6.4 SALT MARSH

6.4.1 Sampling and Laboratory Analysis

Eight general areas for salt marsh study were specified in the original POS. Locations of the eight areas are shown in Figure 6.4-1. A reconaissance was made in each area to identify suitable stations. Final station selection was made after considering such factors as accessibility, thickness of the marsh floor, apparent marsh elevation, species composition, exposure and fetch, and overall marsh physiognomy. Final station locations are described in Table 6.4-1.

Four Juncus roemerianus and four Spartina alterniflora sites were situated at each station. Depending on local conditions at each station, the four sites for each species were deployed over different microenvironmental features such as shoreline vs marsh interior; low vs high marshes; creek bank vs uniform marsh; and pure stands vs stands intermixed with other marsh species. Site locations are given in Figures 6.4-2 through 6.4-9.

Marshes were sampled during low tides. Stations 3-5 (Control, Midway, and Thermal), were accessible from land, while the other stations were accessible only by boat. Stations 3-5 were generally sampled first during each sampling period.

Thickness of peat at marsh stations was measured with a steel reinforcing bar driven by hand to resistance. At least 10 probes were made at each station. Data were recorded to the nearest 3 cm. Marsh elevations were estimated by correlating times and water depths at each marsh station at slack high water to simultaneous observations made at a staff gauge at the mouth of the discharge canal. The gauge is registered to mean low water.

Temperature was recorded continuously in one Juncus site and one Spartina site in each station, using Peabody Ryan Model J-90 (10-40°C) thermographs. Each unit was tethered to a concrete block and set on the marsh floor, then retrieved and replaced on subsequent sampling visits. Details of chart preparation and processing are given in Section 10.1.1.

All collections were made using 0.25 m^2 quadrats. Three replicates were collected at each site. Quadrat frames made of PVC were deployed on the marsh floor at sampling sites in a checkerboard pattern. All plants were manually clipped at the surface of the marsh floor and placed in prelabeled bags. At the field station, plants were rinsed with freshwater, counted, inspected for flowers or seeds, sorted into live, dead, and miscellaneous fractions, and bundled with nylon netting. Each batch was labeled, dipped in mildewcide to arrest respiration and fungal growth, and air-dried. All material from a single collection was dried further in a solar hot-house equipped with auxiliary heaters until weight loss was at least 97 percent (as determined by oven dried subsamples). Batches were unbundled and weighed to the nearest 0.01 gram.

Marsh samples occasionally bore epiphytic algal growth which was scraped from the shoots and preserved in 15 percent formalin for later inspection. Motile epifauna were collected when quadrat frames were set and again after plants were clipped. Animals were placed in prelabled jars containing 15 percent

formalin in seawater and later identified and enumerated. Once a quadrat was clipped, all burrows in the area covered by the quadrat frames were counted.

A SAS GLM procedure was used to compare shoot densities (live and live plus dead), biomass (live and live plus dead) among stations, sampling dates, and for the station by date interaction. Burrow density and density of Littorina were compared spatially and temporally including a live weight covariate. Other covariates were explored as well. Tukey's HSD tests were used to compare means of station and time period of sampling.

6.4.2 Results

Introduction

This assessment is the fifteenth in a series of reports since 1974 on the subject of salt marsh thermal structure or response to thermal stress at Crystal River. Prior reports include Homer (1974), Young (1974), Klausewitz et al (1974), Florida Power Corporation (1975), Hornbeck (1978), Odum and Caldwell (1978), Goforth (1979), Goforth and Kosik (1980), Coggins (1980), Kosik (1981), Odum and Montague (1981), Applied Biology (1982; 1983) and Knight and Coggins (1982). Past salt marsh studies have produced a considerable volume of data and insight into salt marsh structure, metabolism, animal use, and response to thermal stress. Data collected in 1983-1984 address the geographical extent and nature of thermal impacts, if any, on salt marshes in the vicinity of the Crystal River Power Station. The study also addresses:

(a) The gradient of temperature in marshes related to the thermal discharge;

(b) Differences in standing crop, plant density, or invertebrate activity between previous thermal and control stations;

(c) Trends or patterns for standing crop, plant density or invertebrate activity at additional stations.

Historical data and evaluations of new data will be considered separately for Spartina alterniflora and Juncus roemerianus. In each case, the evaluation treats standing crop (live, total), plant densities, lengths, and flowering. Variables to be considered as measures of invertebrate activity include total species number, total faunal density, Littorina irrorata density, and burrow density.

Between 1974-1981, pre- and post operational marsh studies conducted by the University of Florida included productivity and respiration measurements and other parameters required to model marsh system metabolism. Beginning with Applied Biology, Inc. (ABI) studies in 1981, marsh studies have been limited to structural analyses of plants and invertebrate studies. The ABI studies and the present investigation were based on the assumption that marsh structure is a meaningful indicator of marsh system metabolism or that the measured parameters are independently useful indicators of environmental stress. Knight and Coggins (1982) reviewed four years of post-operational data and concluded that structural aspects such as shoot density had changed in thermal marshes in compensation for metabolic adaptations to heat.

Isolated measurements of marsh structure may be used as indicators of thermal adaptation as described above, but metabolic estimates cannot be performed entirely on structural data. On the other hand, marsh structure is useful as an independent indicator (Oviatt et al 1977).

Four assumptions of the present study are that stations have been comparable both between and within studies; that sampling techniques have been comparable and adequate; and that a gradient of temperature in marshes exists, but not other factors capable of affecting the marshes. Each assumption is addressed separately in the following paragraphs.

"Thermal" and "control" station locations have remained unchanged since the first postoperational study by Hornbeck (1978). Young (1974) conducted control measurements at Negro Point south of all postoperational control sites and also on the west shore of Luttrell Island. All "thermal" stations in past studies coincide with the Thermal Station, and Control Station is equivalent to "control" sites used since 1977.

Marshes used as controls for thermal impact comparisons are valid only to the extent that all other relevant variables are the same as found at the thermal site. While no two marsh sites can be perfectly comparable, the extent of differences between them for several factors can be evaluated.

Young (1974) stated that Control and Thermal sites were approximately the same in elevation and species composition but gave no data. The Thermal Station is exposed to Crystal Bay and a long northwesterly fetch resulting in moderate wave climates during winter frontal passages. The Control Station is sheltered to the northwest by the intake spoil and is exposed to the relatively quiet west-southwest. These differences are reflected by the steeper western shoreline at New Rocky Creek than at the Control Station.

Elevations of the Thermal and Control Stations have not been established by any study to date, but the fact that Rocky Creek has a higher water surface to marsh ratio than Cutoff Creek suggests that the thermal marsh is lower. Water levels were compared in each marsh to the tide staff at the POD.

	Mean Elevation, m above MLW	
Station	Spartina	Juncus
Thermal	2.49	2.90
Control	3.45	4.05

Spartina marshes were lower than Juncus by about 15 cm, which is consistent with findings from several other studies (Daiber and Ganzman 1978). Both Thermal marshes were lower than the Control counterparts by about 30 cm. Salinities differ between the Thermal and Control Stations. In Quarters I and III mean surface salinity at the Control Station was less than 20.0 o/oo, compared to mean salinities greater than 22.5 o/oo at the Thermal Station.

Six additional stations were sampled in 1983-84. Upper Salt Creek was completely sheltered, and Midway was protected to the northwest by the discharge dike. The Fence and Davis Island stations were partially protected.

Most marshes fronted onto shorelines with mild to moderate slope, except Upper Salt Creek and parts of Davis Island. The mean elevation above MLW of all Spartina marshes was 0.84 m (+/-0.22 m), about 0.12 m lower than the mean Juncus marsh elevation of 0.96 m (+/-0.22 m). The Thermal Station had mean marsh elevations near the overall means for Spartina and Juncus.

Mean salinities based on quarterly data varied from 12.5 o/oo to more than 22.5 o/oo. The Thermal Station had highest mean salinities (greater than 22.5 o/oo). Davis Island had consistently low mean salinity (12.5 -15.0 o/oo) due to the influence of the Withlacoochee River. The Thermal Station was a locus of high salinity surrounded by tiers of decreasing salinity both to the north and south. Salt Creek stations and Davis Island were shaded by nearby hammocks. Shading was greatest at Upper Salt Creek.

Overall, Thermal and Control Stations differ with respect to exposure and salinity and probably elevation. New stations in Salt Creek do not appreciably resemble the Control, especially due to an abundance of Distichlis spicata. Stations north of the POD represent approximately comparable marshes along a pronounced salinity gradient.

Marsh standing crop and shoot density have been determined in all pre-and post operational studies with 0.25 m^2 quadrats. Young (1974) determined that 9 Spartina and 5 Juncus quadrats maintained a minimum error of 15 percent about mean live and dead biomass (95 percent probability), and all subsequent studies until 1983 used the same sampling effort. Twelve quadrats were used in Spartina and Juncus marshes for the present study to provide for greater coverage of microenvironmental differences such as proximity to creeks or intermixing of other marsh species. Intermixing is very common in marshes of the region. For the 8 stations in this study, 25 of 32 total Spartina sites were pure stands, whereas only 14 of 32 total Juncus sites were pure stands. It is not known whether only pure stands of each species were sampled in previous studies. Counts and collections of invertebrates have been made by the same techniques in all studies.

Penetration of the thermal plume into the salt marsh around New Rocky Creek was demonstrated by Carder (1971; 1972) and Homer (1974) for preoperational conditions. Young (1974) provided the first data on actual marsh temperatures and reported a 3-6°C increase in the "thermal" site over his Negro Island "control" site. Young also confirmed reports of 37°C temperatures in thermal marshes during summer. Hornbeck (1977) stated, "Water which flooded the thermally impacted marshes was 2.6° - 7.2°C higher than that which flooded the control marsh". Apparently, there have been no reports of in situ marsh water temperatures since 1977, essentially the entire postoperational period. Thermograph data for 1983-84 illustrate differences in marsh temperature between Thermal and Control Stations. Figure 6.4-10 is a comparison of mean daily temperature at the two stations for January 1984. Mean daily temperature at the thermal site exceeded mean control site temperature for nearly 75 percent of the month. The greatest temperature increase between paired means was 4.5°C. The mean monthly temperature of the Control marsh for January 1984 was 13.1°C (+/-2.1°C) compared to a monthly Thermal marsh mean of 14.0°C (+/- 3.1°).

Summer data for both stations were compared for August, the hottest month of 1983, based on temperatures during predicted slack high tides. Data were

taken from thermograph traces from August 5 - September 5, 1983. Results are given in Table 6.4-2. Thermal marsh means were significantly higher than Control means for daytime, nighttime and all high tides in August. Overall, thermal marsh temperatures were increased more at night than during the day.

Temperature of the Control Station Spartina marsh rose at low tide and fell at high tide with relative stability during the night (Figure 6.4-11). The Thermal Station Spartina temperatures, on the other hand, exhibited the same cyclic temperature pattern but with an extra period of high temperature caused by the thermal plume at high tide. This phenomenon occurred during the night and day. The doubling of temperature cycles was evident at the Thermal Station in winter but with dampened amplitudes.

Table 6.4-3 summarizes high tide water temperatures in Spartina marshes north of the Control Station for the period August 6-15, 1983. Units 1 and 2 were operational for all but a few hours then, and Unit 3 ran uninterrupted. The Thermal Station was hotter during days, nights and overall than other stations. Patterns of mean daily and mean overall temperatures were similar. It was followed by northern stations and then the Control (in order of descending temperature). Mean nightly temperatures were the same at all stations except the Thermal marsh, which was warmer by about 8°C. Thermal Station means had low or lowest standard deviations due to moderating effects of the thermal plume. Salt marsh stations were classified by thermal range in Table 6.4-4.

Spartina marsh temperatures in winter were mildly warmer at Midway and Fence Stations and moderately warmer at Thumb Island, whereas summer temperature effects were detectable at Midway and Thumb Island (in addition to the Thermal Station). Since Spartina marshes were lower (elevation) than Juncus marshes at each station, it is probable that Spartina data accurately reflect thermal discharge effects.

Spartina Trends and Patterns

Two way analyses of variance were conducted using live standing crop and live plant density as dependent variables and time and station as independent variables. The analyses were performed once using all data for Spartina only in Spartina marshes and again for Spartina and Juncus combined, where they occurred together in Spartina marshes. Sampling periods and stations contributed significantly to observed variance in all analyses, and so did station-time interaction terms (Table 6.4-5). Consequently, pairwise comparisons of each parameter were made between sampling periods and between stations using Tukey's studentized range (HSD) test, with alpha = 0.05 and confidence = 0.95. Results are shown as network diagrams in which any stations or times connected by a line were significantly different at the 0.05 level.

Standing Crop

Figure 6.4-12 illustrates station differences for standing crop data compiled across all sampling periods. For the study as a whole, live weight of Spartina in Spartina marsh at Lower Salt Creek was significantly different than all other stations. The Thermal Station was like Rocky Cove, Thumb Island, and the Fence, but different than Control Stations and Davis Island.

Stations from Midway to Fence were alike but generally different than "end" stations. Figure 6.4-13 illustrates numerous differences between sampling periods for standing crop data compiled across all stations. Similarity of July and September 1983, and January and March 1984 suggest seasonality in live Spartina standing crop. Very distinct seasonality did occur as shown by Figure 6.4-14. Live Spartina weights increased in 1983 to maxima from October-December, then fell to minima in January-March. June and July 1984 weights were similar but significantly lower than summer 1983. This pattern was observed at all stations although 1983 means varied considerably. Thermal lower. Means at Midway, Thumb Island, and Fence were between those at Control and Thermal Stations in 1983 and greater than either in 1984, suggesting a gradient of stimulation centered at the Thermal Station. Lower Salt Creek and the Fence were similar and with Upper Salt Creek had lower than average mean Spartina weights.

Analyses were repeated with Juncus weights added because intermixed marshes are commonplace near Crystal River. Both time and station were significant as independent variables (Table 6.4-5), but patterns of similarity were exactly the same as for Spartina weights alone (Figures 6.4-12 and 6.4-13) except that Davis Island became similar to Lower Salt Creek and Control. It may be concluded from these results that Spartina marshes could be treated as either "pure" or "mixed" stands with regard to live weight. Figure 6.4-15 (combined live weight at thermal and control stations) illustrates that (a) means at each station are equal to or slightly greater than their respective counterparts in Figure 6.4-14 due to addition of live Juncus; (b) standard deviations are relatively great despite sample size of 12 due to the intentional effort to sample in different microenvironments at each station; and (c) live weights at the Thermal Station were significantly greater than at the Control in some months of 1983 but none in 1984.

Plant Density

In the analysis of plant density, both time and station were significant independent variables (Table 6.4-5). Figure 6.4-16 illustrates station differences for data compiled across all sampling periods. The network is notably different than Figure 6.4-12, meaning that weight was not a simple consequence of density and that each parameter may respond differently to the same independent variable. Davis Island density means were unique; Control was like its neighboring stations and Thermal and Fence were similar. The network of live density means during each period (stations combined) is shown in Figure 6.4-17. Seasonality in plant density was strongly indicated because periods at the end of 1983, when the growing season was over, were different from one another (suggesting rapid change). Seasonality was further indicated by the affinity of successive periods in 1984, once the new seasonal density of live plants was established.

Trends in mean live Spartina density are illustrated in Figure 6.4-18. Means were at their highest in December 1983 and fell to minima in January 1984. Densities were steady in 1984 but trended downward to a level in July not significantly different than July 1983. The similarity of July means to January means suggests that baseline densities were established at the onset of the growing season. The Thermal Station had highest densities and was paralleled more closely by the Fence than other stations. Midway and Thumb Island had similar trends and their means were intermediate between Control

and Thermal stations. Salt Creek Stations and Davis Island had typically low densities of live Spartina.

The addition of live Juncus shoots to Spartina densities did not affect the results of the ANOVA (Table 6.4-5) and had minor effects on station and time networks. As in the case of live standing crop, Spartina marshes could be treated as either "pure" or "mixed" stands with regard to live density. Figure 6.4-19 (combined live plant and shoot density at Control and Thermal Stations illustrates that (a) means are the same at Control and slightly more at Thermal in 1984 than their counterparts in Figure 6.4-18; (b) variances are not as great as for mean standing crop, meaning that density was affected less by microenvironmental changes; and (c) plant density at the thermal site was consistently greater than at the control and was usually significantly greater.

Marsh Height

At least 100 shoots were measured from each station in June 1984 when standing crop was high and densities stable (Figures 6.4-14 and 6.4-18). Results are shown in Figure 6.4-20. The inset shows that all but 4 comparisons were significantly different. Live Spartina at the Thermal Station was significantly shorter than neighboring stations or Control. Davis Island was significantly taller than all other marshes except Midway. Thumb Island and the Fence were intermediate in height between Thermal and Davis Island.

Shoot Weight

Data on live standing crop and density can be combined to assess shoot weight if shoot lengths are comparable or if the mean weights per unit length of shoot are comparable. Because the preceding section showed that mean shoot lengths were significantly different between stations in June 1984, standing crop and density data for the same period were used to assess variation of weights per unit length (Table 6.4-6). Mean weights per centimeter of live Spartina shoot ranged nearly twofold between means at Thermal and Midway Stations. The ranking of stations by shoot weight and standard shoot weight was essentially unchanged, meaning that shoot weight in live Spartina is a valid condition index and does not need correction for length.

Mean plant weights by station are shown in Figure 6.4-21. Salt Creek Stations and Davis Island were not plotted to simplify the figure. Shoot weights were highest in June-July of each year and lowest in January-March 1984. Mean weights at Control Station were consistently greater than Thermal Station means. It is evident in comparing Figures 6.4-14 and 6.4-18 that standing crop affects shoot weights more than density with regard to seasonality but that density is more important in the relation of Control to Thermal Stations.

Reproduction

The incidence of flowering was seasonal at all Spartina stations except Davis Island, which had nearly continuous flowering (Figure 6.4-22). Flowering at the Salt Creek Stations and Control peaked in October. Flowering at the Thermal Station also peaked in October but continued into 1984. Flowering at stations near Thermal peaked in December. Overall, flowering peaks differed on either side of the intake canal and marshes near the Thermal Station flowered later in the year.

Live and Dead Standing Crop and Density

Standing crop of dead Spartina varies seasonally (Figure 6.4-23), doubling at the end of the growing season. More dead Spartina was present at the outset of the 1984 growing season at the Thermal Station than at Control but both declined through time. Two way ANOVA were performed on total (live plus dead) standing crop and density of Spartina, both with and without intermixed species (Table 6.4-5). Time and station were significant as sources of variance. Total Spartina weight differences were identical to Figure 6.4-13 except that Thermal and Thumb Island Stations were significantly different. Even when dead weights of other species were added, the only novelty was that Midway and Thumb Island became dissimilar. Thus, the Spartina marshes under study varied consistently with respect to standing crop and observed trends and patterns were the same whether dead tissues or other species were considered.

A different result is obtained when temporal variation is considered. Figure 6.4-24 is a similarity network for total Spartina weight (and for total weight of all species) for each sampling period, averaged across stations. Figures 6.4-24 and 6.4-13 differ mostly with regard to summer conditions. Summer live weights differed from other periods, whereas summer total weights did not, and neither did weights for January 1984 because of the dead weight carry-over. Less seasonality can be expected in total weight measurements than live weight.

Mean total standing crop of Spartina varied as expected at all stations during the study (Figure 6.4-25). Total weights were greatest at the end of the growing season and lowest at the start. Annual variation was less definite than for live weight (Figure 6.4-14). On the other hand, relative station differences were more definite using combined total weight. For example, Lower Salt Creek, Control, and Davis Island were consistently lower than Thermal marshes or neighboring sites. Mean total weights at Control and Thermal Stations covaried but the latter had greater weights in 9 of 10 cases. Stations were significantly different in most months (Figure 6.4-26).

The total (live plus dead) Spartina density network is the same as Figure 6.4-16 except that Midway and Thumb Island became similar. Adding counts of other dead shoots was unimportant; thus, total density is as useful as total standing crop. A breakdown by time (Figure 6.4-27) indicates that seasonality patterns differed when dead shoots were considered (compare Figure 6.4-17). Overall, strong seasonality would not be expected in total shoot density, but differences between stations would be considered meaningful indices of marsh condition.

Seasonal trends of total Spartina density at all stations are given in Figure 6.4-28. Mean total weights rose at all stations but Davis Island to their respective station maxima from December to March and then fell. Relative to Thumb Island, Control and Fence Stations had consistently higher total weights. Control and Thermal Stations covaried, but Thermal was always higher (Figure 6.4-29).

Station Summary

Upper Salt Creek is like Davis Island relative to live and total standing crop of Spartina but unlike other stations. It was different than the Control Station, for reasons unrelated to the thermal discharge, where Spartina variables were concerned.

Live weight at Lower Salt Creek was similar to, but usually lower than, at Upper Salt Creek. Density was similar to that at Control Station and Midway. Lower Salt Creek Spartina marshes are more useful than Upper Salt Creek as controls but are not very similar to marshes at Control. No thermal effects were evident beyond the natural influence of the Crystal River.

The Control was similar to its neighbors relative to live plant density but differed from all northern stations relative to standing crop. Control had less dead material than Thermal. Density patterns in time were regular but values were lower than those at any northern station except Davis Island. Marsh heights in June 1983 were low but much higher than thermal marshes (p greater than .001). Flowering was typical. This site is an imperfect control for physical reasons; however, it more closely resembles the Thermal Station than either Salt Creek Station; and it is not affected by heated effluent. Use of Control as a control for Spartina assessments is therefore warranted but can be supplemented by data from stations north of the discharge canal.

Midway was unlike southern stations and Davis Island relative to live standing crop but similar to other northern stations. Mean live densities were like southern stations. Seasonally, weights at Midway were very similar to weights at the Thermal Station, whereas densities were comparable to values at the Control Station. Midway resembled controls in some regards and the Thermal Station in others. Overall it was a transitional Spartina marsh with definite affinities to the Thermal Station.

The Thermal Station, was like its neighbors in standing crop but unlike more distant stations. It was like Fence for live plant density but significantly different than all other sites, and it had higher densities through the study period than all other stations with the exception of Fence in 1984. Marsh height and specific shoot weight were lower than any other station, as was specific shoot weight. Flowering began during the same period as Spartina at Control Stations but lasted into January 1985. Otherwise, Thermal Station Spartina data were rarely intermediate. Means were usually extreme relative to other stations, and the overall placement of Thermal Station Spartina marshes at the upper end of marshes on a gradient of thermal response is justified.

Thumb Island Spartina marshes resembled Thermal marshes in terms of live standing crop, but densities were always lower, usually between mean counts at Control and Thermal. The marsh was significantly taller than thermal marshes. Flowering was prolonged into December and peaked about 6 weeks later than controls. Standing crop at Thumb Island was like that at Midway and Fence. Overall, the Thumb Island marsh was definitely related to the marsh at Thermal; and was different than the controls.

Fence was also different in standing crop from Control and Davis Island and different in density from all sites but Thermal. Seasonal changes in density

were more similar to changes at Thermal than at any other station. Marsh height was above average but specific shoot weight was below average, like the Thermal Station. Flowering was limited to one episode in December, like marshes at Midway. Fence had surprising affinities to Thermal, in some cases more so than Thumb Island, and is the farthest station from Thermal with evidence of thermal influence.

Davis Island was the northernmost site and closest to the influences of the barge canal and Withlacoochee River. While different in all respects from southern stations, including controls, it is an accurate representative of low salinity, nonthermal marshes and helped to align Fence with the Thermal Station.

Juncus Trends and Patterns

Two way analyses of variance were conducted using live standing crop and live plant density as dependent variables and time and station as independent variables. The analyses were performed using all data for Juncus only in Juncus marshes and again for Juncus and Spartina combined, where they occurred together in Juncus marshes. Sampling periods and stations contributed significantly to observed variance in all analyses of live data and some of the combined data bases (Table 6.4-7). Consequently, network diagrams were made for differences at 0.05 probability level, using Tukey's Standardized Range Test.

Live Standing Crop

Figure 6.4-30 illustrates station differences for data compiled across all sampling periods. For the study as a whole, live Juncus weights at Control and Thermal Stations were significantly different than one another and all other stations. Midway was like Thumb Island and Fence among centrally located stations, and Salt Creek Stations were alike among distantly located sites. Overall, stations were more similar for Juncus live weight than for Spartina live weight. There were no significant differences in live Juncus weight between sampling periods (averaged across stations), implying a lack of seasonality in this parameter. Scrutiny of Figure 6.4-31 reveals that seasonality is not strong but that weights at Upper and Lower Salt Creek and Control were low in winter, weights at Midway, Thermal, and Thumb Island were relatively constant after September, and weights at Fence peaked in winter. There was considerable overlap of means and variances, but Control and Thermal Stations bracketed most station data as the respective maxima and minima (e.g., other station data were intermediate). Patterns of Juncus live weight therefore differ completely from Spartina patterns by lacking seasonality and by the control weights for Juncus exceeding thermal weights, whereas thermal Spartina outweighs its control (compare to Figure 6.4-14).

About one in two sites within Juncus marshes at the 8 stations were intermixed with varying amounts of Spartina. Analyses were repeated using Spartina weights to assess their effect on the outcome of station comparisons (Figure 6.4-32). Effects were significant, unlike the case where Juncus was added to Spartina. Midway became different from all stations except Thermal and Thumb Island, and Thermal became similar to neighboring stations. Moreover, several differences between sampling periods became significant (Figure 6.4-33). Opposite times in the growing season differed, although overall

seasonality was not enhanced (Figure 6.4-34). Although comparisons of live standing crop in Juncus marshes near Crystal River were affected by the inclusion of other species, overall relationships were less affected. For example, Figure 6.4-35 illustrates mean live standing crop of all species at Control Station and Thermal Station. Compared to Figure 6.4-34, (a) Control was still greater than Thermal; (b) their covariance was the same; and (c) several mean differences were significant.

Live Shoot Density

Both time and station were significant as independent variables in the analysis of shoot density (Table 6.4-7). Figure 6.4-36 illustrates station differences for data compiled across all sampling periods. As in the case of Spartina density, the network is different than Figure 6.4-30, meaning that weight and density were separate indices of condition. The data indicate a gradient in shoot density since as control stations differ from Thumb Island, Fence, and Davis Island but not one another, and all neighboring stations were alike. Stations were more alike with regard to Juncus density than Spartina density (Figure 6.4-16).

The network of live density means during each period (stations combined) is shown in Figure 6.4-37 and illustrates that May and June 1984 differed from 1983 but that seasonality in shoot density was not pronounced. In fact, densities at all stations were aseasonal but trended upward into 1984, accounting for the distinction in May-June of that year (Figure 6.4-38). The suggestion of latitudinal gradients in live density was confirmed by Figure 6.4-38 because southern stations had consistently higher counts than northern ones and central stations had intermediate counts.

Addition of Spartina densities to Juncus densities affected station and time networks (Figure 6.4-39 and 6.4-40, respectively) but had negligible effects on trends depicted in Figure 6.4-38. Addition of Spartina made stations between Midway and the Fence more distinctive but the apparent difference of Control and Thermal Station must be regarded as an artifact (Figure 6.4-41). Spartina counts reversed the network of differences between time periods, which was consistent with the high densities of Spartina at the end of the growing season. Overall, data indicate a latitudinal gradient in Juncus shoot density compared to a gradient in Spartina density which corresponds to the thermal gradient between stations. Addition of Spartina counts distinguishes central Juncus stations from distant ones for reasons attributable to Spartina seasonality.

Marsh Height

At least 100 shoots were collected from each station in June 1984 and measured. Results are shown in Figure 6.4-42. The inset shows that all but 4 comparisons were significantly different. Live Juncus at Thermal was significantly shorter than at all other marshes. Thumb Island was similar to Midway and both were similar to Salt Creek marshes. Relative to Thermal, there was a trend both north and south of increasing height to a maximum, followed by lower marshes. Midway and Thumb Island were transitional between Thermal and distant stations. In these respects the height of Juncus marsh was related better to distance from Thermal than Spartina marsh heights.

Shoot Weight

Because mean Juncus height in June 1984 was significantly different, weight and density data were used to assess variation in weight per unit length (Table 6.4-8). Mean weight per centimeter of live Juncus shoot ranged from (0.015 to 0.021 g), a smaller amount than observed for Spartina. As expected, ranking of stations by shoot weight and standardized shoot weight did not cause large differences. Shoot weight in Juncus does not need standardizing to compare stations, as was done in Figure 6.4-43. As in Figure 6.4-34 (live standing crop), Control and Thermal bracketed most other data. Midway and Thumb Island were clearly intermediate, and Fence covaried as Thermal but was more like Control than other stations. This condition index indicates affinity of Thermal to its nearest neighbors (Midway and Thumb Island) but not to Fence or the Control.

Reproduction

The incidence of flowering was continual at low levels in control marshes and at Fence and Davis Island. Flowering at the Thermal Station was low and limited to May-June, with no flowering from July-March. Midway flowered in September and May at low levels and Thumb Island flowered until September (Figure 6.4-44). Overall, Juncus flowered more often but at lower levels than Spartina.

Live and Dead Standing Crop and Density

Standing crop of dead Juncus was lowest in December and highest in January-February with a gradual decline during the growing season. Standing crop of dead Juncus followed the same pattern as Spartina dead weight (Figure 6.4-23), but total range and monthly changes were considerably less for Juncus. Between station differences in dead Juncus standing crop were low.

Two way ANOVA were made on total standing crop and density of Juncus, both with and without intermixed species (Table 6.4-7). Time was not a significant source of variance for total standing crop of Juncus. This result is consistent with the non-seasonal aspect of live standing crop, and differs from Spartina for the same reason. Addition of dead weights did affect Juncus station differences whereas Spartina networks were unaffected.

Station differences are given in Figure 6.4-45, which resembles Figure 6.4-30 except for the distinction of Davis Island. Comparing Figure 6.4-46 to Figure 6.4-31 reveals a dampening of station variation by the addition of dead weights but maintenance of each station's relation to other stations. Overall, station relationships were not affected by consideration of dead material.

Station differences were affected by addition of Spartina total weights, which was an expected result given the degree of intermixing (Figure 6.4-47). This network depicts station similarity for total standing crop of intermixed marshes. Midway, Thermal and Thumb Island Stations were similar to one another but unlike more distant stations. The nature of this difference is illustrated in Figure 6.4-48. Total combined standing crop of Juncus marshes was significantly greater at the Control Station than at the Thermal Station during the 1983 and 1984 growing seasons, even when intermixing by Spartina

was considered. Thermal enhancement of intermixed Spartina did not offset the thermal reduction of Juncus standing crop.

The total (live + dead) Juncus density network is the same as Figure 6.4-36 except that Midway differs from Thumb Island, and Control differs from Thermal Station. In all but one period, Control Station density was greater than Thermal Station density (Figure 6.4-49). Thumb Island had lower total shoot density than the Thermal Station, but the fact that Davis Island also had lower shoot density provides evidence for the latitudinal gradient described earlier. Comparison of Figures 6.4-38 and 6.4-49 also points out the role of dead Juncus in establishing a seasonal cycle in shoot abundance, with maxima in summer and minima in December and January. It follows from these findings that total shoot density was a meaningful index of Juncus marsh condition; that station differences occurred; and that, relative to thermal effects, total density was lower at stations nearer the discharge canal than at more distant stations.

Station Summary

Upper Salt Creek resembled most stations in live standing crop and densities of Juncus, but not the Control or Thermal Stations. It also differed from Thermal, but not Control, with respect to live standing crop and densities. Marsh height was average and flowering was typical. Intermixing was common in Upper Salt Creek so combined Juncus and Spartina data were above average. Overall, Upper Salt Creek was a vigorous Juncus marsh more similar to Lower Salt Creek than to Control, but it could be compared to Davis Island, where salinities were also low.

Lower Salt Creek was like Upper Salt Creek for live weight and like the other controls for density. It was consistently different than Thermal and Thumb Island relative to these parameters Lower Salt Creek had tall Juncus and typical flowering, and was structurally more like northern stations than Control Station.

Control was significantly different from northern stations with regard to all measures of standing crop and usually bracketed standing crop at other stations as an upper limit. Standing crop but not density was significantly greater at Control than Thermal during the growing season. Marsh height and shoot weight were above average and flowering was typical.

Midway was like Thumb Island with respect to all measures of standing crop but had higher values than the Thermal Station, at times significantly so. It was usually different than Control and the Fence Station. In both weight and density, Midway was average, between Control and Thermal. The marsh was shorter than at Control but taller than at Thermal; it was not significantly different in height than Thumb Island. It was also intermediate between Control and Thermal with respect to shoot weight and the cessation of flowering in 1983. Overall, Midway was a thermally affected station relative to structural measures of condition in Juncus, but was affected less than Thumb Island when both were compared to the Thermal Station.

The Thermal Station differed from Upper and Lower Salt Creek and Control in most comparisons and from at least two of the sites in all comparisons. The significance of its differences from neighboring stations depended upon

whether dead Juncus and Spartina was included. Standing crop differed most from Control during the growing season. Marsh height and shoot density were lower at Thermal than at any other station and flowering was reduced to the greatest extent. Conditions at the Thermal Station were extreme in all comparisons and must be attributed to the influence of thermal enrichment.

Thumb Island always differed from Control. With respect to standing crop and density, it was like Thermal and often covaried in the same manner. The affinity of Thumb Island to Fence depended on whether dead material or any Spartina was included. Juncus height was lower at Thumb Island than at any other station but the Thermal Station, and flowering patterns resembled those at Midway. Overall, conditions in Juncus at Thumb Island resembled conditions at the Thermal Station more than at any other station, and the station should be included as a thermally influenced station.

The Fence differed significantly from the Thermal Station relative to any form of standing crop. Values of standing crop were lower than values at Control, and Fence differed from Control in density when Spartina was excluded. Weight trends at Fence were out of phase with other stations and density trends were more erratic than average. Marsh height and shoot weight at the Fence were higher than elsewhere; flowering was typical.

Davis Island bore no consistent relationship to any station for standing crop but was lower than average or lowest in shoot density. Perhaps the most interesting feature of Davis Island was its similarity to Thermal, Thumb Island, and Fence Stations and difference from controls or midway when only Juncus was considered, and the reverse (similarity to controls) when Spartina was added to the comparison. This result was due to intermixing in Juncus marshes north of the intake canal and the complicating influence of the Withlacoochee River.

Burrow Density Trends and Patterns

An analysis of variance was performed on burrow density data for all stations and sampling periods (Table 6.4-9). Time, station, marsh type and live weight of plant material were significant sources of variation in burrow densities. Average burrow density in Juncus marshes was $158/m^2$ (N = 948) compared to burrow density in Spartina marshes of $139/m^2$ (N = 947). Because this difference was highly significant, the remaining data are presented for Spartina and Juncus separately. The network of significant differences between overall station means is shown in Figure 6.4-50. The Thermal Station was different than distant stations, other than the Control. Thumb Island was different from all stations but the Thermal Station. Trends through time showed more definite patterns (Figure 6.4-51). Samples taken in 1983 differed from one another and from 1984 samples, whereas 1984 samples were similar to one another but different from those taken in 1983. This pattern suggests a seasonal trend in which changes through time were more rapid in 1983 than in 1984. As Figure 6.4-52 illustrates, seasonality was pronounced for burrow densities in Spartina marshes. Overall, density increased through the Spartina growing season and peaked in October when sea level was highest. Average densities were lowest from December to February and trended gradually upward in most cases, accounting for the pattern depicted in Figure 6.4-51. Compared to the Thermal Station, Midway and Thumb Island were most similar.

Station differences in Juncus marshes are depicted in Figure 6.4-53 and very closely resemble the network shown in Figure 6.4-50, except that the Thermal Station became different than the Control Station, and Midway differed from the Fence. Burrow densities varied between stations in a manner not dependent upon marsh type. Comparison of Figures 6.4-54 and 6.4-51, which Figure 6.4-54 resembles in essential elements, leads to the conclusion that seasonal patterns in burrow density were also independent of marsh type. As in Figure 6.4-51, 1983 samples in Figure 6.4-54 differ from one another and from 1984 periods, whereas 1984 sampling times are like one another but different than 1983 sampling periods. Seasonality suggested by Figure 6.4-54 is demonstrated in Figure 6.4-55. Figure 6.4-55 and 6.4-52 are similar insofar as maximum densities occurred in October and minimum densities occurred in January. The rate of density increases during the first half of 1984 was greater in Juncus marshes than in Spartina marshes. Thumb Island and the Fence exhibited a close covariance in Juncus marshes, and both had higher densities for most periods relative to the Thermal Station. Thus, burrow densities and Juncus marshes at Thumb Island and the Fence showed a greater response relative to the Thermal Station than did burrow densities in Spartina marshes at those two stations. Distant stations had low burrow densities compared to the Thermal Station, and Lower Salt Creek and Control had average densities with reduced seasonality.

Overall, burrow densities in Juncus marshes were better indicators of station differences than burrow densities in Spartina marshes. Elevation and the pattern of burrow seasonality in Juncus marshes is attributed to annual variation in sea level which affects the Juncus marshes considerably more than Spartina marshes growing at lower elevation. Station differences in burrow density within Juncus marshes can be interpreted relative to thermal effects with greater confidence due in part to the tidal sorting of thermal loads. No useful patterns were found in plots of Spartina or Juncus live standing crop against burrow count when station means or means per sampling periods were used, except for an affinity in the covariance of live Spartina weights and burrow count between the Thermal and Thumb Island Stations, and between Midway and the Fence relative to Upper and Lower Salt Creek and Davis Island.

Littorina Density Patterns and Trends

Littorina density data are summarized in Table 6.4-10. Periwinkles were more abundant in Spartina marshes than Juncus marshes, and the Fence Spartina marsh supported very high densities throughout the year. In the Spartina marshes, Midway had above average densities and Thermal densities were below average, like Lower Salt Creek. Mean densities for Midway, Thermal, and Thumb Island Stations were greater than means for Salt Creek and Control Stations in every quarter but spring 1984. Overall, thermally related effects on Littorina density in Spartina marshes were erratic and stimulatory if present at all.

Littorina density in Juncus marshes was considerably lower than in Spartina marshes except at Thumb Island. Fence Juncus had very few periwinkles, in contrast to high densities in Spartina marshes at that station. Mean density of Littorina in southern stations was not significantly greater than densities at stations with other indications of thermal influence.

Epiflora Patterns and Trend

Too few shoots of either marsh species were collected for meaningful intepretation, other than to mention that no algae were reported from thermal or Thumb Island Stations. The shoreline between Thermal and Fence Stations was inspected in June 1984 for evidence of macroflora. None was found south of the Fence. The only attached epiflora found in this segment was filamentous blue-green algae. Information on epiphytes within the marsh interior was not collected.

6.4.3 Impact Assessment

Introduction

Studies conducted both before and after construction of Unit 3 at Crystal River have demonstrated long term differences in the structure of Spartina and Juncus marshes near the point of discharge and at a site south of the intake canal. In studies conducted between 1974 and 1981, the relationship of marsh structure and productivity was documented, and monitoring programs thereafter focused on trends and patterns of particular structural features shown to be useful measures of marsh condition.

The historical Thermal and Control Sites differ with regard to exposure and salinity and probably elevation. New stations in Salt Creek do not appreciably resemble Control and will not be considered further. Stations between Midway and Fence represent approximately comparable marshes along a gradient of temperature and salinity. Davis Island was within the regular influence of the Withlacoochee River.

Thermal data generated in this study for temperatures in the salt marsh represent the first such information since operation of Unit 3. Plume effects were evident in winter and in summer. Winter temperatures at Thermal, Thumb Island, and Fence Stations were different than control temperatures. In the summer, temperatures at Midway, Thermal, and Thumb Island Stations were above background levels. Thus, possible thermal effects were evaluated at Midway, Thermal, Thumb Island, and Fence.

Spartina

Data from Midway, Thumb Island, and the Fence Stations were compared to the Thermal Station with respect to standing crop, density, height, shoot weight, and flowering (Table 6.4-11). Midway resembled the Thermal Station and differed from control stations with regard to standing crop and flowering patterns. Thumb Island standing crop and flowering were affected the same way, but values of live density and shoot weight were transitional between those of the Thermal Station and those at control stations. It is interesting that Fence marsh heights showed no effect and in this respect were similar to Midway and Thumb Island, but other parameters resembled the Thermal Station more than Thumb Island. Fence Juncus marshes did not exhibit similarities to Thermal marshes equal to those in Spartina.

Studies in Spartina marshes north of the intake canal reveal similarities among Thermal and adjacent stations. Effects were noticeable more to the north at Thumb Island and the Fence than to the south at Midway. The linear shoreline affected by thermal effluent extends northward to a point near the Fence, on Luttrell Island.

Juncus

Relative to the Thermal Station, Midway standing crop was different with regard to trends but the values were similar (Table 6.4-11). Live densities at Midway were transitional between Control and Thermal Stations, but total densities were higher than those at the Thermal Station. Marsh height was low and, shoot weight was higher than at the Thermal Station, but trends through time were synchronous. Flowering was reduced, similar to that at Thumb Island. Thumb Island had a live standing crop trend similar to that at the Thermal Station in 1983. Total density was not like that at the Control Station. Marsh height was low and intermediate between that at Thermal and Fence Stations. Flowering was reduced, not as much as at the Thermal Station but similar to that observed at Midway. Fence live standing crop was high, not at all like that at the Thermal Station. Live densities at Fence were like that at Thumb Island and Davis Island, whereas total densities were similar to Thumb Island and lower than Thermal.

Reference was made in preceding sections to the apparent gradient in live shoot densities within Juncus marshes which corresponded to a latitudinal gradient. No difference in this parameter other than the latitudinal gradient could be detected. Comparisons summarized by Table 6.4-11 were based on total densities. Overall, Juncus marshes at the Thermal Station exhibited structural characteristics consistent with those observed in previous studies, and the Thermal Station is therefore classified as a thermally affected station. Flowering in Juncus marshes at Midway was affected, and in this regard the Juncus and Spartina marshes there were similar. Other parameters for Juncus varied inconsistently with Spartina parameters, but it appears that Midway was thermally affected.

Juncus marshes at Thumb Island closely resembled those at the Thermal Station, whereas marshes at the Fence exhibited no thermal effects. Juncus marshes at Midway, therefore, are intermediate in terms of thermal impact between Thumb Island and the Fence. Thumb Island structural features all showed similarity to those at the Thermal Station, although the extent of standing crop response was not as great. In contrast, no similarities in standing crop, height, shoot weight, or flowering could be seen at the Fence and only total densities seemed affected. Overall, Fence Juncus marshes did not seem affected by thermal effluent.

Elevation differences in Spartina and Juncus marshes at the Fence may be responsible for the differential results of this study. Spartina marshes are exposed to the water column for a longer period of time than the higher Juncus marshes. Since heated waters accumulate in the northern portion of Crystal Bay and move northward on flood tides, it is possible that Spartina marshes at Fence were affected differently than Juncus marshes. The same explanation would not apply to effects observed in the Spartina marshes of Thumb Island. The evidence generated by this study for structural features of Juncus marshes is consistent with the finding for Spartina marshes that thermal effects are evident at Midway in Rocky Cove. Juncus marshes at Thumb Island were definitely affected, but the transition between affected and unaffected marshes is located between Thumb Island and Luttrell Island. This delineation of impact applies only to the marshes fringing the coast and not to the marsh interior.

REFERENCES FOR 6.4

Applied Biology, Inc. 1982. Crystal River Benthic Community Structure Study. Post Operational Ecological Monitoring Program Annual Report, 1981.

Applied Bilogy, Inc. 1983. Post Operational Ecological Monitoring Program, Crystal River Units 1, 2, and 3, 1977-1981. Summary Report. Decatur, Georgia.

Coggins, W. F. 1980. Comparison of selected preoperational and operational measurements, Post Operational Ecological Monitoring Program, Crystal River Units 1, 2, and 3, Annual Report 1979. Volume II.

Florida Power Corporation. 1975. Summary Analysis and Supplemental Data Report to the Interagency Research Advisory Committee.

Goforth, G. 1979. Community metabolism of the marsh ecosystems. Post Operational Ecological Monitoring Program, Crystal River Units 1, 2, and 3, Annual Report 1978. Volume II.

Goforth, G. and J. J. Kosik. 1980. Community metabolism of the marsh ecosystems. Post Operational and Ecological Monitoring Program Crystal River Units 1, 2, and 3, Annual Report 1979. Volume II.

Homer, M. 1974. Characteristics of tidal creeks receiving thermal discharge. Section 4E in Vol. I, Crystal River Power Plant Environmental Considerations, 1974.

Hornbeck, D. A. 1978. Marsh metabolism measurements. In: Annual Environmental Operating Report - Nonradiological 1/14/77-12/31/77. Supplement I.

Klausewitz, R. H., S. L. Palmer, B. A. Rodgers, and K. L. Carder. 1974. Natural heating of salt marsh waters in the area of the Crystal River Power Plant. Technical Report No. 3, Vol. III, Crystal River Power Plant Environmental Considerations, 1974.

Knight, R. L. and W. F. Coggins. 1982. Report of estuarine and salt marsh metabolism at Crystal River, Florida 1977-1981. Final Summary Report. Univ. of Fla., Gainesville.

Kosik, J. J. 1981. Community metabolism of the marsh ecosystem. Ch. 6, In: Post Operational Ecological Monitoring Program, Crystal River Units 1, 2, and 3, Annual Report 1980, Vol. II.

Odum, H. T. and J. Caldwell. 1978. Comparison of selected preoperational and operational measurements. pp. iii-160, In: Annual Environmental Operating Report - Nonradiological 1/14/77-12/31/77. Supplement I.

Odum, H. T. and C. Montague. 1981. Comparison of selected preoperational and operational measurements that changed by more than two standard deviations, Ch. 7. In: Post Operational Ecological Monitoring Program, Crystal River Units 1, 2, and 3. Annual Report 1980, Vol. II.

Oviatt, C. A., S. W. Nixon, and J. Garber. 1977. Variation and evaluation of coastal salt marshes. Environ. Mgt. 1(3):201-212.

Young, D. L. 1974. Salt marshes and thermal additions at Crystal River, Florida. Section 4F in Vol. I, Crystal River Power Plant Environmental Considerations, 1974.

TABLE 6.4-1

SALT MARSH STATION DESCRIPTION

Station Name	Aspect	Approx. Elevation of Marsh Floor cm above MLW		Thickness of Marsh Floor, m	Horizon*	Avg. Summer Ht, cm	
		Spartina	Juncus			Spartina	Juncus
1 Upper Salt Creek	Sheltered well-scoured creek, steep banks; near hammocks	118	116	1.5(±0.9)	135°	88	140
2 Lower Salt Creek	*Spartina* sites exposed, *Juncus* sheltered; mild banks, much *Distichlis*.	49	82	1.0(±0.3)	140°	91	140
3 Control	Sheltered to north by intake canal levee, exposed to west; drift algae seasonally abundant.	106	122	1.0(±0.3)	180°	82	171
4 Midway	Sheltered by intake & discharge canal levees; relief affected by historical filling. Deeply incised creeks.	67	118	1.5(±0.5)	170°	98	143
5 Thermal	Similar to Station 1, sheltered to south by discharge canal levee, mild relief on open shore; steep creek banks.	76	88	1.1(±1.0)	180°	79	134
6 Thumb Island	Sheltered by Thumb Island; low relief across dissected marsh.	79	76	0.7(±0.2)	180°	88	140
7 Fence	Sheltered but subject to tidal currents; some sites on a deep creek; hammocks nearby.	85	79	1.3(±0.8)	180°	88	171
8 Davis Island	Sheltered, with steep to gently sloping banks; hammocks nearby.	94	88	1.4(±0.6)	165°	107	171

*Horizon refers to the solar arc between 090° and 270°, an estimate of relative insolation potential.

Table 6.4-2 Mean water temperature at slack high tide for the period August 5-September 5, 1983 at Crystal River Salt Marsh Control and Thermal Sites. Data are ^{o}C.

	Control	Thermal	N
Days	28.3 ± 3.5	34.3 ± 1.9	28
Nights	22.8 ± 1.4	32.9 ± 1.7	28
All times	25.0 ± 4.9	23.6 ± 1.9	56

Table 6.4-3 Mean water temperature at slack high water near Crystal River, August 6-15, 1983.

Value, ^{o}C	3 Control	4 Midway	5 Thermal	6 Thumb Island	7 Fence	8 Davis Island
Day Mean	28.1	29.3	33.9	32.4	28.4	28.0
Sd	3.1	2.1	1.8	3.7	2.8	0.9
N	10	10	10	10	10	10
Night Mean	23.8	24.9	33.3	23.6	24.5	25.0
Sd	1.5	1.1	0.7	1.6	2.3	1.7
N	10	10	10	10	10	10
Overall Mean	25.9	27.1	33.6	28.0	26.5	26.5
Sd	3.2	2.8	1.4	5.3	3.2	2.0
N	20	10	20	20	20	20

Table 6.4-4 Thermal characteristics of salt marsh stations.

Station	Temperature Range, °C Winter (December-February)	Summer (June-August)
1. Upper Salt Creek	>14.0	<30.0
2. Lower Salt Creek	>14.0	<30.0
3. Control	13.5-14.0	<30.0
4. Midway	<16.0	<31.0
5. Thermal	>20.0	32.5
6. Thumb Island	18.5-20.0	>31.5
7. Fence	15.5-16.5	<30.0
8. Davis Island	<15.5	<30.0

Table 6.4-5 GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: Spartina live weight in Spartina marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	79	3083998.80805491	39039.7707197	18.86	0.0001	0.629350	39.1780
ERROR	876	1801424.30469214	2056.42043915		ROOT MSE		MILIVE MEAN
CORRECTED TOTAL	955	4885423.19154907			45.34777215		115.29812762

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	9	2310930.60705412	124.84	0.0001	9	2320670.46650450	125.39	0.0001
STATION	7	292056.92802352	20.29	0.0001	7	286676.79245122	19.92	0.0001
TIME*STATION	63	461509.27177927	3.56	0.0001	63	461509.27177927	3.56	0.0001

DEPENDENT VARIABLE: Spartina total weight in Spartina marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	71	2919497.33239348	41119.60073799	8.53	0.0001	0.435707	32.5515
ERROR	784	3781098.65533070	4822.02991751		ROOT MSE		STCROP MEAN
CORRECTED TOTAL	855	6700595.98772417			69.44659759		213.34307850

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	8	557550.51477045	14.45	0.0001	8	560703.68987452	14.53	0.0001
STATION	7	1736106.78017528	51.43	0.0001	7	1732041.29797611	51.31	0.0001
TIME*STATION	56	625840.03794773	2.32	0.0001	56	625840.03794773	2.32	0.0001

DEPENDENT VARIABLE: Spartina and Juncus live weight in Spartina marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	81	3090736.20495033	38157.23709020	18.56	0.0001	0.631773	39.2599
ERROR	876	1801424.30469151	2056.42043915		ROOT MSE		LIVECROP MEAN
CORRECTED TOTAL	957	4892160.50964503			45.34777215		115.50648225

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	11	2337170.08515165	103.32	0.0001	11	2344690.07407657	103.65	0.0001
STATION	7	292056.92802361	20.29	0.0001	7	286676.79245131	19.92	0.0001
TIME*STATION	63	461509.27177906	3.56	0.0001	63	461509.27177906	3.56	0.0001

DEPENDENT VARIABLE: Spartina and Juncus total weight in Spartina marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	81	3953073.42631377	42630.53059647	8.40	0.0001	0.436176	33.0556
ERROR	879	4963631.15160752	5070.00097610		ROOT MSE		TOTCROP MEAN
CORRECTED TOTAL	960	7916706.77800320			71.26065497		215.57035580

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	11	812551.45726927	14.55	0.0001	11	801237.17833761	14.34	0.0001
STATION	7	1660032.01709750	46.70	0.0001	7	1659379.13116739	46.68	0.0001
TIME*STATION	63	980909.35200192	3.06	0.0001	63	980909.35200192	3.06	0.0001

Table 6.4-5 continued.

DEPENDENT VARIABLE: Spartina live density in Spartina marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	79	145441.32904650	1841.02949173	13.52	0.0001	0.549480	34.3070
ERROR	876	119247.83333333	136.12766362		ROOT MSE		MOLIVE MEAN
CORRECTED TOTAL	955	264689.16317992			11.66737609		33.92887027

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	9	33409.06490093	27.27	0.0001	9	33097.26572909	27.01	0.0001
STATION	7	82100.01060556	86.29	0.0001	7	82020.01626796	86.07	0.0001
TIME*STATION	63	29051.45926009	3.40	0.0001	63	29051.45926009	3.40	0.0001

DEPENDENT VARIABLE: Spartina total density in Spartina marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	79	298174.90707810	3774.36591238	10.17	0.0001	0.478282	34.1000
ERROR	876	325259.09166667	371.29456011		ROOT MSE		SHDEN MEAN
CORRECTED TOTAL	955	623428.99874477			19.26900537		56.50732718

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	9	62073.60001209	18.02	0.0001	9	62593.27798323	18.73	0.0001
STATION	7	180250.24575356	69.35	0.0001	7	179999.66731537	69.26	0.0001
TIME*STATION	63	55051.09131166	2.35	0.0001	63	55051.09131166	2.35	0.0001

DEPENDENT VARIABLE: Spartina and Juncus live density in Spartina marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	81	147730.05977731	1823.93654046	13.40	0.0001	0.553357	34.9597
ERROR	876	119247.83333333	136.12766362		ROOT MSE		LIVEDEN MEAN
CORRECTED TOTAL	957	266906.69311065			11.66737609		33.05803758

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	11	35706.59903166	23.05	0.0001	11	36226.62009136	24.19	0.0001
STATION	7	82100.01060556	86.29	0.0001	7	82020.01626796	86.07	0.0001
TIME*STATION	63	29051.45926009	3.40	0.0001	63	29051.45926009	3.40	0.0001

DEPENDENT VARIABLE: Spartina and Juncus total density in Spartina marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	81	286905.99265919	3542.04867979	8.61	0.0001	0.442017	35.3573
ERROR	880	362170.00833333	411.56600379		ROOT MSE		TOTDEN MEAN
CORRECTED TOTAL	961	649074.02598753			20.28708950		57.37733008

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	11	56366.00723753	12.45	0.0001	11	57890.67993209	12.79	0.0001
STATION	7	170731.40229167	59.26	0.0001	7	170731.40229167	59.26	0.0001
TIME*STATION	63	59007.65312500	2.31	0.0001	63	59007.65312500	2.31	0.0001

Table 6.4-6. Shoot weight and specific weight of *Spartina* in June 1984. Weights in grams and grams/cm, respectively.

Station	Shoot Weight	Shoot Rank	Specific Shoot Weight	Specific Shoot Rank
1	3.8	5	.035	7
2	3.7	7	.038	6
3	5.0	2	.055	2
4	6.2	1	.059	1
5	2.9	8	.033	8
6	4.7	3	.047	3
7	3.8	6	.039	5
8	4.7	4	.044	4

Note: shoot- average weight in grams of individual shoots
specific shoot- grams per centimeter of shoot

Table 6.4-7 GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: Juncus live weight in Juncus marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	79	3303440.46017007	41810.80020490	4.55	0.0001	0.290049	41.4049
ERROR	674	8085029.43500049	9195.23337335		ROOT MSE		MILIVE MEAN
CORRECTED TOTAL	753	11388472.90329137			95.89177799		231.19000753

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	9	519929.11700000	6.62	0.0001	9	544199.04596393	6.40	0.0001
STATION	7	1660697.02784734	25.72	0.0001	7	1671309.40146739	25.97	0.0001
TIME*STATION	63	1075994.02803349	1.09	0.0001	63	1075994.52003541	1.09	0.0001

DEPENDENT VARIABLE: Juncus total weight in Juncus marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	71	7032419.15941930	99051.10527633	3.88	0.0001	0.260236	91.4202
ERROR	789	19991307.15762622	25499.21030997		ROOT MSE		STCROP MEAN
CORRECTED TOTAL	859	27024021.30924560			159.60479669		305.49912303

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	8	506451.70502791	2.40	0.0115	8	517300.41498639	2.54	0.0099
STATION	7	4954740.93716505	29.97	0.0001	7	4966500.92193267	25.02	0.0001
TIME*STATION	56	2049233.73242533	1.45	0.0199	56	2049233.73242532	1.45	0.0199

DEPENDENT VARIABLE: Juncus and Spartina live weight in Juncus marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	71	487770.34074043	6870.20600395	8.07	0.0001	0.422002	111.0017
ERROR	705	668105.81239057	851.00769731		ROOT MSE		LIVECROP MEAN
CORRECTED TOTAL	856	1155875.70115120			29.17399169		26.26304551

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	8	151692.09791599	22.57	0.0001	8	154199.20351932	22.65	0.0001
STATION	7	223500.39513079	37.53	0.0001	7	223600.09469902	37.53	0.0001
TIME*STATION	56	110557.12917309	2.32	0.0001	56	110557.12917309	2.32	0.0001

DEPENDENT VARIABLE: Juncus and Spartina total weight in Juncus marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	71	792473.05749816	11169.69090096	7.01	0.0001	0.385023	99.9303
ERROR	792	1261056.68107995	1593.25330523		ROOT MSE		TOTCROP MEAN
CORRECTED TOTAL	863	2059597.74857811			39.91557023		42.04370170

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	8	110329.09777732	9.20	0.0001	8	110329.09777732	9.20	0.0001
STATION	7	451738.72927900	40.50	0.0001	7	451738.72927900	40.50	0.0001
TIME*STATION	56	222630.20759676	2.50	0.0001	56	222630.20759676	2.50	0.0001

Table 6.4-7 continued.

DEPENDENT VARIABLE: Juncus live density in Juncus marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	79	511111.81156099	[illegible]	[illegible]	[illegible]	0.223493	41.0352
ERROR	872	1881478.42121262	[illegible]		ROOT MSE		DOLIVE MEAN
CORRECTED TOTAL	951	1171070.91277311			[illegible]		05.02903193

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	9	67079.19950551	6.29	0.0001	9	69523.07340545	5.33	0.0001
STATION	7	190201.17249367	16.15	0.0001	7	190019.99610963	16.22	0.0001
TIME*STATION	63	112036.29991173	1.93	0.0175	63	112036.29991173	1.93	0.0175

DEPENDENT VARIABLE: Juncus total density in Juncus marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	79	1000041.91607226	12649.13211174	3.79	0.0001	0.259112	40.7623
ERROR	847	2917795.02272770	3380.94049519		ROOT MSE		SHOEH MEAN
CORRECTED TOTAL	996	3918836.85999850			58.21090613		142.80969625

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	9	118701.81100017	3.09	0.0001	9	116452.31921131	3.03	0.0001
STATION	7	671079.90255198	19.07	0.0001	7	671826.07326913	19.08	0.0001
TIME*STATION	63	410202.99110789	1.92	0.0001	63	410202.99110759	1.92	0.0001

DEPENDENT VARIABLE: Juncus and Spartina live density in Juncus marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	79	29229.52151770	306.63751200	7.03	0.0001	0.415050	106.9017
ERROR	872	38137.69676970	39.15102063		ROOT MSE		LIVEDEH MEAN
CORRECTED TOTAL	951	50349.21808739			6.25707020		5.85073950

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	9	2810.09020293	7.78	0.0001	9	2779.55201746	7.09	0.0001
STATION	7	14799.98570009	61.30	0.0001	7	16739.03037417	61.00	0.0001
TIME*STATION	63	9413.69593972	1.07	0.0001	63	9413.69553972	1.07	0.0001

DEPENDENT VARIABLE: Juncus and Spartina total density in Juncus marshes.

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	79	876790.10256200	11005.41901970	3.71	0.0001	0.251152	36.2952
ERROR	873	2611170.56040486	2991.04073300		ROOT MSE		TOTDEH MEAN
CORRECTED TOTAL	952	3486926.66316099			54.67940006		150.68205666

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	9	75477.91991183	2.81	0.0030	9	75563.91516913	2.81	0.0031
STATION	7	409934.78040919	19.56	0.0001	7	409810.09270260	19.55	0.0001
TIME*STATION	63	390591.00279211	2.07	0.0001	63	390591.00279210	2.07	0.0001

Table 6.4-8. Shoot weight and specific weight of *Juncus* in June 1984. Weights in grams and grams/cm, respectively.

Station	Shoot		Specific Shoot	
	Weight	Rank	Weight	Rank
1	2.2	7	.015	8
2	2.3	6	.015	7
3	3.2	2	.019	2
4	2.5	5	.016	5
5	1.9	8	.015	6
6	2.7	4	.018	3
7	3.6	1	.021	1
8	2.8	3	.017	4

Note: shoot- average weight in grams of individual shoots
specific shoot- grams per centimeter of shoot

Table 6.4-9 Analysis of Variance for Burrow Density.

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: DEN

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	82	3431689.52838145	41849.87229733	15.52	0.0001	0.412554	34.9042
ERROR	1812	4886472.82729137	2696.72893338		ROOT MSE		DEN MEAN
CORRECTED TOTAL	1894	8318162.35567283			51.93003803		148.77889182

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
TIME	9	1666421.99675243	68.66	0.0001	9	1363308.45252755	56.17	0.0001
STATION	7	675192.94917944	35.77	0.0001	7	665123.97724805	35.23	0.0001
TYPE	1	169628.75299059	62.90	0.0001	1	54376.51154099	20.16	0.0001
TNOLIVE	1	6820.92469851	2.53	0.1119	1	7746.23212453	2.87	0.0903
THTLIVE	1	33075.73361870	12.27	0.0005	1	24104.85260428	8.94	0.0028
TIME*STATION	63	880549.17114178	5.18	0.0001	63	880549.17114178	5.18	0.0001

Table 6.4-10. *Littorina* density in *Spartina* and *Juncus* marshes near Crystal River.

A. *Spartina*

	Littorina Density, No./m^2 at Station							
Quarter	1	2	3	4	5	6	7	8
II 1983	5.2	4.3	0	6.0	11.3	3.6	54.3	4.3
III 1983	6.0	0	0.6	15.3	0	1.0	61.6	7.0
IV 1983-1984	1.7	0	0.3	3.6	0	2.0	33.0	3.0
I 1984	3.6	0.6	1.0	10.3	3.3	0.6	44.8	1.6
II 1984	3.6	45.6	0.6	10.3	0	1.3	32.6	1.0

B. *Juncus*

Quarter	1	2	3	4	5	6	7	8
II 1983	1.0	7.6	0.6	0.6	11.3	2.6	1.0	5.6
III 1983	1.0	2.3	0	0.3	0	0.6	0	8.0
IV 1983-1984	2.0	1.6	0	0.3	1.6	1.3	0	0.6
I 1984	2.0	0.6	1.3	0.3	0.3	0	0	1.0
II 1984	1.3	1.6	1.0	1.6	1.3	2.0	0	0.6

Table 6.4-11. Summary of impacts at Stations 4-7.

Parameter	STATION 4	5	6	7
Spartina				
Standing Crop	Thermal	Thermal	Thermal	Thermal
Live Density	No effect	Thermal	Transitional	Thermal
Height	No effect	Thermal	No effect	No effect
Shoot Weight	No effect	Thermal	Transitional	Thermal
Flowering	Thermal	Thermal	Thermal	Thermal
Juncus				
Standing Crop	No effect	Thermal	Transitional	No effect
Total Density	No effect	Thermal	Thermal	Transitional
Height	Transitional	Thermal	Thermal	No effect
Shoot Weight	Transitional	Thermal	Thermal	No effect
Flowering	Thermal	Thermal	Thermal	No effect

Table 6.4-10. *Littorina* density in *Spartina* and *Juncus* marshes near Crystal River.

A. *Spartina*

	Littorina Density, No./m^2 at Station							
Quarter	1	2	3	4	5	6	7	8
II 1983	5.2	4.3	0	6.0	11.3	3.6	54.3	4.3
III 1983	6.0	0	0.6	15.3	0	1.0	61.6	7.0
IV 1983-1984	1.7	0	0.3	3.6	0	2.0	33.0	3.0
I 1984	3.6	0.6	1.0	10.3	3.3	0.6	44.8	1.6
II 1984	3.6	45.6	0.6	10.3	0	1.3	32.6	1.0

B. *Juncus*

Quarter	1	2	3	4	5	6	7	8
II 1983	1.0	7.6	0.6	0.6	11.3	2.6	1.0	5.6
III 1983	1.0	2.3	0	0.3	0	0.6	0	8.0
IV 1983-1984	2.0	1.6	0	0.3	1.6	1.3	0	0.6
I 1984	2.0	0.6	1.3	0.3	0.3	0	0	1.0
II 1984	1.3	1.6	1.0	1.6	1.3	2.0	0	0.6

Table 6.4-11. Summary of impacts at Stations 4-7.

Parameter	STATION 4	5	6	7
Spartina				
Standing Crop	Thermal	Thermal	Thermal	Thermal
Live Density	No effect	Thermal	Transitional	Thermal
Height	No effect	Thermal	No effect	No effect
Shoot Weight	No effect	Thermal	Transitional	Thermal
Flowering	Thermal	Thermal	Thermal	Thermal
Juncus				
Standing Crop	No effect	Thermal	Transitional	No effect
Total Density	No effect	Thermal	Thermal	Transitional
Height	Transitional	Thermal	Thermal	No effect
Shoot Weight	Transitional	Thermal	Thermal	No effect
Flowering	Thermal	Thermal	Thermal	No effect

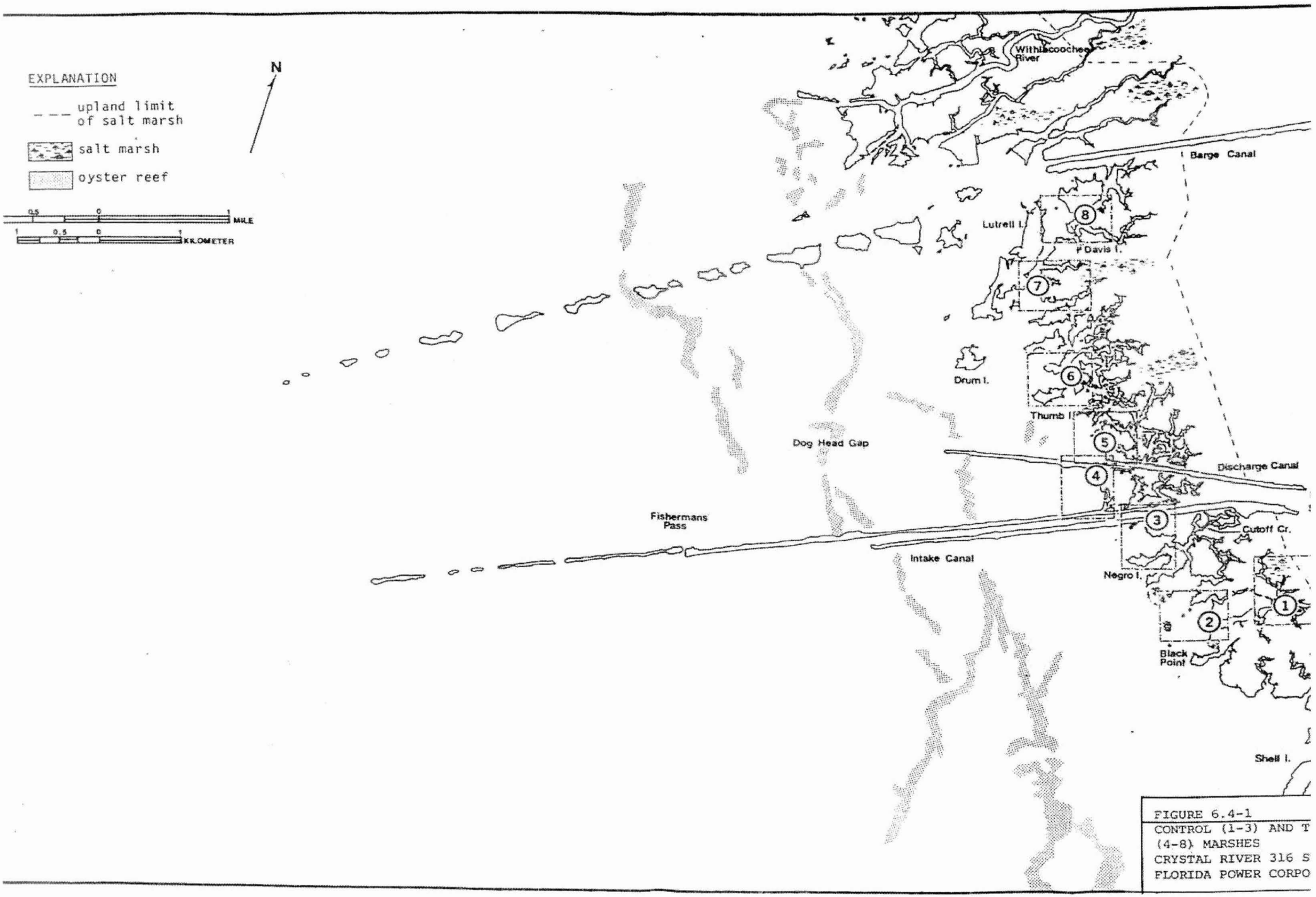


FIGURE 6.4-1
CONTROL (1-3) AND T
(4-8) MARSHES
CRYSTAL RIVER 316 S
FLORIDA POWER CORPO

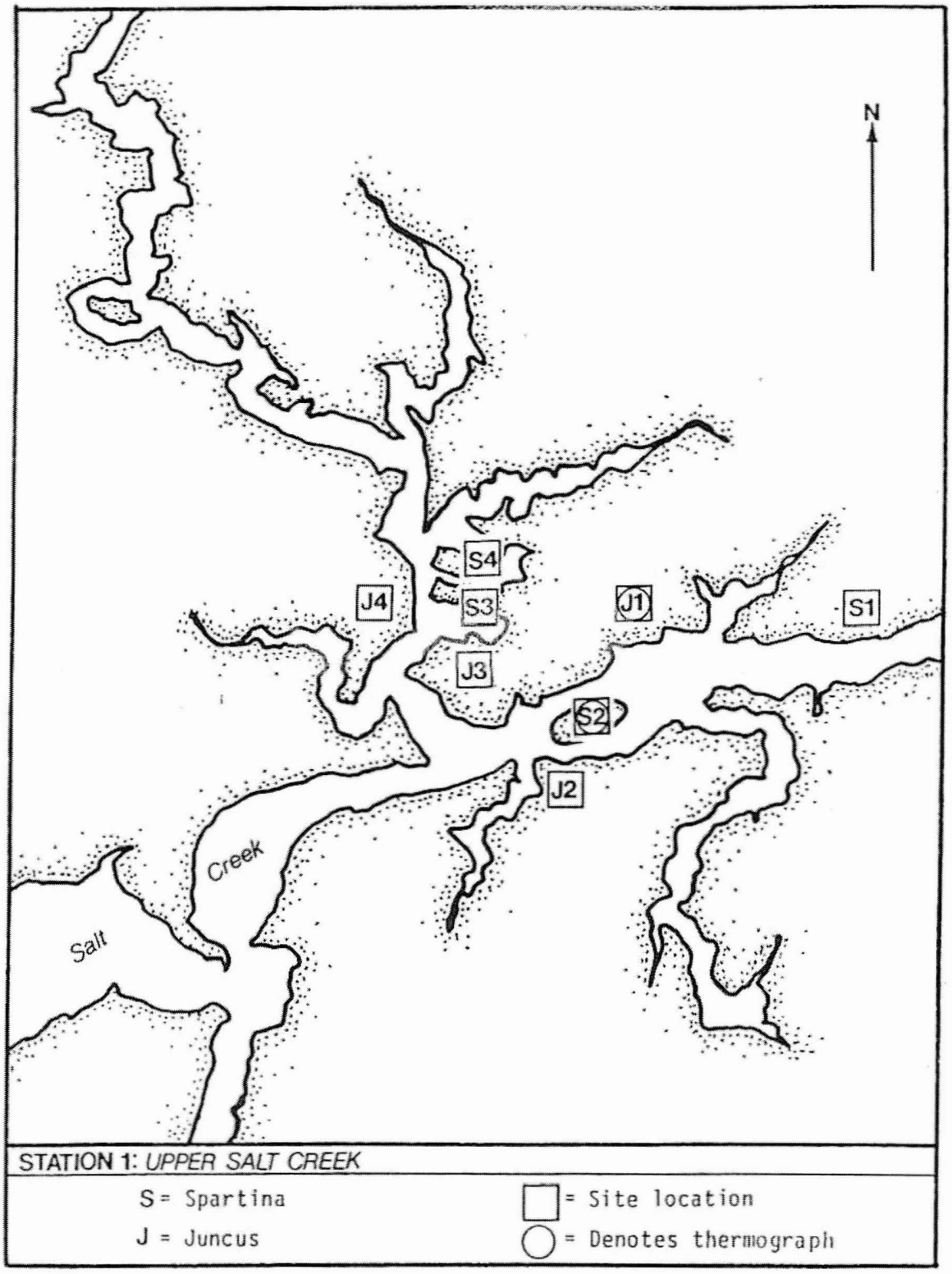


FIGURE 6.4-2
STATION 1
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

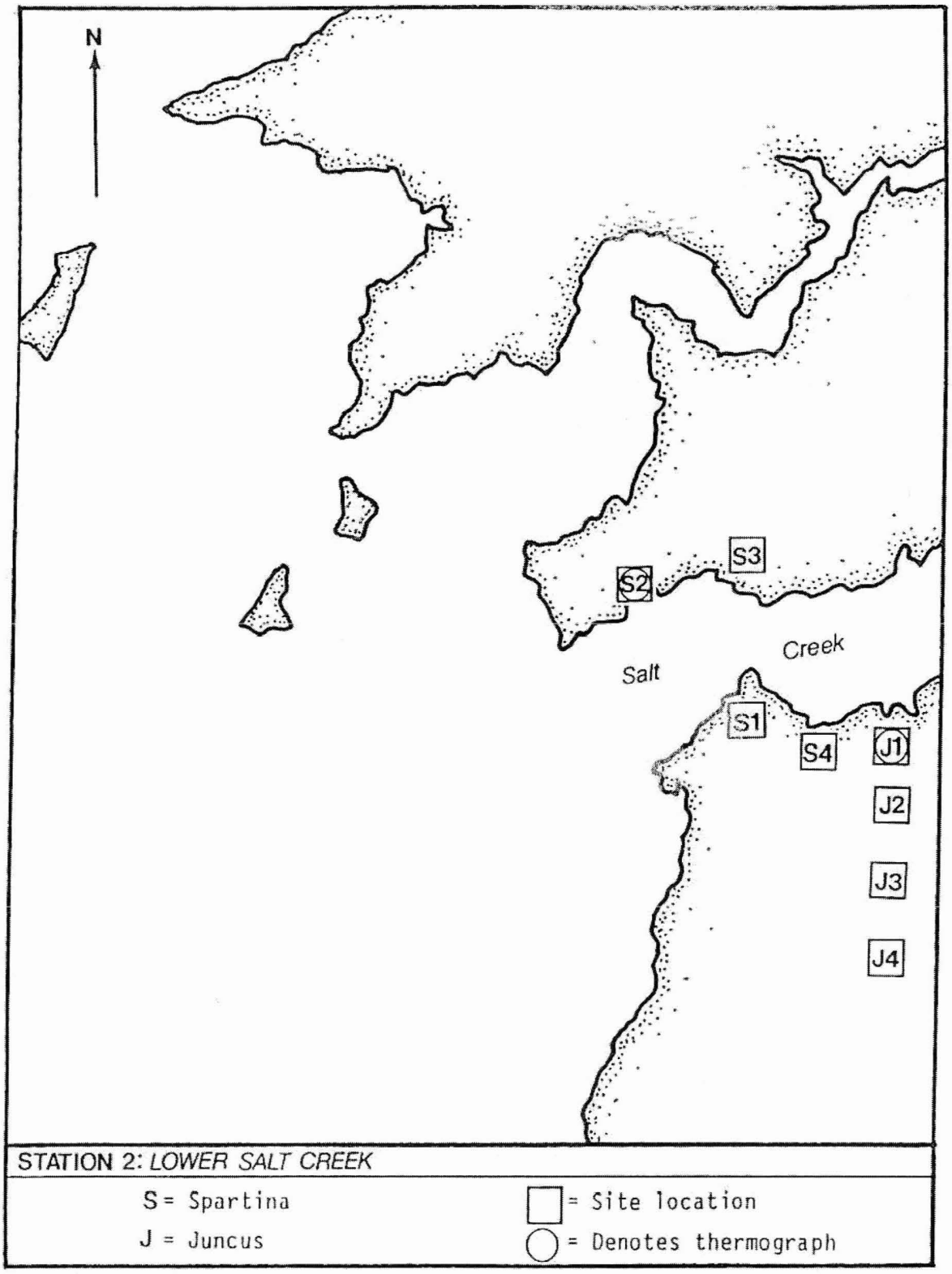
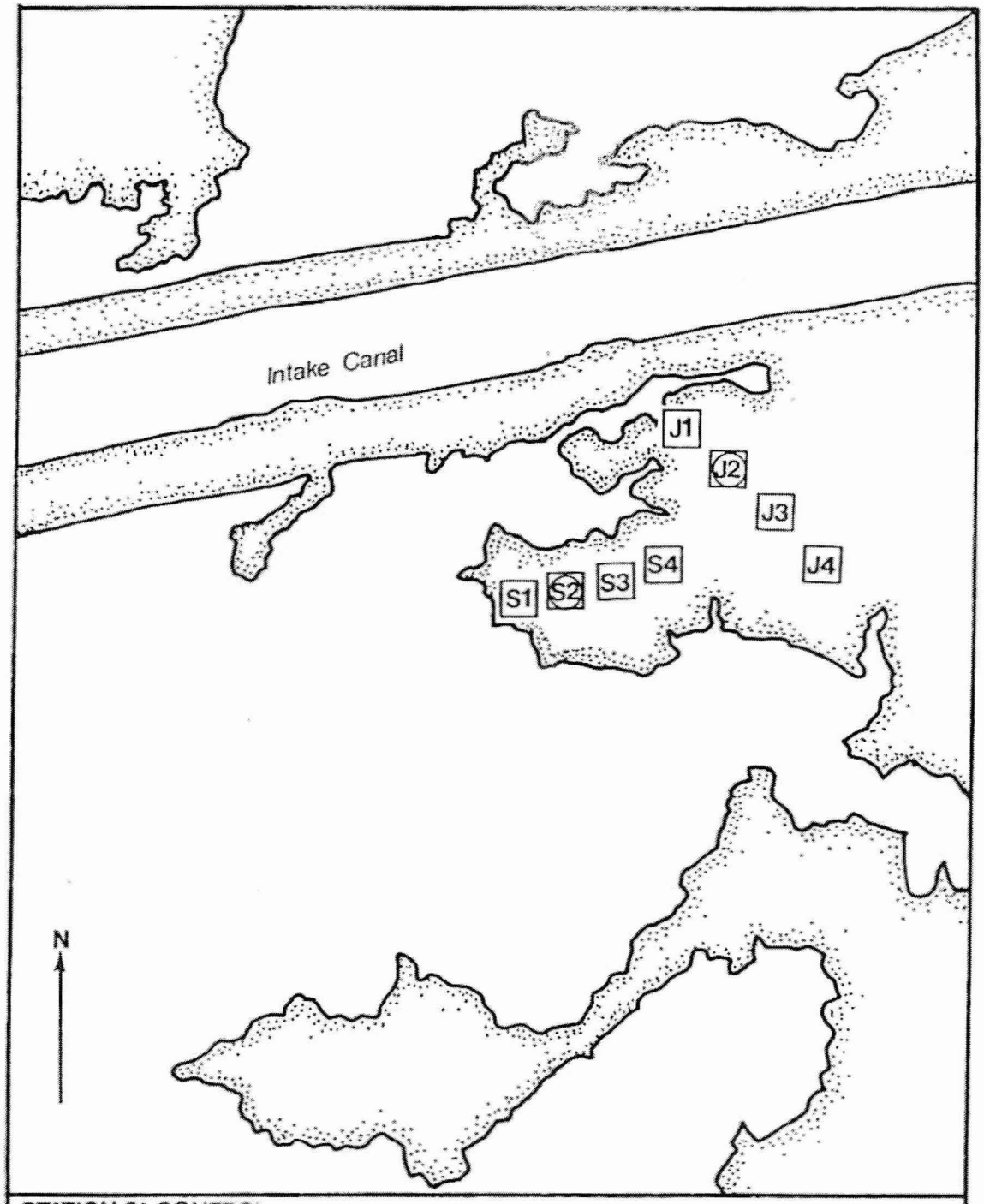


FIGURE 6.4-3
STATION 2
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION 3: *CONTROL*

S = Spartina

J = Juncus

□ = Site location

○ = Denotes thermograph

FIGURE 6.4-4
STATION 3
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

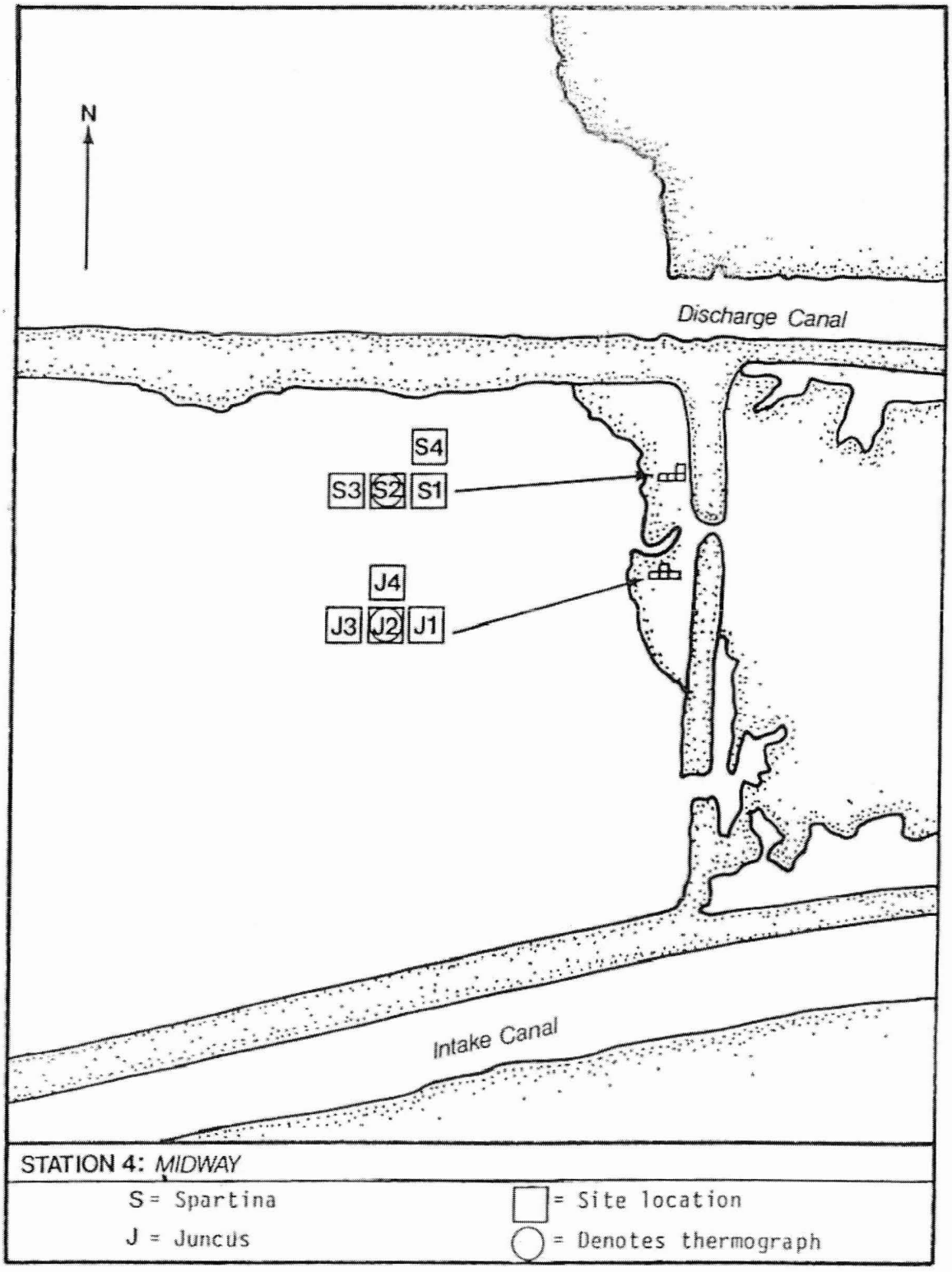


FIGURE 6.4-5

STATION 4
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

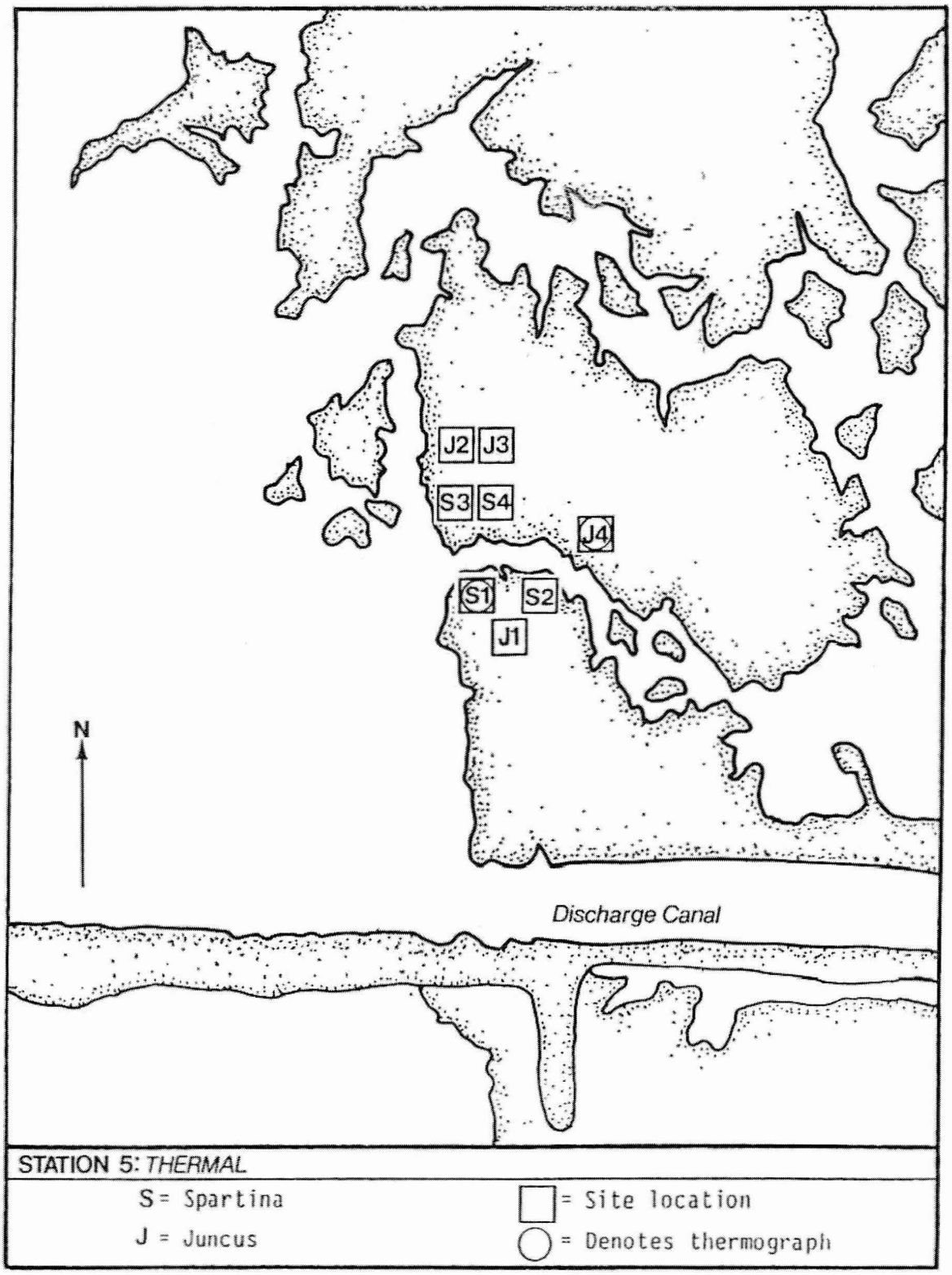


FIGURE 6.4-6

STATION 5
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

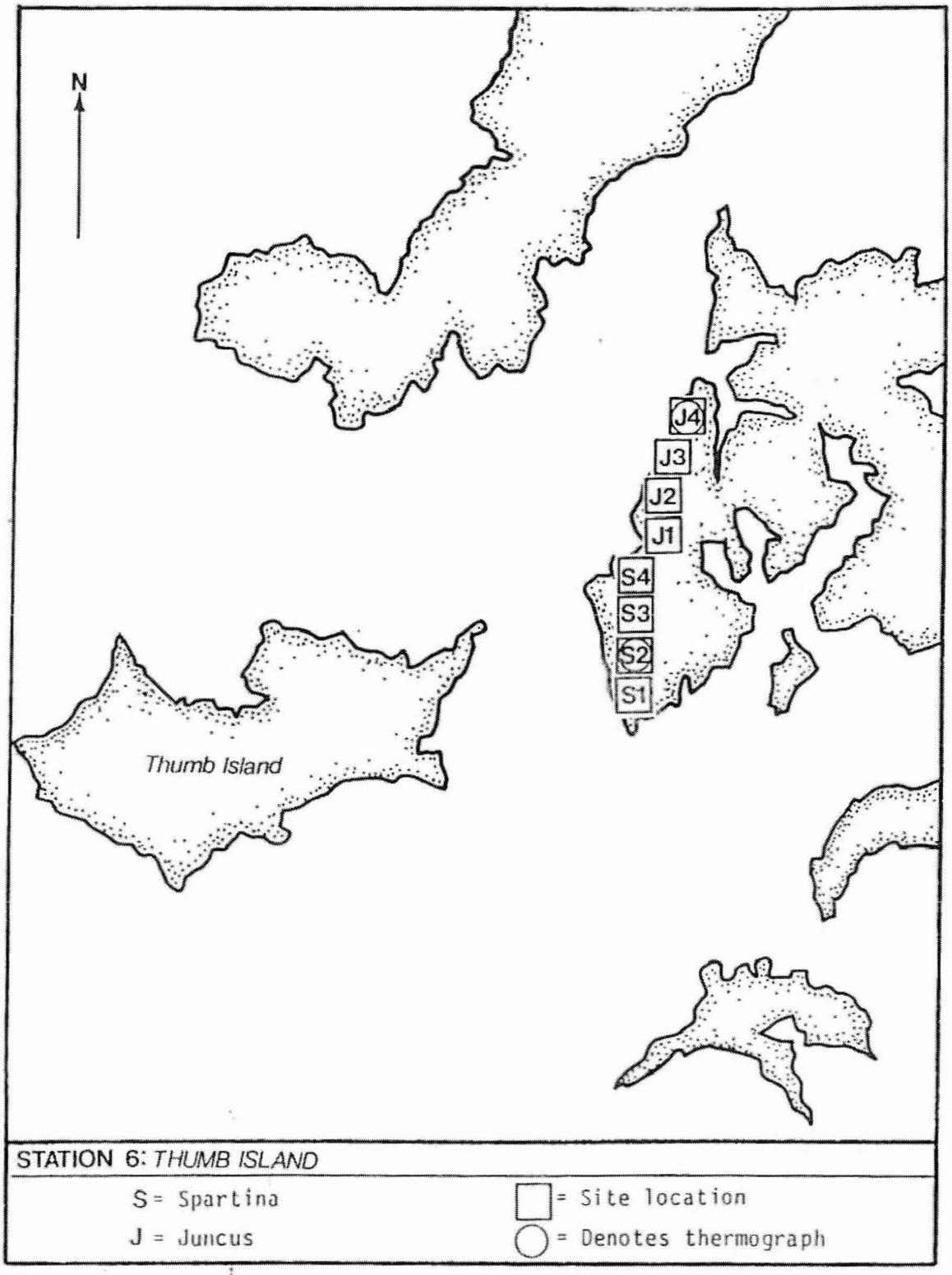


FIGURE 6.4-7

STATION 6
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

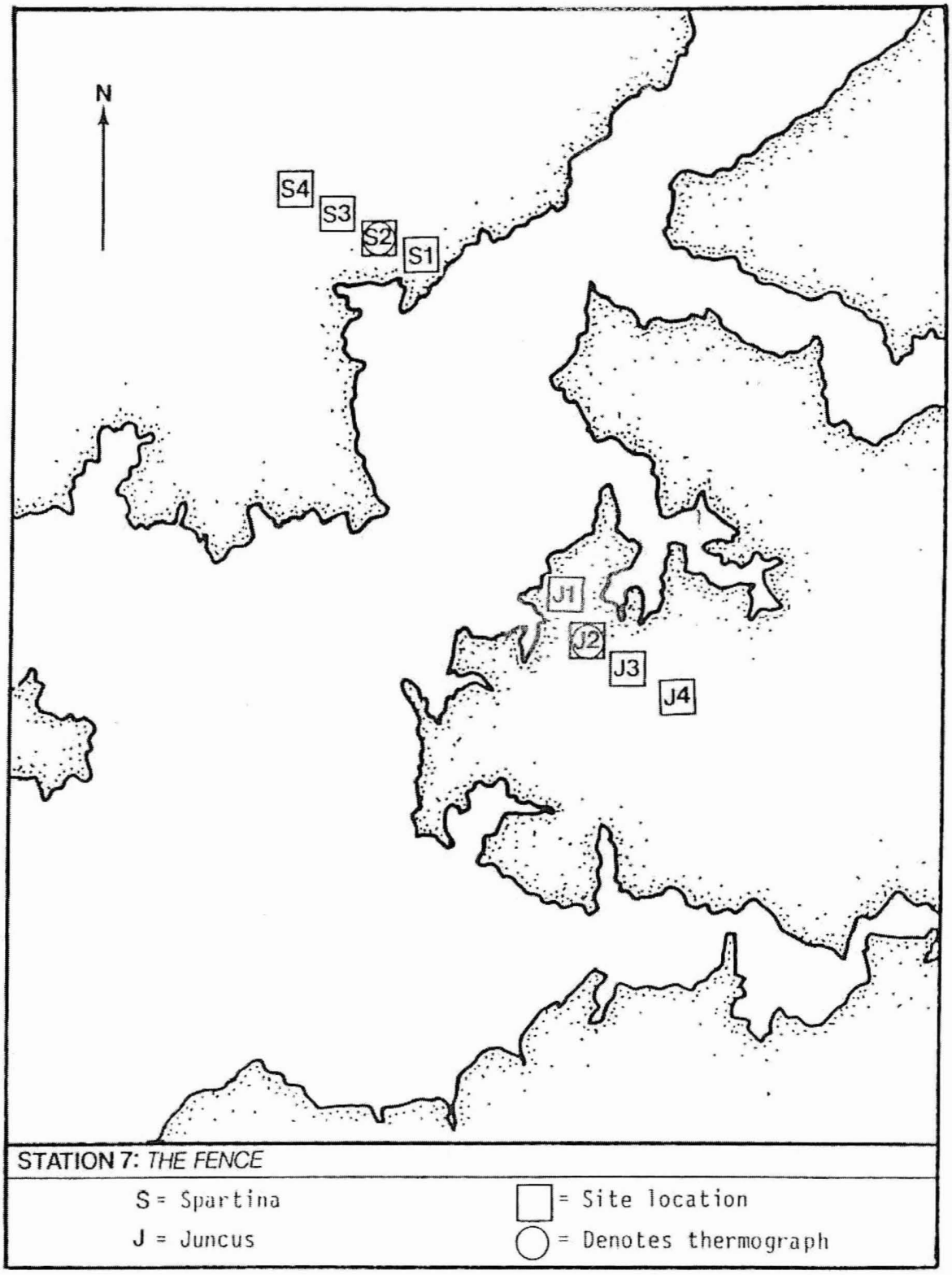
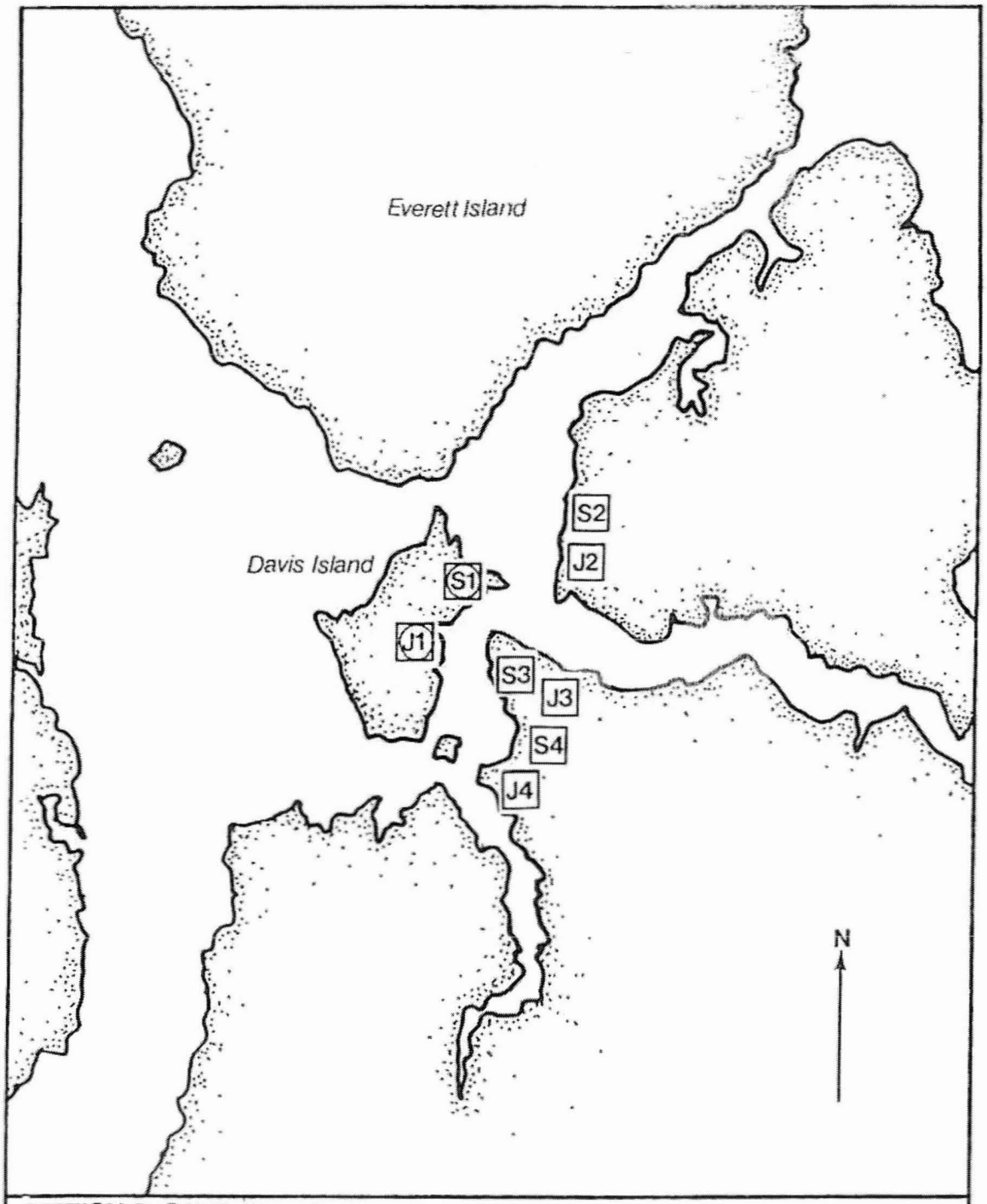


FIGURE 6.4-8

STATION 7
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION 8: *DAVIS ISLAND*

S = Spartina

J = Juncus

□ = Site location

○ = Denotes thermograph

FIGURE 6.4-9

STATION 8
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

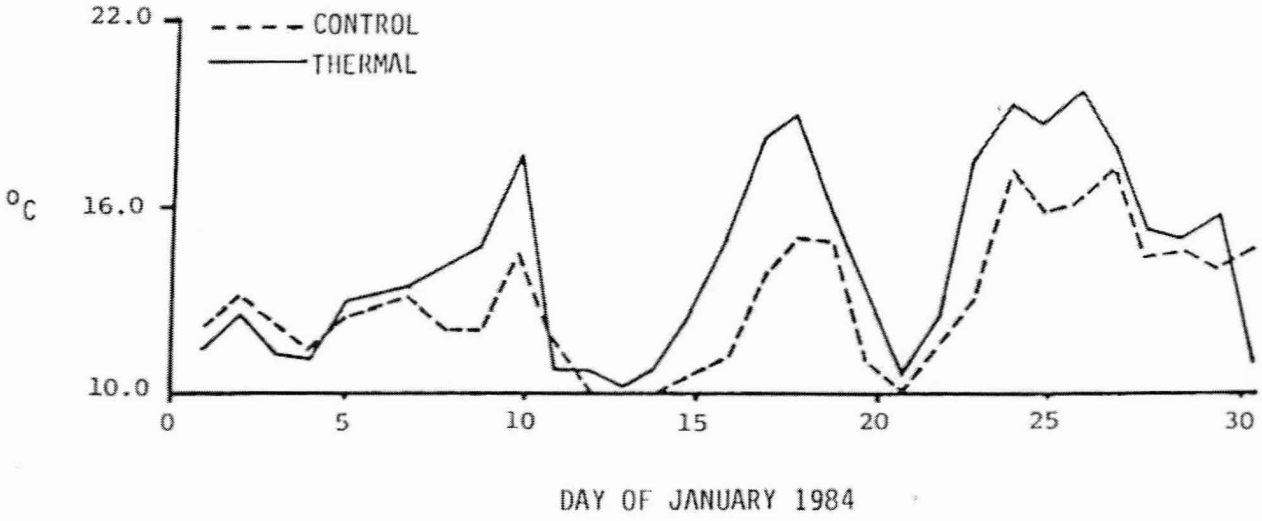
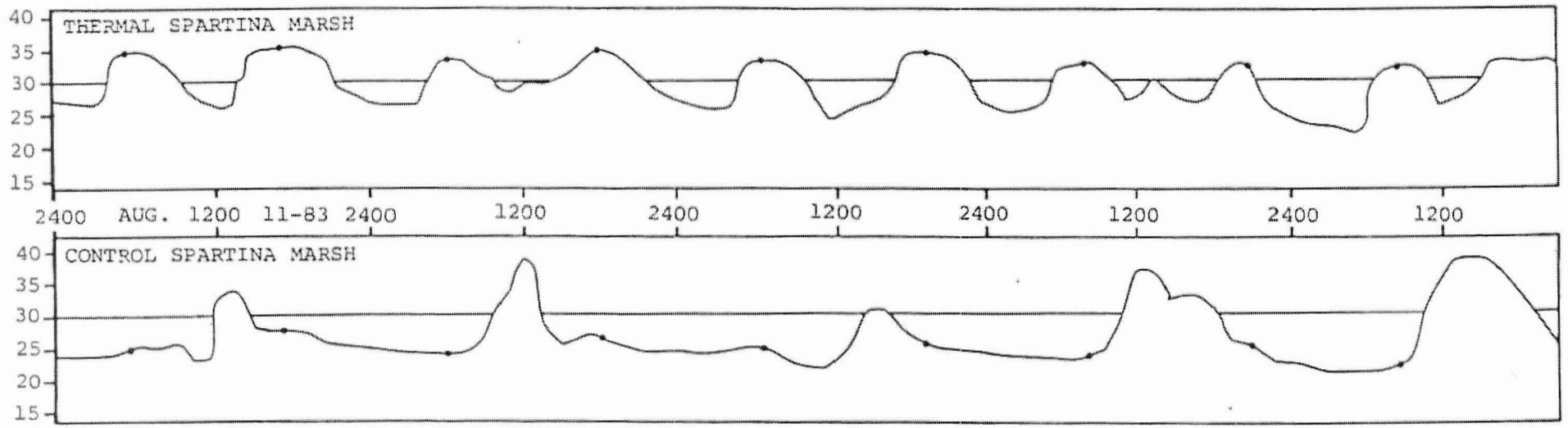


FIGURE 6.4-10

MEAN DAILY TEMPERATURE
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

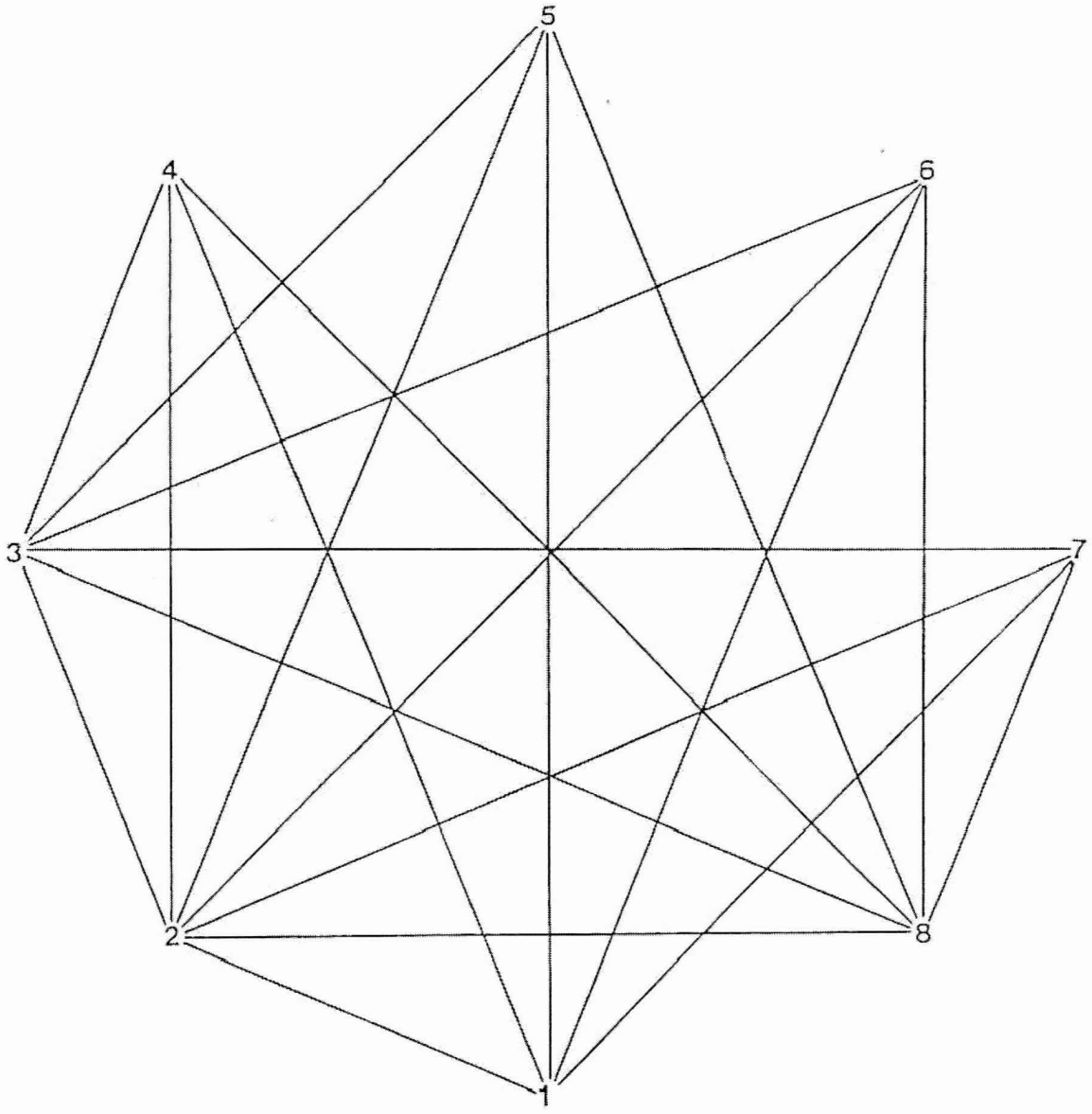


NOTE:

Closed circuits indicate times of slack high tide.

FIGURE 6.4-11

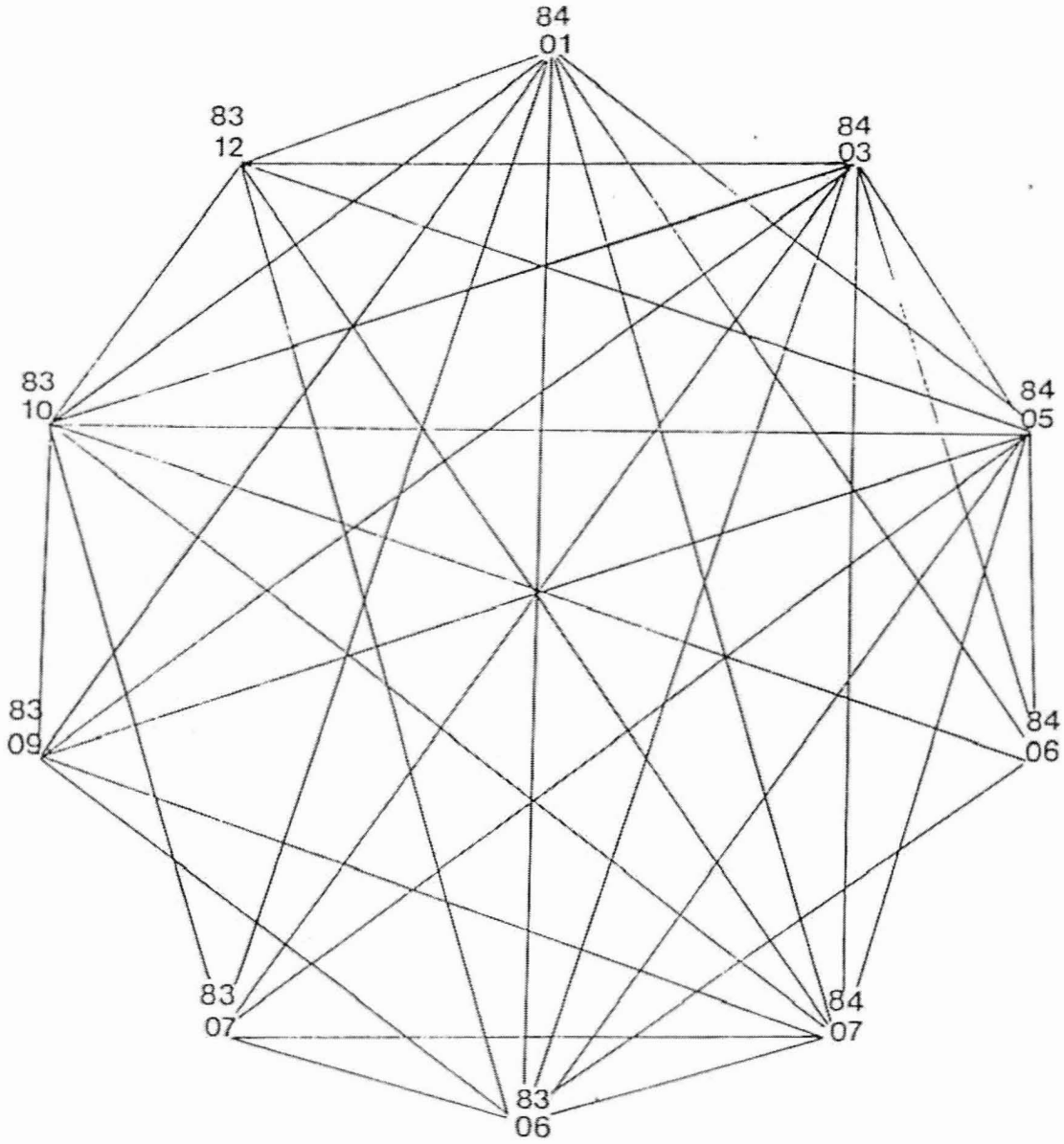
CONTROL AND THERMAL MARSH TEMPERATURES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION DIFFERENCES

FIGURE 6.4-12

SPARTINA LIVE WEIGHT
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



TIME DIFFERENCES

FIGURE 6.4-13

SPARTINA LIVE WEIGHT
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

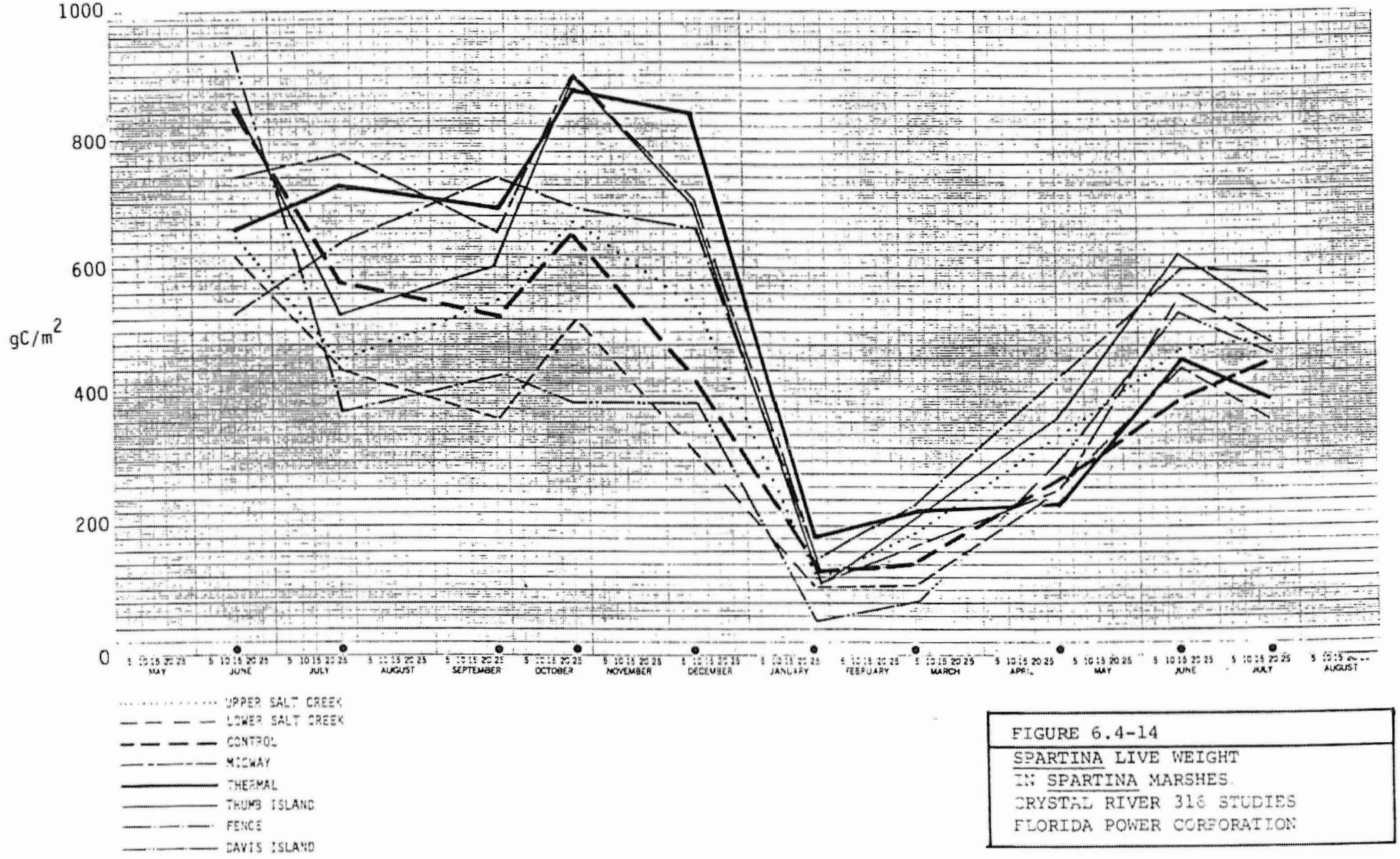


FIGURE 6.4-14
SPARTINA LIVE WEIGHT
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

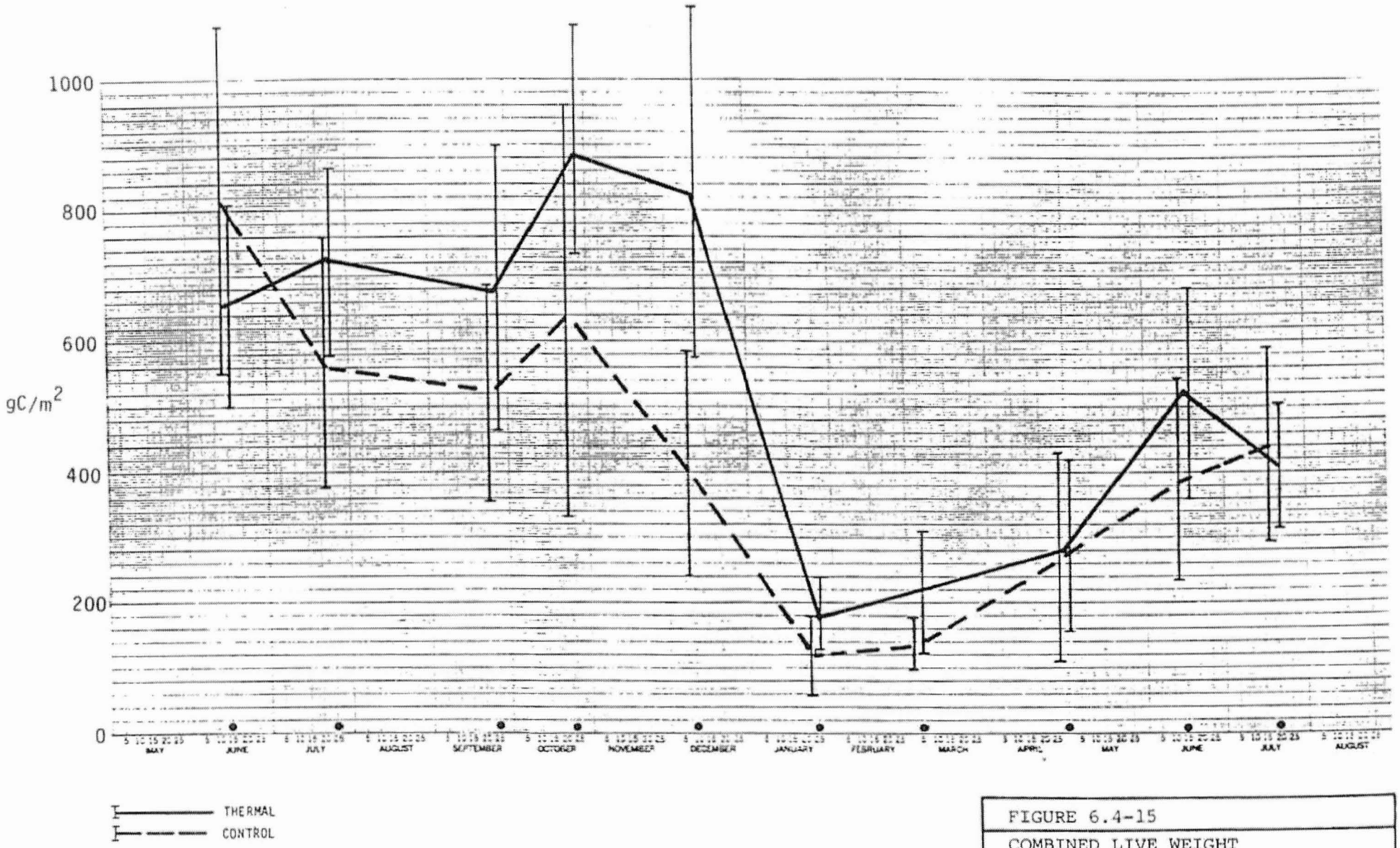
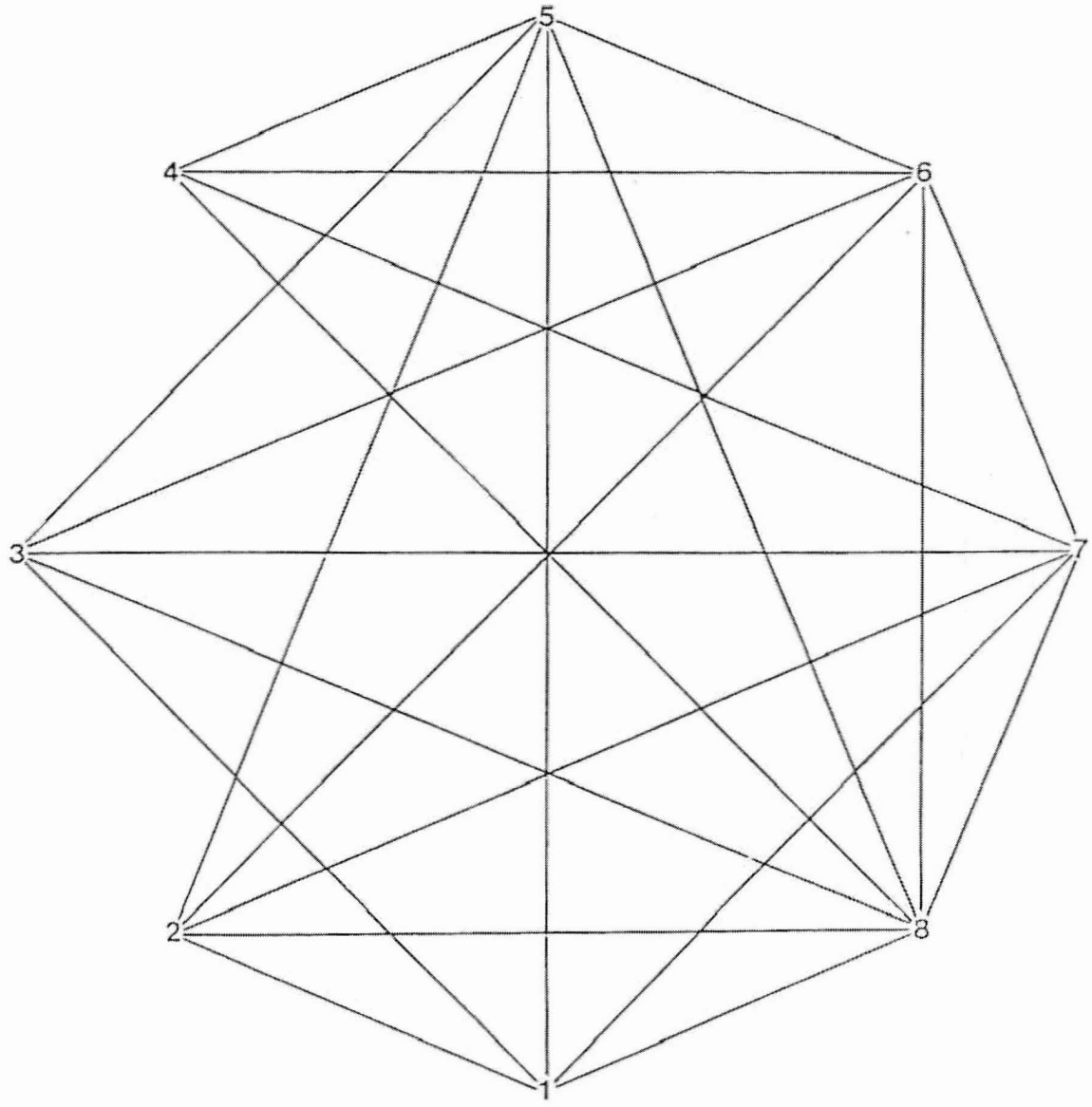


FIGURE 6.4-15

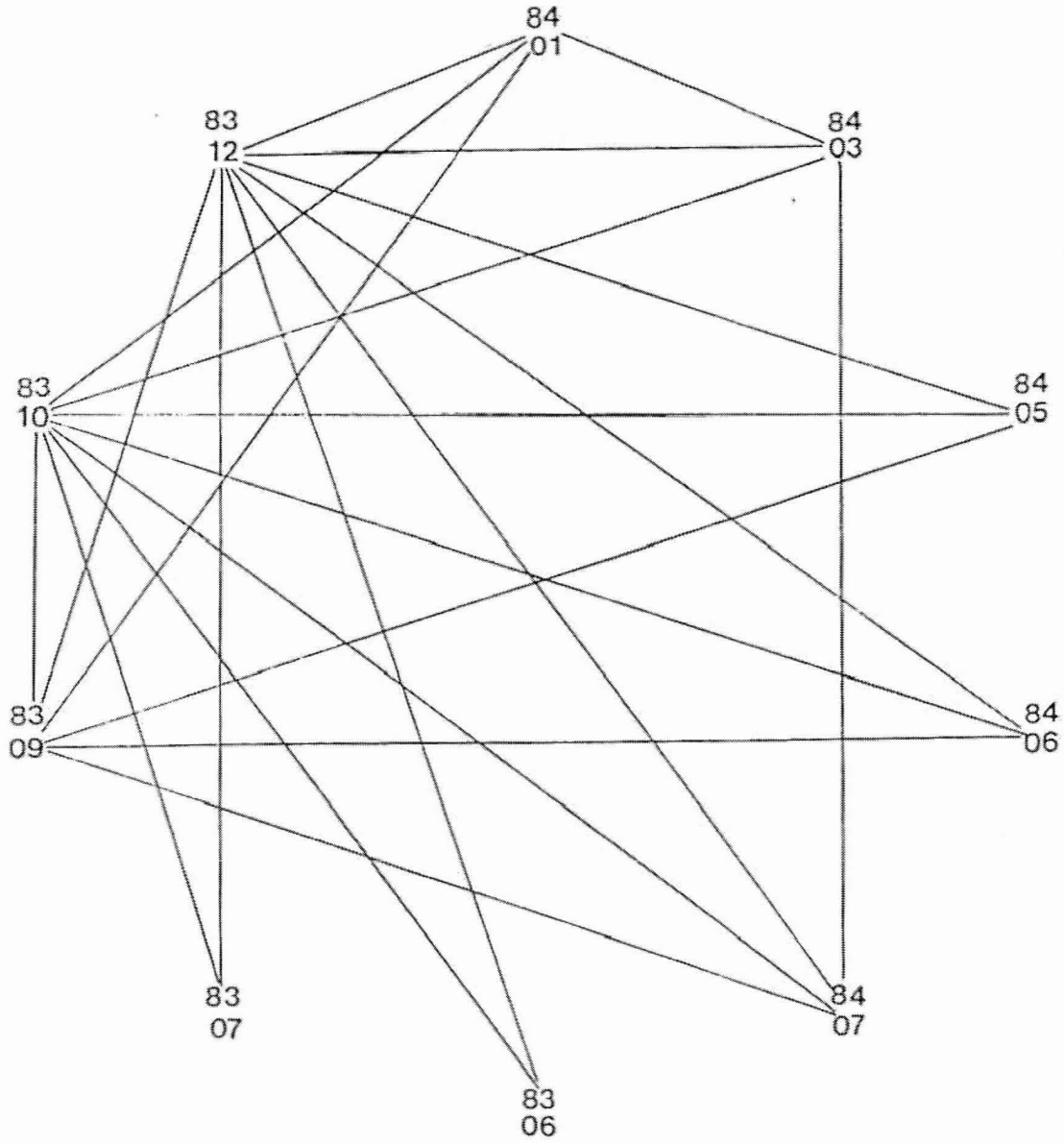
COMBINED LIVE WEIGHT
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION DIFFERENCES

FIGURE 6.4-16

SPARTINA LIVE DENSITY
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



TIME DIFFERENCES

FIGURE 6.4-17

SPARTINA LIVE DENSITY
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

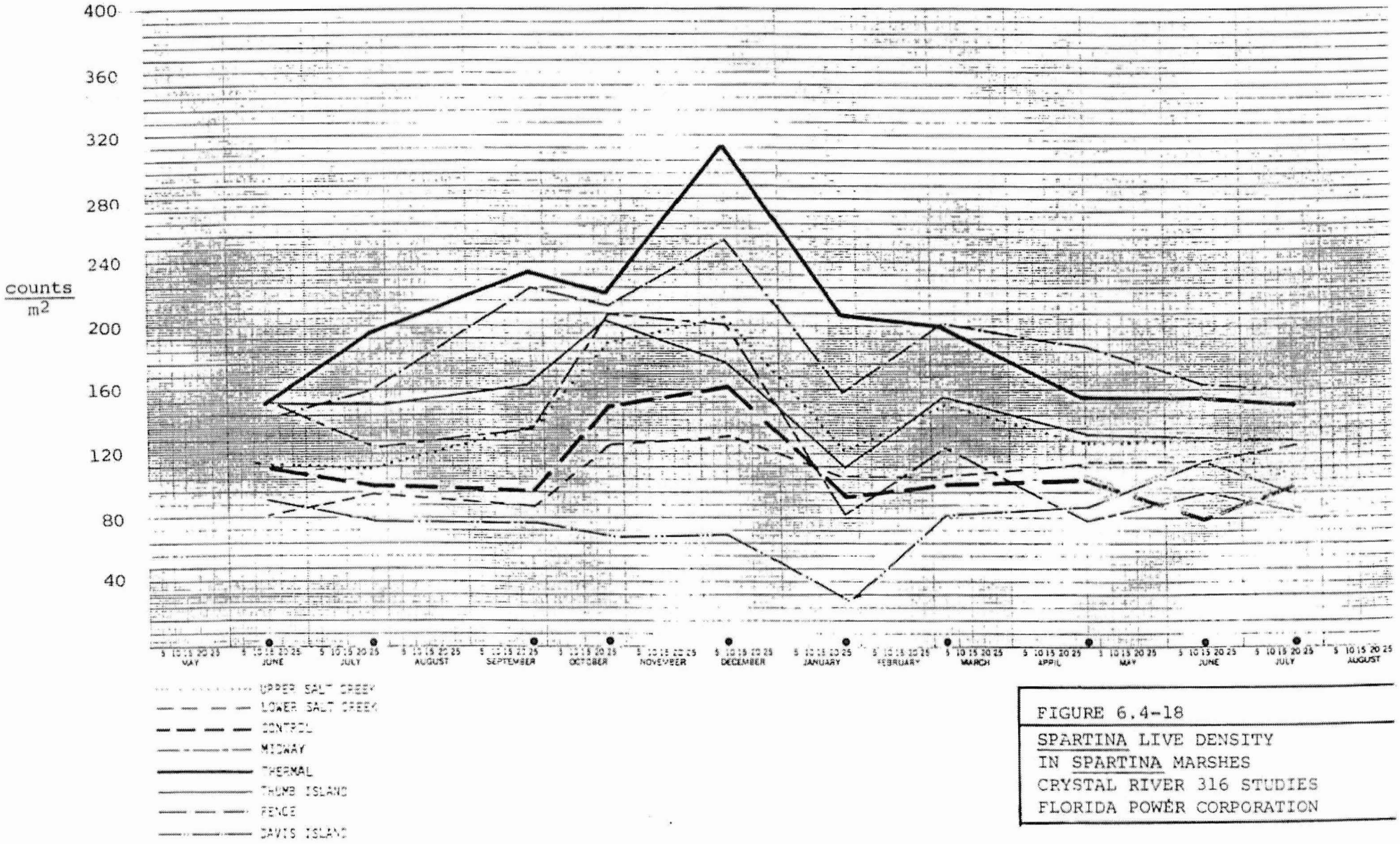


FIGURE 6.4-18

SPARTINA LIVE DENSITY
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

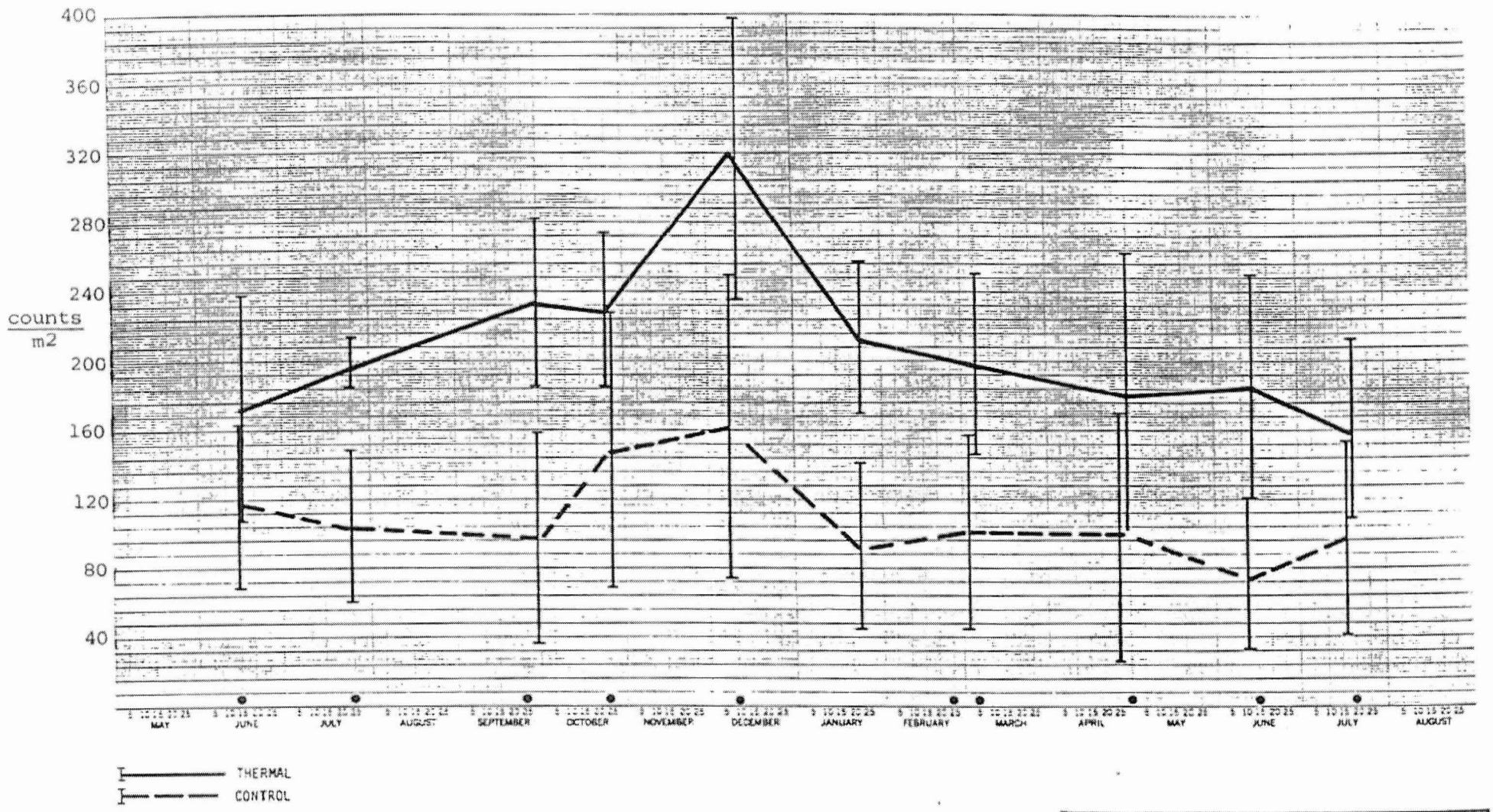
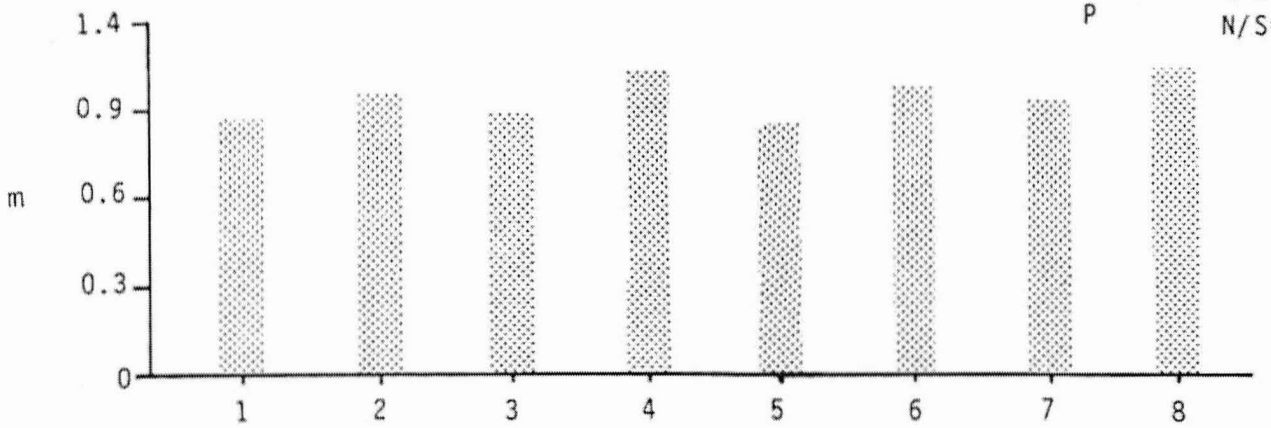


FIGURE 6.4-19

COMBINED LIVE DENSITY
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



2 Sided P

	Thumb	Thermal	Davis	Upper Salt	Lower Salt	Control	Fence	Midway
Thumb								
Thermal	••							
Davis	••	••						
Upper Salt	••	N/S	••					
Lower Salt	•	••	••	••				
Control	••	••	••	N/S	••			
Fence	••	••	••	••	N/S	••		
Midway	N/S	••	••	••	••	••	••	

•• = p<.01
• = p<.05
N/S= not significant

df≈238

FIGURE 6.4-20

MEAN HEIGHT OF
SPARTINA JUNE 1984
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

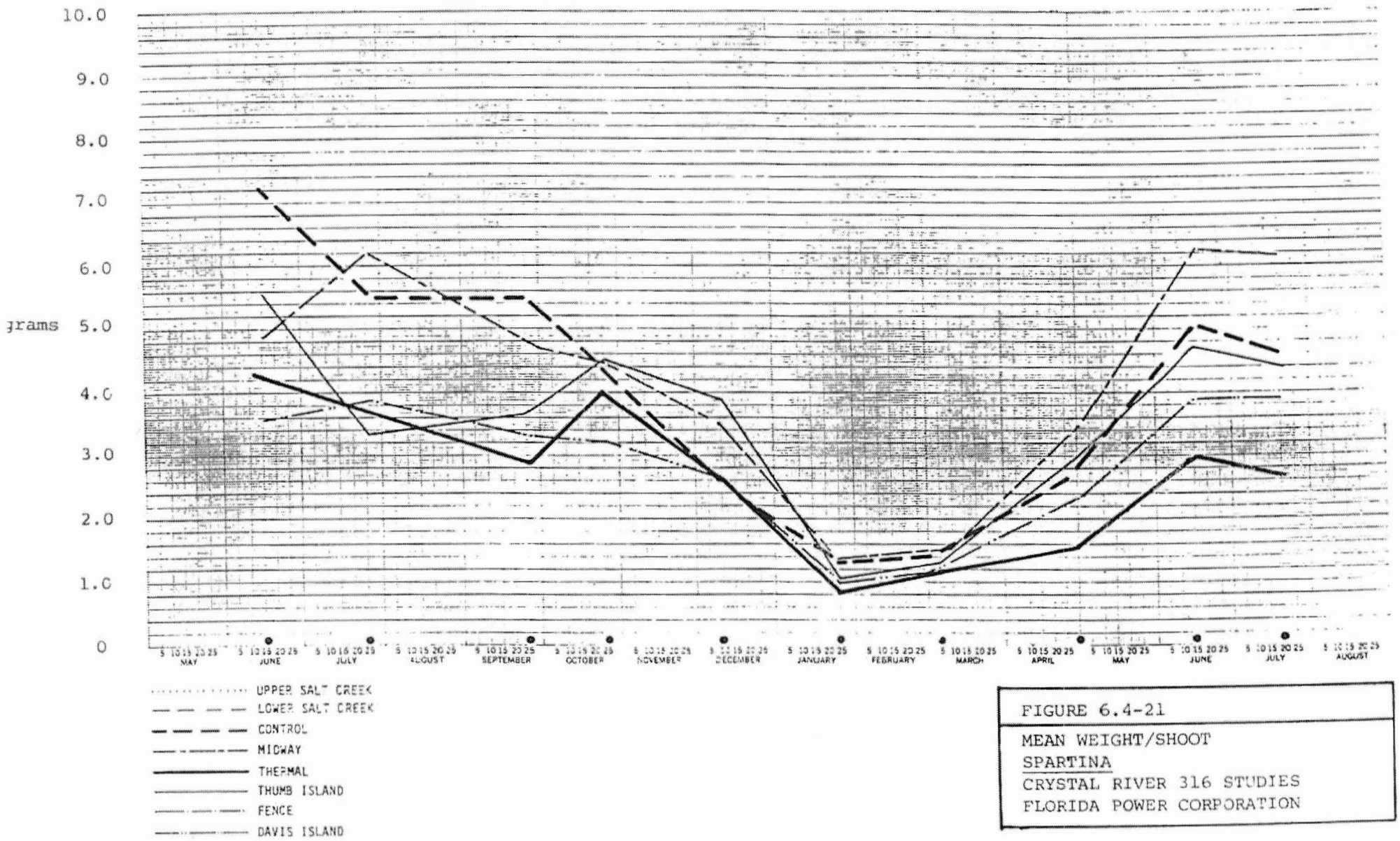


FIGURE 6.4-21

MEAN WEIGHT/SHOOT
SPARTINA
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

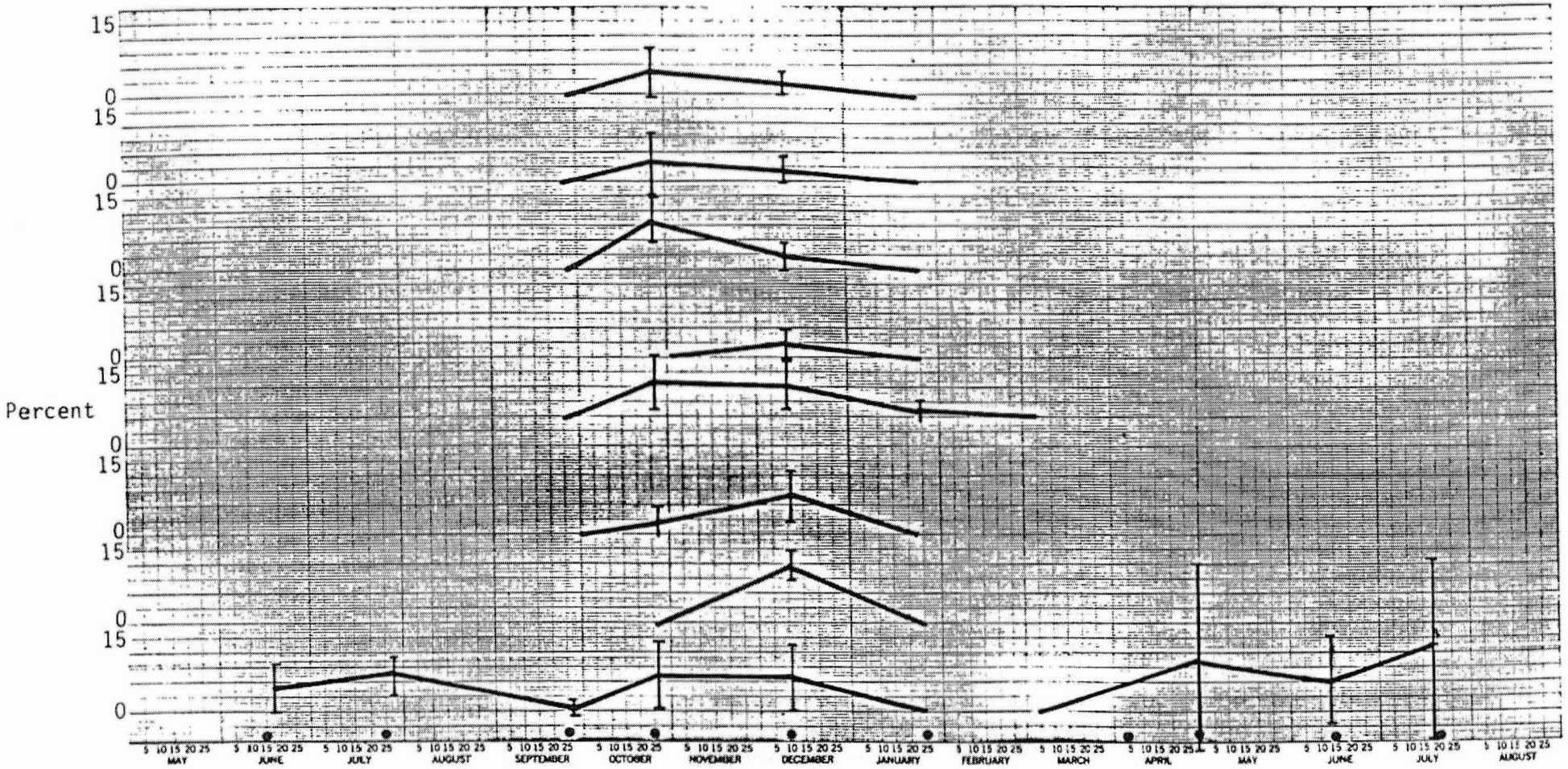


FIGURE 6.4-22

REPRODUCTIVE SPARTINA SHOOTS, PERCENT TOTAL
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

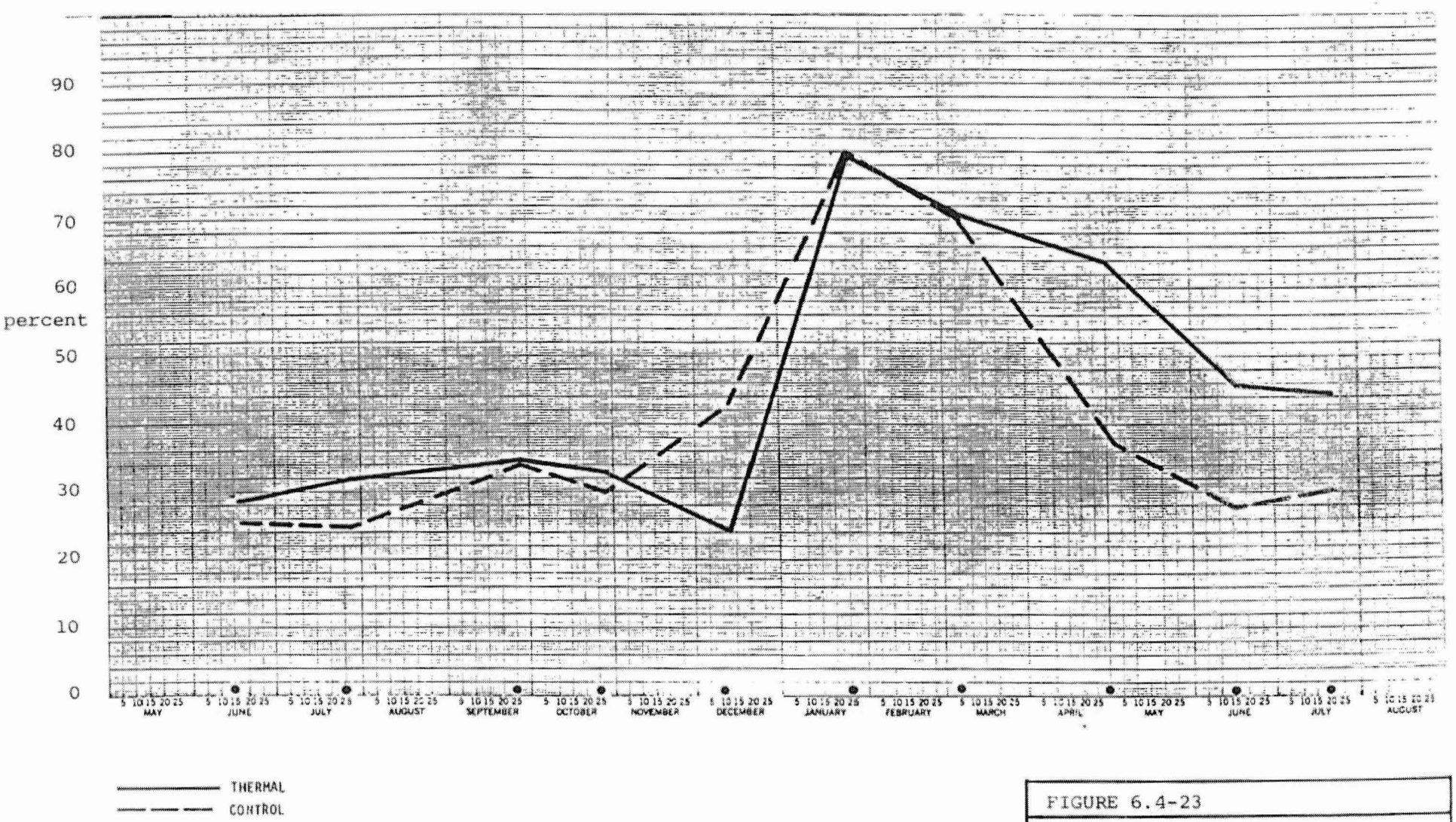
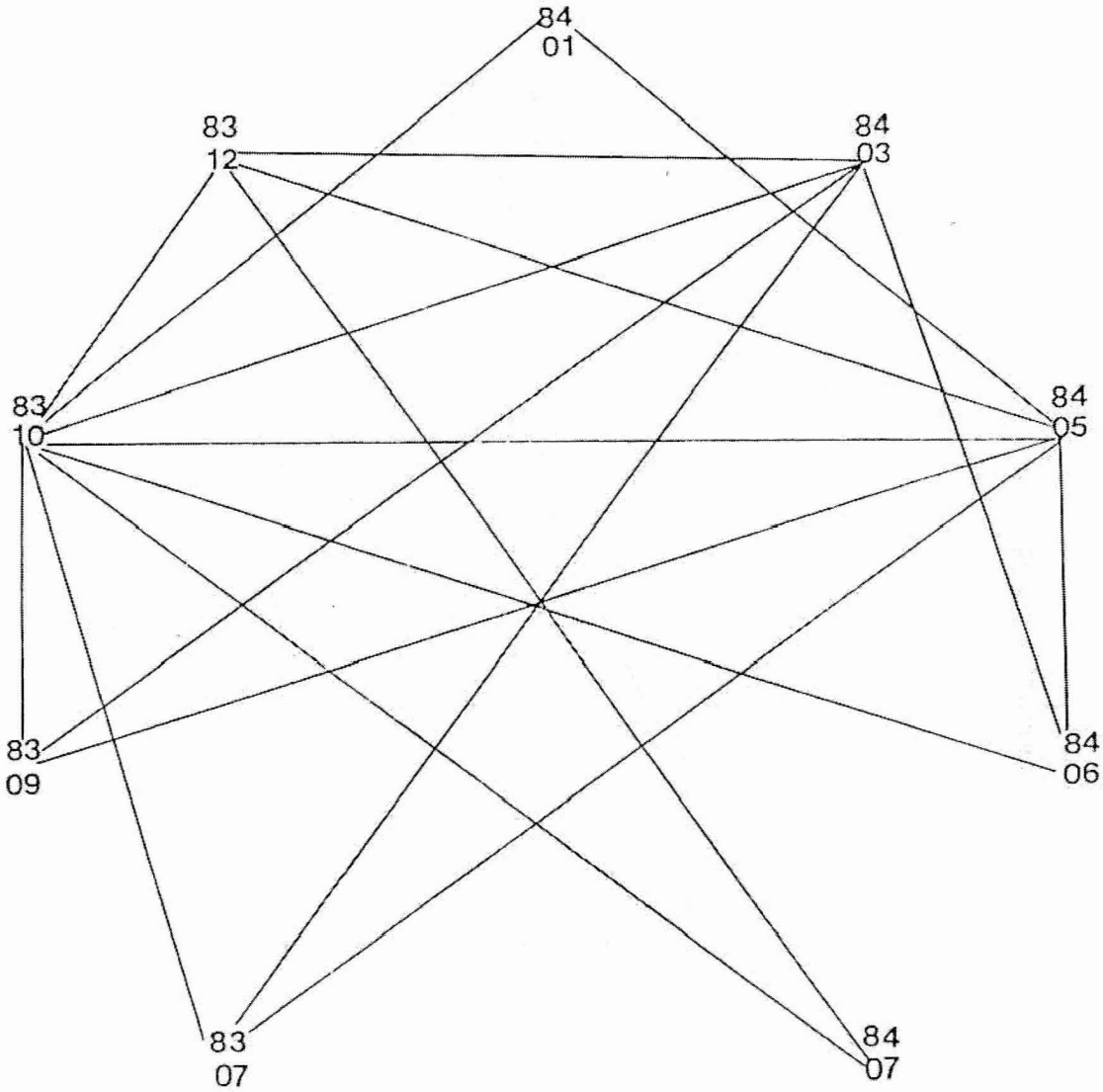


FIGURE 6.4-23

SPARTINA DEAD WEIGHT
(%) IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



83
06
NOT CONSIDERED

TIME DIFFERENCES

FIGURE 6.4-24
SPARTINA TOTAL WEIGHT IN SPARTINA MARSHES CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION

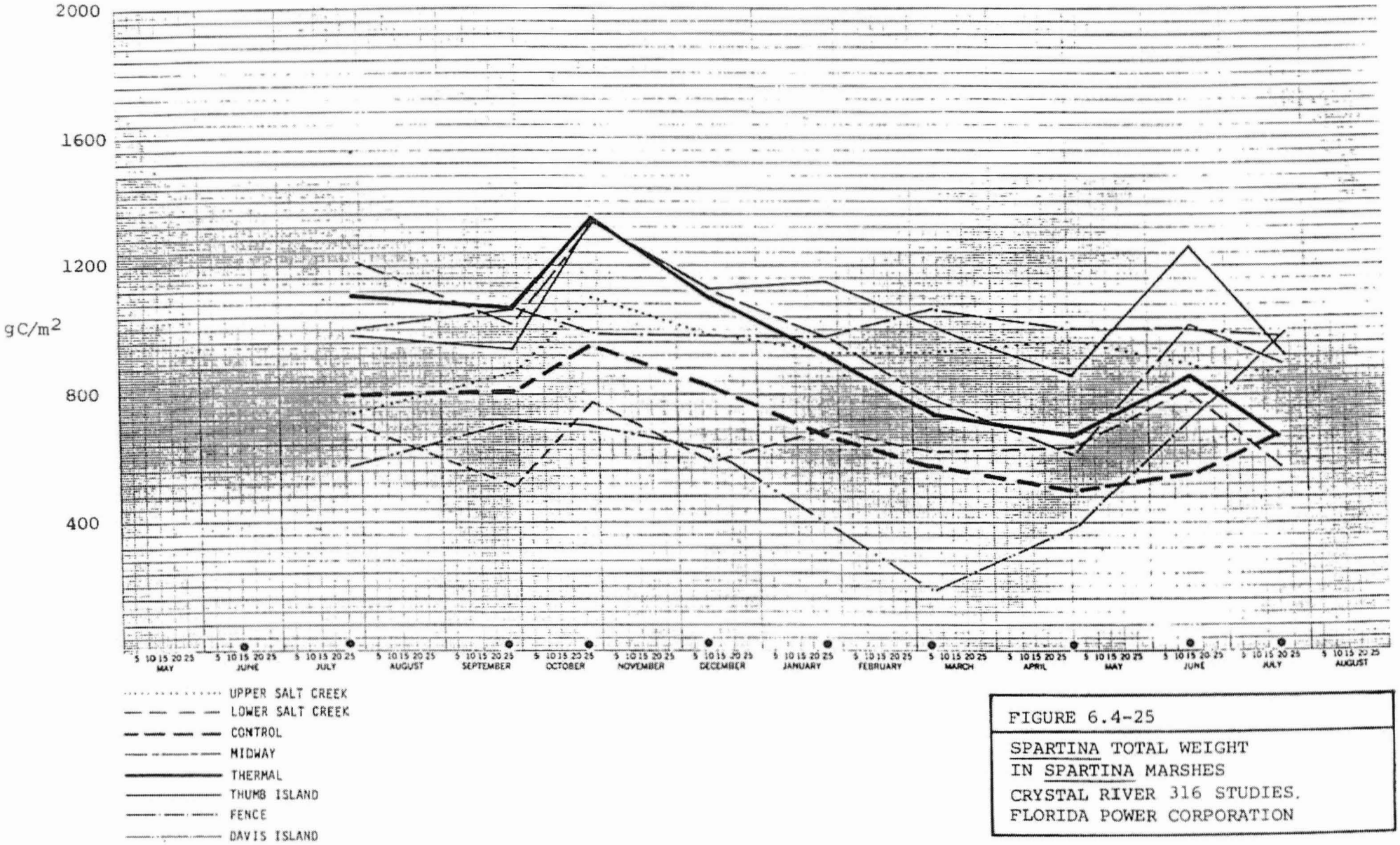


FIGURE 6.4-25

SPARTINA TOTAL WEIGHT
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES.
FLORIDA POWER CORPORATION

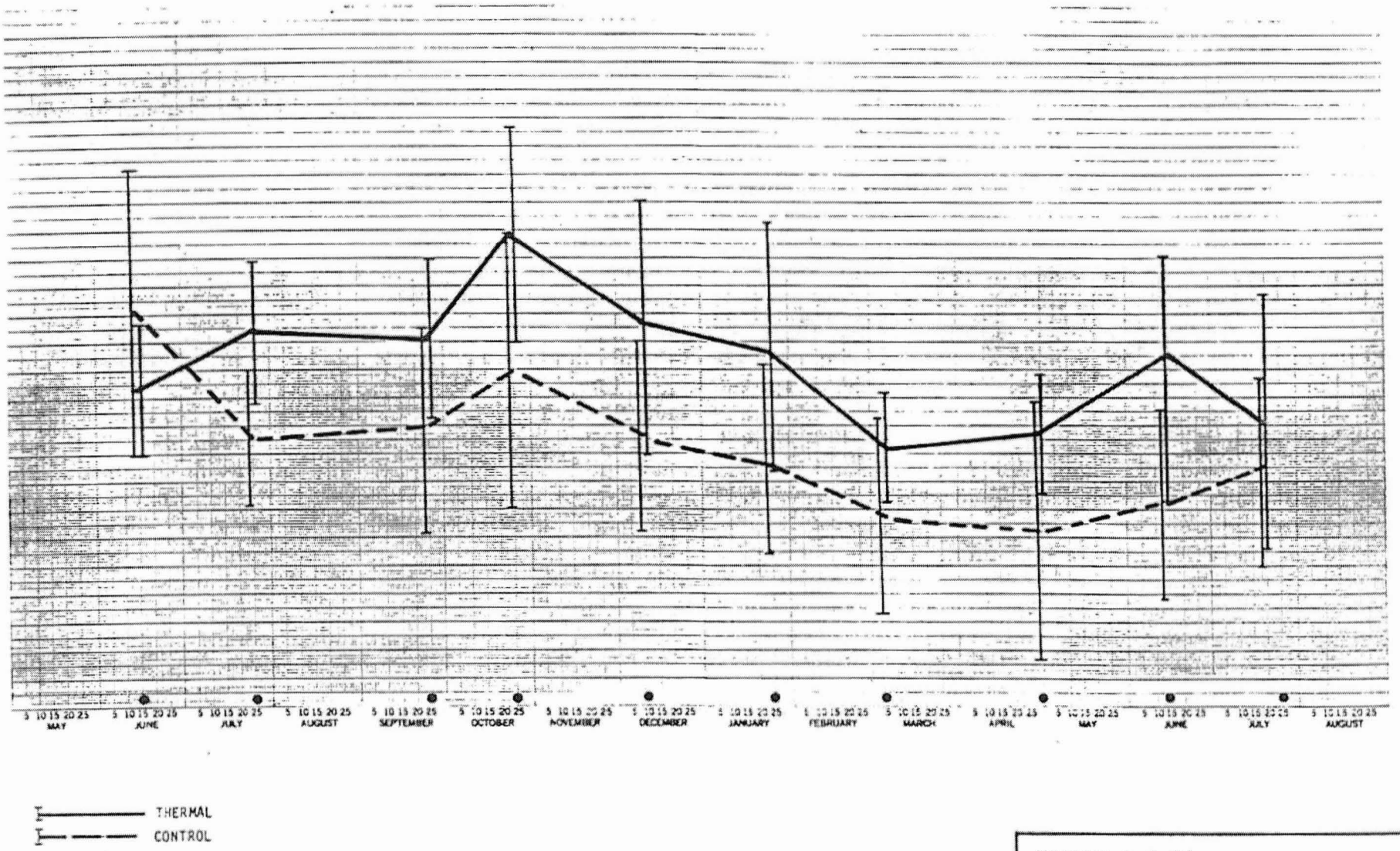
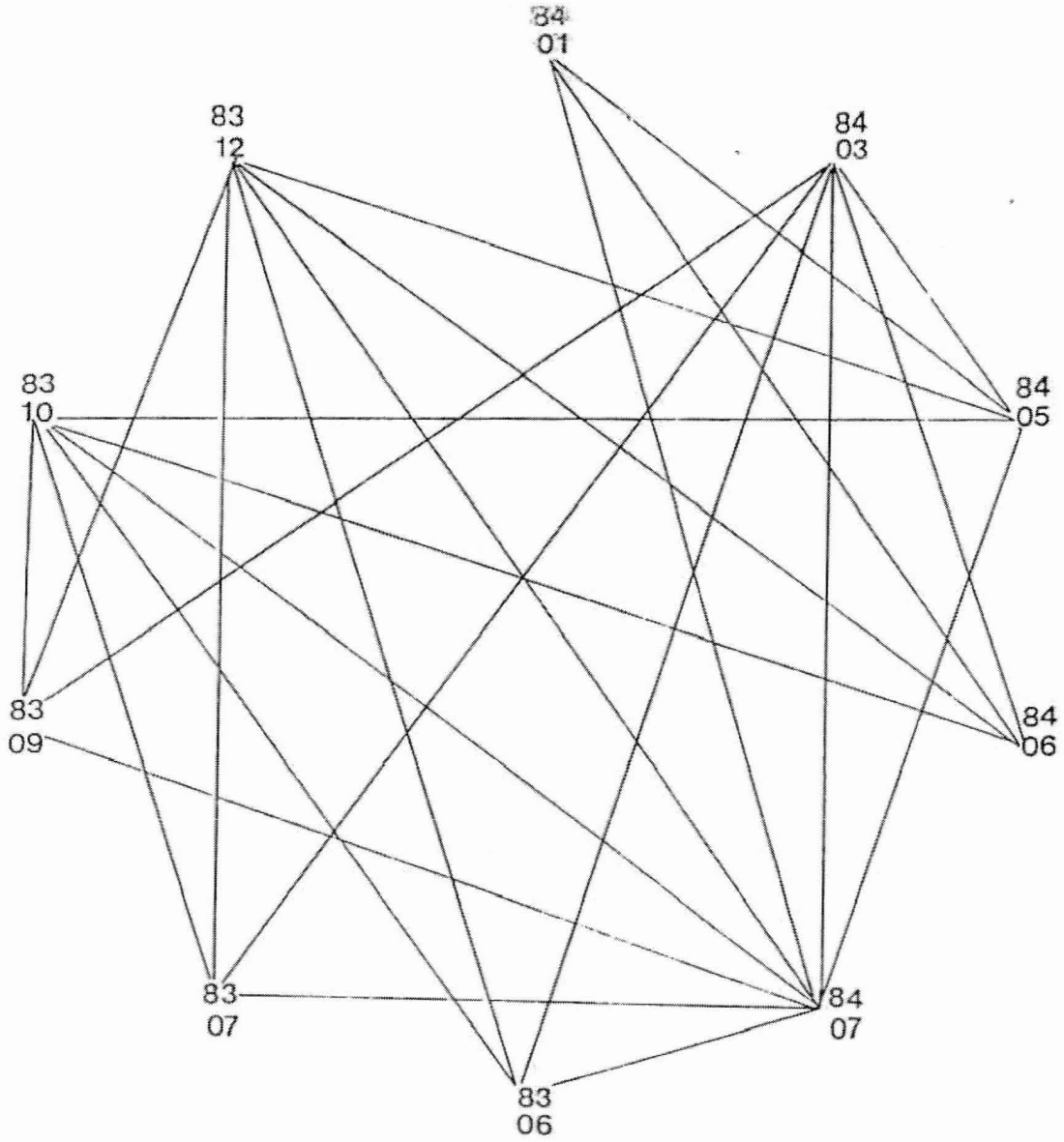


FIGURE 6.4-26

COMBINED TOTAL WEIGHT
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



TIME DIFFERENCES

FIGURE 6.4-27

SPARTINA TOTAL DENSITY
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

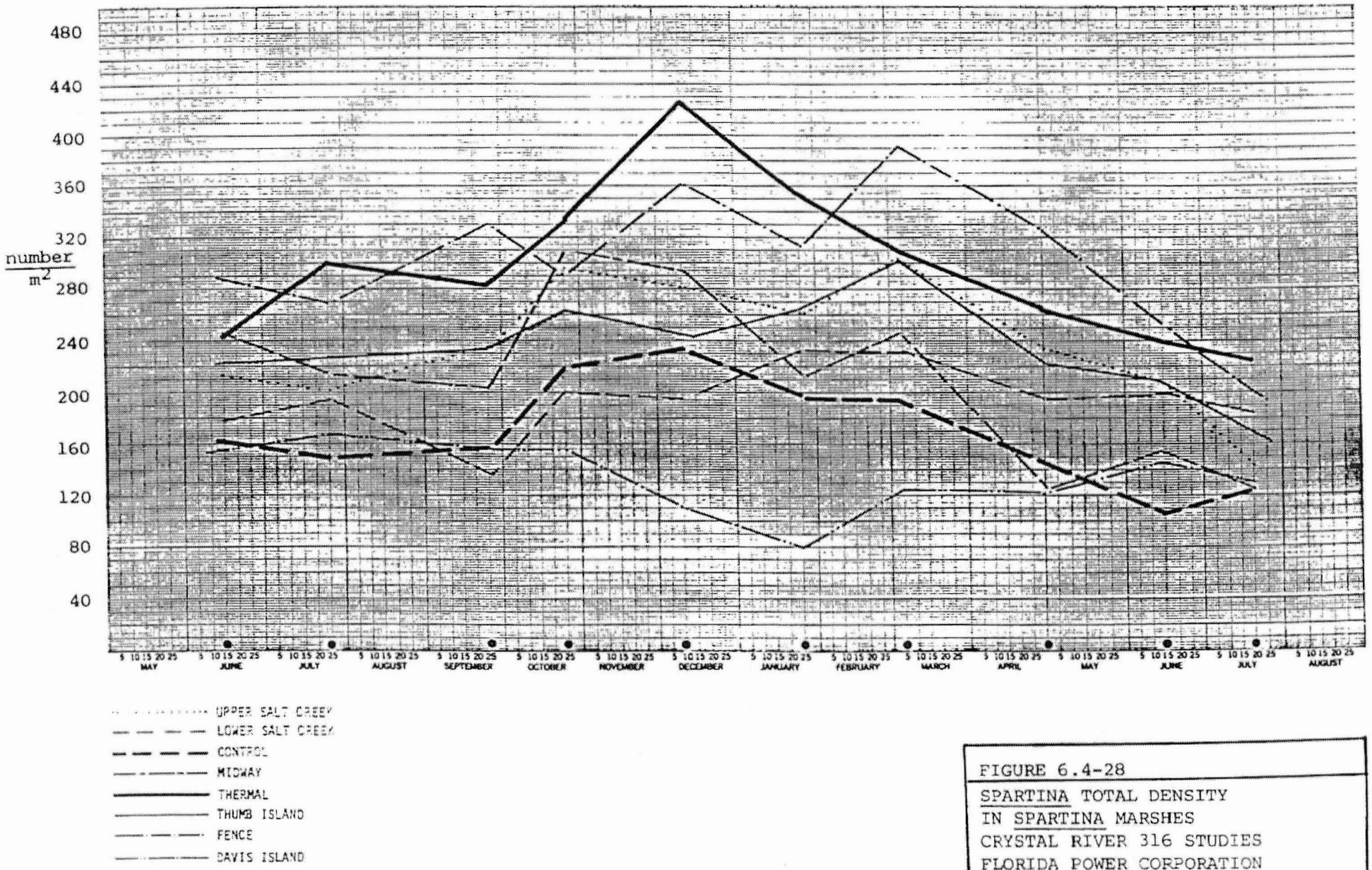


FIGURE 6.4-28

SPARTINA TOTAL DENSITY
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

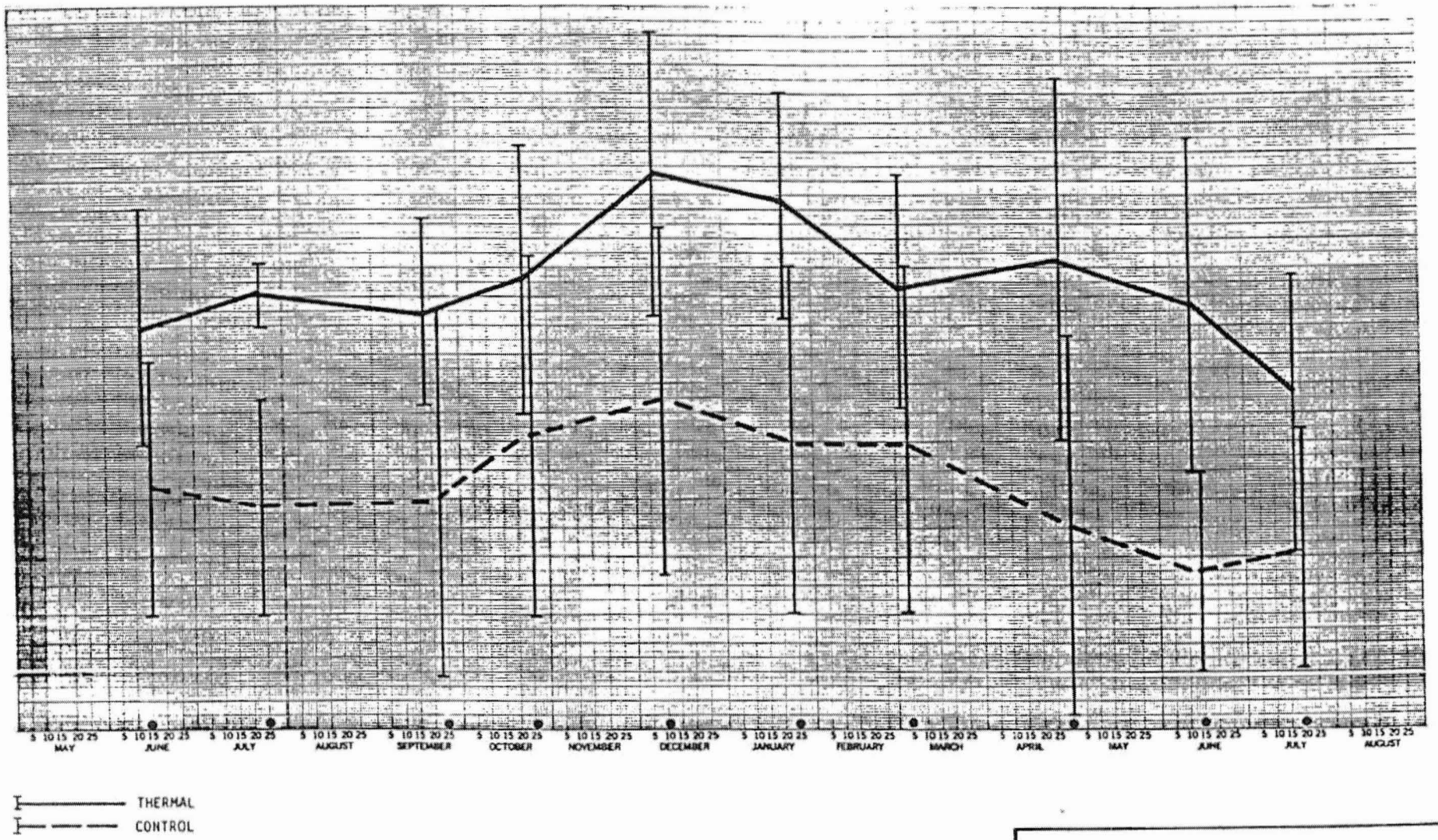
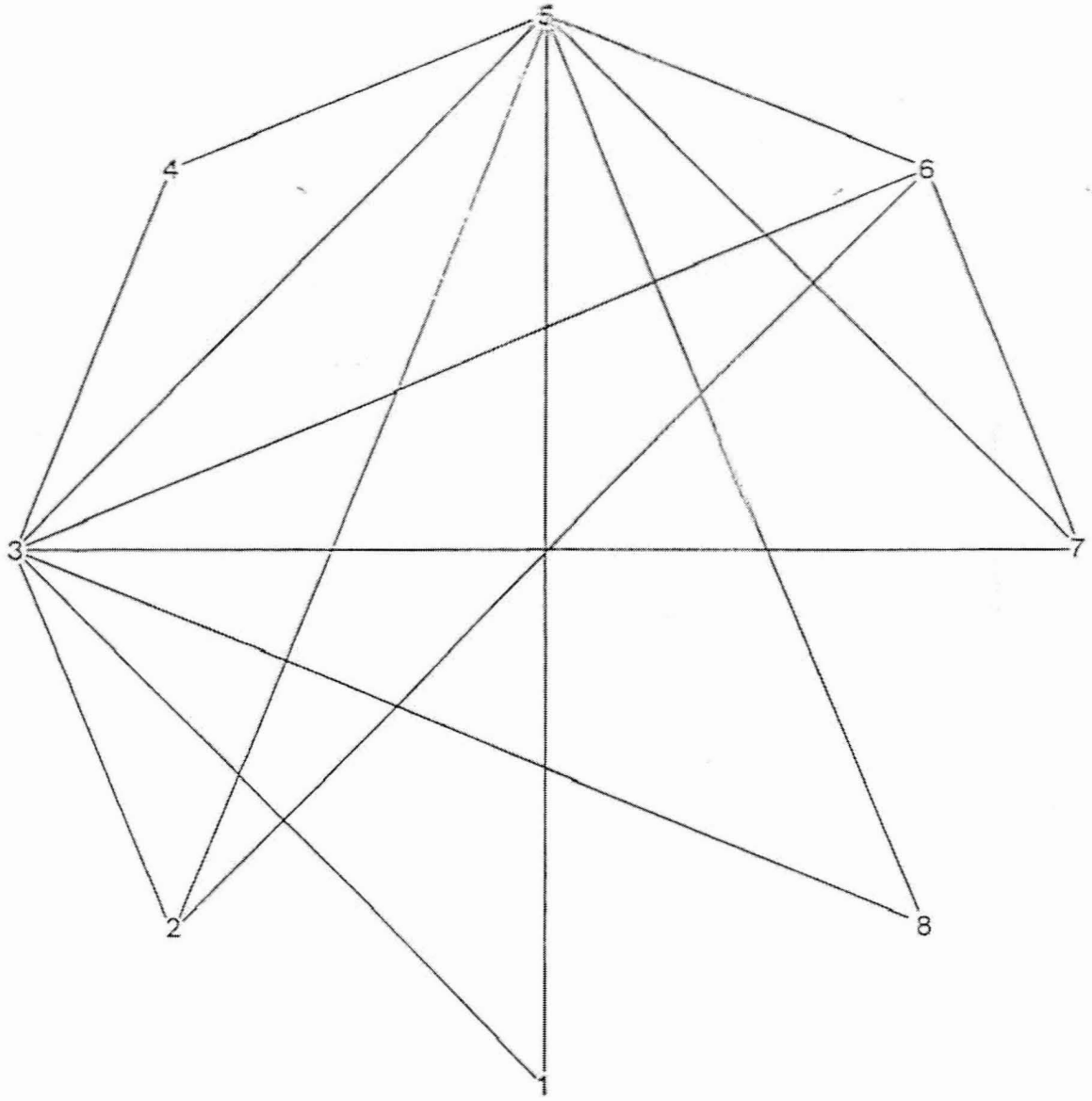


FIGURE 6.4-29

COMBINED TOTAL DENSITY
IN SPARTINA MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION DIFFERENCES

FIGURE 6.4-30

JUNCUS LIVE WEIGHT
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

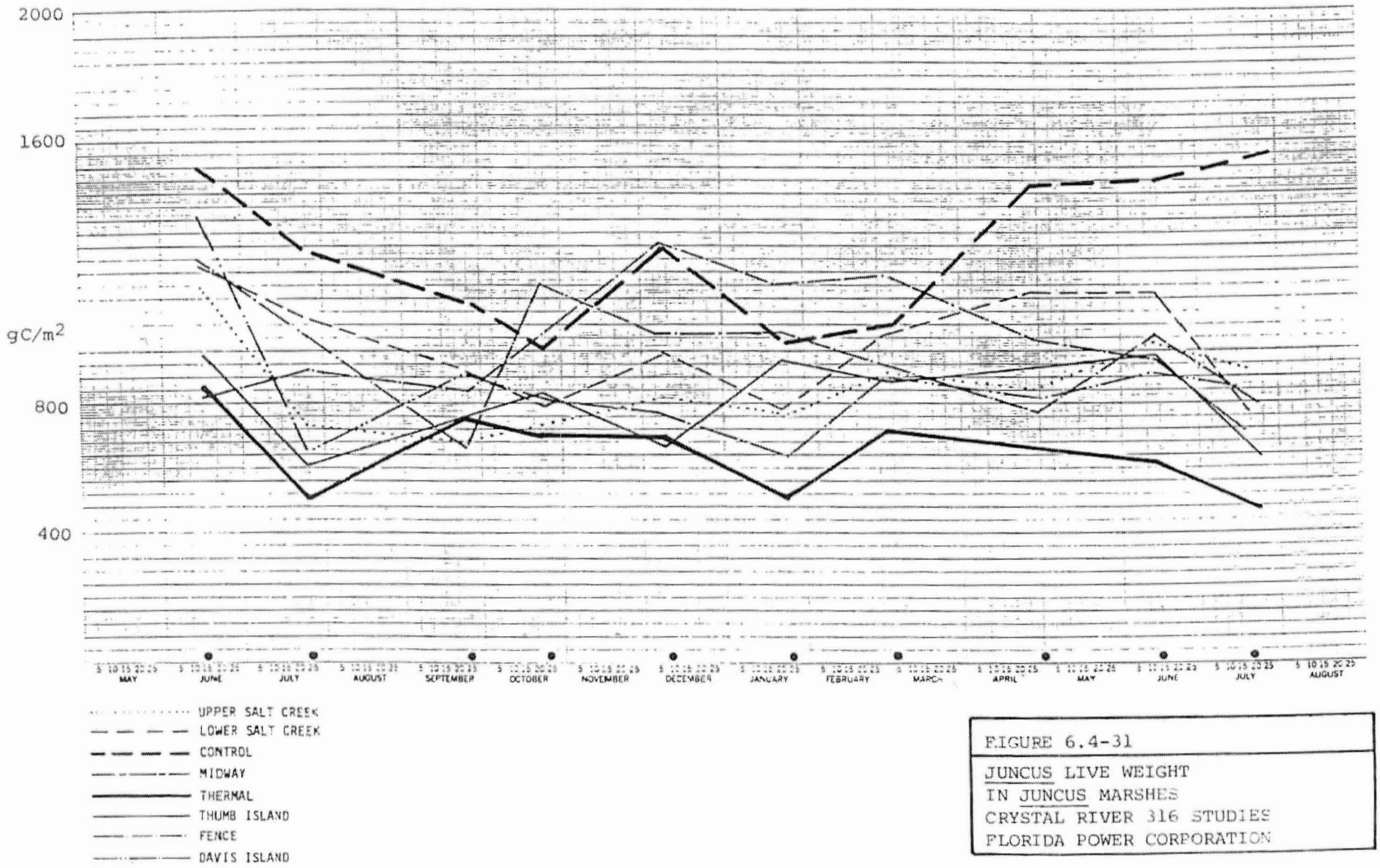
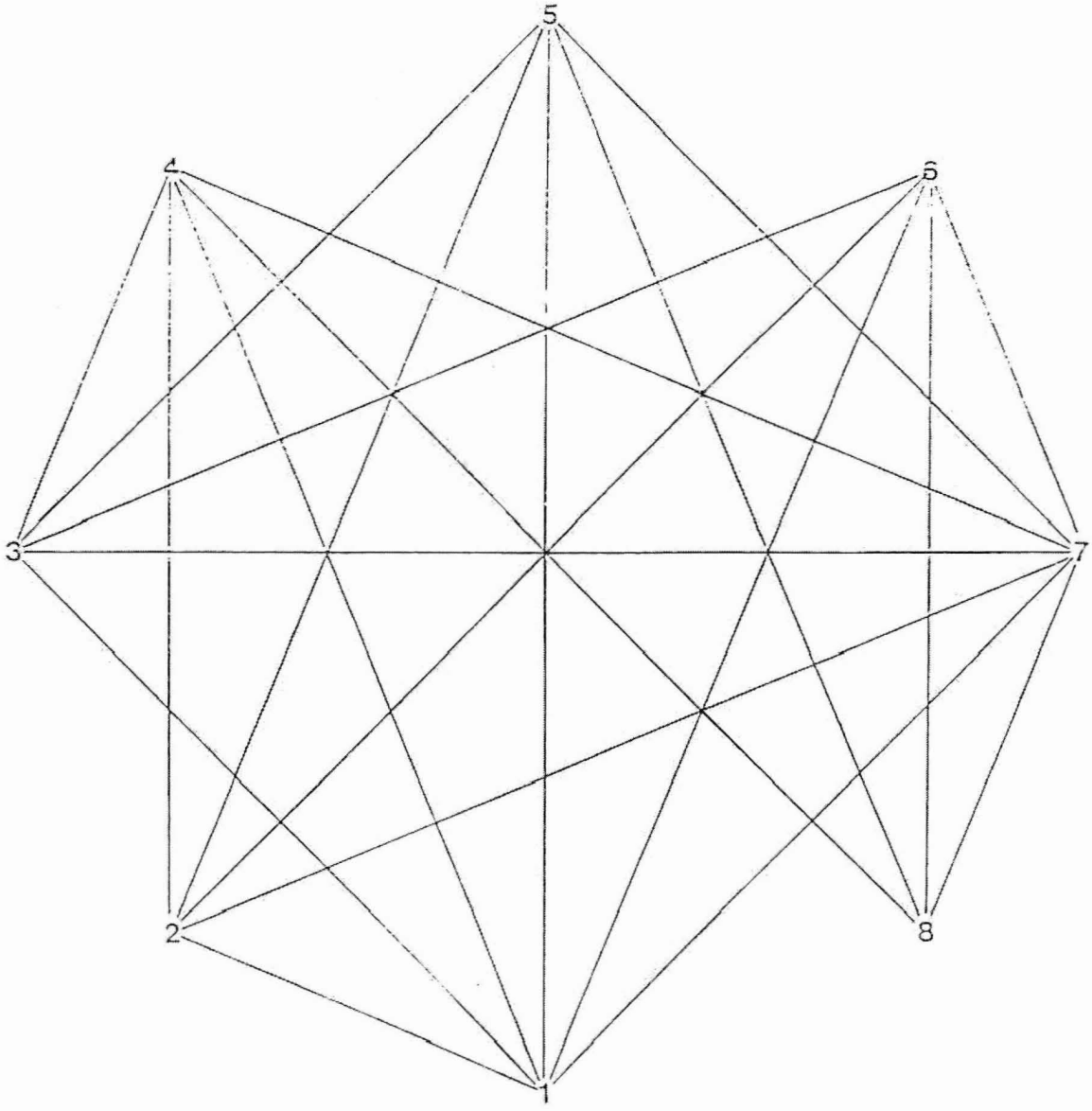


FIGURE 6.4-31

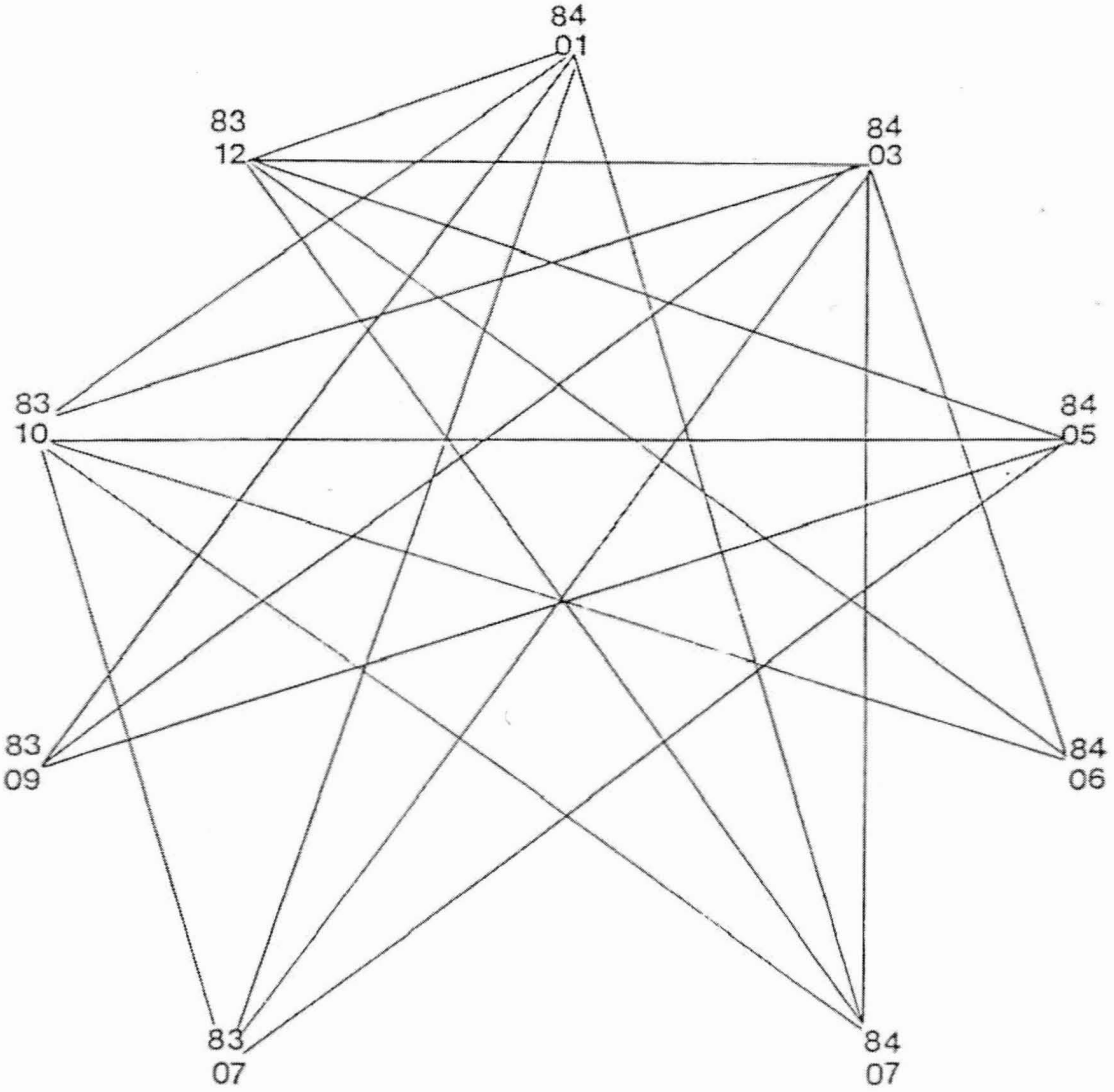
JUNCUS LIVE WEIGHT
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION DIFFERENCES

FIGURE 6.4-32

COMBINED LIVE WEIGHT
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



83
06
NOT CONSIDERED

TIME DIFFERENCES

FIGURE 6.4-33

COMBINED LIVE WEIGHT
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

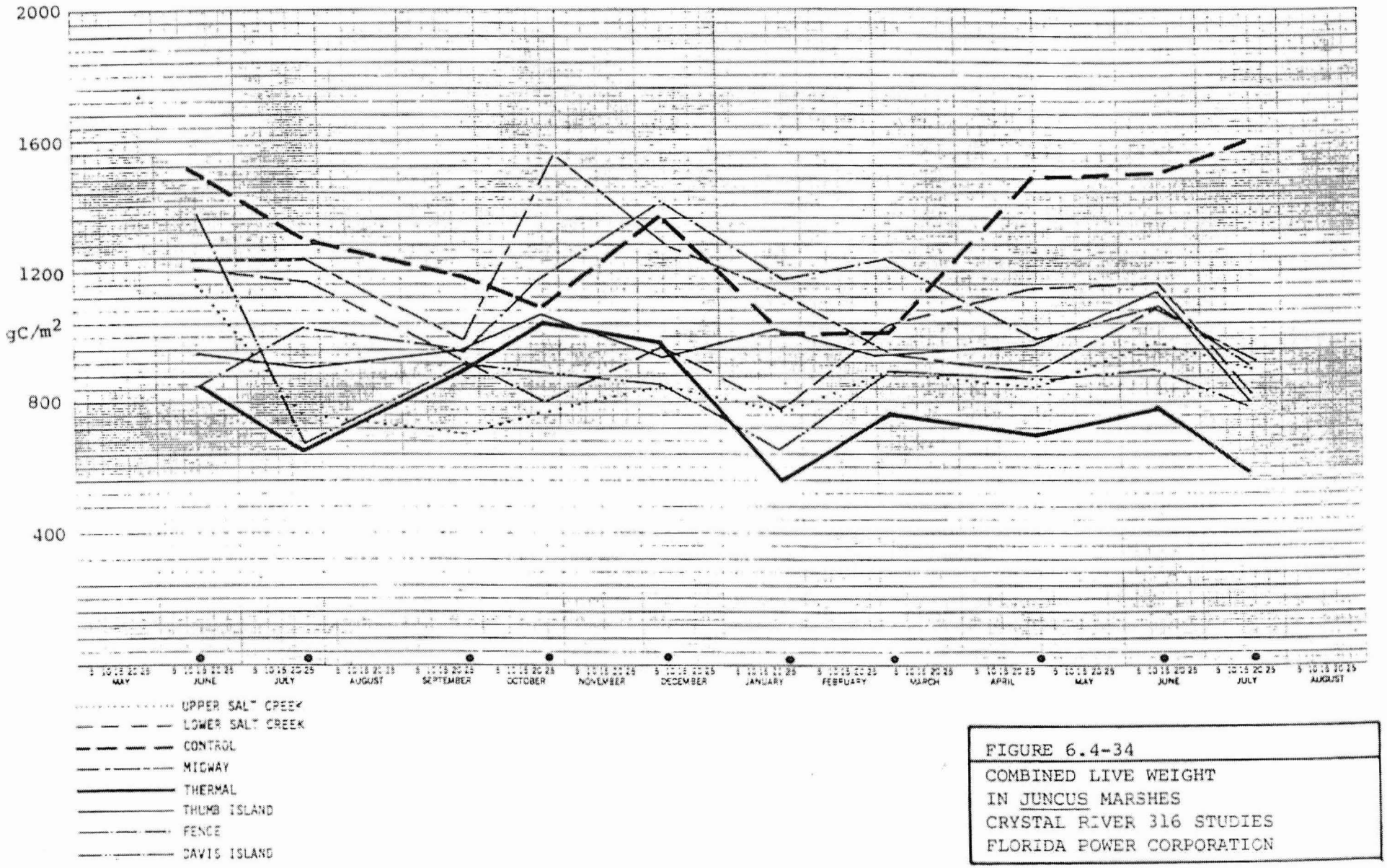


FIGURE 6.4-34
COMBINED LIVE WEIGHT
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

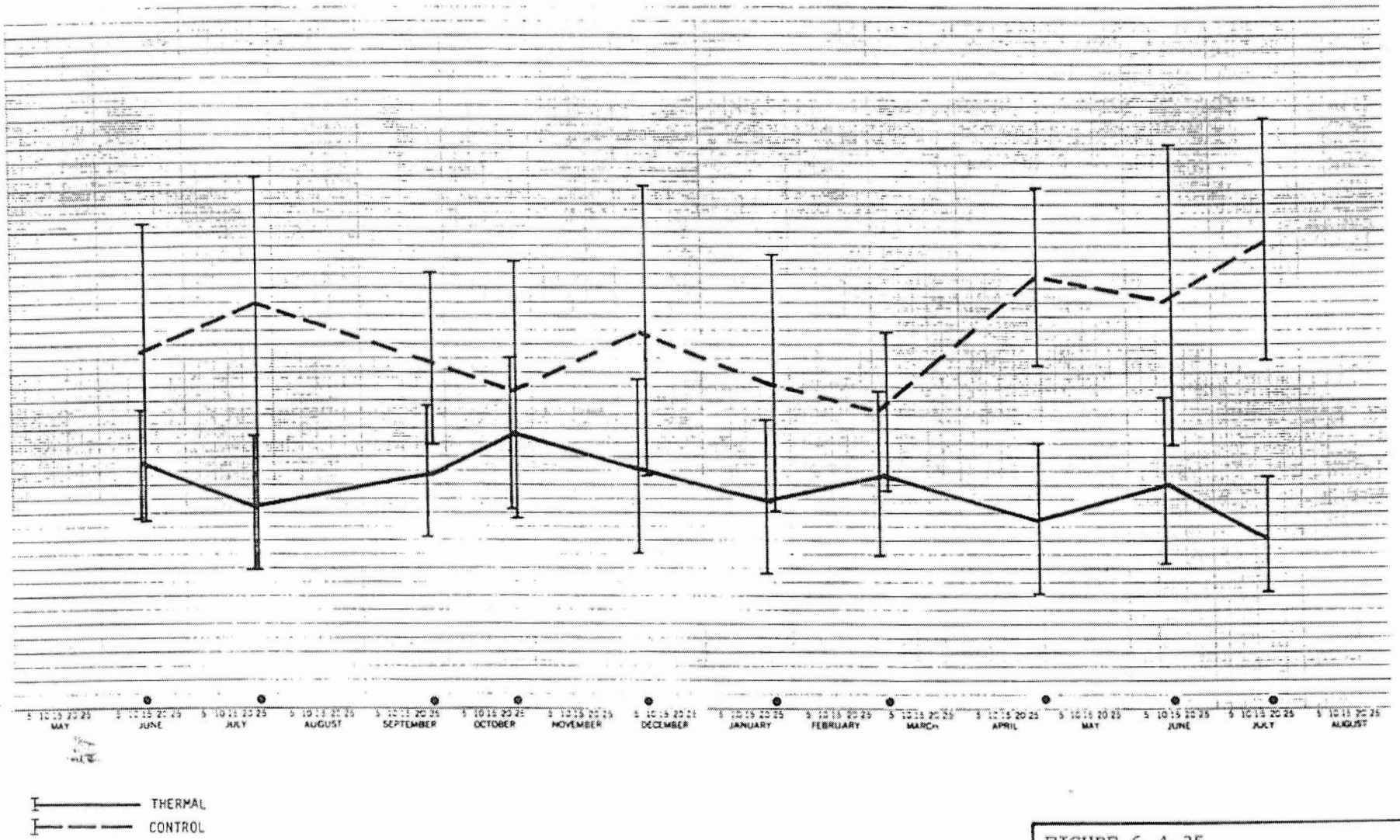
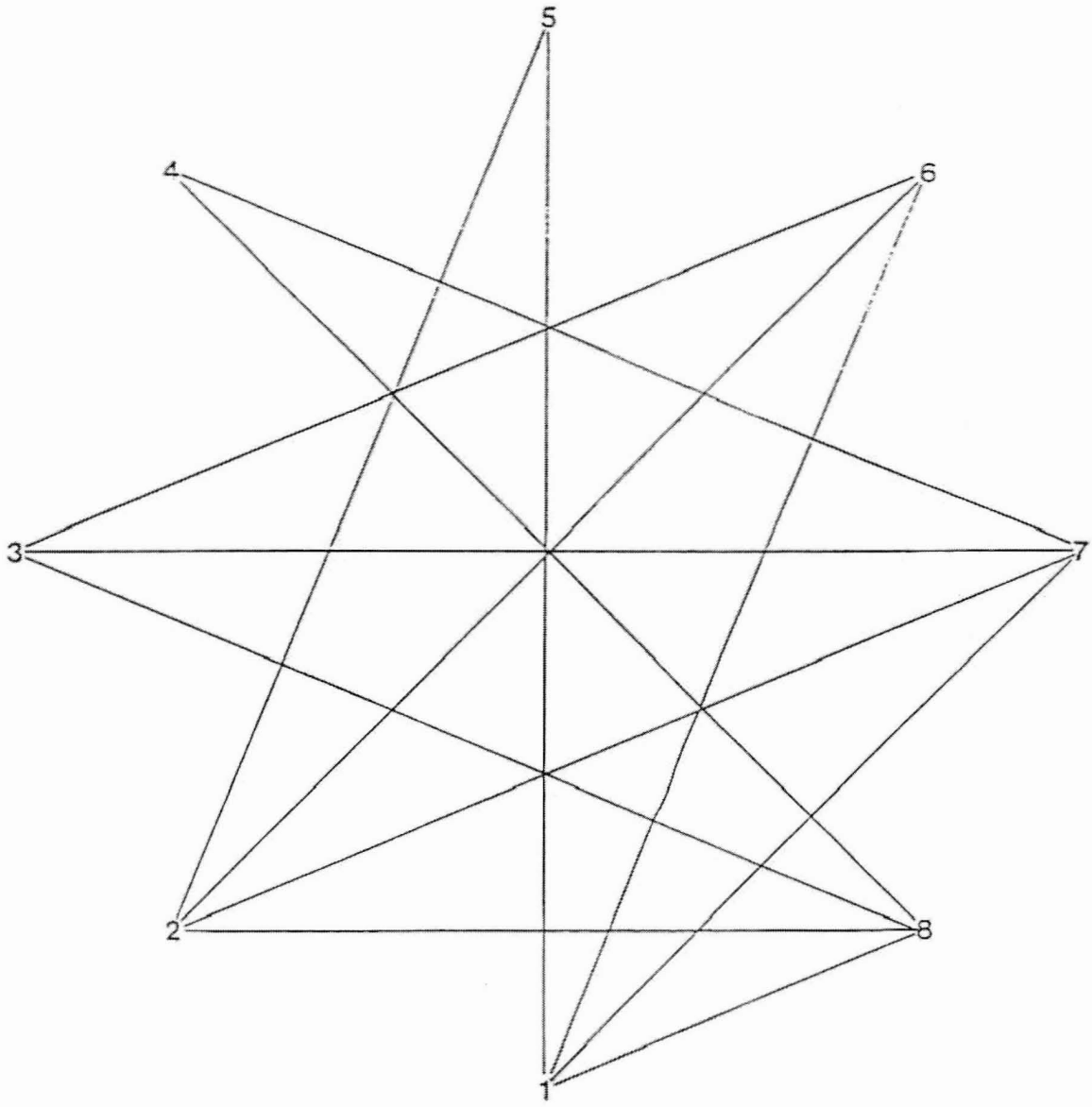


FIGURE 6.4-35

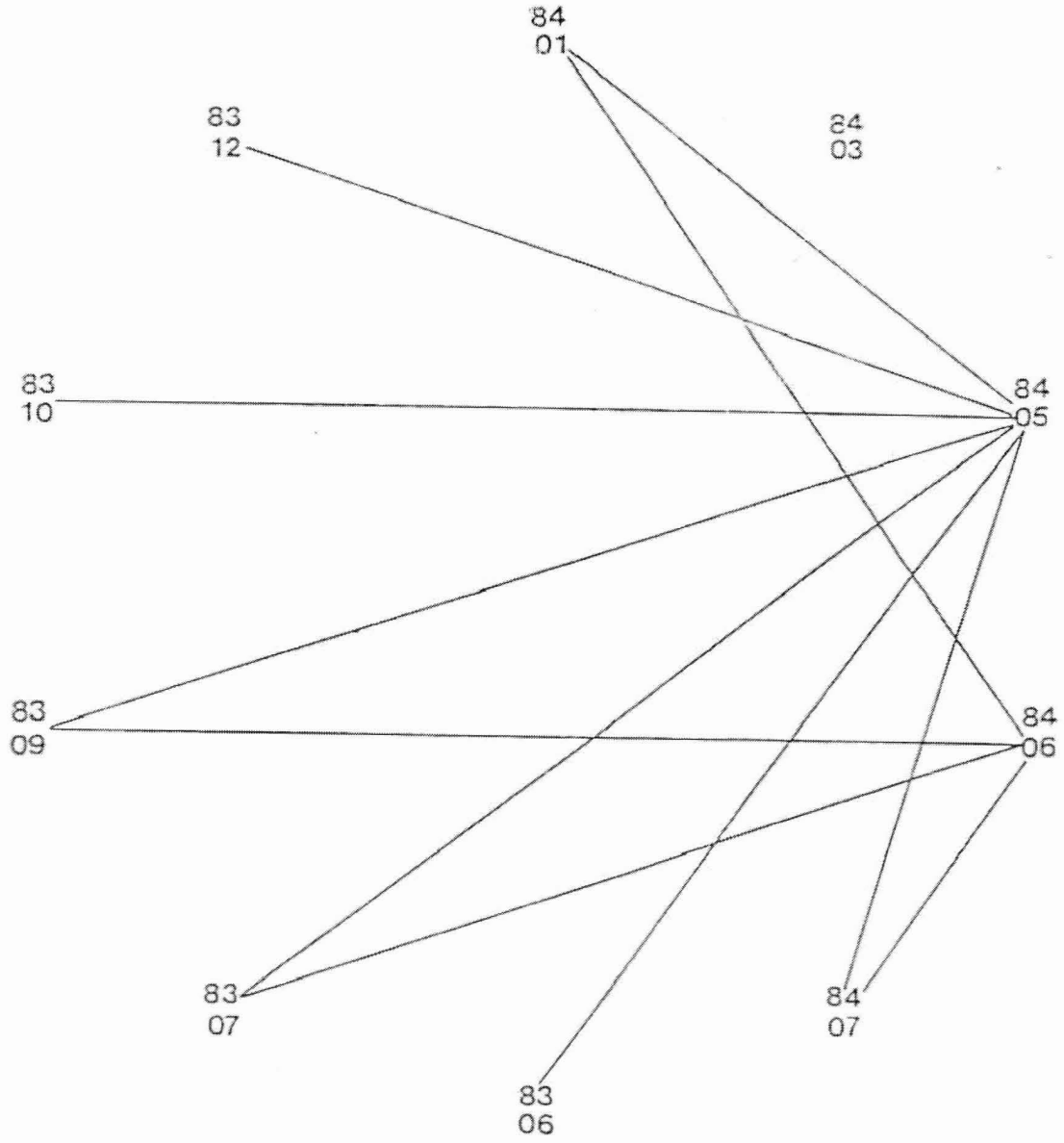
COMBINED LIVE WEIGHT
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION DIFFERENCES

FIGURE 6.4-36

JUNCUS LIVE DENSITY
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



TIME DIFFERENCES

FIGURE 6.4-37

JUNCUS LIVE DENSITY
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

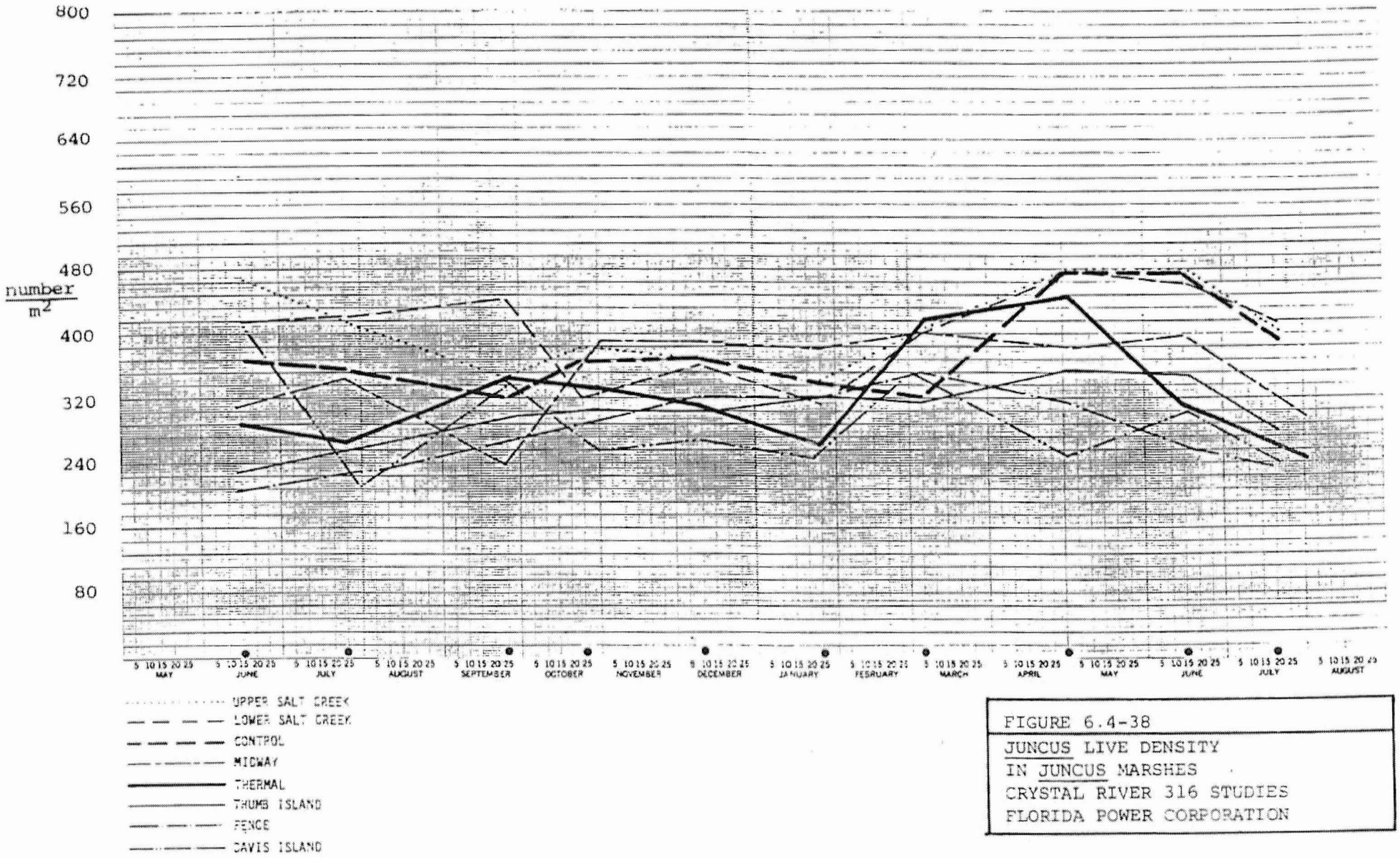
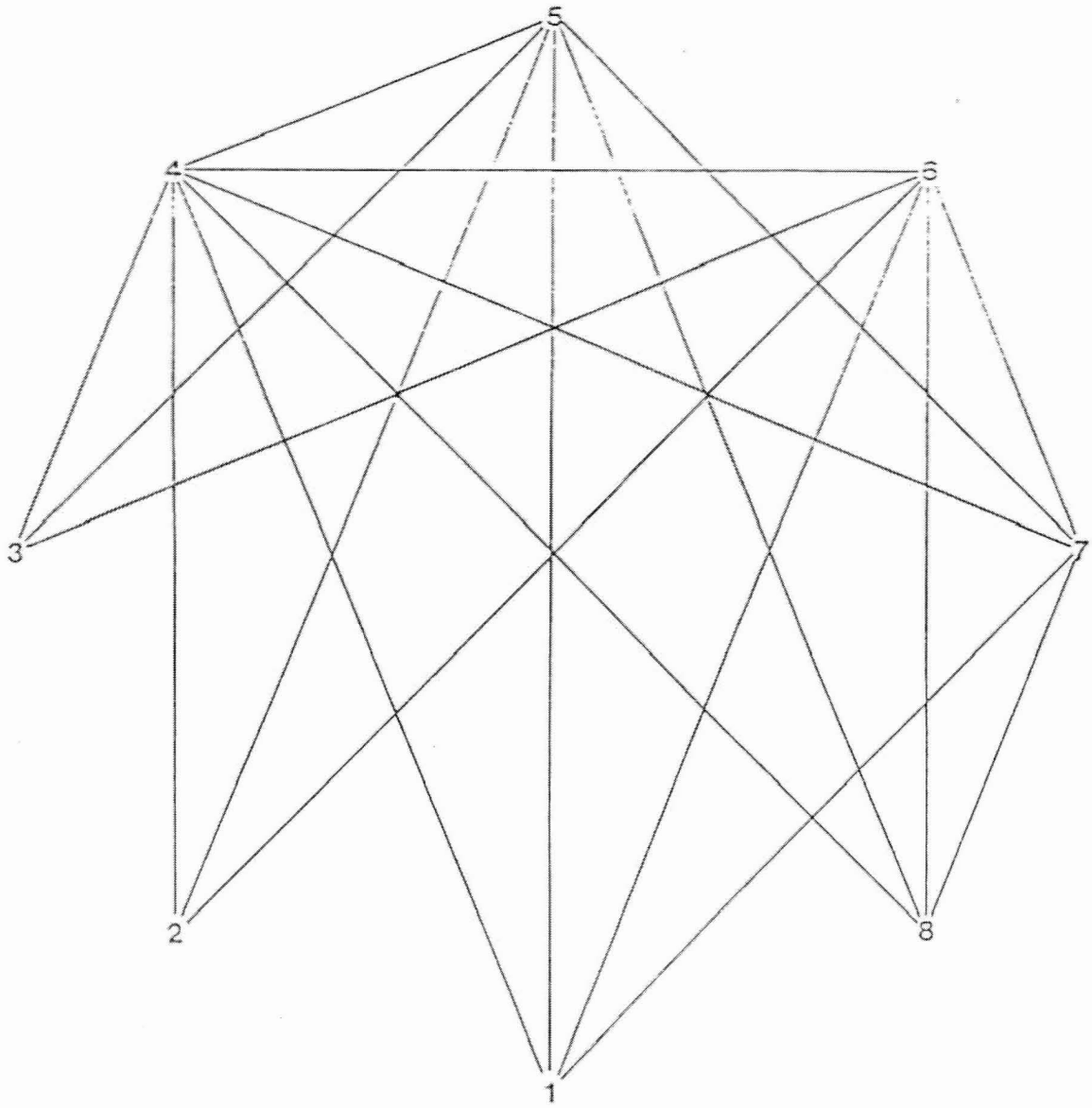


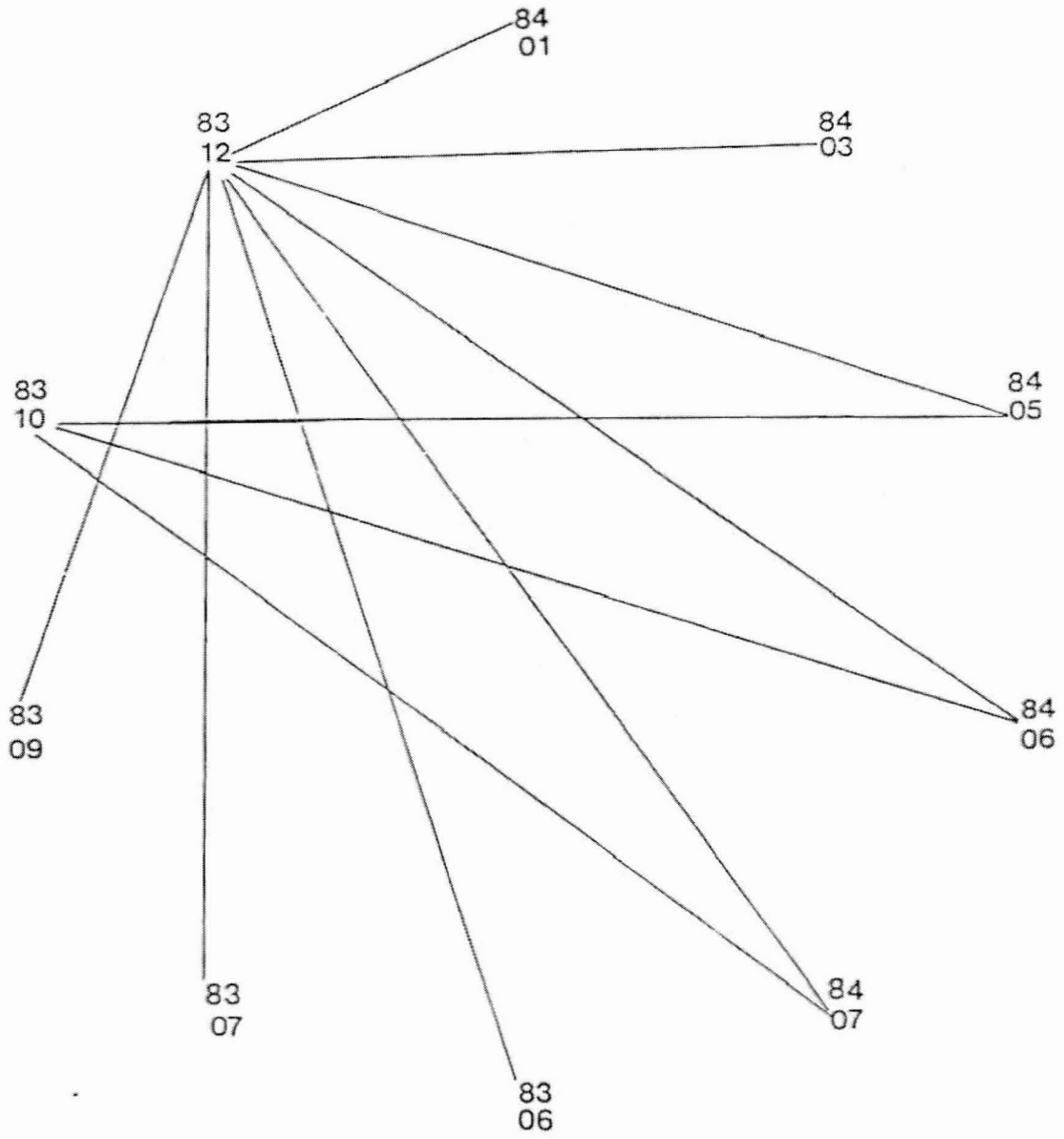
FIGURE 6.4-38

JUNCUS LIVE DENSITY
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION DIFFERENCES

FIGURE 6.4-39
COMBINED LIVE DENSITY
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



TIME DIFFERENCES

FIGURE 6.4-40

COMBINED LIVE DENSITY
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

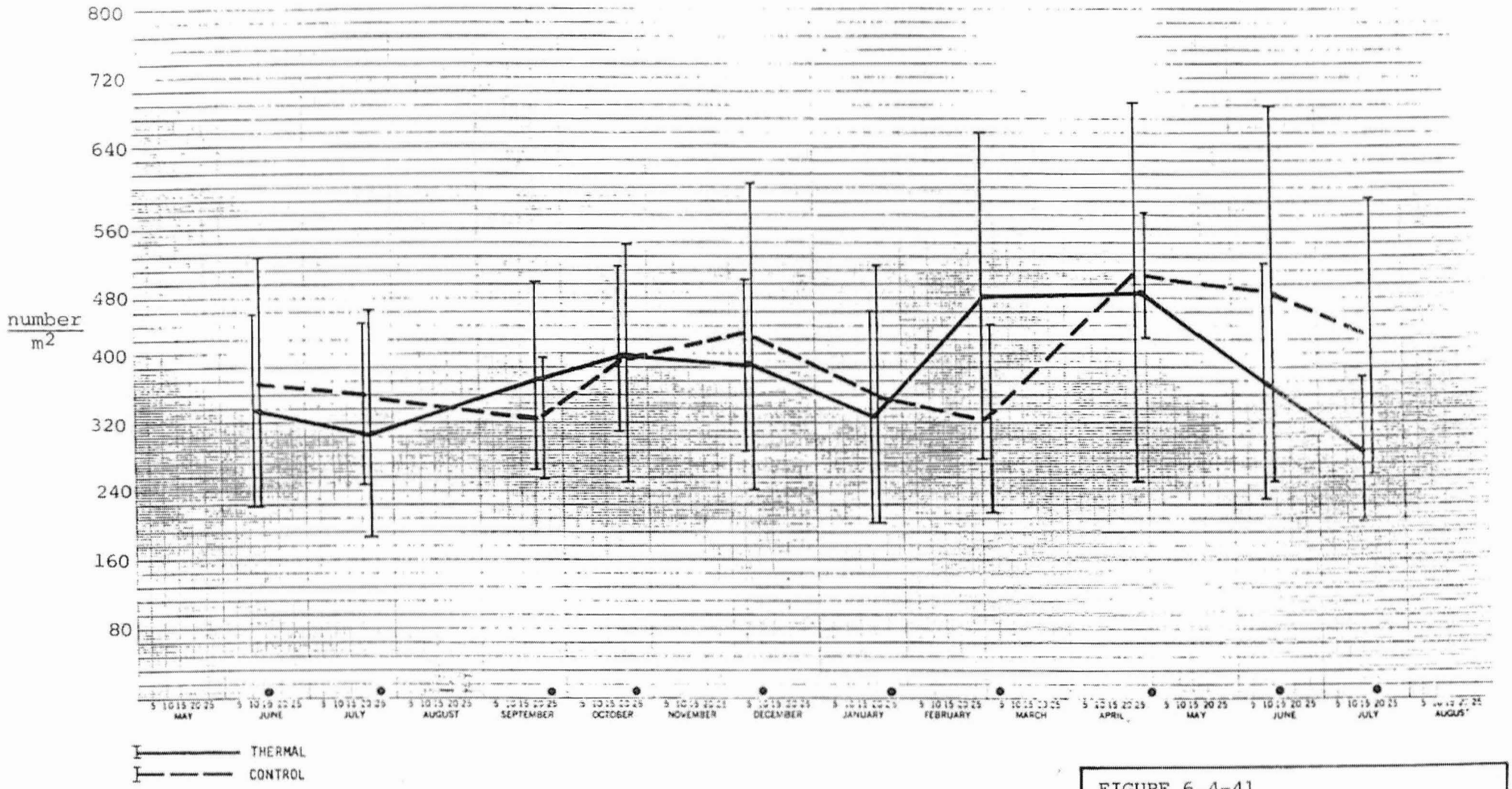
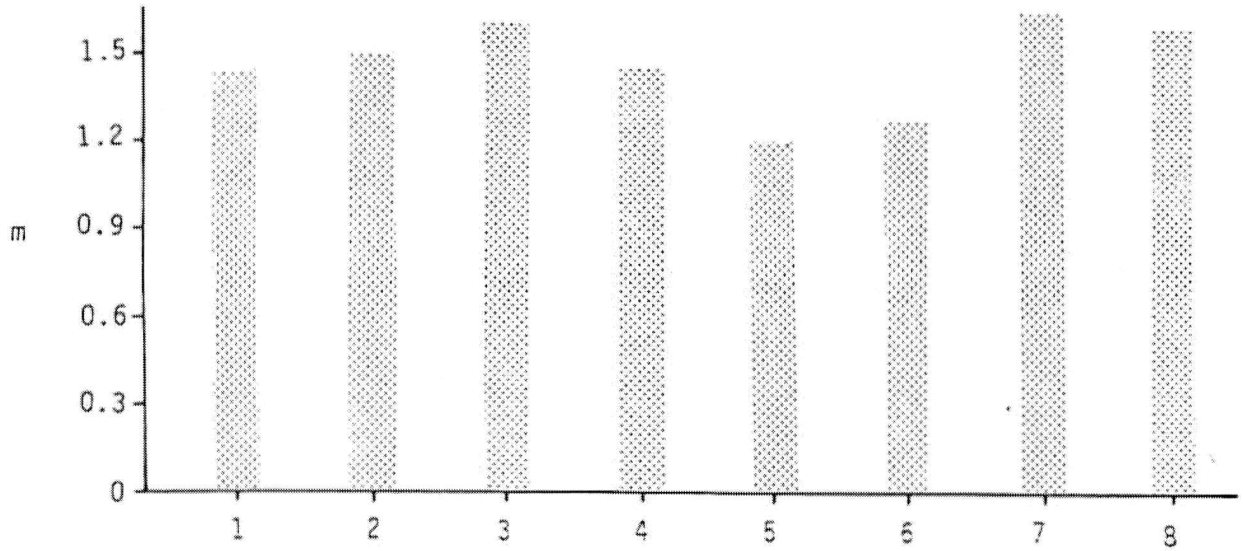


FIGURE 6.4-41

COMBINED LIVE DENSITY
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



	Thumb	Thermal	Davis	Upper Salt	Lower Salt	Control	Fence	Midway
Thumb								
Thermal	••							
Davis	••	••						
Upper Salt	N/S	••	••					
Lower Salt	••	••	••	••				
Control	••	••	N/S	••	••			
Fence	••	••	••	••	••	••		
Midway	N/S	••	••	N/S	••	••	••	

2 Sided P

•• = p<.01
• = p<.05
N/S= not significant

df≈238

FIGURE 6.4-42

MEAN HEIGHT OF
JUNCUS JUNE 1984
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

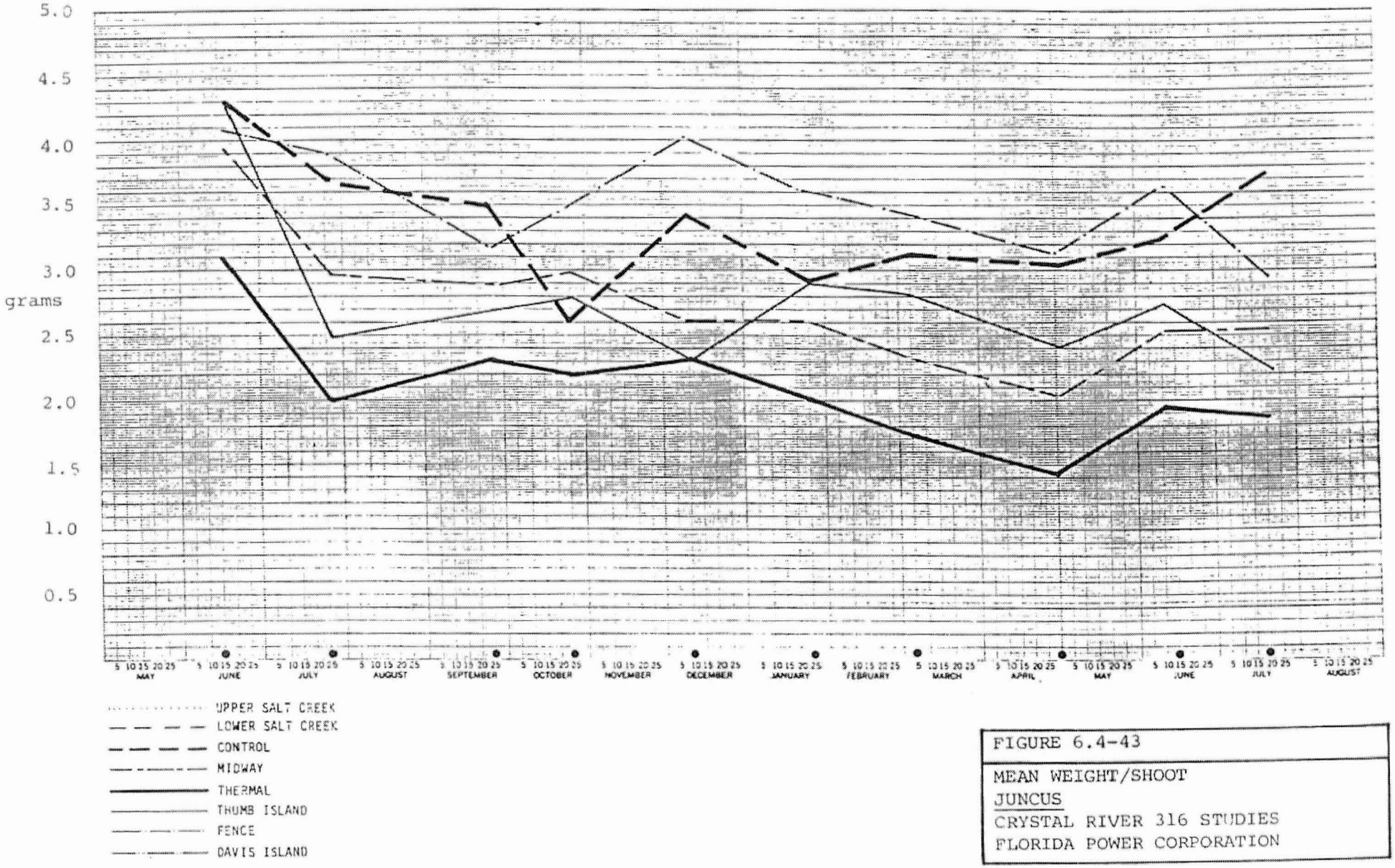


FIGURE 6.4-43

MEAN WEIGHT/SHOOT
JUNCUS
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

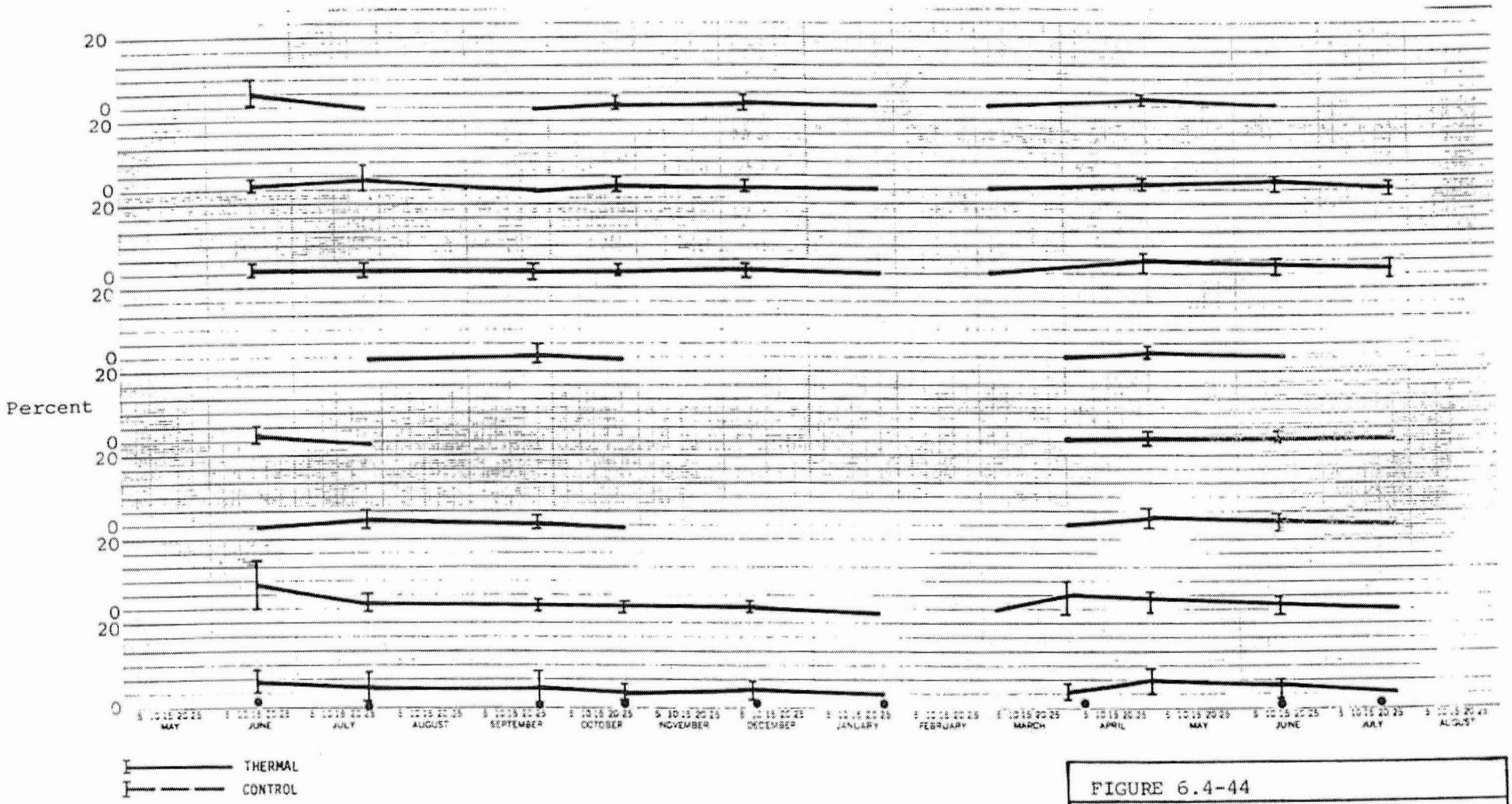
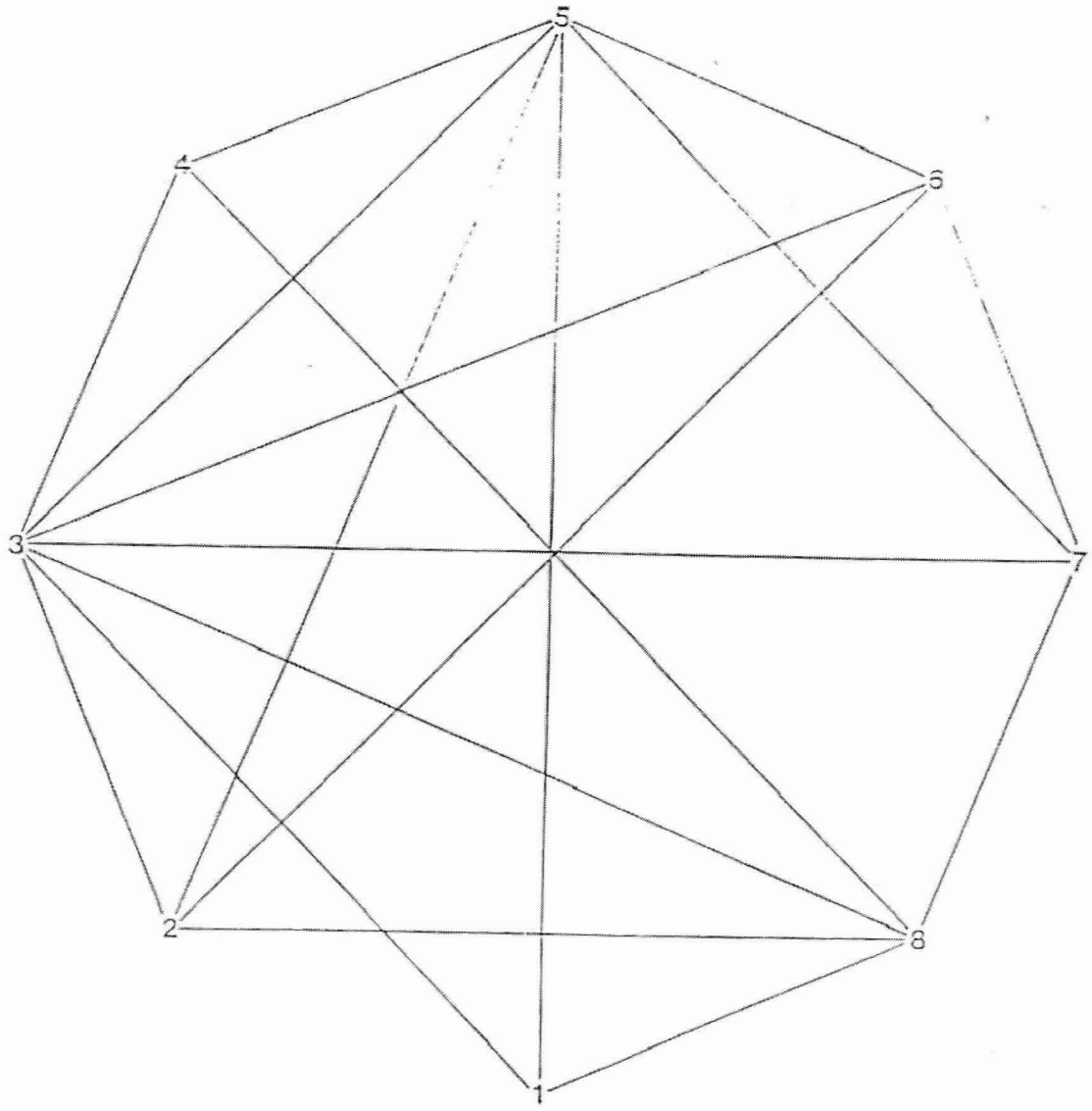


FIGURE 6.4-44

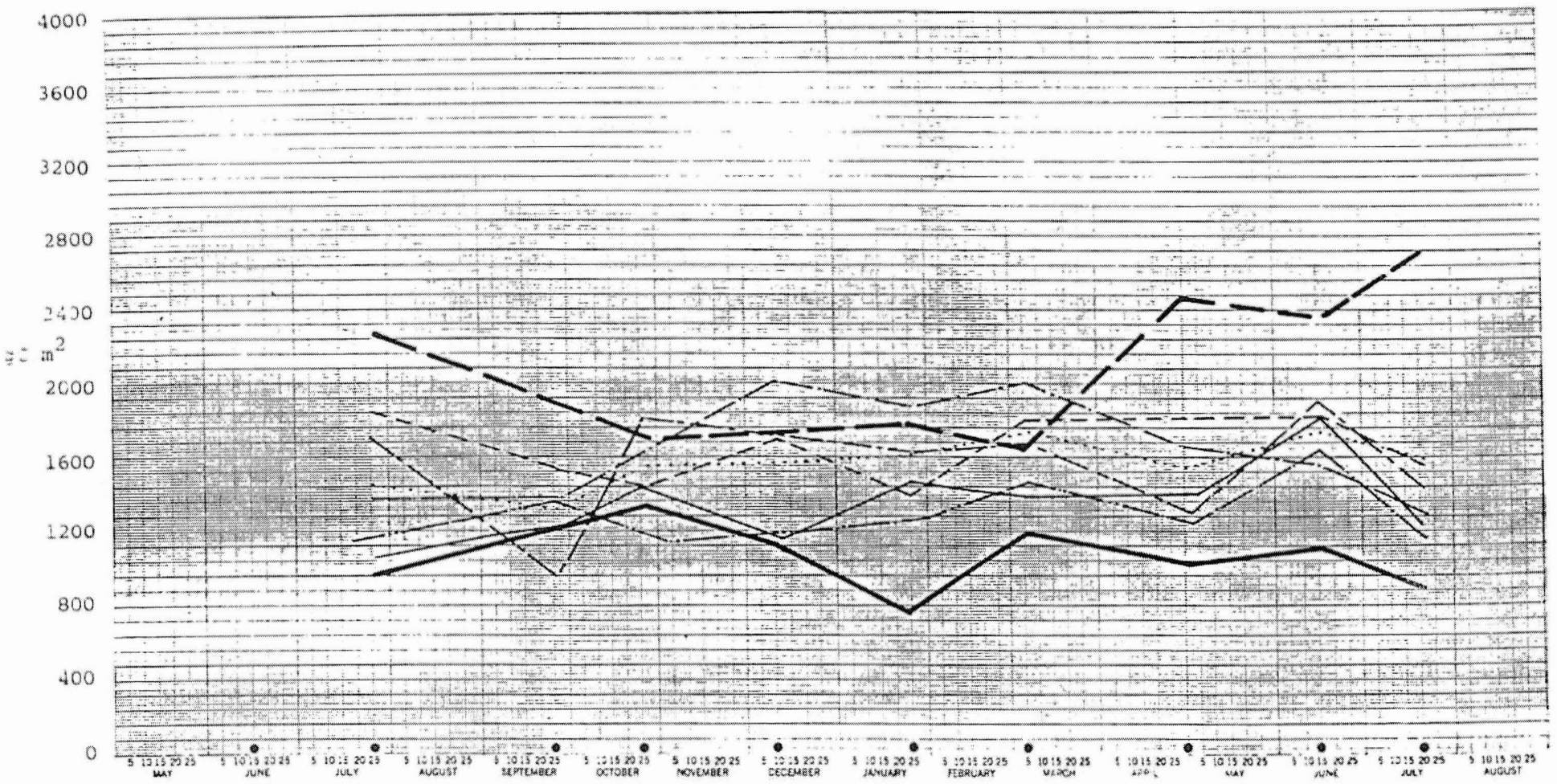
REPRODUCTIVE JUNCUS SHOOTS, PERCENT TOTAL
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION DIFFERENCES

FIGURE 6.4-45

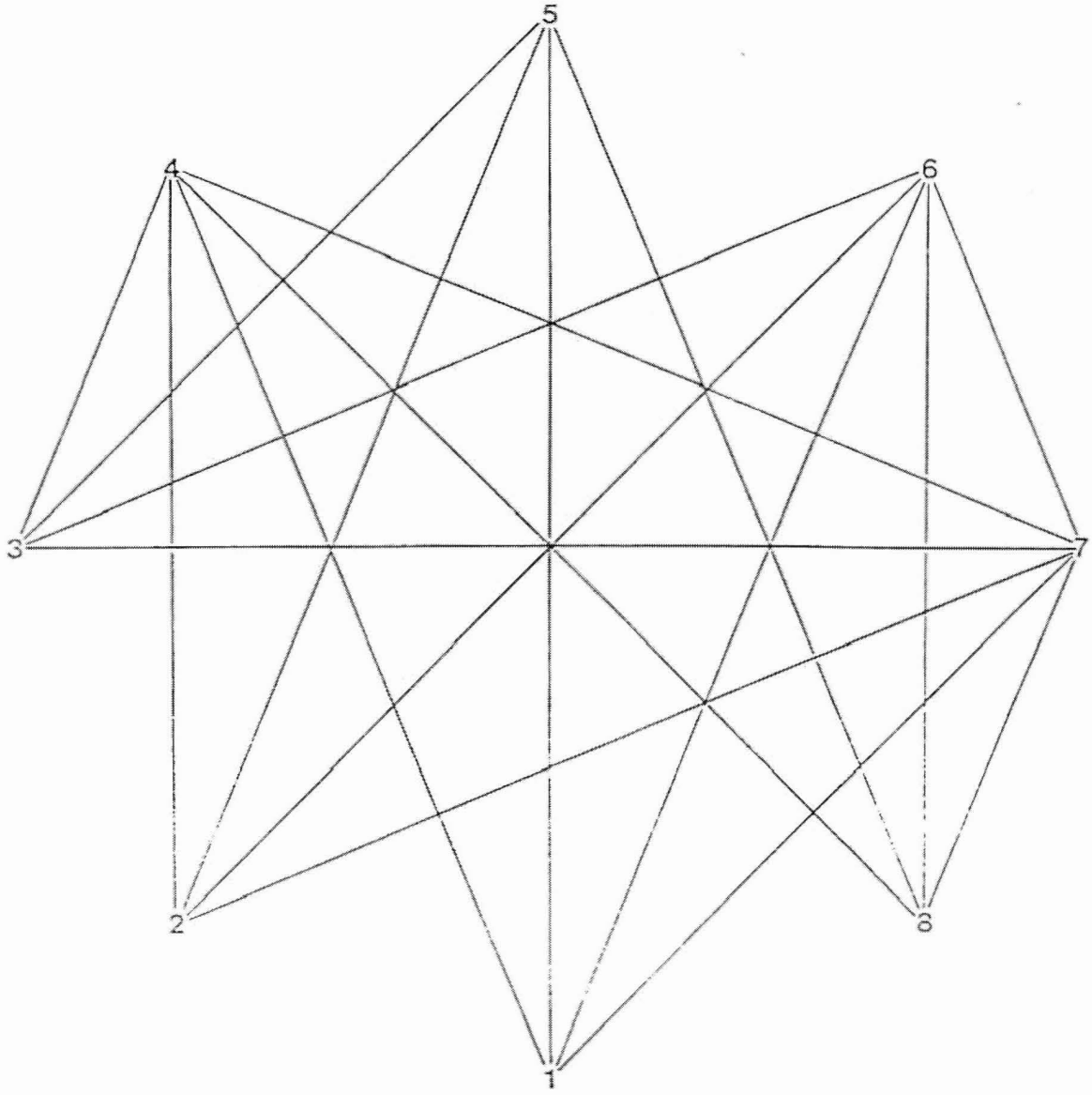
JUNCUS TOTAL WEIGHT
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



UPPER SALT CREEK
LOWER SALT CREEK
CONTROL
MIDWAY
THERMAL
THUMB ISLAND
FENCE
DAVIS ISLAND

FIGURE 6.4-46

JUNCUS TOTAL WEIGHT
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION DIFFERENCES

FIGURE 6.4-47

COMBINED TOTAL WEIGHT
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

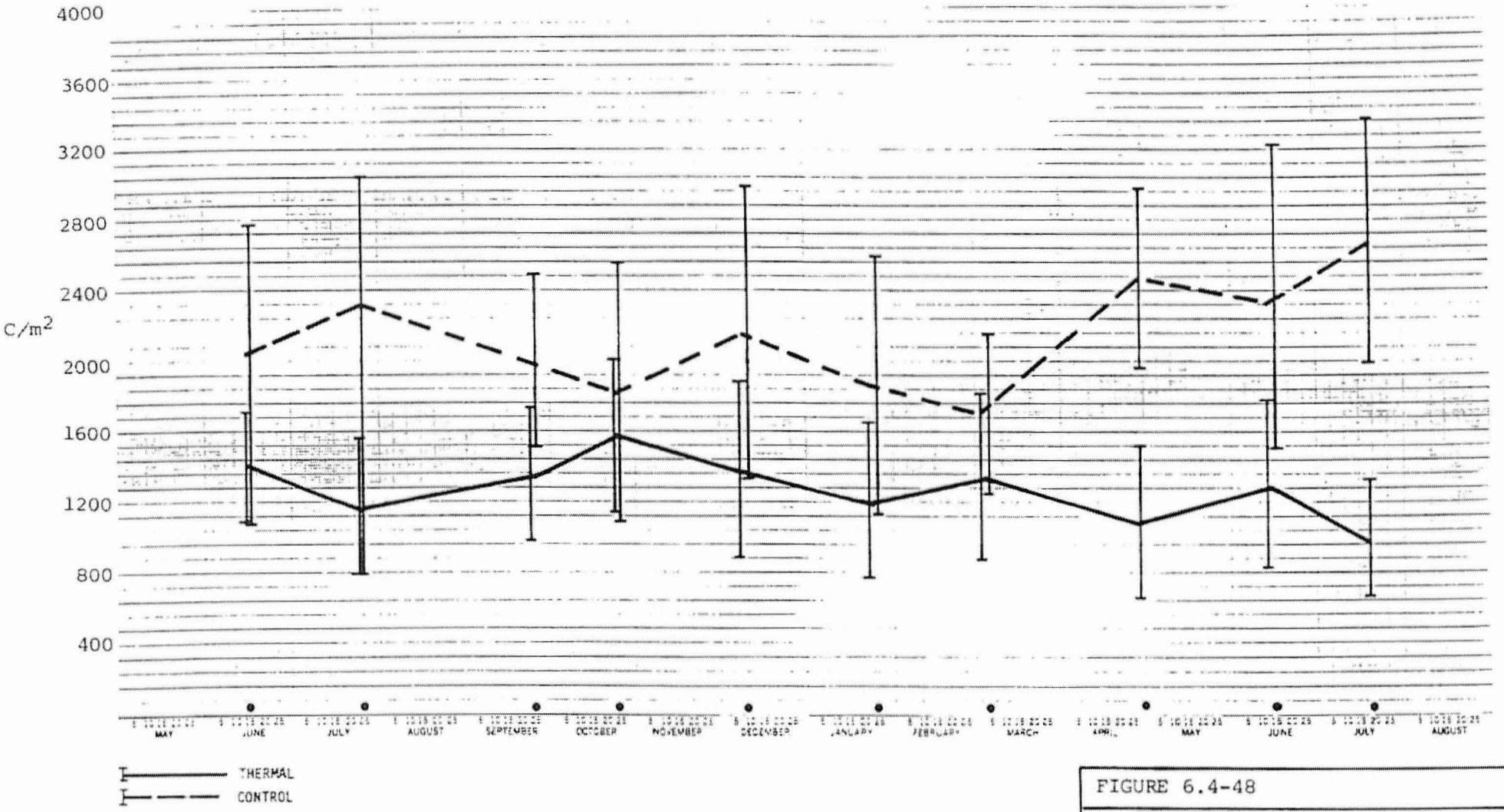


FIGURE 6.4-48

COMBINED TOTAL WEIGHT
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

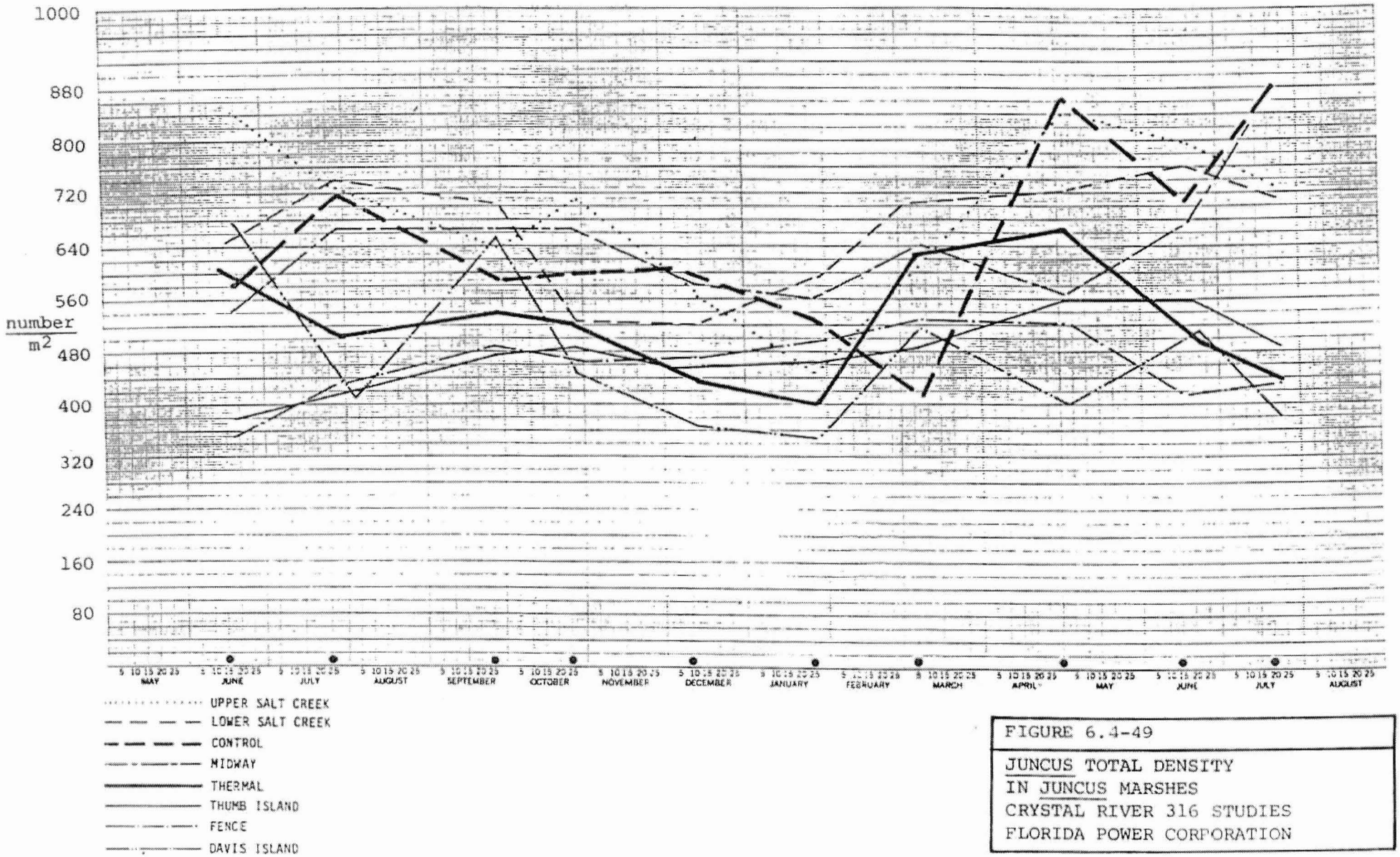
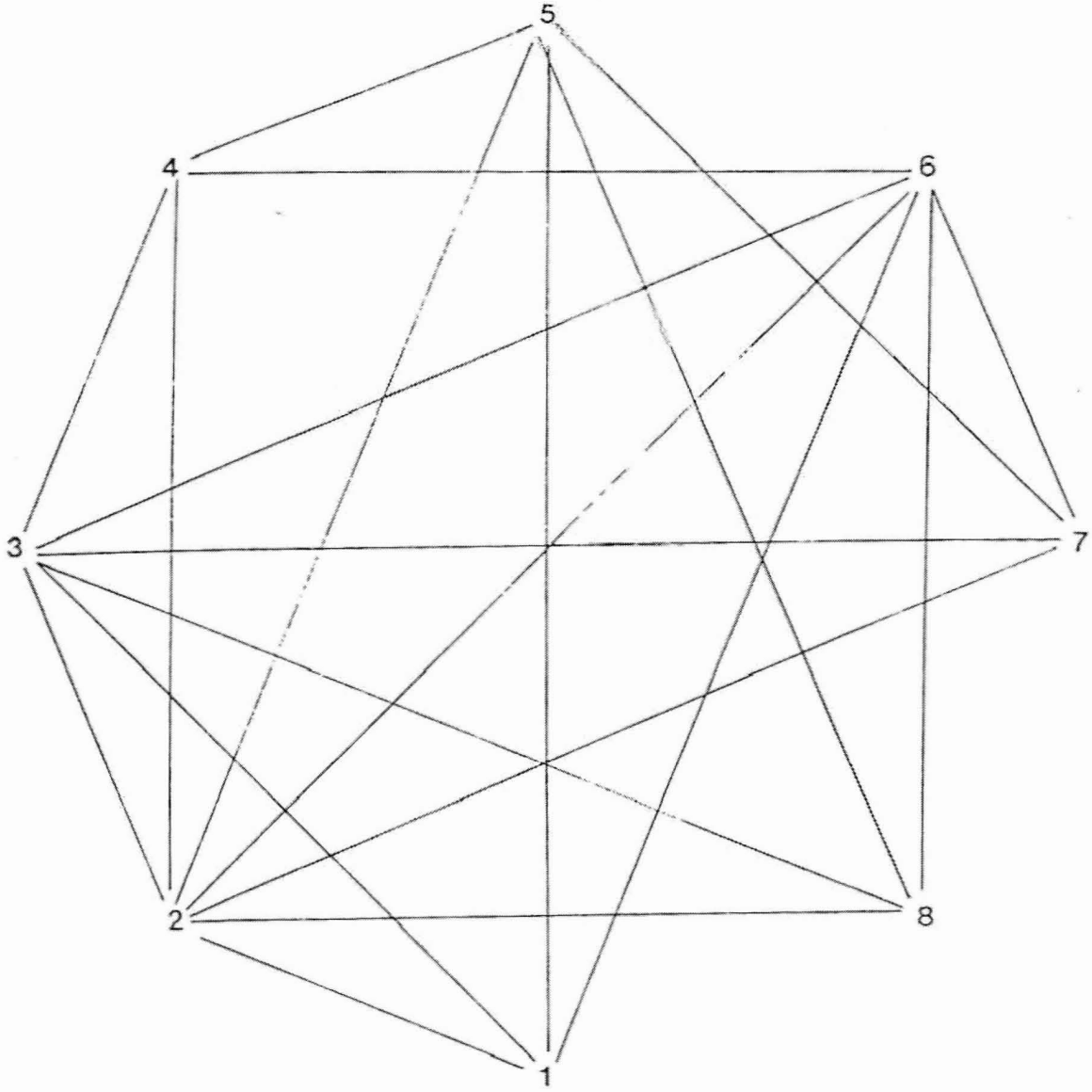


FIGURE 6.4-49

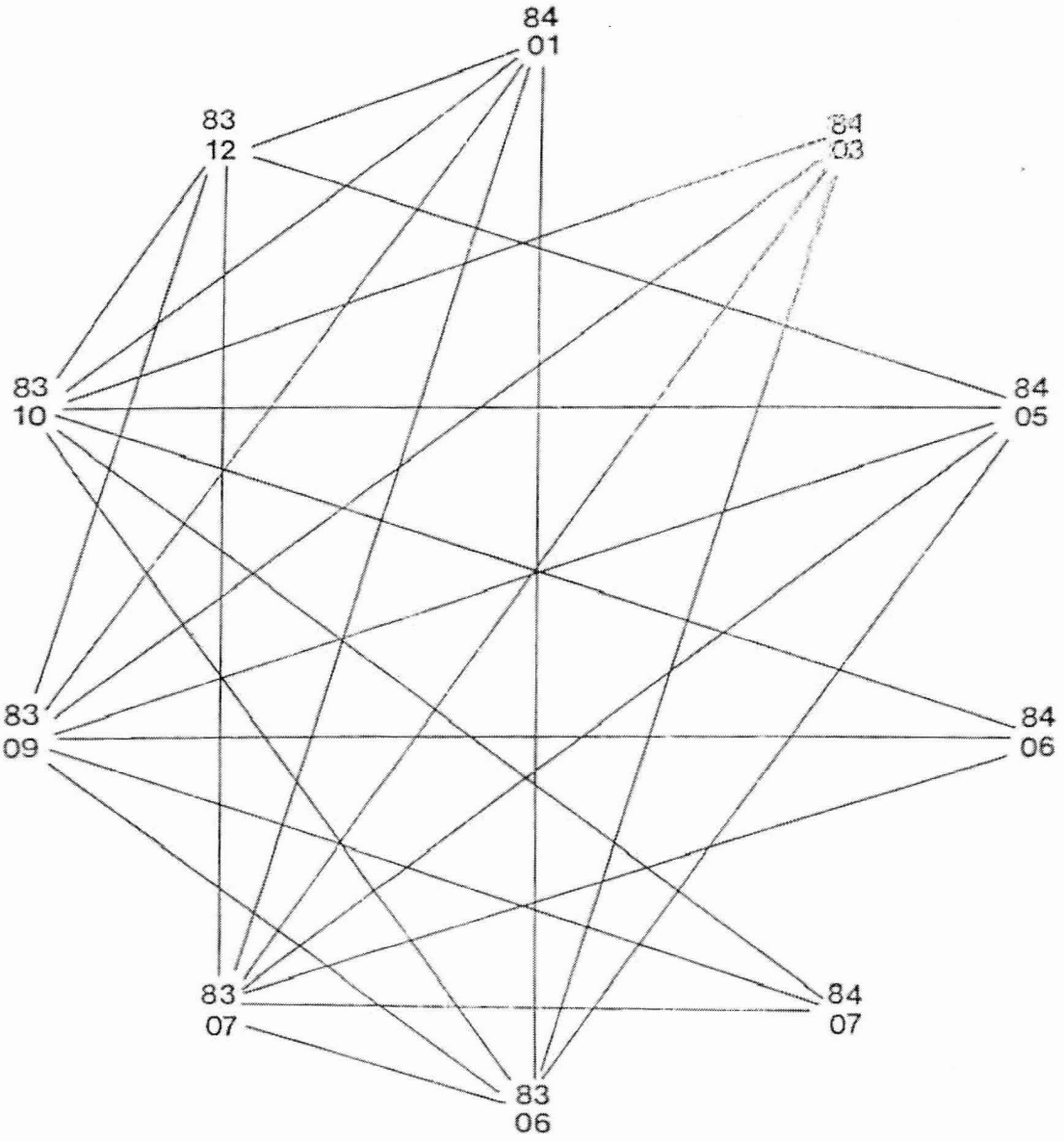
JUNCUS TOTAL DENSITY
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION DIFFERENCES

FIGURE 6.4-50

SPARTINA MARSH
BURROW DENSITY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



TIME DIFFERENCES

FIGURE 6.4-51

SPARTINA MARSH
BURROW DENSITY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

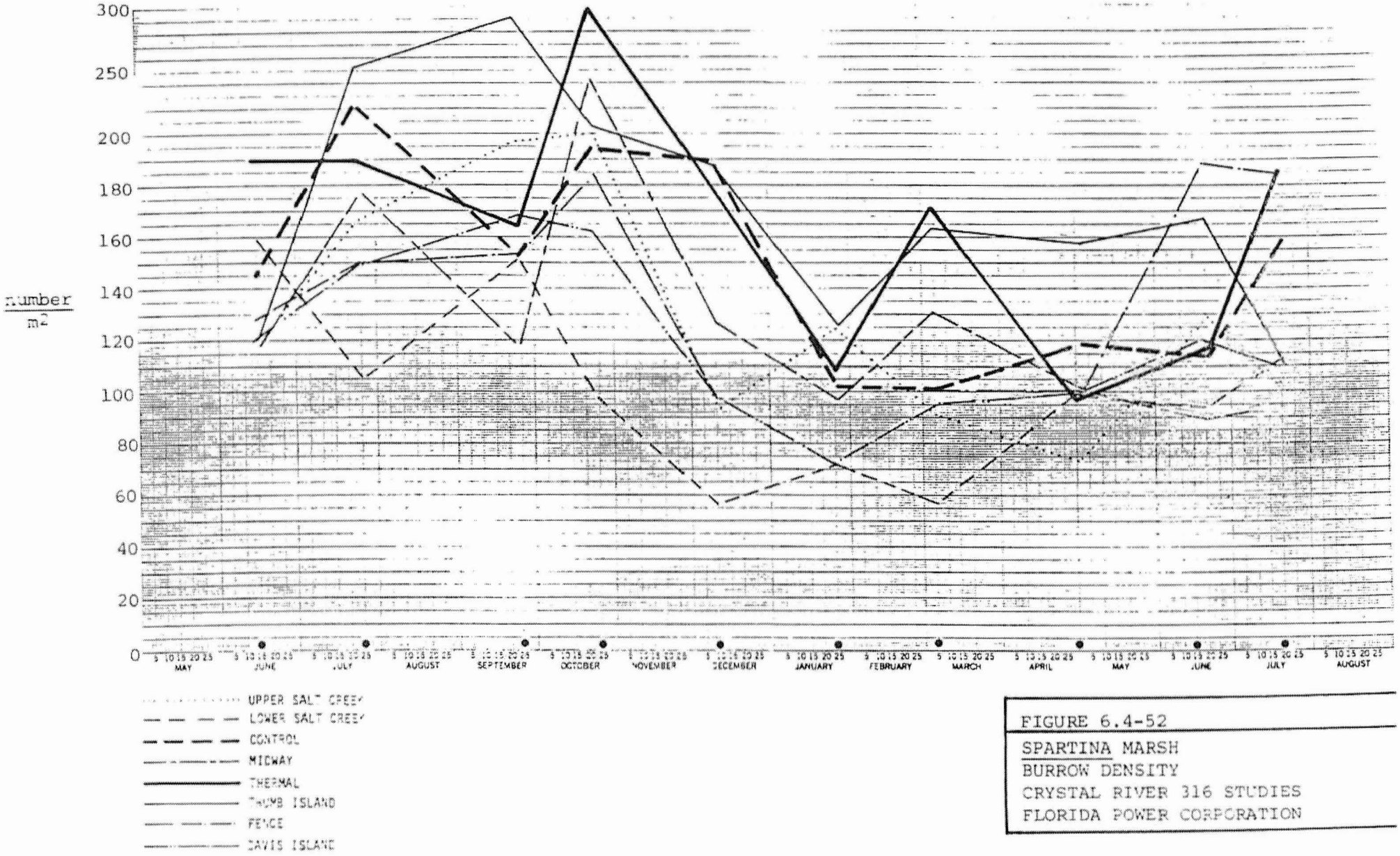
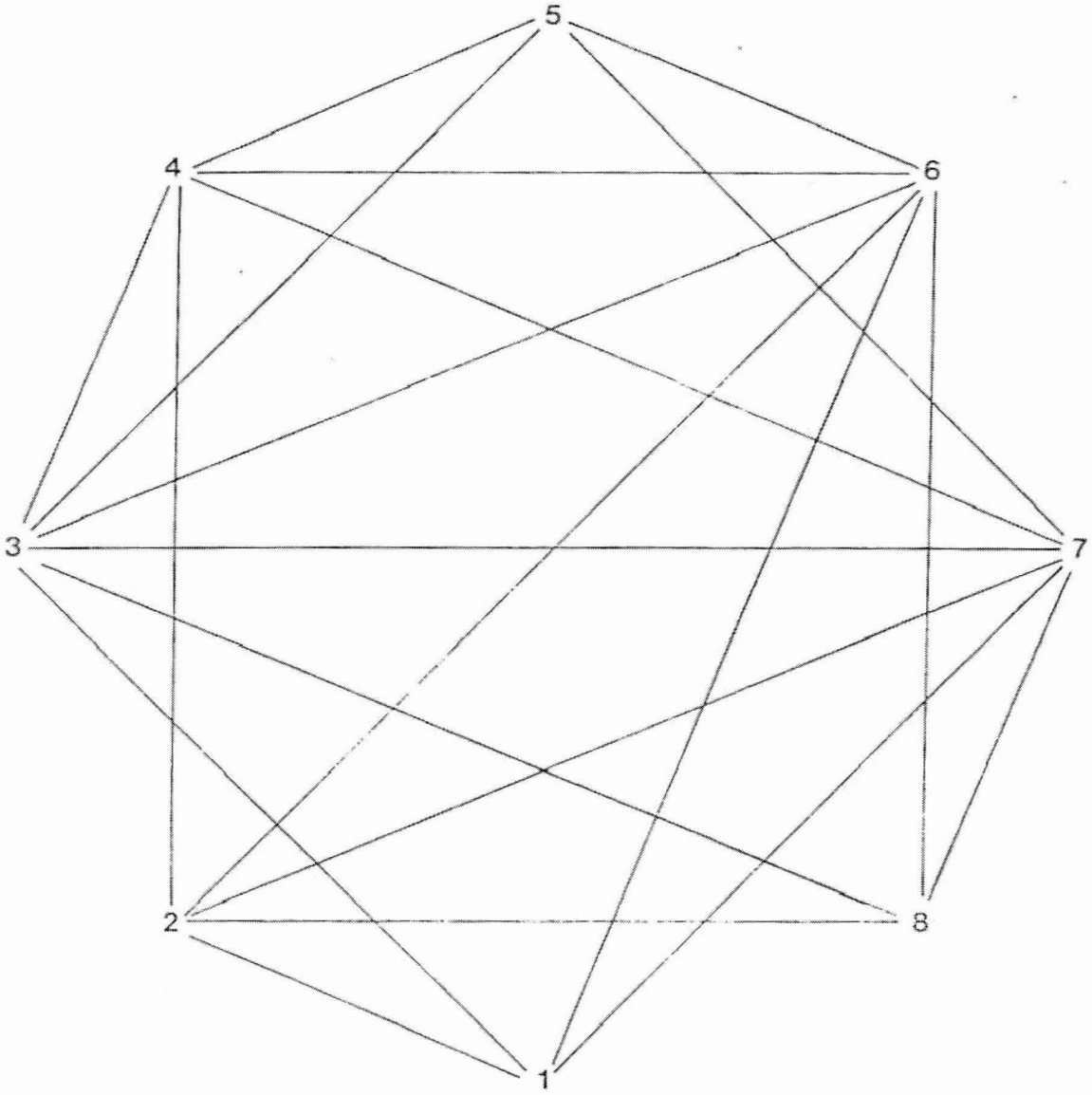


FIGURE 6.4-52

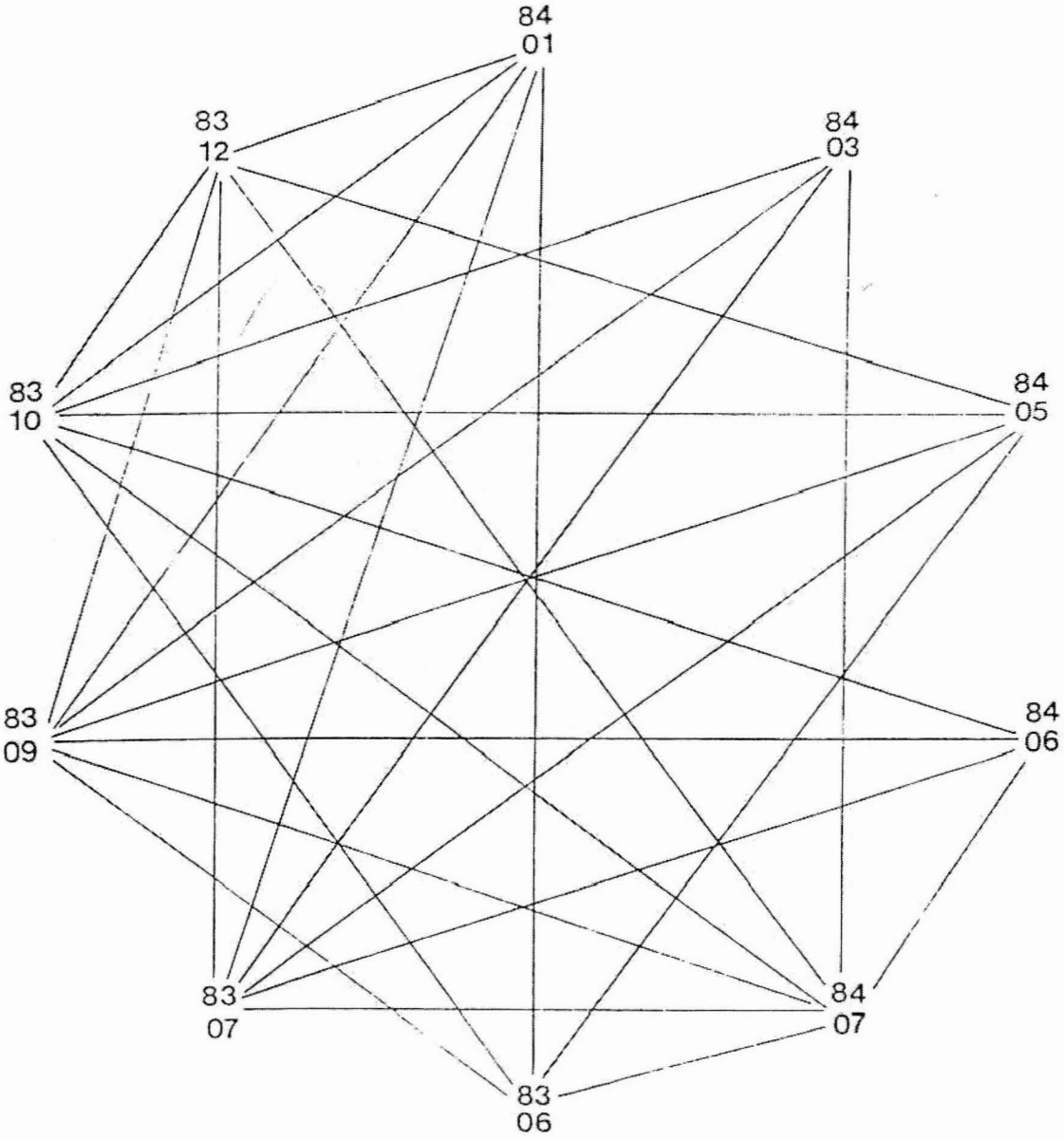
SPARTINA MARSH
BURROW DENSITY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION DIFFERENCES

FIGURE 6.4-53

JUNCUS MARSH
BURROW DENSITY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



TIME DIFFERENCES

FIGURE 6.4-54

JUNCUS MARSH
BURROW DENSITY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

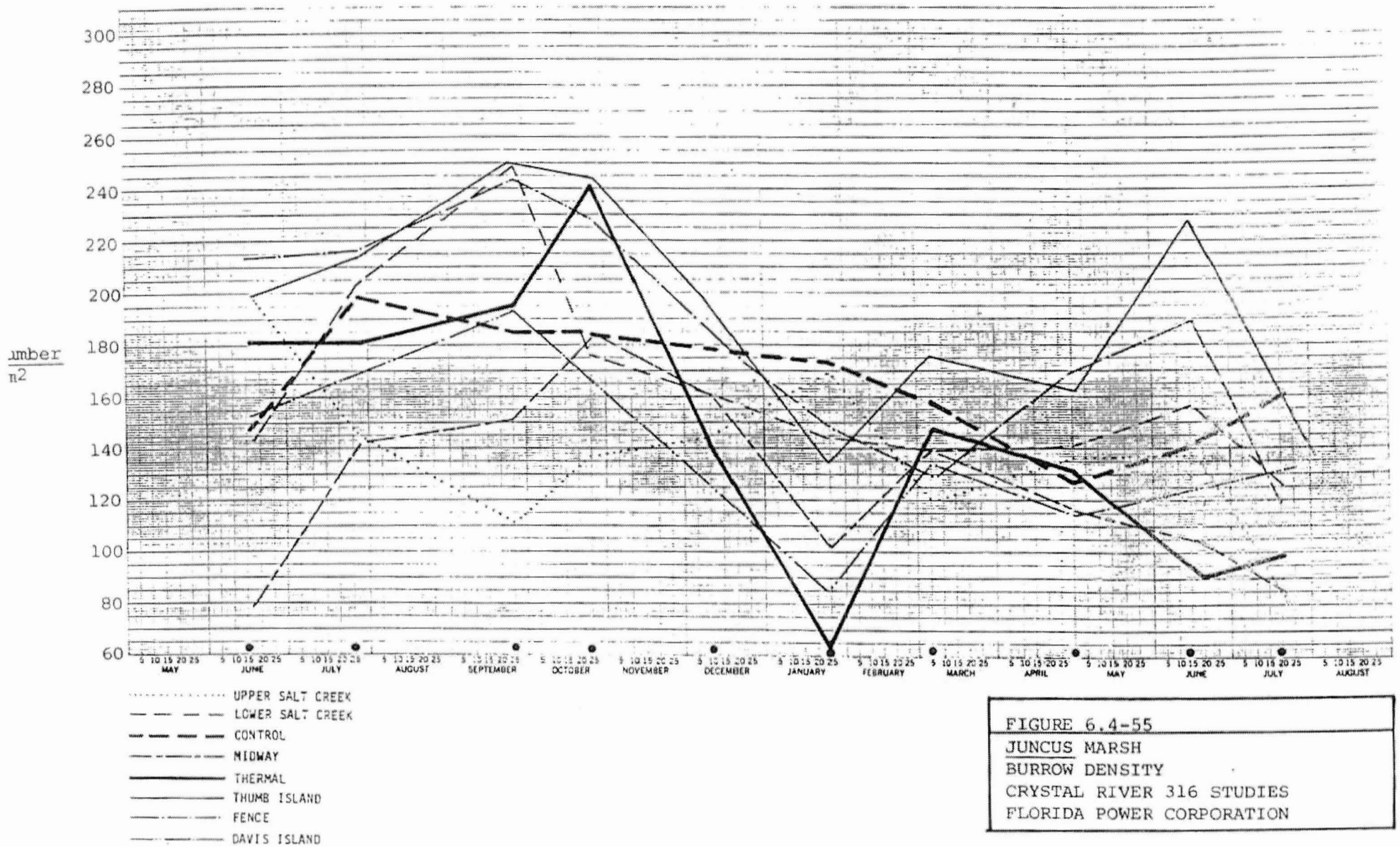


FIGURE 6.4-55
JUNCUS MARSH
BURROW DENSITY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION