control		
Water Temp.	0.031	NS	Water Temp	0.056	NS
D.O.	0.076	NS	D.O.	0.122	NS
Salinity	-0.403	**	Salinity	-0.460	**
pH	-0.247	NS	pH	0.002	NS
Water Level	0.319	*	Water Level	0.178	NS
Culvert			SP-2		
Water Temp.	0.075	NS	Water Temp.	-0.219	NS
D.O.	-0.089	NS	D.O.	-	-
Salinity	-0.419	**	Salinity	-0.426	*
pH	-0.268	NS	pH	-	-
Water Level	0.268	NS	Water Level	0.247	NS
Indian River			P-3		
Water Temp.	0.054	NS	Water Temp.	-0.257	NS
D.O.	-0.020	NS	D.O.	-	-
Salinity	-0.455	**	Salinity	-0.437	*
pH	-0.239	NS	pH	-	-
Water Level	0.236	NS	Water Level	0.354	*

Table 7. Descriptive statistics for mangrove growth at the experimental and control sites. The first seven columns after eSPECIES (code for the different species) give statistics for the size of the specimens at the experimental site (e) on the individual sampling dates (i.e. 3-82 = Feb. 1982). The following 6 columns (labelled GR-1 - GR-6) give statistics for growth during succesive periods (i.e. GR-1 = growth between 3/82 and 8/82). GR-TOT = statistics for growth from 3/82 to 11/83. The pattern is then repeated for seedlings at the control site (c). Other abbreviations as in Table 3.

TABLE 7.

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$ type red.des;2
```

******************IRC # 12 MANGROVE DATA: REDS********************************

Descriptive Statistics

	e3-82	e8-82	e11-82	e3-83	e5-83	e8-83	e11-83	eGR-1
N	12	11	11	10	9	9	9	11
NMISS	0	1	1	2	3	3	3	1
MEAN	59.7	56.8	64.6	64.6	68.8	71.6	76.3	0.45
MEDIAN	55.1	53.9	57.4	57.0	58.2	60.0	68.0	0.30
TMEAN	58.6	57.0	64.7	65.0	68.8	71.6	76.3	0.33
STDEV	18.7	16.0	19.5	21.2	20.1	20.7	21.7	2.76
SEMEAN	5.4	4.8	5.9	6.7	6.7	6.9	7.2	0.83
MAX	97.4	80.6	95.5	92.2	96.7	101.0	106.0	5.90
MIN	33.0	31.1	32.2	33.7	43.5	46.2	49.2	-4.00
Q3	74.2	74.1	81.5	88.7	89.1	93.6	99.1	2.20
Q1	46.8	42.4	49.1	48.5	52.9	55.4	57.3	-1.50

	eGR-2	eGR-3	eGR-4	eGR-5	eGR-6	eGR-TOT	ePCTGR	c4-82
N	11	10	9	9	9	9	9	26
NMISS	1	2	3	3	3	3	3	0
MEAN	7.83	1.41	0.74	2.77	4.70	18.3	0.325	65.1
MEDIAN	5.40	1.05	0.60	2.70	3.70	12.3	0.199	65.5
TMEAN	6.47	1.03	0.74	2.77	4.70	18.3	0.325	64.2
STDEV	7.92	4.43	1.94	1.86	4.31	14.0	0.282	21.3
SEMEAN	2.39	1.40	0.65	0.62	1.44	4.7	0.094	4.2
MAX	27.60	10.70	4.50	5.50	12.10	48.0	1.000	120.9
MIN	0.30	-4.80	-2.30	-0.50	-2.00	2.8	0.060	29.9
Q3	11.60	2.75	1.90	4.25	8.15	27.4	0.429	78.8
Q1	2.30	-0.82	-0.45	1.35	2.10	8.8	0.163	48.4

	c8-82	c11-82	c3-83	c6-83	c8-83	c11-83	cGR-1	cGR-2
N	26	26	26	26	26	25	26	26
NMISS	0	0	0	0	0	1	0	0
MEAN	82.1	96.4	103.2	115.7	129.3	145.2	17.0	14.3
MEDIAN	80.3	93.6	100.5	103.6	112.0	131.5	16.9	13.3
TMEAN	81.3	95.7	102.6	114.3	127.9	144.0	16.7	14.3
STDEV	24.7	30.0	31.8	39.8	44.3	47.2	11.6	11.0
SEMEAN	4.8	5.9	6.2	7.8	8.7	9.4	2.3	2.2
MAX	141.2	162.0	171.3	212.0	224.0	235.5	39.8	38.8
MIN	42.4	47.1	49.8	55.0	69.0	81.3	0.4	-8.4
Q3	96.1	110.3	124.9	136.7	160.0	185.9	27.1	22.9
Q1	64.7	78.0	79.6	87.3	93.6	104.7	8.3	4.7

	cGR-3	cGR-4	cGR-5	cGR-6	cGR-TOT	cPCTGR
N	26	26	26	25	25	25
NMISS	0	0	0	1	1	1
MEAN	6.76	12.6	13.60	19.6	80.6	1.355
MEDIAN	5.85	7.2	12.30	19.6	67.4	1.304
TMEAN	6.65	9.1	13.26	19.5	79.7	1.311
STDEV	6.19	20.6	8.37	10.1	38.2	0.738
SEMEAN	1.21	4.0	1.64	2.0	7.6	0.148
MAX	18.50	109.0	32.90	41.7	161.5	3.473
MIN	-2.50	-1.1	2.60	0.0	20.9	0.244
Q3	10.53	12.9	19.50	27.1	114.0	1.710
Q1	1.38	3.5	6.45	12.0	53.2	0.816

TABLE 7 (Continued).

********************IRC # 12 MANGROVE DATA: BLACKS***************************

Descriptive Statistics

	eSPECIES	e3-82	e8-82	e11-82	e3-83	e5-83	e8-83	e11-83
N	>6	56	53	54	54	55	55	51
NMISS	0	0	3	2	2	1	1	5
MEAN	2.00000	56.8	68.0	75.5	79.7	83.8	88.1	95.0
MEDIAN	2.00000	50.9	60.4	68.4	72.7	76.8	81.8	86.9
TMEAN	2.00000	54.0	65.4	72.9	76.8	80.6	84.8	91.7
STDEV	0.00000	27.8	27.3	28.1	27.8	30.6	31.1	33.0
SEMEAN	0.00000	3.7	3.7	3.8	3.8	4.1	4.2	4.6
MAX	2.00000	184.3	182.6	187.7	196.6	207.0	207.6	208.0
MIN	2.00000	17.0	36.7	37.0	48.2	50.5	52.6	54.3
Q3	2.00000	67.6	81.5	90.6	93.5	100.0	101.9	113.8
Q1	2.00000	39.1	48.4	55.3	59.8	61.2	66.3	70.3

	eGR-1	eGR-2	eGR-3	eGR-4	eGR-5	eGR-6	eGR-TOT	cSPECIES
N	53	52	54	54	55	51	51	46
NMISS	3	4	2	2	1	5	5	0
MEAN	10.19	8.04	4.14	3.83	4.30	6.35	37.2	2.00000
MEDIAN	8.10	7.10	2.55	2.35	3.50	4.60	34.4	2.00000
TMEAN	9.70	7.72	3.24	3.32	3.98	5.79	36.2	2.00000
STDEV	8.74	6.94	7.05	5.53	4.31	8.12	23.6	0.00000
SEMEAN	1.20	0.96	0.96	0.75	0.58	1.14	3.3	0.00000
MAX	34.00	26.70	37.30	22.60	18.70	37.20	106.0	2.00000
MIN	-3.90	-2.10	-5.60	-5.30	-1.70	-7.00	-5.4	2.00000
Q3	14.15	13.37	4.38	5.35	7.10	12.00	51.9	2.00000
Q1	4.70	1.62	0.63	0.38	0.60	0.60	18.9	2.00000

	c4-82	c8-82	c11-82	c3-83	c6-83	c8-83	c11-83	cGR-1
N	46	46	45	45	46	46	42	46
NMISS	0	0	1	1	0	0	4	0
MEAN	80.8	106.8	115.6	123.4	132.0	140.2	149.7	26.0
MEDIAN	84.5	107.2	112.8	125.0	120.8	130.4	140.6	22.3
TMEAN	80.8	106.2	113.7	122.2	130.8	139.4	148.5	25.1
STDEV	21.1	34.2	39.8	41.6	45.3	45.9	47.9	17.9
SEMEAN	3.1	5.0	5.9	6.2	6.7	6.8	7.4	2.6
MAX	122.4	181.5	222.1	222.0	235.6	236.1	258.7	74.1
MIN	39.8	44.1	42.5	46.1	46.7	61.1	61.7	-6.7
Q3	98.0	129.3	139.1	154.7	168.3	181.6	184.6	36.0
Q1	63.7	78.8	82.1	86.2	97.7	103.8	107.0	12.6

	cGR-2	cGR-3	cGR-4	cGR-5	cGR-6	cGR-TOT	ePCTGR	cPCTGR
N	45	44	45	46	42	42	51	42
NMISS	1	2	1	0	4	4	5	4
MEAN	9.6	6.12	9.09	8.19	12.0	69.0	0.837	0.870
MEDIAN	5.7	4.00	8.30	5.90	9.9	76.2	0.683	0.867
TMEAN	9.0	5.24	9.16	7.25	11.6	68.2	0.778	0.866
STDEV	11.4	7.83	8.63	9.67	10.4	35.8	0.713	0.428
SEMEAN	1.7	1.18	1.29	1.43	1.6	5.5	0.100	0.066
MAX	40.6	44.10	25.30	52.30	36.7	149.3	3.988	1.832
MIN	-7.3	-1.60	-8.50	-6.80	-5.0	6.7	-0.080	0.122
Q3	15.0	9.68	16.30	13.75	15.7	93.2	1.335	1.223
Q1	2.2	1.20	3.25	1.55	5.1	39.0	0.332	0.552

TABLE 7 (Continued)

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$ type white.des
*******************IRC # 12 MANGROVE DATA: WHITES*****************************
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Descriptive Statistics

	eSPECIES	e3-82	e8-82	e11-82	e3-83	e5-83	e8-83	e11-83
N	9	9	9	9	9	9	9	8
NMISS	0	0	0	0	0	0	0	1
MEAN	3.00000	77.4	85.3	90.6	95.5	98.4	99.8	103.9
MEDIAN	3.00000	73.6	83.7	83.5	97.0	104.4	104.2	100.7
TMEAN	3.00000	77.4	85.3	90.6	95.5	98.4	99.8	103.9
STDEV	0.00000	15.9	19.6	21.4	21.2	22.6	21.7	24.3
SEMEAN	0.00000	5.3	6.5	7.1	7.1	7.5	7.2	8.6
MAX	3.00000	109.3	126.3	130.4	127.3	130.4	130.7	139.8
MIN	3.00000	54.2	59.6	61.2	63.3	60.0	62.8	73.2
Q3	3.00000	86.9	95.7	105.5	114.2	117.1	117.9	127.1
Q1	3.00000	69.7	70.1	75.3	79.0	82.6	83.5	84.0

	eGR-1	eGR-2	eGR-3	eGR-4	eGR-5	eGR-6	eGR-TOT	cSPECIES
N	9	9	9	9	9	8	8	25
NMISS	0	0	0	0	0	0	0	0
MEAN	7.92	5.21	5.0	2.87	1.47	7.91	30.5	3.00000
MEDIAN	5.40	4.10	0.3	3.10	0.30	7.85	22.2	3.00000
TMEAN	7.92	5.21	5.0	2.87	1.47	7.91	30.5	3.00000
STDEV	8.11	6.03	10.7	3.35	3.29	6.81	21.6	0.00000
SEMEAN	2.70	2.01	3.6	1.12	1.10	2.41	7.6	0.00000
MAX	22.60	17.10	28.5	7.40	7.40	19.00	65.3	3.00000
MIN	-2.50	-3.30	-3.1	-3.30	-2.50	-0.50	5.4	3.00000
Q3	14.70	8.55	10.2	5.50	4.20	13.85	52.7	3.00000
Q1	2.00	0.70	-1.7	0.70	-1.05	1.77	13.5	3.00000

	c4-82	c8-82	c11-82	c3-83	c6-83	c8-83	c11-83	cGR-1
N	25	25	25	25	25	25	24	25
NMISS	0	0	0	0	0	0	1	0
MEAN	75.4	104.1	116.8	123.4	138.9	142.8	154.5	28.7
MEDIAN	68.4	98.0	108.7	117.3	123.5	124.3	145.7	24.9
TMEAN	74.9	101.9	115.0	121.6	137.6	141.3	153.9	27.8
STDEV	26.0	38.6	42.4	44.5	49.5	51.3	47.4	21.3
SEMEAN	5.2	7.7	8.5	8.9	9.9	10.3	9.7	4.3
MAX	130.0	210.3	218.5	227.7	241.0	253.2	255.0	80.3
MIN	31.5	48.4	56.3	62.3	67.3	67.3	66.6	-3.8
Q3	95.0	129.4	152.2	158.8	178.9	184.3	195.4	46.6
Q1	55.5	75.7	83.4	92.3	105.7	109.6	120.8	13.3

	cGR-2	cGR-3	cGR-4	cGR-5	cGR-6	cGR-TOT	ePCTGR	cPCTGR
N	25	25	25	25	24	24	8	24
NMISS	0	0	0	0	0	0	0	0
MEAN	12.7	6.67	15.5	3.86	15.1	79.9	0.421	1.188
MEDIAN	8.5	5.00	10.4	3.90	13.5	82.0	0.323	1.096
TMEAN	11.8	6.45	11.9	3.75	14.6	79.6	0.421	1.175
STDEV	15.1	7.03	22.7	4.77	14.4	36.5	0.292	0.617
SEMEAN	3.0	1.41	4.5	0.95	2.9	7.4	0.103	0.126
MAX	53.1	25.70	113.1	13.70	42.7	155.9	0.877	2.594
MIN	-6.9	-7.40	-0.5	-3.40	-2.6	9.3	0.068	0.080
Q3	15.9	11.50	17.6	6.35	28.0	96.8	0.723	1.585
Q1	2.6	1.75	3.2	0.50	1.5	62.0	0.185	0.829

TABLE 8: Data on mangrove deaths at the experimental (E) and control (C) sites.

	3-82	8-82	11-82	3-83	5-83	8-83	11-83
R. mangle							
E (N = 22)							
Total No. Dead	0	1	1	4	6	7	13
No. Died in Interval	0	1	0	3	2	1	6
No. Remaining	22	21	21	18	16	15	9
Proportion Dead	0	0.045	0.045	0.182	0.272	0.318	0.590
Proportion Died in Interval	0	0.045	0	0.143	0.111	0.063	0.400
C (N = 28)							
Total No. Dead	0	1	1	2	2	2	2
No. Died in Interval	0	1	0	1	0	0	0
No. Remaining	28	27	27	26	26	26	26
Proportion Dead	0	0.036	0.036	0.071	0.071	0.071	0.071
Proportion Died in Interval	0	0.036	0	0.037	0	0	0
A. germinans							
E (N = 73)							
Total No. Dead	0	1	2	3	7	7	19
No. Died in Interval	0	1	1	1	4	0	12
No. Remaining	73	72	71	70	66	66	54
Proportion Dead	0	0.014	0.027	0.041	0.096	0.096	0.260
Proportion Died in Interval	0	0.013	0.014	0.014	0.057	0	0.182
C (N = 47)							
Total No. Dead	0	1	1	1	1	1	1
No. Died in Interval	0	1	0	0	0	0	0
No. Remaining	47	46	46	46	46	46	46
Proportion Dead	0	0.021	0.021	0.021	0.021	0.021	0.021
Proportion Died in Interval	0	0.021	0	0	0	0	0
L. racemosa							
E (N = 13)							
Total No. Dead	0	0	0	0	2	2	3
No. Died in Interval	0	0	0	0	2	0	1
No. Remaining	13	13	13	13	11	11	10
Proportion Dead	0	0	0	0	0.154	0.154	0.231
Proportion Died in Interval	0	0	0	0	0.154	0	0.091
C (N = 25)							
Total No. Dead	0	0	0	0	0	0	0
No. Died in Interval	0	0	0	0	0	0	0
No. Remaining	0	0	0	0	0	0	0
Proportion Dead	0	0	0	0	0	0	0
Proportion Died in Interval	0	0	0	0	0	0	0

Table 9. Descriptive statistics for mangrove growth for all specimens surviving to 11/82. Abbreviations as in Table 7.

TABLE 9.

****************IRC # 12 MANGROVE DATA (Alive by 11/83)*********************

	PLANTn	eSPECIES	e3-82	e8-82	e11-82	e3-83	e5-83	e8-83
N	108	77	77	73	74	73	73	73
NMISS	0	0	0	4	3	4	4	4
MEAN	54.5	1.961	59.7	68.5	75.7	79.6	83.8	87.5
MEDIAN	54.5	2.000	54.0	62.3	70.2	73.6	77.9	84.3
TMEAN	54.5	1.957	57.6	66.3	73.6	77.5	81.2	84.8
STDEV	31.3	0.524	26.1	25.9	26.9	27.1	29.3	29.6
SEMEAN	3.0	0.060	3.0	3.0	3.1	3.2	3.4	3.5
MAX	108.0	3.000	184.3	182.6	187.7	196.6	207.0	207.6
MIN	1.0	1.000	17.0	31.1	32.2	33.7	43.5	46.2
Q3	81.7	2.000	72.1	82.2	90.6	93.8	100.0	102.5
Q1	27.2	2.000	42.2	50.5	55.6	59.0	60.1	65.3

	e11-83	eGR-1	eGR-2	eGR-3	eGR-4	eGR-5	eGR-6	eGR-TOT
N	68	73	72	73	72	73	68	68
NMISS	9	4	5	4	5	4	9	9
MEAN	93.6	8.44	7.66	3.86	3.32	3.76	6.32	33.9
MEDIAN	87.1	6.50	6.95	1.90	1.95	3.00	4.70	30.3
TMEAN	91.2	7.80	7.25	2.95	2.84	3.46	5.90	32.9
STDEV	31.4	8.69	6.96	7.26	5.06	4.07	7.55	23.1
SEMEAN	3.8	1.02	0.82	0.85	0.60	0.48	0.92	2.8
MAX	208.0	34.00	27.60	37.30	22.60	18.70	37.20	106.0
MIN	49.2	-4.00	-3.30	-5.60	-5.30	-2.50	-7.00	-5.4
Q3	112.2	13.65	11.47	4.00	4.88	5.95	11.25	47.6
Q1	70.3	2.15	1.63	0.20	0.33	0.55	1.13	17.1

	cSPECIES	c4-82	c8-82	c11-82	c3-83	c6-83	c8-83	c11-83
N	97	97	97	96	96	97	97	91
NMISS	0	0	0	1	1	0	0	6
MEAN	1.990	75.2	99.5	110.7	117.9	129.4	138.0	149.7
MEDIAN	2.000	72.6	95.9	103.8	113.3	120.1	124.3	140.4
TMEAN	1.989	74.9	97.9	108.6	116.1	127.6	136.5	148.3
STDEV	0.729	23.2	34.6	38.8	40.6	45.4	46.7	47.2
SEMEAN	0.074	2.4	3.5	4.0	4.1	4.6	4.7	4.9
MAX	3.000	130.0	210.3	222.1	227.7	241.0	253.2	258.7
MIN	1.000	29.9	43.4	42.5	46.1	46.7	61.1	61.7
Q3	3.000	92.6	119.6	131.8	146.6	165.6	177.8	185.7
Q1	1.000	57.4	76.1	81.2	86.8	96.2	103.5	113.0

	cGR-1	cGR-2	cGR-3	cGR-4	cGR-5	cGR-6	cGR-TOT
N	97	96	95	96	97	91	91
NMISS	0	1	2	1	0	6	6
MEAN	24.3	11.7	6.44	11.7	8.52	14.9	75.0
MEDIAN	20.8	8.4	4.90	8.6	6.20	12.3	74.8
TMEAN	23.1	10.9	5.90	9.6	7.77	14.5	74.3
STDEV	17.9	12.4	7.14	16.8	8.97	11.8	36.6
SEMEAN	1.8	1.3	0.73	1.7	0.91	1.2	3.8
MAX	80.3	53.1	44.10	113.1	52.30	42.7	161.5
MIN	-6.7	-8.4	-7.40	-8.5	-6.80	-5.0	6.7
Q3	34.2	17.1	9.70	16.2	13.65	23.5	99.5
Q1	10.5	3.7	1.50	3.4	2.35	5.5	46.8

TABLE 10. Results of t-tests (t) and Mann-Whitney Tests (W) for differences in growth by Red, Black and White mangroves at the experimental (E) and control (C) sites during the intervals shown. * = P.≤0.05, ** = P.≤0.01, *** = P.≤0.001, NS = P.>0.05. Individuals that died by 11/83 were excluded from all calculations.

<u>R. mangle</u>

INTERVAL	S	N	MEAN	SE	MEDIAN	DF	t	P.	W	P.
	E	11	0.45	0.82	0.30					
3/82- 8/82						31	6.83	***	84.0	***
	C	26	17.00	2.30	16.95					
	E	11	7.83	2.40	5.40					
8/82-11/82						26	2.03	*	149.5	*
	C	26	14.30	2.20	13.30					
	E	10	1.41	1.40	1.05					
11/82- 3/83						23	2.88	**	118.0	**
	C	26	6.76	1.20	5.85					
	E	9	0.74	0.65	0.60					
3/83- 5/83						26	2.89	**	59.5	***
	C	26	12.60	4.00	7.25					
	E	9	2.77	0.62	2.70					
5/83- 8/83						31	6.17	***	62.0	***
	C	26	13.60	1.60	12.30					
	E	9	4.70	1.40	3.70					
8/83-11/83						31	6.02	***	66.5	***
	C	25	19.60	2.00	19.60					
	E	9	18.30	4.70	12.30					
3/82-11/83						32	6.97	***	52.0	***
	C	25	80.60	7.60	67.40					

TABLE 10. (Continued).

A. germinans

INTERVAL	S	N	MEAN	SE	MEDIAN	DF	t	P.	W	P.
	E	53	10.19	1.20	8.10					
3/82- 8/82						63	5.45	***	1946.5	***
	C	46	26.00	2.60	22.3					
	E	52	8.04	0.96	7.10					
8/82-11/82						71	0.79	ns	2551.5	ns
	C	45	9.60	1.70	5.70					
	E	54	4.14	0.96	2.55					
11/82- 3/83						88	1.31	ns	2412.0	ns
	C	44	6.12	1.20	4.00					
	E	54	3.83	0.75	2.35					
3/83- 5/83						72	3.53	***	2219.5	***
	C	45	9.09	1.30	8.30					
	E	55	4.30	0.58	3.50					
5/83- 8/83						60	2.52	*	2485.0	*
	C	46	8.19	1.40	5.90					
	E	51	6.35	1.10	4.60					
8/83-11/83						77	2.86	**	2043.0	**
	C	42	12.00	1.60	9.95					
	E	51	37.20	3.30	34.40					
3/82-11/83						69	4.94	***	1833.5	***
	C	42	69.00	5.50	76.15					

TABLE 10. (Continued).

L. *racemosa*

INTERVAL	S	N	MEAN	SE	MEDIAN	DF	t	P.	W	P.
	E	9	7.92	2.70	5.40					
3/82- 8/82						32	4.11	***	88.0	**
	C	25	28.70	4.30	24.90					
	E	9	5.21	2.00	4.10					
8/82-11/82						31	2.07	*	120.0	ns
	C	25	12.70	3.00	8.50					
	E	9	5.00	3.60	0.30					
11/82- 3/83						11	0.45	ns	120.0	ns
	C	25	6.67	1.40	5.00					
	E	9	2.87	1.10	3.10					
3/83- 5/83						27	2.69	*	93.5	*
	C	25	15.50	4.50	10.40					
	E	9	1.47	1.10	0.30					
5/83- 8/83						21	1.65	ns	123.0	ns
	C	25	3.86	0.95	3.90					
	E	8	7.91	2.40	7.85					
8/83-11/83						26	1.89	ns	113.0	ns
	C	24	15.1	2.90	13.45					
	E	8	30.5	7.60	22.20					
3/82-11/83						21	4.63	***	58.0	**
	C	24	79.9	7.40	82.00					

TABLE 11. Results of t-tests (t) and Mann-Whitney Tests (W) for differences in proportional growth of mangroves at the experimental (E) and control (C) sites. Proportional growth = (final size-initial size)/initial size. *** = P.$\leqslant$0.001, NS = P.>0.05.

SPECIES	S	N	MEAN	S.E.	MEDIAN	DF	t	P.	W	P.
	E	9	0.33	0.09	0.20					
R. mangle						32	5.88	***	60	***
	C	25	1.36	0.15	1.30					
	E	51	0.84	0.10	0.68					
A. germinans						84	0.27	ns	2277	ns
	C	42	0.87	0.07	0.87					
	E	8	0.42	0.10	0.32					
L. racemosa						26	4.71	***	59	***
	C	24	1.19	0.13	1.10					

TABLE 12. Changes (Δ) in relative frequency of the more common plant species in the quadrats along the transects at the experimental (E) and control (C) sites. Sixty quadrats were measured at each site during each sampling date.

		R. mangle	*A. germinans*	*L. racemosa*	*C. erectus*	*S. virginica*	*S. bigelovii*	*B. maritima*	*R. maritima*	*S. linearis*	*P. vermicularis*
4/82	C	.0167	.0500	.0167	0	.6333	.4500	.1667	.0167	0	.0167
5/83		0	.1186	.1017	0	.4915	0	.2034	.4746	0	0
Δ		-.0167	.0686	.085	0	-.1418	-.4500	.0367	.4579	0	-.0167
[illegible]/82	E	0	.0167	.0167	0	.3500	.6167	.0833	.0167	0	0
5/83		0	0	.0167	.0167	.3500	.1833	.2167	0	0	0
Δ		0	-.0167	0	.0167	0	-.4334	.1334	-.0167	0	0
7/82	C	.0333	.1167	.0500	0	.6500	.2167	.1500	.1167	0	.0167
8/83		.0167	.1667	.1500	0	.6167	.0667	.3000	0	0	0
Δ		-.0166	.0500	.1000		-.0333	-.1500	.1500	-.1167	0	-.0167
7/82	E	0	0	.0167	.0167	.3167	.5000	.1667	.0333	0	0
8/83		0	.0167	.0167	0	.3333	.2333	.2500	0	.0167	0
Δ		0	.0167	0	-.0167	.0166	-.2667	.0833	-.0333	.0167	0
11/82	C	.0339	.1186	.1017	0	.5932	0	.2034	0	0	0
11/83		.0678	.2712	.1379	0	.3793	.0517	.1897	.4137	.0345	0
Δ		.0339	.1526	.0362	0	-.2139	.0517	-.0137	.4137	.0345	0
11/82	E	0	0	.0167	0	.3167	0	.2333	.1000	0	0
11/83		0	.0167	.0167	.0167	.2333	.1333	.2500	0	0	0
Δ		0	.0167	0	.0167	-.0834	.1333	.0167	-.1000	0	0

Table 13. Descriptive statistics for frequency of occurrence of the different species during the quadrat surveys. Species names are as follows: RMANGLE = *Rhizophora mangle*, AGERMIN = *Avicennia germinans*, LRACEM = *Laguncularia racemosa*, CERECT = *Conocarpus erectus*, SVIRG = *Salicornia virginica*, SBIGELV = *Salicornia bigelovii*, BMAR = *Batis maritima*, RMAR = *Ruppia maritima*, SLIN = *Sueda linearis*, PVERM = *Philoxerus vermicularis*. Letter preceeding species names indicate control (c) or experimental (e) cells. Other abbreviations as in Table 3.

TABLE 13.

**************************IRC # 12: TRANSECT DATA********************************

~ Descriptive Statistics ~

(Frequency of Occurrence)

	cRMANGLE	cAGERMIN	cLRACEM	cCERECT	cSVIRG	cSBIGELV	cBMAR	cRMAR
N	6	6	6	6	6	6	6	6
MEAN	0.0281	0.1403	0.0930	0	0.561	0.208	0.2022	0.170
MEDIAN	0.0250	0.1186	0.1017	0	0.605	0.142	0.1966	0.067
TMEAN	0.0281	0.1403	0.0930	0	0.561	0.208	0.2022	0.170
STDEV	0.0232	0.0741	0.0512	0	0.105	0.228	0.0524	0.217
SEMEAN	0.0095	0.0303	0.0209	0	0.043	0.093	0.0214	0.089
MAX	0.0678	0.2712	0.1500	0	0.650	0.517	0.3000	0.475
MIN	0.0000	0.0500	0.0167	0	0.379	0.000	0.1500	0.000
Q3	0.0424	0.1928	0.1409	0	0.637	0.467	0.2275	0.429
Q1	0.0125	0.1000	0.0417	0	0.463	0.000	0.1625	0.000

	cSLIN	cPVERMIC	eRMANGLE	eAGERMIN	eLRACEM	eCERECT	eSVIRG	eSBIGELV
N	6	6	6	6	6	6	6	6
MEAN	0.058	0.00557	0	0.00835	1.67E-02	0.00835	0.3167	0.278
MEDIAN	0.000	0.00000	0	0.00835	1.67E-02	0.00835	0.3250	0.208
TMEAN	0.058	0.00557	0	0.00835	1.67E-02	0.00835	0.3167	0.278
STDEV	0.141	0.00862	0	0.00915	0.00E+00	0.00915	0.0435	0.234
SEMEAN	0.057	0.00352	0	0.00373	0.00E+00	0.00373	0.0177	0.095
MAX	0.345	0.01670	0	0.01670	1.67E-02	0.01670	0.3500	0.617
MIN	0.000	0.00000	0	0.00000	1.67E-02	0.00000	0.2333	0.000
Q3	0.086	0.01670	0	0.01670	1.67E-02	0.01670	0.3500	0.529
Q1	0.000	0.00000	0	0.00000	1.67E-02	0.00000	0.2959	0.100

	eBMAR	eRMAR	eSLIN	ePVERMIC
N	6	6	6	6
MEAN	0.2000	0.0250	0.00278	0
MEDIAN	0.2250	0.0083	0.00000	0
TMEAN	0.2000	0.0250	0.00278	0
STDEV	0.0650	0.0391	0.00682	0
SEMEAN	0.0265	0.0160	0.00278	0
MAX	0.2500	0.1000	0.01670	0
MIN	0.0833	0.0000	0.00000	0
Q3	0.2500	0.0500	0.00417	0
Q1	0.1459	0.0000	0.00000	0

TABLE 14. Comparison of mean percent coverage of various species between the experimental (E) and control (c) sites.

A. germinans	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82	C	60	0.55	0.30	64	1.55	0.13
	E	60	0.07	0.07			
8/82	C	-	-	-	-	-	-
	E	-	-	-			
11/82	C	-	-	-	-	-	-
	E	-	-	-			
2/83	C	60	4.00	1.80	61	2.03	0.05
	E	60	0.30	0.23			
5/83	C	59	2.20	0.98	58	2.19	0.03
	E	60	0.05	0.05			
8/83	C	60	4.40	1.80	69	2.12	0.04
	E	60	0.52	0.52			
11/83	C	58	11.8	3.10	58	3.70	0.0005
	E	60	0.23	0.23			

L. racemosa	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82	C	60	1.6	1.60	118	0.02	0.98
	E	60	1.6	1.60			
7/82	C	60	2.3	1.70	50	1.25	0.22
	E	60	0.13	0.13			
11/82	C	59	2.6	1.70	117	0.38	0.70
	E	60	1.7	1.70			
2/83	C	60	2.8	1.80	115	0.56	0.57
	E	60	1.5	1.50			
5/83	C	59	3.1	1.80	115	0.63	0.53
	E	60	1.6	1.60			
8/83	C	60	5.9	2.60	101	1.38	0.17
	E	60	1.7	1.70			
	C	58	7.6	3.00	79	1.91	0.06
	E	60	1.3	1.30			

TABLE 14. (Continued)

S. virginica	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82	C	60	16.7	2.80	115	0.74	0.46
	E	60	13.5	3.40			
7/82	C	60	20.3	3.00	118	1.91	0.06
	E	60	11.9	3.10			
11/82	C	59	11.5	2.10	113	0.79	0.43
	E	60	9.0	2.50			
2/83	C	60	15.0	2.70	117	1.20	0.23
	E	60	10.1	3.00			
5/83	C	59	18.8	3.20	115	1.94	0.06
	E	60	10.5	2.80			
8/83	C	60	12.1	2.40	106	0.13	0.90
	E	60	12.6	3.50			
11/83	C	58	10.4	2.60	109	1.08	0.28
	E	60	6.9	2.00			

S. bigelovii	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82	C	60	4.8	1.30	107	-2.47	0.02
	E	60	10.4	1.80			
7/82	C	60	2.70	0.86	79	-3.16	0.002
	E	60	9.80	2.10			
11/82	C	-	-	-	-	-	-
	E	-	-	-			
2/83	C	60	0	0	-	-	-
	E	60	0.18	0.05			
5/83	C	-	-	-	-	-	-
	E	-	-	-			
8/83	C	60	0.22	0.17	61	-1.46	0.15
	E	60	2.20	1.30			
11/83	C	58	0.97	0.63	91	-1.17	0.25
	E	60	2.52	1.20			

TABLE 14. (Continued)

B. maritima	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82	C	60	1.55	0.59	117	0.36	0.72
	E	60	1.23	0.66			
7/82	C	60	2.18	0.79	81	-1.34	0.19
	E	60	4.80	1.80			
11/82	C	59	3.58	1.20	103	-0.50	0.62
	E	60	4.70	1.80			
2/83	C	60	4.10	1.40	105	-0.63	0.53
	E	60	5.60	2.00			
5/83	C	59	8.4	2.80	90	1.29	0.20
	E	60	4.3	1.50			
8/83	C	60	5.1	1.60	116	-0.23	0.82
	E	60	5.7	1.80			
11/83	C	58	3.6	1.30	90	-1.59	0.12
	E	60	8.0	2.50			

R. maritima	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82	C	60	0.017	0.02	59	-1.12	0.27
	E	60	0.48	0.42			
7/82	C	60	4.40	2.20	76	1.49	0.14
	E	60	0.92	0.84			
11/82	C	60	-	0	-	-	-
	E	60	-	-			
2/83	C	60	9.60	2.80	65	2.68	0.0009
	E	60	1.82	0.64			
5/83	C	60	-	-	-	-	-
	E	60	-	-			
8/83	C	60	-	-	-	-	-
	E	60	-	-			
11/83	C	60	-	-	-	-	-
	E	60	-	-			

TABLE 15. T-tests for differences of change in % coverage ofthe more common plant species along the transects in the experimental (E) and control (C) sites.

A. germinans	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82- 5/83	C	59	1.64	0.89	58	1.87	0.67
	E	60	- 0.017	0.02			
7/82- 8/83	C	60	3.00	1.50	73	1.62	0.11
	E	60	0.52	0.52			
11/82-11/83	C	57	9.0	2.60	57	3.39	0.002
	E	60	0.23	0.23			

L. racemosa	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82- 5/83	C	-	-	-	-	-	-
	E	-	-	-			
7/82- 8/83	C	60	3.6	1.90	114	0.87	0.39
	E	60	1.5	1.50			
11/82/11/83	C	57	5.1	2.30	58	2.34	0.02
	E	60	- 0.33	0.33			

S. virginica	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82- 5/83	C	59	2.0	2.80	103	1.50	0.14
	E	60	- 3.0	1.90			
7/82- 8/83	C	60	- 8.1	2.40	118	-2.64	0.009
	E	60	0.7	2.40			
11/82-11/83	C	57	- 0.60	1.60	112	0.59	0.55
	E	60	- 2.10	2.00			

TABLE 15. (Continued)

S. bigelovii	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82- 5/83	C	59	- 4.9	1.30	107	2.36	0.02
	E	60	-10.3	1.80			
7/82- 8/83	C	60	- 2.48	0.80	72	2.01	0.05
	E	60	- 7.60	2.40			
11/82-11/83	C	57	0.98	0.64	91.4	-1.15	0.25
	E	60	2.52	1.20			

B. maritima	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82- 5/83	C	59	6.9	2.50	88	1.35	0.18
	E	60	3.1	1.30			
7/82- 8/83	C	60	2.92	1.10	101	1.07	0.29
	E	60	0.90	1.60			
11/82-11/83	C	57	- 0.5	1.30	106	-1.69	0.09
	E	60	3.3	1.80			

R. maritima	S	N	$\overline{X}$	S.E.	D.F.	t	P.
4/82- 5/83	C	59	35.0	5.90	59	5.98	0.0001
	E	60	- 0.48	0.42			
7/82- 8/83	C	60	- 4.4	2.20	76	-1.49	0.14
	E	60	- 0.92	0.84			
11/81-11/83	C	57	27.5	5.30	57	5.33	0.0001
	E	60	- 0.73	0.50			

TABLE 16. Data on volumes filtered and on net efficiencies for the plankton sampling gear.

SAMPLE	MEAN VOLUME (M^3)	S.E.	MEAN EFFICIENCY	S.E.
Pump 202μ				
Mole Hole	2.962	0.093	-	-
Culvert	2.990	0.063	-	-
River	2.972	0.081	-	-
Control	2.945	0.084	-	-
Overall	2.967	0.039	-	-
Pump 63μ				
Mole Hole	0.592	0.017	-	-
Culvert	0.599	0.012	-	-
River	0.599	0.014	-	-
Control	0.589	0.017	-	-
Overall	0.595	0.007	-	-
Net 202μ				
Culvert	11.14	0.610	98.2	5.40
River	10.61	0.074	93.6	0.66
Control	9.61	0.367	84.7	3.24
Overall	10.56	0.280	92.2	-
Net 63μ				
Culvert	0.536	0.091	4.7	0.80
River	0.610	0.060	5.4	0.53
Control	0.850	0.008	7.5	0.07
Overall	0.642	0.050	5.9	-

TABLE 17. List of taxa collected in the plankton samples. (T) = Tanaidacea, (I) = Isopoda, (A) = Amphipoda, (D) = Decapoda, (H) = Hemiptera. Taxa marked with an asterisk were not included in the analyses (see text).

SARCODINA		
	Rhizopodea	Foraminifera
CILIOPHORA		
	Polyhymenophora	Tintinnidae
CNIDARIA		
	Anthozoa	Ceriantharia
	Hydrozoa	Hydroid polyps
ROTIFERA		Rotifers*
NEMATODA		Nematodes
MOLLUSCA		
	Gastropoda	Gastropod veligers
		Crepidula sp.
		Cerithidea scalariformes
	Bivalvia	Bivalve veligers
ANNELIDA		
	Polychaeta	Polychaete larvae
	Oligochaeta	Oligochaete larvae
ARTHROPODA		
	Ostracoda	Ostracods
	Copepoda	_Acartia tonsa_
		Tortanus setacaudatus
		Harpacticoid sp. A
		Harpacticoid sp. B
		Harpacticoid sp. C
		Harpacticoid sp. D
		Oithona nana
		Cyclopoid sp. B
		Cyclopoid sp. C
		Cyclopoid sp. D
		Cyclopoid sp. E
		Cyclopoid sp. F
		Cyclopoid sp. G
		Caligoid sp. A
		Misc. nauplii
	Cirripedia	_Balanus_ sp. larvae
	Branchiura	_Argulus_ sp.
CRUSTACEA		
	Malacostraca	Tanaidacea (T)
		Sphaeroma sp. (I)
		Probopyrus pandalicola (I)
		Corophium lacustre (A)
		Corophium ellisi (A)
		Gradidierella bonnieroides (A)
		Gammarus mucronatus (A)
		Caprellid A (A)
		Brachyuran zoea (D)
		Anomuran zoea (D)
		Natantia larva A (D)
		Nantantia larva B (D)
		Palaemonetes pugio (D)*
		Palaemonetes intermedius (D)*
		Hyppolite zostericola (D)
		Hyppolite pleuracantha (D)

TABLE 17. (Continued)

	Insecta	Collembola
		Odonata
		Corixidae (H)
		Halobates sp. (H)
		Coleoptera
		Diptera
		Hymenoptera
	Arachnida	Aranea
		Acarina
CHAETOGNATHA		*Saggita* sp.
CHORDATA		
	Ascidacea	Ascidian larvae
	Larvacea	*Oikopleura* sp.
	Osteichthyes	*Microgobius* sp.*
		*Sygnathus scovelli**
		*Cyprinodon variegatus**
		*Gambusia affinis**
		*Poecilia latipinna**
		*Elops saurus**
		leptocephalus larvae
		Misc. fish eggs
MISC.		Unknown A
		Misc. eggs

TABLE 18. Frequency of occurrence of the different taxa in the hand net collections at P-3 and SP-2.

TAXON	FREQUENCY
Forminifera	0.167
Tintinnidae	0
Ceriantharia	0
Hydroid polyps	0
Nematodes	0.167
Gastropod veligers	0.333
Crepidula sp.	0
Cerithidea scalariformes	0
Bivalve veligers	0.333
Polychaete larvae	0.417
Oligochaete larvae	0
Ostracods	0.833
Acartia tonsa	0.417
Tortanus setacaudatus	0.333
Harpacticoid sp. A.	0.833
Harpacticoid sp. B	0.167
Harpacticoid sp. C	0.833
Harpacticoid sp. D	0
Oithona nana	1.000
Cyclopoid sp. B	0.250
Cyclopoid sp. C	0.333
Cyclopoid sp. D	0.417
Cyclopoid sp. E	1.000
Cyclopoid sp. F	0
Cyclopoid sp. G	0
Caligoid sp. A	0
Misc. nauplii	1.000
Balanus sp. larvae	0
Argulus sp.	0.083
Tanaidacea (T)	0
Sphaeroma sp. (I)	0
Probopyrus pandalicola (I)	0
Corophium lacustre (A)	0
Corophium ellisi (A)	0
Gradidierella bonnieroides (A)	0
Gammarus mucronatus (A)	0
Caprellid A (A)	0
Brachyuran zoea (D)	0.250
Anomuran zoea (D)	0
Natantia larva A (D)	0
Nantantia larva B (D)	0
Hyppolite zostericola (D)	0
Hyppolite pleuracantha (D)	0
Collembola	0
Odonata	0
Corixidae (H)	0.667
Halobates sp. (H)	0
Coleoptera	0

TABLE 18. (Continued)

TAXON	FREQUENCY
Diptera	0
Hymenoptera	0
Aranea	0
Acarina	0.083
Saggita sp.	0
Ascidian larvae	0
Oikopleura sp.	0
leptocephalus larvae	0
Misc. fish eggs	0
Unknown A	0.333
Misc. eggs	0.333

TABLE 19. Mean density/taxa at the various stations from the 202 μ and 63 μ samples.

STATION	PUMP 202 μ	PUMP 63 μ	NET 202 μ	NET 63 μ	TOTAL 202 μ	TOTAL 63 μ
Mole Hole	920	287300	–	–	920	287300
Culvert	585	19251	1184	68592	1769	87842
River	1505	40867	4528	112499	6033	153366
Control	71	35964	17	94496	88	130460

TABLE 20. Pearson correlation coefficients between total densities of each taxon collected at the different sites. Upper matrix shows the results of "within-mesh"comparisons, lower matrix shows the results of "between-mesh" comparisons. * = $p \leq 0.05$, ** = $p \leq 0.01$, *** = $p \leq 0.001$.

		MOLE HOLE		CULVERT		RIVER		CONTROL	
		202	63	202	63	202	63	202	63
MOLE HOLE	202	-		0.041		-0.009		0.708***	
	63	0.249	-		0.986***		0.891***		0.928***
CULVERT	202		-0.030	-		0.987***		0.023	
	63	0.226		0.013	-		0.951***		0.936
RIVER	202		-0.030		0.104	-		-0.034	
	63	0.158		0.352**		0.358**	-		0.899***
CONTROL	202		-0.361**		0.339*	-	0.264	-	
	63	0.034		-0.024		-0.220		0.155	-

TABLE 21. Data on the 15 most common taxa captured with 202μ and 63μ gear.

TAXON	RANK	202 μ TOTAL DENSITY INDIV/M^3	$\overline{X}$
Acartia tonsa	1	322,159.0	5,752.8
Tortanus setacaudatus	2	34,358.0	613.5
Brachyuran zoea	3	33,974.0	606.7
Oithona nana	4	33,570.0	599.5
Ostracoda	5	17,426.0	311
Foraminifera	6	4,183.0	74.7
Harpacticoid A	7	2,581.0	46.1
Anomuran zoea	8	1,823.0	32.6
Larval shrimp B	9	1,533.0	27.4
Copepod nauplii	10	1,332.0	23.8
Misc. eggs	11	891.0	15.9
Nematoda	12	595.0	10.6
Unknown A	13	541.0	9.7
Cyclopoid D	14	509.0	9.1
Larval shrimp A	15	497.0	8.9

TAXON	RANK	63 μ TOTAL DENSITY INDIV/M^3	$\overline{X}$
Copepod nauplii	1	23,411,616	418,065
Oithona nana	2	6,504,674	116,155
Cyclopoid E	3	4,578,429	81,758
Acartia tonsa	4	1,843,970	32,928
Gastropod larvae	5	728,503	13,009
Misc. eggs	6	376,362	6,721
Polychaete larvae	7	351,318	6,274
Cyclopoid C	8	172,592	3,082
Tortanus setacaudatus	9	122,624	2,190
Cyclopoid E	10	104,381	1,864
Unknown A	11	69,842	1,247
Bivalve larvae	12	67,731	1,209
Harpacticoid C	13	46,439	829
Brachyuran zoea	14	40,813	729
Harpacticoid A	15	36,202	646

APPENDIX

Calculations Used to Determine Plankton Concentrations:

Variables:

Do = Density (organisms/m^3).

Ns = Number of organisms.

Vs = Volume of subsample.

Vc = Volume of diluted sample.

Vo = volume of water filtered.

Fr = flow rate of pump.

Af = filtering area of net (0.186m^2).

Cf = flowmeter counts.

Rc = flowmeter rotor constant.

Equations:
(General Oceanics 1979)

$$Vo(pump) = [\ (32/Fr) \times \text{time of sample}\ ] \times 0.003785$$

$$Vo(net) = [\ (Cf \times Rc)/999999\ ] \times Af$$

$$Do = (Ns/Vs) \times Vc \times (1/Vo)$$