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CRYSTAL RIVER UNIT 3

PLANT OPERATING MANUAL

AI-571

Sea Turtle Rescue and Handling Guidance

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1.0 **PURPOSE**

This procedure provides instructions for sea turtle observation, rescue, handling, notifications, and reporting requirements at the Crystal River Energy Complex (CREC).

2.0 **REFERENCES**

2.1 **Developmental References**

2.1.1 CP-151, External Reporting Requirements

2.1.2 CR-3 Safe Work Practices Manual

2.1.3 CR-3 Operating License, Appendix B, Environmental Protection Plan (Non-Radiological)

2.1.4 National Marine Fisheries Biological Opinion (BO)

2.1.5 AI-151, Reporting Requirement Program

2.1.6 FWC, Marine Turtle Permit

3.0 **PERSONNEL INDOCTRINATION**

3.1 **Description**

3.1.1 Sea Turtle Characteristics

Sea turtles are graceful saltwater reptiles, well adapted to life in the marine environment. They are able to swim long distances in a relatively short time due to their streamlined bodies and flipper-like limbs.

Sea turtles are air-breathing, and when they are active they must swim to the water surface for breathing purposes every few minutes. Turtles have been observed swimming underwater for periods of up to 20 minutes, and when resting some have been observed to remain underwater for as long as 2 hours without breathing.

The sea turtle influxes, which occurred in March-May 1998, led to the development of this procedure.

3.1.2 Sea Turtle Protection

Sea turtles are an endangered species protected under the Endangered Species Act. The National Marine Fisheries Service (NMFS), in conjunction with the Florida Fish and Wildlife Conservation Commission (FWC), enforce protection of sea turtles.

3.1.3 National Marine Fisheries Service (NMFS)

The NMFS issued a Biological Opinion (BO) on the potential jeopardy to sea turtles species at the intake area of the Crystal River Energy Complex. The Biological Opinion concluded that there was no jeopardy to any of the sea turtle species, and established terms and conditions governing reporting thresholds and rescue of sea turtles.

3.1.4 NRC Requirements

License Amendment No. 190 incorporated the NMFS non-discretionary terms and conditions into the CR-3 Operating License, Appendix B, Environmental Protection Plan, Section 4.2, Endangered or Threatened Sea Turtles. This procedure implements the NMFS non-discretionary terms and conditions.

3.2 **Definitions**

3.2.1 Annual Period

From January 1, 2002 through December 31, 2002, and each calendar year thereafter.

3.2.2 Clearwater Marine Science Center

The FWC authorized facility for the treatment of sick or injured sea turtles.

3.2.3 Florida Fish and Wildlife Conservation Commission (FWC)

The State Agency responsible for controlling activities related to protected species.

3.2.4 National Marine Fisheries Service (NMFS)

The Federal Agency responsible for controlling activities related to endangered sea turtles.

3.2.5 Nuclear Regulatory Commission (NRC)

The Federal Agency responsible for ensuring the health and safety of the general public relative to the actions and activities of the Crystal River Unit 3 nuclear plant.

3.2.6 Take

For the purposes of this procedure, take is defined as the capture of endangered species sea turtles, including stranded, healthy, sick, or deceased turtles.

3.3 Responsibilities

3.3.1 Environmental Coordinator

The Environmental Coordinator is responsible for:

a. Managing and coordinating the sea turtle program
b. Establishing the appropriate observation/surveillance schedule
c. Making required notifications and submitting reports
d. Submitting any revisions of this procedure pertaining to turtle rescue and handling to the NMFS and FWC for their review (post issuance)
e. Maintaining a sea turtle log
f. Assuring CR3 Operations is notified when an NRC notification is required

3.3.2 Environmental Services

Environmental Services staff is responsible for:

a. Training of observation rescue personnel
b. Sea turtle evaluations and care
c. Tagging and release or disposition
d. Determining the causation of mortality, and for requesting FWC to verify the determination
e. Making required notifications and submitting reports
f. Preparing records required by the NMFS and submitting these records to the Environmental Coordinator
g. Maintaining a sea turtle stranding log
h. Assuring CR3 Operations is notified when an NRC notification is required
i. Rescue of sea turtles

3.3.3 Nuclear Security

Nuclear Security personnel are responsible for performing intake canal observations and bar rack inspections, and making internal notifications to facilitate sea turtle rescues.

3.3.4 CR-3 Operations

CR-3 Operations personnel are responsible for performing CR-3 bar rack inspections (visual and underwater through trash rake operation) and providing support for turtle rescue efforts as needed.

3.3.5 CR-1 and 2 Operations

CR-1 and 2 Operations personnel are responsible for performing bar rack inspections and providing support for turtle rescue efforts as needed.

3.3.6 CR-3 Maintenance

CR-3 Maintenance personnel are responsible for performing bar rack inspections (underwater through trash rake operation) and bar rack cleaning maintenance.

3.3.7 CR-3 Operations Work Coordinator

CR-3 Operations Work Coordinator is responsible for ensuring that NRC notifications are made upon notification that a report or notification to the National Marine Fisheries Service must be made.

3.3.8 Site Emergency Response Coordinators

Emergency Response Coordinators provide support for rescue of sea turtles from the intake areas of Units 1, 2, and 3, although other site personnel may also rescue the sea turtles.

3.4 Limits and Precautions

3.4.1 Sea turtles have powerful crushing jaws. They will bite when handled and can cause significant bodily harm. Keep clear of the turtle's head whenever possible.

3.4.2 Sea turtles may have claws on their front flippers. Keep clear of the front flippers whenever possible. Gloves should be worn when handling sea turtles.

3.4.3 Sea turtles should be handled with the rescue nets. Only if necessary, handle the turtle by the front and back of the shell. They should not be picked up by the flippers, head, or tail.

3.4.4 All safety procedures should be observed when working at the waterfront. Personal flotation devices or harnesses must be worn when working on the catwalk at the waterfront, as required by established safety practices.

3.4.5 NMFS anticipates that no more than 75 live sea turtle takes and 3 causally related sea turtle mortalities will occur annually. If takes reach one of these levels, the NRC must request reinitiation of formal consultation.

3.4.6 NMFS reporting thresholds:

- The 70th non-lethal take occurs in the annual period
- The 2nd causally related mortality occurs in the annual period
- The 8th non-causally related mortality occurs in the annual period
- Any injury or death in the intake canal or the bar racks causally related to CREC operations

4.0 **INSTRUCTIONS**

4.1 **Observation and Rescue**

4.1.1 Observation Schedule

4.1.1.1 The CR3 Environmental Coordinator in conjunction with Environmental Services will determine the appropriate observation schedule based on the frequency of turtle sightings or takes. The following guidance will be used by energy complex staff in the absence of specific instructions requiring more frequent observations:

4.1.1.1.1 Turtle watch observations are normally conducted 24 hours per day at CR3 during periods of high turtle population observations and/or strandings on the bar racks. During this period it is likely that supplemental staff will be used to perform observations and make rescue notifications.

4.1.1.1.2 During periods with low numbers of sea turtle strandings, or infrequent observations, or absence of sea turtles, a reduced turtle observation schedule is established. This reduced program will normally consist of the following:

- Nuclear Security will perform a sea turtle watch by:
  - Inspecting CR3 bar racks an average of once every 2 hours (except when responding to a non-routine Security call out).
  - Making observations of the intake basin during inspections of bar racks to determine presence of sea turtles.
- CR-1, 2 Operations
  - Visually inspect bar racks approximately once per shift.
- CR-3 Operations
  - Visually inspect bar racks approximately once per shift.
- CR-3 Maintenance or CR-3 Operations
  - Inspect CR-3 bar racks for underwater strandings using the trash rake as requested by the Environmental Coordinator.

4.1.2 Rescue Notifications

4.1.2.1 Nuclear Security performs turtle watches and records turtle observations so that the presence/absence of turtles is known.

4.1.2.2 When a turtle is found stranded against the bar racks Nuclear Security will notify designated recovery personnel.

4.1.2.3 Nuclear Security may provide support personnel to help with the turtle rescue and transport.

4.1.2.4 Supplemental staff may be used for turtle watch, and to perform rescue notifications.

4.2 Turtle Rescue and Handling Guidance

4.2.1 <u>Sea Turtle Rescue & Evaluation</u>

> **NOTE**
>
> All steps possible should be taken to minimize stress and prevent harassment to sea turtles.

4.2.1.1 Sea turtles stranded on the bar racks should be rescued using a dip net or other equipment provided (do not release turtle back to the intake canal since the turtle may become stranded again).

4.2.1.2 Sea turtles that have been stranded against the intake bar racks should be held for identification and evaluation by the Environmental Services staff.

4.2.1.3 Turtle recovery personnel should try to make a preliminary evaluation of the physical condition of sea turtle in order to determine whether the turtle appears sick or injured, and therefore needs immediate attention by the Environmental Services staff.

4.2.1.4 Environmental Services staff must make a sea turtle evaluation which includes general health, species, size, and date and time of stranding, and disposition.

4.2.2 <u>Healthy Turtles</u>

4.2.2.1 Turtle recovery personnel should transport the turtle to the holding tank at the Mariculture Center.

4.2.2.2 Observe the turtle's behavior for several minutes before leaving to assure the turtle appears healthy.

4.2.2.3 If the turtle appears weak (e.g. is not strong enough to lift its head), an Environmental Services staff member should be called out (24 hours per day) to evaluate the turtle and provide appropriate care. Otherwise, notify Environmental Services staff of the turtle rescue 7 days a week, during the first hours of day shift.

4.2.2.4 Environmental Services will inform the FWC of the rescue of a stranded healthy turtle.

4.2.2.5 Environmental Services will also notify the CR3 Environmental Coordinator during normal work hours of any rescued sea turtle.

4.2.2.6 Environmental Services or the Environmental Coordinator will determine whether a live take meets the reporting thresholds of Section 4.3.

4.2.3 Sick or Injured Turtles

NOTE
Do not place turtle on any hot or abrasive surface.

4.2.3.1 Place turtle on a wet towel in a cool, quiet area out of direct sunlight. Cover turtle shell with wet towel to prevent desiccation, and leave head exposed so turtle can breathe freely.

4.2.3.2 Turtle recovery personnel immediately (24 hours per day) notify Environmental Services regarding condition of turtle.

NOTE
The Clearwater Marine Science Center is an authorized facility for the treatment of sick or injured turtles.

4.2.3.3 Environmental Services will notify the FWC or the Clearwater Marine Science Center and make arrangements for the care of the sick or injured turtle.

4.2.3.4 Environmental Services will determine whether the turtle injury was causally related to CREC operations.

4.2.3.5 If the sea turtle injury was causally related to CREC operations, Environmental Services or the CR3 Environmental Coordinator will notify Unit 3 Operations (normally the Operations Work Coordinator) of the intent to make a notification to the National Marine Fisheries and the need to make an NRC notification.

4.2.3.6 Environmental Services will also notify the Environmental Coordinator during normal work hours of any injured sea turtle causally related to CR-3 operations.

4.2.4 Comatose Turtles

NOTE
Sea turtles can remain motionless and appear dead for up to several hours.

4.2.4.1 Place the turtle on its belly.

4.2.4.2 Elevate the hind quarters several inches.

4.2.4.3 Place turtle on a wet towel in a cool, quiet area out of direct sunlight.

4.2.4.4 Attend to sea turtle until the Environmental Services staff responds to the call out.

4.2.4.5 The Environmental Services staff will perform advanced resuscitation techniques if appropriate.

4.2.4.6 IF the turtle revives,
THEN follow the appropriate instructions in Section 4.2.3 for injured or sick turtles.

4.2.4.7 IF the turtle expires,
THEN follow the appropriate instructions in Section 4.2.5 for dead turtles.

4.2.5 Dead Turtles

4.2.5.1 Turtle recovery personnel will notify the Environmental Services staff 24 hours per day, 7 days a week, to arrange for dead turtle pick-up and disposal per FWC instructions.

4.2.5.2 IF Environmental Services is unable to respond in a timely manner,
THEN recovery personnel should place dead turtles in a freezer at the Mariculture Center, or a container with ice to prevent decomposition, until Environmental Services is able to respond.

4.2.5.3 Environmental Services will determine if the mortality was causally related to plant operations. Environmental Services staff will notify the FWC and request verification of the determination of causation.

4.2.5.4 IF the sea turtle mortality was found to be causally related to CREC operations,
THEN Environmental Services, or CR3 Environmental Coordinator, will immediately notify Unit 3 Operations (Operations Work Coordinator) that a report to the National Marine Fisheries Services is required and that this also requires a report to the NRC.

4.2.5.5 Environmental Services will also notify the CR3 Environmental Coordinator of any dead sea turtle.

4.3 Notifications

4.3.1 Environmental Services or CR3 Environmental Coordinator

Upon determination that a recovered turtle is a protected species and that a report or notification to the NMFS is required to be made, Environmental Services or the CR3 Environmental Coordinator will notify the CR3 Operations (normally the Operations Work Coordinator) as soon as possible, and inform CR3 Operations of the need to make an NRC report.

4.3.2 Healthy Turtles

Environmental Services or CR-3 Environmental Coordinator informs the FWC of the turtle stranding and rescue.

4.3.3 Injured Turtles

For injured sea turtles, Environmental Services staff notifies (depending on the sea turtle's condition) the FWC and/or Clearwater Marine Science Center rehabilitation facility. A follow-up report to the NMFS is required within 30 days of the incident if the injury was causally related to CREC operations. The Mariculture Center is the interim facility to hold sea turtles prior to pick-up for rehabilitation.

4.3.4 Dead Turtles and 30-Day Reports

For dead sea turtles, the Environmental Services staff notifies the FWC within the next working day to request independent confirmation of FPC's determination of causation. A follow-up report to the NMFS is required within 30 days of the incident for any mortality which was causally related to CREC operations. An NRC report is also required, in accordance with Section 4.1 of the Environmental Protection Plan, if the sea turtle mortality was due to CR3's operation.

4.3.5 5-Day Notifications

The Environmental Coordinator or Environmental Services staff notifies the NMFS within 5 days whenever:

- The 70th non-lethal take occurs in the annual period, or
- The 2nd causally related mortality occurs in the annual period, or
- The 8th non-causally related mortality occurs in the annual period.

Turtle takes beyond these threshold values do not require NMFS notification within 5 days.

4.3.6 NRC Notification

CR-3 Operations (normally the Operations Work Coordinator) notifies the NRC in accordance with the requirements of CP-151, External Reporting Requirements.

4.4 **Reports**

4.4.1 Procedure Revisions and Reviews

The Environmental Coordinator must submit revisions (updates) to this procedure that pertain to rescue and handling of sea turtles to the NMFS and FWC (post issuance) for review.

4.4.2 Annual Report

The CR3 Environmental Coordinator assures that a report on sea turtle strandings is submitted to the NMFS annually, by March 1 of each following year. The report shall include species, size, and date and time of stranding, location, condition, and disposition. A copy of this report is also provided to the NRC within 30 days of its submittal to the NMFS.

4.4.3 30-Day Written Report

The Environmental Coordinator assures that a written report is submitted to the NMFS within 30 days of any causally related injured or dead sea turtle in the intake canal or the bar racks. The report must summarize the incident. An NRC report is also required, in accordance with Section 4.1 of the Environmental Protection Plan, if the sea turtle mortality was due to CR3's operation.

4.5 **Documentation**

4.5.1 Turtle recovery personnel should provide date, time, and location of stranding to the Environmental Coordinator and Environmental Services.

4.5.2 Environmental Services prepares official documentation of all strandings. The documentation shall include species, size, and date and time of stranding, condition, and disposition. A copy of each stranding report should be sent to the CR-3 Environmental Coordinator.

4.5.3 The Environmental Coordinator maintains a turtle log, which will be used as a tool to track the dates and types (i.e., live, causal death, or non-causal death) of each stranding. The turtle log cannot be maintained up to date at all times because of strandings that occur after hours and on weekends. It should be used in conjunction with Operation's logs and condition reports to determine the numbers of each type of stranding. The turtle log does not replace the stranding log, which is maintained separately by Environmental Services and the Environmental Coordinator for purposes of reporting to the National Marine Fisheries. The turtle log should provide the date of each stranding, whether the turtle was live, a causal death, or a non-causal death. The log should only track protected species. The log should also provide a running total of each type of stranding and the date and time of the last update.

4.6 Reinitiation of Consultation

The Environmental Coordinator will ensure that a reinitiation of formal consultation occurs if the annual take reaches 75 live sea turtles or 3 sea turtles killed as a result of CREC operations.

4.7 Records

The documentation prepared in Step 4.5.2 are lifetime quality assurance records. The Environmental Coordinator is responsible for submitting the records to Document Services on an annual basis.

REVISION SUMMARY

1. Reformatted entire procedure to current writer's guide.
2. In References Section, Step 2.1.5 - Replaced reference to NOD-03 with AI-151.

FINAL REPORT

CRYSTAL RIVER 316 STUDIES

January 15, 1985

CONTRACTOR
Stone & Webster Engineering Corporation

SUBCONTRACTOR
Mote Marine Laboratory

Prepared for
Florida Power Corporation

CRYSTAL RIVER 316 STUDIES

Prepared for

FLORIDA POWER CORPORATION

By

STONE & WEBSTER ENGINEERING CORPORATION

JANUARY 15, 1985

APPROVED BY: Program Manager   Division Head

Engineering Management

Stone & Webster Engineering Corporation
Boston, Massachusetts 02107

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Appendices

1.0 INTRODUCTION

In response to requirements of Part III-H, NPDES Permit No. FL0000159 dated July 9, 1979 for Crystal River Units 1, 2, and 3, Florida Power Corporation (FPC) has conducted an ecological monitoring program for the area adjacent to the Crystal River Power Station site. The sampling program was designed to address the effects of plant operation including: 1) thermal impacts on water quality, benthos, macrophytes, salt marsh and fisheries and 2) intake effects in the form of plankton entrainment and adult impingement. Thermal considerations are based primarily on comparison of control and thermally affected areas. Hydrodynamic and hydrothermal modeling were conducted to simulate offshore temperature increases under known plant operating conditions. Impingement and entrainment effects are quantified and compared to relevant population statistics. The elements of the program were grouped into four categories: Benthos, Impingement and Entrainment, Fisheries, and Physical Studies. These headings will be used in subsequent sections to provide specific information on field and laboratory procedures, results and impact assessments.

2.0 CRYSTAL RIVER UNITS 1, 2, AND 3

The Crystal River Power Station is located in Citrus County, Florida, about 13.7 km north of the town of Crystal River (see Figure 2.0-1). The site contains five units arranged as shown in Figure 2.0-2. Units 1 and 2 are coal-fired and Unit 3 is nuclear. These units utilize once through condenser cooling with water drawn from the Gulf of Mexico. Units 4 and 5 are coal-fired and have closed cycle cooling using natural draft cooling towers. Unit 4 went into operation shortly before initiation of field collections for the present program. Unit 5 became operational in October 1984, after data collection ended. Makeup for Units 4 and 5 is drawn from and blowdown is discharged to the discharge canal serving Units 1, 2, and 3. Thus, the physical and chemical environment of the discharge canal is related to operation of all operating units. However, neither the conditions of the discharge permit nor the plan of study (POS) included any separate consideration of Units 4 and 5. Therefore, the environmental descriptions and impact assessments are addressed solely in terms of Units 1, 2, and 3.

Construction at the site began in 1964 and has continued to date. Major offshore construction was completed in 1966, although dredging of the intake canal to increase the depth took place in 1979-1980. Spoil from initial offshore construction was used to create dikes adjacent to the intake and discharge channels.

Startup of Units 1, 2, and 3 spanned 12 years as shown in Table 2.0-1. Rated generating capacity, cooling water flow and condenser temperature rise are also given in the table. Actual operating conditions, however, exhibit considerable variation. Table 2.0-2 includes weekly average values of megawatts generated and temperature rise for each unit. Cooling water flows vary similarly. This variation occurs despite the units being operated to maximize operational efficiency within permitted limits. Planned or unplanned time offline is kept to a minimum. During the periods of field collection, Units 1, 2, and 3 were only offline for 72, 66, and 87 days, respectively. The units were offline for periods of a week and more at the times shown in Table 2.0-2.

2.1 INTAKES

Water for all three units is drawn through a common canal located south of the units and extending generally westward into the Gulf of Mexico as shown on Figure 2.1-1. The canal has been dredged to -20 feet at MLW and is used to bring coal barges into the site. The barges dock on the south side of the canal just west of the intakes for Units 1 and 2. The dredged channel is confined between two dikes for about 5.5 km, at which point the southern dike terminates. The northern dike parallels the channel for another 8.5 km with the first opening at Fisherman's Pass occurring 2.3 km past the southern dike. Other openings occur at irregular intervals. Water flows eastward in the canal. Current velocities at the mouth of the canal were measured in August 1983 and January 1984 and ranged from 0.2 to 0.8 meters/second. Much of this range is accounted for by tidal rather than seasonal variation, however. Current velocities measured over a tidal cycle in August 1983 ranged from 0.2 to 0.6 meters/second.

2.2 DISCHARGES

The common discharge canal for all units is located just north of Units 1, 2, and 3. The canal extends WNW for almost 2.6 km to the point-of-discharge (POD) at the shoreline, where the canal opens into a bay. The dredged channel, bordered to the south by a spoil bank, continues for another 1.9 km. Water depth in the canal is about 3 meters.

The discharges of the three units enter the canal near the eastern end. They are located as shown in Figure 2.1-2. The designs of the three discharges are all similar. Four circulating water lines enter an open, concrete discharge chamber. The pipes turn downward, discharging the flow in a basin. The discharge exits the chamber over a short weir and mixes immediately with water in the canal.

TABLE 2.0-2

CRYSTAL RIVER PLANT DATA
JUNE 1983 TO AUGUST 1984
MEAN VALUES FOR 7 DAY PERIODS STARTING ON SUNDAY

Date	Unit 1			Unit 2			Unit 3			POD
	MWe	Flow (10^3 gpm)	ΔT (^oF)	MWe	Flow (10^3 gpm)	ΔT (^oF)	MWe	Flow (10^3 gpm)	ΔT (^oF)	Temp. (^oF)
01JUN83*	346.61	301.12	13.73	458.14	322.02	14.11		170.00		94.04
05JUN83	352.75	306.31	11.93	433.52	300.10	12.98		170.00	1.07	93.28
12JUN83	362.32	308.62	11.80	423.52	322.14	12.01		181.13	1.20	91.43
19JUN83	358.91	310.00	13.17	480.03	328.00	13.34		170.00	1.07	94.20
26JUN83	330.07	297.93	12.85	466.81	326.53	13.71		208.68	0.68	95.29
03JUL83	369.13	310.00	13.60	422.74	317.26	12.26		366.31	0.77	95.45
10JUL83	357.40	310.00	14.18	473.73	325.56	13.48		342.02	0.45	94.88
17JUL83	359.63	310.00	14.08	453.46	328.00	13.11		443.21	0.48	95.29
24JUL83	334.98	290.16	14.39	459.07	325.07	14.40	274.51	629.40	4.66	95.00
31JUL83	352.08	310.00	14.42	425.44	328.00	13.30	539.75	620.30	12.83	97.35
07AUG83	309.40		14.53	429.54		14.14	616.50	678.99	13.25	99.18
14AUG83	357.42		14.50	344.47		16.72	637.76	680.00	13.47	99.89
21AUG83	356.48		15.03	374.76		13.56	549.74	579.22	12.35	100.09
28AUG83	326.03	305.69	14.61	455.18	328.00	13.44	616.81	622.32	14.57	99.54
04SEP83	345.41	309.08	14.66	447.45	328.00	13.95	631.21	642.56	13.37	98.46
11SEP83	341.52	292.47	15.16	413.99	321.17	14.43	536.24	614.23	13.54	96.31
18SEP83	348.06	310.00	15.27		129.83		646.10	680.00	13.26	92.73
25SEP83	324.87	293.85	15.67		135.69		626.59	571.73	13.65	85.78
02OCT83	349.06	306.77	14.52	454.66	291.88	12.20		474.83	1.47	85.51
09OCT83	280.81	308.15	14.16	466.38	313.85	13.14	811.46	631.91	3.80	87.15
16OCT83		298.93		459.47	328.00	13.04	753.02	656.73	7.96	86.81
23OCT83		307.31		452.59	328.00	12.93	863.18	680.00	16.62	87.86
30OCT83		310.00		426.33	325.56	11.91	885.32	680.00	17.30	85.08
06NOV83	356.15	309.54	16.81	452.46	327.02	13.03	826.19	643.57	16.18	83.83
13NOV83	317.21	289.24	16.41	445.87	328.00	13.10	823.29	657.74	16.80	80.26
20NOV83	283.89	268.48	15.85	395.05	328.00	12.69	817.95	637.50	16.35	78.13
27NOV83	311.83	305.39	15.26	335.36	327.02	10.09	899.85	680.00	17.28	78.65
04DEC83	276.94	306.77	14.38	337.84	328.00	9.35	894.74	680.00	17.39	79.09
11DEC83	282.75	289.24	14.91	347.27	291.27	10.62	808.00	626.37	17.06	75.01
18DEC83	309.97	304.46	17.02	312.72	328.00	10.14	891.36	673.93	17.46	74.85
25DEC83	325.40	291.55	19.53	426.74	308.96	14.70	786.96	630.12	16.32	65.67

*4 day average

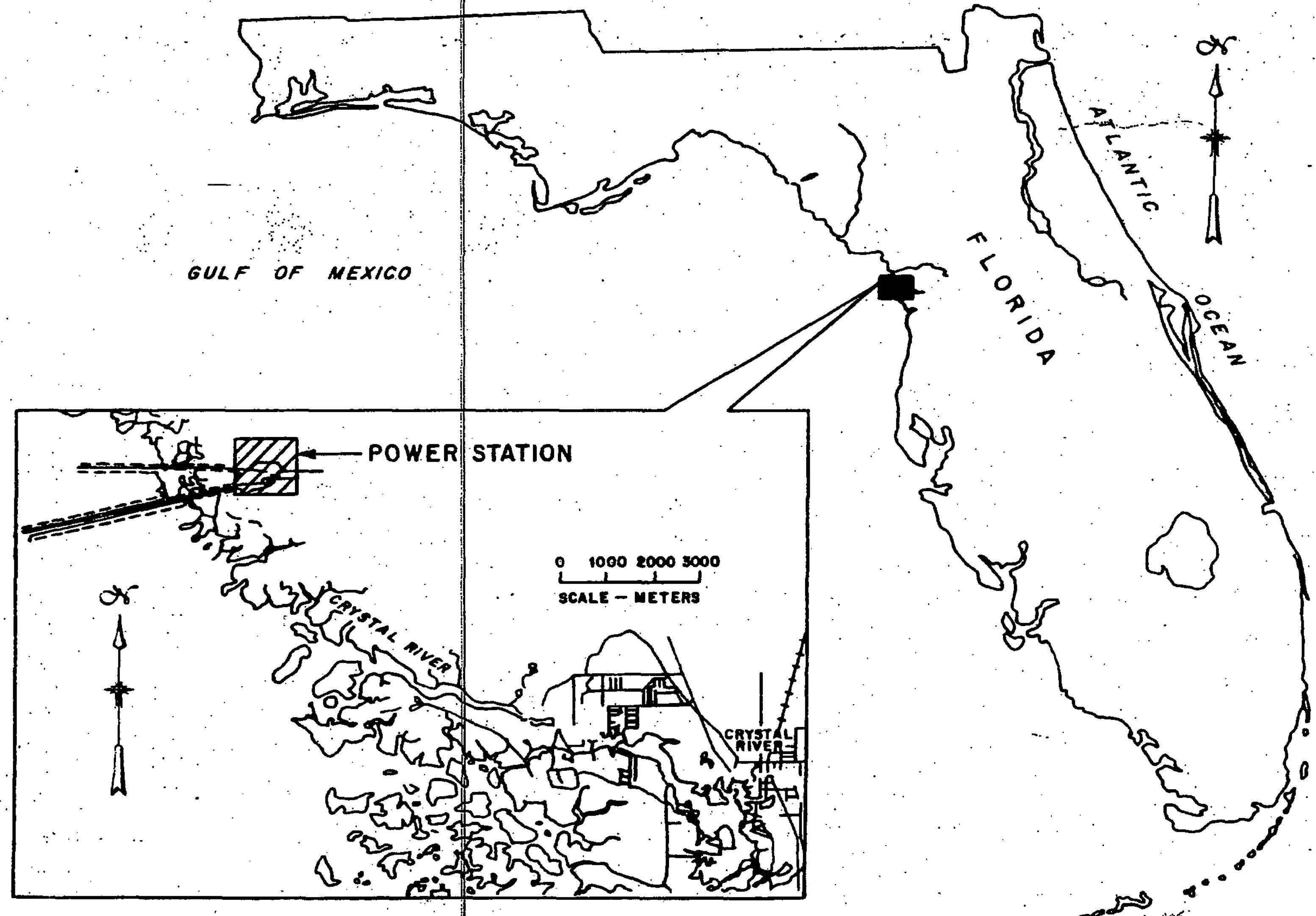

FIGURE 2.0-1

LOCATION OF THE
CRYSTAL RIVER POWER STATION
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

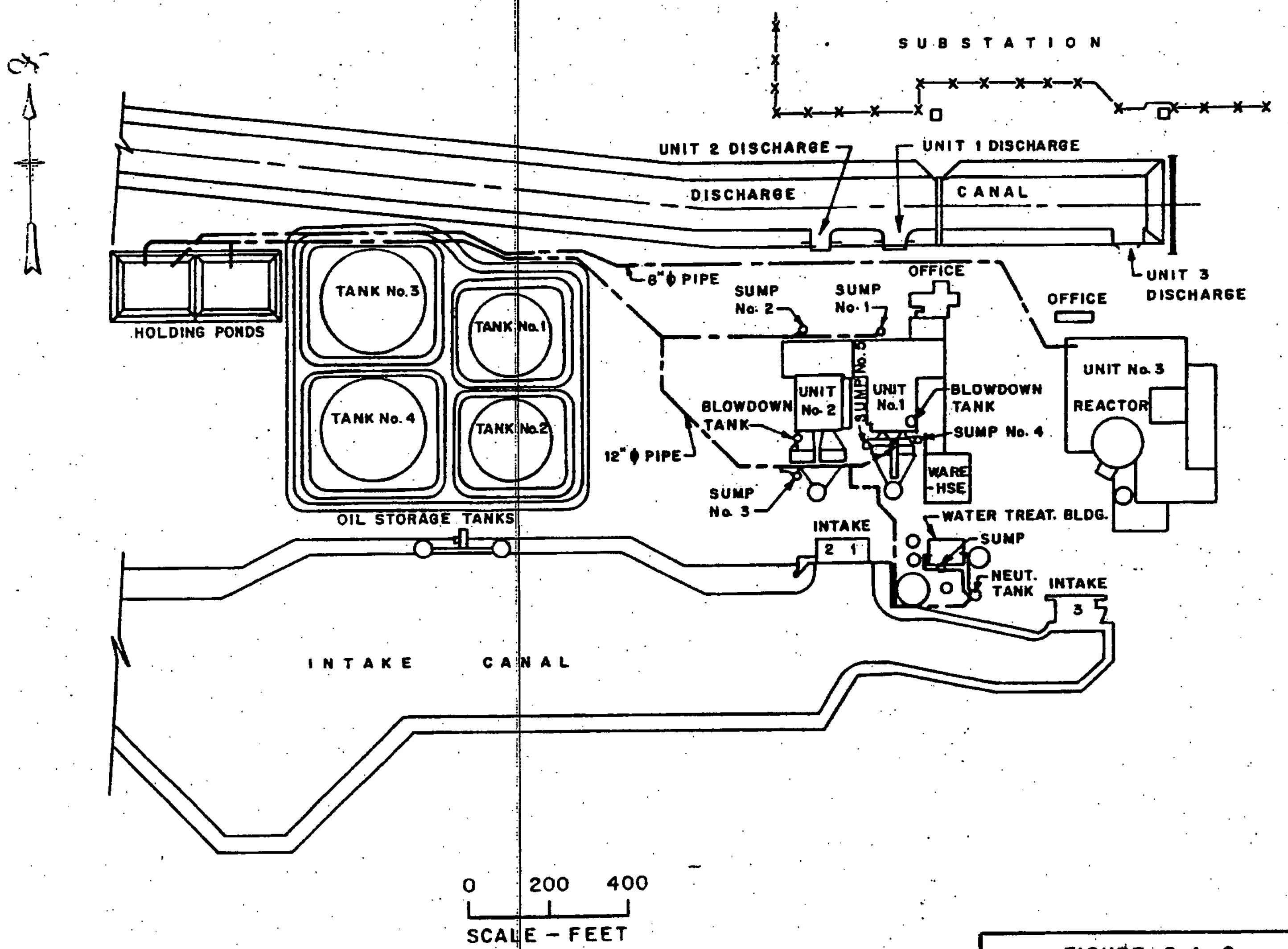

FIGURE 2.1-2

LOCATION OF INTAKES AND DISCHARGES FOR UNITS 1, 2 AND 3
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

3.0 DESCRIPTION OF CRYSTAL BAY

Navigation charts covering the area of the Gulf of Mexico adjacent to the Crystal River Power Station designate the waters off the mouth of the Crystal River as Crystal Bay (see Figure 3.0-1). This term will be used here to refer to that same area as well as the inshore waters north of the intake spoil as far as the mouth of the Withlacoochee River. The study area encompasses all of Crystal Bay and extends offshore about 16 km from the power plant as shown in Figure 2.1-1.

Crystal River enters Crystal Bay from the southeast. A navigation channel is maintained in the river and for several kilometers offshore. The Withlacoochee River enters the Bay from the northeast. It is somewhat smaller than the Crystal River, but it is navigable, and an offshore channel is maintained. About 1.6 km south of the Withlacoochee River lies the western terminus of the Cross Florida Barge Canal (CFBC). While the canal was never completed, the canal was dug far enough to the east to alter the local watershed and to permit drainage through the canal and into the Gulf. Flows in the canal are regulated by locks.

Offshore of the CFBC, a deep channel was dredged extending WSW from the canal. Dredge spoil was deposited south of the channel creating a series of islands paralleling the channel. Several natural islands also occur in Crystal Bay; these are generally close to shore. Larger islands such as Thumb, Drum, and Lutrell are located north of the discharge and Negro Island, and a few small islands, are found near Cutoff and Salt Creeks, south of the intake. Shell Island is located at the mouth of the Crystal River.

Crystal Bay tends to be very shallow; depths rarely reach 3 m as far out as Fisherman's Pass, and depths of 6 m infrequently occurred at the furthest offshore stations. The shallow inshore environment is dominated by oyster reefs or bars which are generally oriented parallel to shore at intervals from the shoreline. The reefs are composed of oyster shell with the bulk of the reef being composed of broken shell. Clumps of shells are apparent on the surface. The reefs are exposed at low tide, but almost all are covered at high tide. Sections of reef tend to be short with narrow passages between sections. When viewed from above, the pattern of reefs appears to define a series of basins with slightly deeper water in the center and the bottom gently sloping up to the surrounding reefs. Previous reports on Crystal Bay have defined and numbered the basins as shown in Figure 2.1-1.

The coastal area of Crystal Bay is characterized by salt marsh dominated by *Juncus roemerianus* with bands of *Spartina alterniflora*. The marshes are fairly flat and extend inland for about 1.6 km in places. A number of small creeks drain the marshes. The creek system adjacent to Basin 1 is particularly extensive.

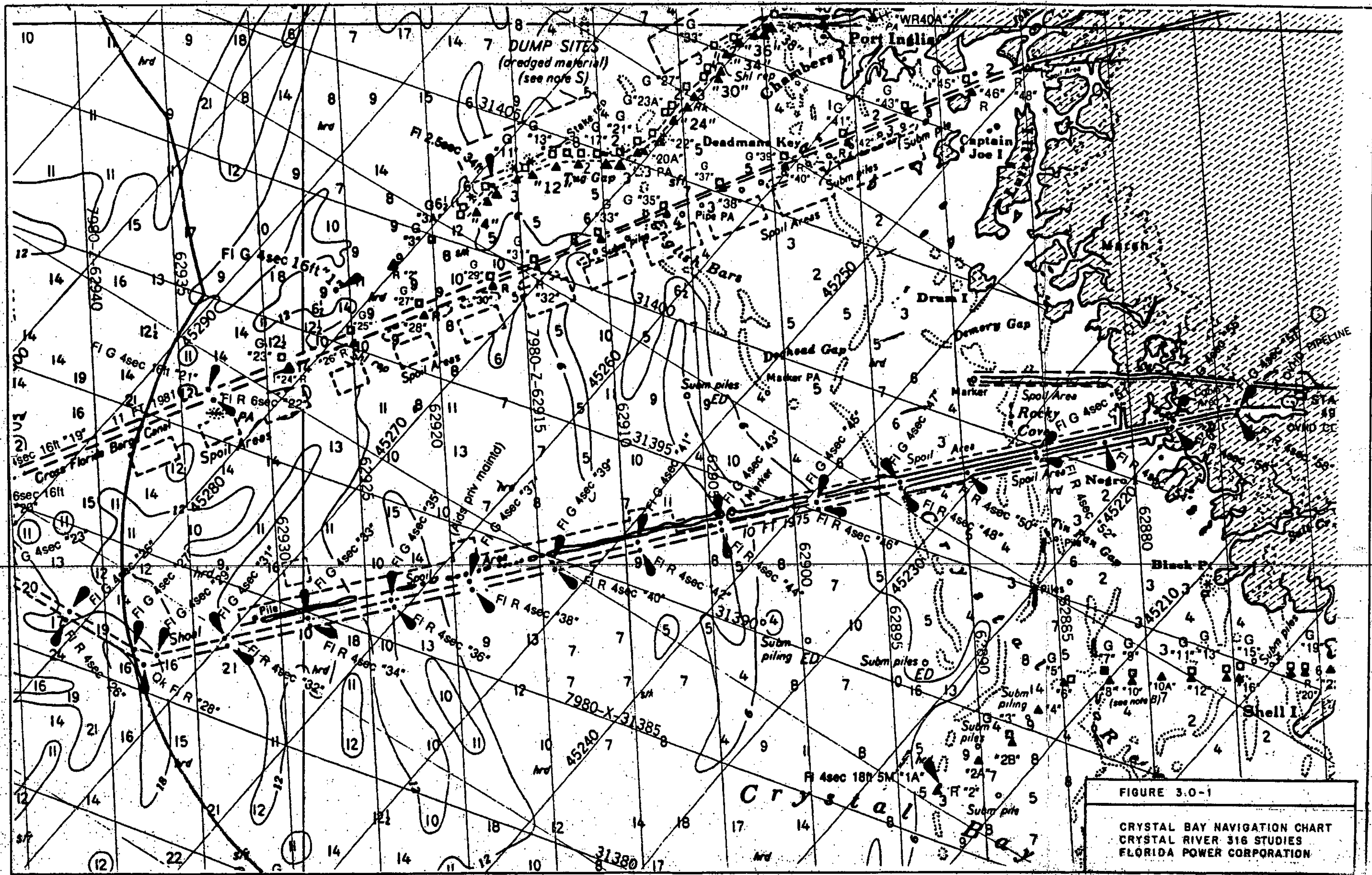

FIGURE 3.0-1

CRYSTAL BAY NAVIGATION CHART
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

4.0 PREVIOUS STUDIES

The present program is one in a series of studies conducted at the Crystal River site. Most of the studies were intended to address the effects of power plant construction and operation on the local ecosystem. Three exceptions were Dawson's (1955) early study of oyster biology and hydrology, Philiips' (1960) study of marine plants, and the more recent study conducted by CH2M Hill (1983) to provide data for the Withlacoochee Regional Planning Council.

Comprehensive studies relating to the power plants essentially began in 1969 at which time Unit 1 was in operation, Unit 2 was starting up, and a construction permit had been issued for Unit 3. The studies were performed by the Florida Department of Natural Resources (DNR) and a series of publications resulted (Grimes 1971; Lyons et al 1971; Quick 1971; Steidinger and Van Breedveld 1971; Grimes and Mountain 1971; and Mountain 1972). The last data collection took place in 1971. In approximately the same time frame, the University of South Florida initiated studies of thermal effects (Carder 1970; Klausewitz 1972). Plume mapping and modeling were emphasized.

Licensing activities related to Unit 3 resulted in initiation of further studies in 1972. Personnel from the University of Florida performed a variety of studies; other participants were the University of South Florida, Gilbert and Associates, and Dames and Moore. In 1973, the studies came under the auspices of a specially formed Interagency Research Advisory Committee. Study results were presented in a multiple volume report (FPC 1974a) and several supplemental publications (FPC 1974b; FPC 1975; Osterling 1976). Predictive hydrothermal modeling continued through 1975 and into 1976. Results of the modeling addressed the effects of future operation of Unit 3 (Carder et al 1976).

Unit 3 began commercial operation in March 1977, and an operational monitoring program required by the environmental technical specifications began at that time. Initial participants in the program were the University of Florida, NUS and Connell, Metcalf and Eddy. Applied Biology held a contract in the later stages. Although the scope of the program varied over time, elements of the studies continued through 1981. Results were reported in a series of annual reports (FPC 1978a; 1978b; 1979a; 1979b; 1980; 1981; 1982a) and summarized in two publications (FPC 1982b; Applied Biology, 1983).

The publications cited above report studies of essentially all components of the Crystal Bay ecosystem; however, the results from almost all of these studies cannot be directly compared to results from the present study. Comparisons are limited because: 1) plant construction and operating conditions did not approximate present conditions until 1981, 2) collection techniques for particular biotic groups varied, and 3) laboratory and analytical techniques varied. The data from these previous studies were used in designing the present study.

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5.0 DEVELOPMENT OF THE PLAN OF STUDY

Field sampling conducted at Crystal River is described for each program element in subsequent sections of this report. The program originally was designed for FPC by a series of contractors and was described in the document entitled "Plan of Study, Crystal River 1, 2, and 3 NPDES 316(a) and 316(b) Ecological Monitoring Program." The Plan of Study (POS) was prepared in August 1979 and revised in November 1982. It was submitted to the U.S. Environmental Protection Agency (EPA) for approval on November 15, 1982.

Subsequent to approval of the POS, Mote Marine Laboratory (MML) reviewed the program and proposed changes to the Benthos, Impingement and Entrainment, and Fisheries sections. The changes were presented in "Proposed Revisions to Plan of Study, Crystal River 1, 2, and 3 NPDES 316." More limited changes were also proposed for water quality aspects of the Physical Studies section. FPC accepted the proposed revisions, obtained preliminary approval from regulatory personnel and submitted a request for proposal for the revised POS. Stone & Webster Engineering Corporation's (SWEC) proposal was to implement the program as written with the exception of the hydrodynamic/hydrothermal modeling which would accomplish the objectives using different models. Field collections remained unchanged. The proposed revisions and the pertinent proposal material were submitted to the EPA on February 22, 1983. In March 1983, SWEC was awarded the contract to implement the program. The field work and preparation of the Benthos section of the report were conducted by MML under contract to SWEC. MML utilized personnel from Mangrove Systems, Inc. to work on the macrophyte component. Personnel responsible for specific program elements are listed in Appendix I.

As the field program began in June 1983, some modifications to the sampling program were needed to accommodate local conditions or to enhance analysis of the resulting data. These changes were summarized in the First Quarterly Progress Report (SWEC 1983) and presented orally at the First Quarterly Progress Meeting held on October 27, 1983. All changes were discussed before implementation and written notice was provided to EPA and to the Florida Department of Environmental Regulation (DER). Formal approval of all changes in the program was received by FPC on April 17, 1984.

Throughout the program, quarterly reports have been issued containing summary data tables for the field components and other related information (SWEC 1983, 1984a, b, c, d). These reports were submitted to U.S. Fish and Wildlife Services (FWS) National Marine Fisheries Service (NMFS), EPA, DER, and the Nuclear Regulatory Commission (NRC). In addition to data tables, a tape of computerized data will be made available to EPA at the program's completion. Quarterly progress meetings have been held with state and federal regulatory agency personnel invited to participate. Regular participants have included the EPA and the DER. As a result of the meetings, phone conversations, correspondence or other discussions, any program changes initiated after the start of field sampling have been subject to prior approval by the agencies.

FPC summarized the above information in "Crystal River 316 Study, Plan of Study - Summary," to provide a single document outlining the program in its final form. Table 3.0-1 summarizes the field program and provides for each component the pertinent number of stations, replicates, samples, sampling frequency, and period of study. Field collections were completed in August

1984. The dates of these collections were summarized in the Fifth Quarterly Progress Report (SWEC, 1984d).

After collection and laboratory analysis of samples and summarization in the quarterly reports, the data were analyzed in a variety of ways for presentation in this report. Nearly all of the statistical summaries and analyses of data were done with Version 82.3 of the Statistical Analysis System (SAS) (SAS 1982). This system offers a high level language of commands (called PROCs) which follow many of the standardized statistical procedures found in most statistical methods texts such as Snedecor and Cochran (1967). The most frequently used SAS PROC for this study is the Generalized Linear Model (GLM) procedure. A linear model in this case could be represented as:

$$Y = b_1X_1 + b_2X_2 = b_3X_3$$

where Y represents the dependent variable (such as surface temperature), X represents a discrete (such as station) or continuous (water depth) independent variable or treatment, and b represents the i^{th} treatment mean or deviation of the i^{th} treatment mean (for the discrete case) or the slope of the least squares relation of Y on X (for the continuous case).

This SAS procedure provides an analysis of variance type summary of the relative importance of the independent variables in the model. The procedure also provides estimates of the values of the b's in the model. For nearly all the GLM analyses a Tukey's Honestly Significant Difference (HSD) test was provided. The anova type format confirms if at least one individual level, e.g., station, of an independent variable is statistically significantly different from at least one other level (station) of the same variable. The HSD test identifies which of the levels is different.

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TABLE 5.0-1

SUMMARY OF ECOLOGICAL PROGRAM
CRYSTAL RIVER STUDIES

Study Component	No. of Stations	No. of Rep.	Frequency	Total No. Samples	Study Period
I. Benthos					
A. Benthic core	20	6(+2)	Quarterly	600	15 mos
	20	6(+2)	6 wks	1200	15 mos
B. Macrophyte mapping	50	10	Quarterly + 1 Preliminary	3000	15 mos
	9(intens.)	10	6 wks	900	15 mos
	9(intens.)	5	6 wks	450	15 mos
	9(intens.)	3	6 wks	270	15 mos
C. Aerial photographs	1	1	3 times	3	15 mos
D. Oyster reef	9	90	Monthly & Bimonthly	14580	12 mos
E. Salt marsh program	8	24	6 wks	1920	15 mos
F. Physical					
a. Chlorophyll 'a'	8	2 depths	Weekly	1040	15 mos
b. Sediment	40	3	Quarterly	1200	15 mos
c. Photometry	40	1 profile	Weekly	2600	15 mos
d. Turbidity, D.O., pH, Salinity, Temperature	40	multiple depth	Weekly	5200	15 mos
e. Sediment Temperature, Eh	40	1 depth	Quarterly	200	15 mos
	20	1 depth	6 wks	200	15 mos

TABLE 5.0-1 (Cont)

Study Component	No. of Stations	No. of Rep.	Frequency	Total No. Samples	Study Period
II. Impingement and Entrainment					
A. Impingement	3	4	Weekly + 3 times	660	12 mos
B. Entrainment	15	3	Biweekly day/night	2880	15 mos
III. Fisheries					
A. Trawl	9	7	Monthly (night)	756	12 mos
B. Seines	4	2	Monthly	96	12 mos
C. Drop net	2	2	Monthly	48	12 mos
D. Creek trawls	4	7	Monthly (day)	336	12 mos
E. Crab traps	120	1	17 times	2040	4 mos
F. Crab impingement	1	1	17 times	17	4 mos
IV. Physical Studies					
A. Suspended loads	40	4 analyses	Biweekly	5120	15 mos
B. Bathymetry				1 survey	
C. Short-term	16	1		Variable	2 mos
D. Long-Term	51	1 or 2	Continuous	Variable	12 mos
E. Meteorology	1	1	Continuous	Variable	15 mos
F. Temperature profiles	Variable	2	Variable	Variable	2 mos

6.0 BENTHOS

The benthos component of the present study includes the following elements: water quality, sediments, benthic infauna, macrophytes, salt marsh, and oyster reefs. Each of these elements was sampled by unique methods and these methods, as well as results from each type of sampling, will be described separately in subsequent sections. For the biotic elements, impact assessment associated primarily with the station discharge will be addressed.

6.1 WATER QUALITY

6.1.1 Sampling and Laboratory Analysis

Water quality investigations during this study included both in situ and laboratory determinations performed weekly at 40 stations over a period of approximately 15 months, from June 9, 1983 to August 27, 1984. Station locations are shown in Figure 6.1-1. Sampling dates were selected to provide information for both high and low tide conditions.

Actual sampling times on each day were designed around two temporal windows. During a 90 minute interval centered on the predicted time of high or low tide, in situ temperature and conductivity data alone were collected at 27 selected stations (4-30). The second window was a 4 hour interval centered on local noon, during which measurements of water column depth, temperature, conductivity, pH, dissolved oxygen, and light penetration were made at all 40 stations. Salinities and corrected dissolved oxygen values were later calculated from these data.

Water samples for laboratory analysis were also collected from all stations during the 4 hours centered on local noon, the photometry window. Determinations of turbidity at the surface and bottom of each station were made weekly. Samples for chlorophyll analysis were collected at a randomly chosen eight of the 40 stations. On alternate weeks, surface and bottom samples were collected for suspended load analysis (total and volatile nonfilterable residue).

Station locations were typically identified by the use of onboard Loran C (Sitex Koden C787). Water column depths were recorded with either calibrated fathometers or with marked leadlines.

In situ measurements of temperature and conductivity were made with Beckman RS5-3 inductive salinometers. Surface and bottom measurements were made in depths less than 1 meter. For water column depths of 1-3 meters or less, surface, mid-depth, and bottom readings were taken. In depths greater than 3 meters, data were recorded from surface, one-quarter depth, mid-depth, three-quarters, and bottom. Calculations of salinity from these data were performed later using equations developed by Cox et al (1967), UNESCO (1966) oceanographic tables, and the salinity-conductivity relationships of Jaeger (1973).

Dissolved oxygen measurements were performed with YSI 57 dissolved oxygen meters and polarographic membrane electrodes. Measurement depths were surface and bottom for depths of 1 meter or less, and surface, mid-depth, and bottom for depths greater than 1 meter. These instruments were operated without the salinity correction function to minimize possibility of sampler error. Dissolved oxygen readings so obtained were later corrected for salinity and percent saturations were calculated using the polynomial relationship developed by Weiss (1970, cited in Riley and Skirrow 1975).

Measurements of pH were performed with Martek Mark VII multiparameter meters and/or an Orion 201 pH meter. Measurement frequencies were at the same depths as previously described for dissolved oxygen.

Quality assurance measures for these in situ parameters included: full bench calibration of meters before and after sampling; field calibration of salinometers and D.O. meters; a repetition of all water column measurements at one station out of ten; verification of the temperature function of the Beckman salinometers against thermometer readings or the temperature function of the Martek Mark VII meters; and collection of water samples at a rate of 1 for every 10 measurements for laboratory analysis of pH, dissolved oxygen, and conductivity. These water samples were preserved appropriately and the analytical values obtained were compared to the recorded field values.

Photometry measurements, quantification of solar radiation and extinction, were made in situ using LiCor integrating quantum radiometers. These instruments are sensitive in the photosynthetic spectrum of 400-700 nm and measurements were made in air, just below the water's surface, at secchi depth, and/or at bottom. The secchi depth and percent cloud cover were also recorded. The deck and submersible sensors for these instruments were calibrated by the manufacturer on an annual basis and checks of the mechanical zero were performed at the beginning of each sampling episode.

Surface water samples were collected from just below the surface as grab samples. Samples at depth were secured using a Niskin or Kemmerer type sampler. Samples for pH and conductivity analysis were maintained at ambient temperature, those for dissolved oxygen determinations were fixed with manganous sulfate and alkaline azide iodide solutions for later Winkler titrations. All remaining samples for turbidity, chlorophyll, and suspended load analyses were iced on collection and maintained either on ice or at 4°C until analysis.

Laboratory analyses were performed within the EPA recommended, parameter specific, holding times. Analytical methods employed were as follows:

Conductivity: Method 205, platinum electrode (APHA 1980).

Dissolved Oxygen: Method 360.2, azide modification of Winkler analysis, full bottle technique (EPA 1979).

pH: Method 150.1, electrometric (EPA 1979).

Turbidity: Method 180.1, nephelometric (EPA 1979).

Chlorophyll 'a': Method 1002G, spectrophotometric determination of chlorophyll 'a', corrected for pheophytin 'a' (APHA 1980).

Total and Volatile Nonfilterable Residue: Method 209D and 209G, total nonfilterable residue dried at 103-105°C and volatile nonfilterable residue ashed at 550°C (APHA 1980).

Water quality data were analyzed using the SAS GLM procedures. The specific analysis varied with the parameter, however weekly values, either individually or averaged over depth, were most often evaluated by quarter and station. Other variables used included tide, depth, occurrence of storms, and barge traffic. Where appropriate, variation based on other water quality parameters was considered. For example, turbidity values were analyzed for variation with quarter, station, depth, storms, barge traffic, total suspended solids, conductivity and chlorophyll a.

6.1.2 Results

Samplings were divided into five groups of thirteen episodes each. Months were divided as follows: Summer - Quarter I, June, July, August; Fall - Quarter II, September, October, November, first week of December; Winter - Quarter III, December remaining, January, February; Summer - Quarter IV, March, April, May; Quarter V, June, July, August. Tabular means of parameter values are presented in Appendix II for each quarter and for the project as a whole. It should be noted that project means (Quarters I-V) cannot be used as annual averages, as they are biased by the inclusion of two summer quarters.

Tables of quarterly values were generated from the entire data base for all parameters except pH, dissolved oxygen, turbidity, and total suspended load. These means were computed during analyses of variance as a function of four or more independent variables. Occasionally, when an independent variable was missing, the dependent variable was not included in either the statistical analysis or the calculated mean.

The historical water quality data bases for the study site consist primarily of temperature and salinity observations collected either in conjunction with biological community analyses (Grimes 1971; Applied Biology 1982) or for numerical model calibration and verification efforts (Klausewitz 1973). Efforts have been made to separate the thermal effects attributable to the power plant from those produced by seasonal and daily insolation (Carder 1974). Modeling efforts have centered on prediction of the areal extent of the thermal plume under a number of seasonal, tidal, and plant operation conditions and to accurately simulate interbasin flows forced by the dredged spoil islands and naturally occurring oyster reefs (Klausewitz 1979).

Dissolved oxygen and chlorophyll levels were frequently recorded during previous studies of macrophytes and of phytoplankton communities and productivity/respiration ratios (FPC 1975; FPC 1980).

Subsequent to the construction of the intake and discharge dikes and the redirection of Double Barrel Creek, mapping of bottom types indicated a highly depositional environment in the discharge vicinity and was attributed to the rapid erosion of new stream beds (FPC 1975; Cottrell 1974). With the concern over the effect of light attenuation and non-catastrophic siltation on attached macrophytes and sessile infauna, turbidity, extinction coefficients (secchi depths), and sedimentation rates were quantified (Cottrell 1978; Knight and Coggins 1982; CH2M Hill 1983).

The present study was designed to provide a detailed record of local water quality conditions in the area. Sources of turbidity and suspended load were to be identified as possible sources of light attenuation. The effect of storms and plant related activities (barge traffic) on these parameters was also to be investigated. Chlorophyll concentrations were to be used as a first approximation of the distribution of phytoplankton (for input to the turbidity analyses.)

Temperature

Temperature data and other water quality data presented below were subjected to analyses of variance (ANOVA) using a Generalized Linear Model (GLM) procedure. These statistical procedures are designed for unbalanced data with more than one treatment variable. Comparisons of quarterly and station means were made with Tukey's Studentized Range Test (honestly significant difference) and at a confidence level of 95% (alpha = 0.05). Results of the ANOVA's are provided in Appendix II.

Individual analyses of variance were performed on surface temperatures (ST), and bottom temperatures (BT) as a function of quarter, station, tide, station-tide interaction, and depth. If more than one observation was made at a station during a sampling episode, only that taken closest to the time of predicted slack water was selected for analysis. The models generated for both dependent parameters were highly significant.

For surface and bottom temperatures, both quarter and station terms accounted for a significant portion of the data variability. Seasonal dependence of all temperatures at the site were indicated. The contribution of the station term suggested a constant spatial distribution of temperatures once seasonal fluctuations had been removed. This areal pattern could be the result of the thermal influence of the discharge, insolation and warming of shallow water bodies, or any other relatively constant heat source or sink in the study area.

Seasonal changes in water temperature resulted in quarterly mean surface and bottom values (all stations combined) that were significantly different from one another. The two summer quarters were also significantly different, although the absolute value of the difference between the means was only 0.70 and 0.56°C for surface and bottom temperatures. Temperature plots during those seasons with the lowest and highest mean bottom temperatures are presented in Figures 6.1-2 and 6.1-3.

Station by station statistical comparisons of tidally averaged surface and bottom temperatures (Figures 6.1-4 and 6.1-5) were compiled and stations were grouped based on the pattern of significant differences with other stations. Stations are in order of decreasing temperature means as determined by the GLM with Level A stations having the highest overall temperatures, and presumably the most direct thermal impacts, Level B the next highest, etc.

The highest mean temperatures were recorded at Station 17, the station most proximate to the POD and most likely to be directly influenced by the thermal discharge. Station comparisons produced a core group of four additional stations (13, 18, 19, 29) which are not dissimilar from Station 17. These five stations comprised Level A for both surface and bottom temperatures.

Level B stations, the group with the next highest project temperature means, were comprised of slightly different stations for surface and bottom observations. In addition to Stations 14, 20-22, 28, and 30, Stations 23 and 27 were included for surface but not for bottom temperatures, while Stations 4 and 5, near the CFBC, were included for bottom but not for surface.

Level C stations were those significantly different from the three warmest (17, 18 and 19) and were comprised of Stations 5, 6, 7, 15, and 16 for surface temperatures, and 15, 23, and 27 for bottom values. Level D surface stations were 4, 8, 9, and 24; bottom stations were 6, 7, and 16. These divisions are illustrated in Figures 6.1-6 and 6.1-7).

For the ST model and the BT model, depth did not contribute significantly. As the depth term was applied last in the analysis, and as the station variable is not truly independent of the depth observed on station, it is possible that such phenomena as solar warming of shallow water masses were already evaluated by the station variation.

The results of the ANOVA imply that as the tide term was not significant, there was no consistent fluctuation of temperatures with tide over the study area as a whole. The station-tide interactive term also indicated no significant interaction or multiplicative effect between these two parameters once the variability due to station has been removed. However, despite the insignificant effect of tide in the GLM procedures, isotherms of high and low tide means for the duration of the project showed large differences in the areas enclosed by selected isotherms (Figures 6.1-8 and 6.1-9) and temperature differentials of up to 2°C were observed at several stations (22, 23, 29, 30). A more continuous deseasonalization based on maximum daily air temperature or isolation (Figure 6.1-10) or the inclusion of plant operations (Figure 6.1-11) in the statistical model might have prevented the masking of temperature fluctuation due to tidal stage. Unfortunately, gaps in the meteorological record decreased the utility of this data base and the fluctuations apparently produced by plant discharges appeared to be less than those due to seasonal climatic temperature changes.

As illustrated in Figures 6.1-8 and 6.1-9, during low tides the thermal plume turns SW and includes Station 29 in the stations classified as Level A. During high tides, a steeper thermal gradient was maintained in the immediate discharge area, and temperatures at stations to the north (4, 5, 13) were elevated. These observations were compatible with the modeling and short term results (see Section 10).

Concern has been voiced previously (Carder 1974) that a large portion of the acreage of the observed thermal plumes was an artifact of water flowing from the CFBC and entering the study area, particularly on an ebbing tide. This water would have been confined and subject to warming from solar radiation and the effect should have been most evident at Stations 4 and 5. This solar warming phenomena was not observed to be the most influential factor on bottom temperatures at Stations 4 and 5 of the present study, although freshwater inputs from the CFBC to the study area were apparent. During low tide samplings, when CFBC influence was highest (lowest salinities) and surface to bottom salinity gradients were most pronounced. Warmer, more saline water was found at the bottom of the water column. More pronounced temperature differences (bottom higher) were observed at high tides. This pattern was observed during all quarters of the study, including Quarters I and V when maximum insolation and warming of the less saline waters of the Canal was expected.

Radiation absorption and subsequent heat transfer to the water column by bottom sediments was apparently not a factor in producing this temperature gradient at Stations 4 and 5, as only approximately 2% of the subsurface light reached the bottom on the average. Stations of comparable depths, south of the intake, did not develop thermal inversions to this extent even though 25% of the subsurface light reached the bottom.

Surface temperatures did not show an obvious effect of heat input from the CFBC. Tidally averaged surface temperatures of Stations 4, 5, and 6 during the summer (Quarter I, maximum insolation) (Figure 6.1-12) were cooler than adjacent stations (1, 7, or 14) and were comparable to Stations 31 and 38, nearshore stations south of the intake and less subject to freshwater influences. Finally, mean surface temperatures observed during low tides at Stations 4 and 5, when salinity indicated maximum input from the CFBC, were again less than observations at high tide (Figures 6.1-13 and 6.1-14).

Thermal stratification was investigated by an ANOVA of DT, surface temperature minus bottom temperature, as a function of quarter, station, tide, station-tide, and depth. Again quarter and station were the most significant factors in accounting for the variation in observed data. For this model, however, the F value produced for the quarter term, while still significant, was two orders of magnitude less than for the models of ST and BT, indicating seasonal fluctuations are less statistically significant. The station-tide interactive term and depth (a function of station) also contributed significantly to the variations observed.

Mean vertical gradients of temperature were inverted (negative values of DT) in Basins 2 and 3. This previously observed (Grimes and Mountain 1971), phenomenon was attributed to the withdrawal of waters from approximately 5.5 km offshore (salinity 23-24 o/oo) and discharge into a nearshore, less saline environment. The warmed discharge, however, was still denser than the receiving waters, and higher temperatures were observed by the authors at the bottom of the water column until mixing produced a more homogenous water mass.

During the project, repetitive temperature measurements made on a single station visit differed by an average of $0.06^{\circ}C$ and the instrumental precision criterion that was generated allowed the detection of differing water masses when temperature differentials exceeded $0.22^{\circ}C$. Station means for the project showed thermal inversions of $0.22^{\circ}C$ or more at Stations 4, 5, 13, 14, and 20 over the course of the project. The maximum inverted gradient, $-0.68^{\circ}C$, was observed at Station 4. These stations were all considered Level A and B thermal stations for bottom waters. Salinities at Station 17 indicated that both surface and bottom waters were relatively uniform and highly saline. The station was also extremely shallow, and almost complete displacement of nearshore waters by the plume was assumed to have prevented any large thermal inversion from occurring. Salinities at Station 19 indicated that some mixing had occurred, again decreasing the thermal inversion.

Vertical temperature gradients were positive in Basins 4 and 5 with the maximum (0.68°C) observed at Station 23. Isotherms of DT were compressed in the vicinity of the oyster bars separating Basin 3 from Basin 5, indicating a zone of rapid change. The plume, approximately 4 km offshore, was in that area mixing with salinities comparable to its origin, although still several degrees warmer than the point of intake (Station 34). The resulting density gradient favored the warmer water on the surface. This result was most prominent during low water (Figure 6.1-15).

Salinity

Salinity patterns in the study area are complex, but are simplistically summarized as two freshwater inputs to an estuary, with a saline input (the plant discharge) situated between. Average flows of the Crystal River and the Withlacoochee River have been reported as approximately 785 and 1183 cfs, respectively (Applied Biology 1982). The flow in the CFBC has been reported to vary between 100 and 3980 cfs (Carder 1974). The plant discharge is approximately 2937 cfs.

The salinity data collected nearest the time of predicted tide during each sampling episode were subjected to GLM procedures. Surface and bottom salinity (SC and BC), as well as the salinity gradient present (DC, surface minus bottom values) were each analyzed as a function of quarter, station, tide, station-tide, and depth. All three salinity models generated were highly significant. Each independent term accounted for a significant portion of the data variability with the single exception of the depth term in the model of DC.

Seasonal salinity differences, a typical response to variable freshwater flows and tidal heights, were strong enough for most quarters to be significantly different from one another. Surface quarterly means were highest in fall, Quarter II (SC, 22.45 o/oo) and lowest in the spring, Quarter IV (17.27 o/oo). Mean bottom salinities ranged between 24.21 o/oo during the second summer (Quarter V, Figure 6.1-16) and 18.31 o/oo in the spring (Quarter IV, Figure 6.1-17).

The seasonal salinity variations observed had no close relationship to rainfalls recorded either at the Crystal River Power Station (incomplete data) or in the Crystal River/Inglis area (National Weather Service unofficial monthly totals, Figure 6.1-18). Flows from the Crystal River, a spring fed river with a low piezometric elevation, have been reported to vary inversely with seasonal tidal heights (Mann and Cherry, 1970). Maximum discharge from this system would then be expected to have occurred during January and February, during periods of lowest predicted tides. Minimum salinities in the study area, however, were observed in March, April, and May.

The variation in salinity during the spring, however, was more pronounced for inshore stations, arguing a variable terragenic source of fresh water. On April 12, 1984, and April 18, 1984, high turbidities were recorded simultaneously with low salinities and indicated either storm conditions (when strong winds may alter times and heights of actual tides from predicted) or pulses of runoff with high suspended solids. A more extensive compilation of watershed rainfall records, assessment of antecedent conditions and soil types, and flow and stage records of the freshwater inputs would be required to fully relate the salinities observed in the study area to precipitation and tides.

The significance of the station term in the salinity ANOVAs illustrated that, once seasonal variations were removed, a relatively constant gradient of salinities existed across the study area. This distribution across the study area was strongly affected by tidal stage, and a station-tide interactive term was significant for models of surface and bottom salinities.

The maximum tidal change was observed at Station 1 (near the Withlacoochee River), approximately 5-6 o/oo. Minimum tidal differences were observed in the region of the discharge canal at Stations 17, 18, and 19 (Figure 6.1-19).

A compilation of station to station statistical comparisons showed a much more continuous distribution of salinities than of temperature in the study area. Groups of similar stations based on the pattern of significant differences were therefore smaller, and as there are two freshwater inputs to this system, similar stations were not always contiguous, occasionally being divided by the intake and discharge spoil dikes.

Maxima of vertical salinity gradients, DC, were observed near the regions of freshwater input (Figure 6.1-20). Negative values represent less saline lenses of water overriding denser, more saline water. Station 17 exhibited the least amount of stratification during both high and low tide conditions. Based on salinity observations, both surface and bottom waters at this station were primarily comprised of discharge from the plant, the volume of saline water discharged by the plant (2937 cfs) apparently overshadowing any less saline flow from the nearby marshes.

Dissolved Oxygen

Two different selections of independent variables were used for ANOVA of the dissolved oxygen (DO) data base. Values from the surface (DO1) and bottom (DO3) of the water column and the percent of dissolved oxygen saturation relative to equilibrium conditions at surface and bottom (DSS and DSB) were all treated separately. The first model type included quarter, station, temperature and chlorophyll concentrations as independent variables. The relatively small number of chlorophyll data points limited the amount of DO data subject to this treatment. Chlorophyll concentrations were found not to account for any significant variability in DO or percent saturation data. GLM procedures were repeated after elimination of the chlorophyll variable. The quarter, station and temperature and salinity terms all accounted for highly significant portions of the variation in the dissolved oxygen data.

Seasonal variations in DO were related to those produced by temperatures. The temperature dependence was to be expected from the thermodynamic laws governing the solubility of all gases in water and the inverse relationship of absolute concentrations to temperature. Solubilities at equilibrium conditions are also inversely related to salinity. Station related variables affecting DO concentrations in addition to those addressed by the GLM could have been the presence of productive submerged grass beds or algal mats, or unvegetated bottom types exerting a benthic oxygen demand. Seasons with minimum and maximum DO means are illustrated in Figures 6.1-21 and 6.1-22.

Spatial patterns of dissolved oxygen were mixed for surface and bottom waters. Station 17, as may have been expected from the elevated temperature observed, had the lowest mean surface DO, 6.7 mg/l. That value was not significantly different from those at stations in Basin 3 and the southern half of Basin 2. These stations were all within Levels A and B of the thermal impact stations.

Due to the number of stations that typically experienced salinity stratifications, dissolved oxygen levels were expected to be less at the bottom of the water column. In addition, this gradient would be exacerbated wherever thermal inversions occurred. Those stations with low bottom DO concentrations, however, were not exclusively the Level A or B thermal stations. Three stations in Basin 4 (7, 8 and 15) had low bottom DO values. Total organic carbon, percent silt clay and free sulfide levels in sediments at these stations imply a depositional environment with low water velocities and a potentially high benthic oxygen demand.

Macrophyte aerial surveys confirmed that Level A and B Thermal Stations that did not have low DO3 concentrations all had seagrass and algae accumulations. Station 38, with highest mean DO levels, was also heavily vegetated.

Models of percent saturation of DO, using the same variables of quarter, station, temperature and salinity, were also highly significant. All independent variables removed a significant portion of the sum of the squares with the exception of salinity for surface values. The difference between surface and bottom saturations was greatest and the overall percent of saturation at bottom was the least (91 percent) during the two summer quarters. This is consistent with elevated benthic demands during warmer weather. Surface waters were closer to equilibrium for all quarters.

The spatial patterns of percent saturation of DO also indicated contributing factors other than equilibrium solubilities as a function of temperature and salinity. The highest percent saturation, 100 and 103 percent for surface and bottom, was recorded at Station 38, where concentrations of seagrasses were observed. The lowest saturations were observed on the bottom at Stations 3-9, 14 and 15, in general those stations immediately south of the CFBC spoil islands and at the northern edge of the influence of the thermal plume (Figure 6.1-23). Absolute DO concentrations, however, were little different from the discharge. Saturation deficits were produced by the decrease in temperature between the discharge and these stations, or sediments producing an increase in theoretical solubility of DO with no change in the absolute concentration. The thermal and salinity stratification also observed would reduce the reaeration rates of bottom waters.

pH

Changes in temperature will affect the distribution of carbon dioxide among its various species. With a constant total carbon dioxide concentration, pH will fall with increasing temperature. Biological respiration and photosynthesis that deplete the total concentration of carbon dioxide present will also elevate pH values to daily maxima in late afternoon after periods of high productivity. Seasonal trends in pH are generally apparent in open oceans. Lowest carbon dioxide and highest pH values are observed in warmer months when productivity is high. This pattern is complicated nearshore by local weather conditions. The wet season in Florida typically occurs during the warmer months, and acidic runoff (low pH) is greatest when pH values are expected to be at a maximum.

Initial statistical analyses of pH data from Crystal Bay found chlorophyll to account for an insignificant portion of the variability in pH values. The ANOVA's were subsequently repeated after eliminating chlorophyll. Models generated were highly significant for surface (PH1) and bottom (PH3) values. The quarter, station, and temperature contributions to the model were all significant, and salinity was significant for PH3 but not for PH1.

Over all stations, the highest pH values were recorded during Quarter I, the first summer quarter (Figure 6.1-24). Lowest pH values occurred in the fall rather than during the spring quarter when runoff was most apparent and low pH values would be expected.

Based on the pattern of differences, two groups of stations were identified, one with low values over the course of the project, the other with high values. Those stations with low values included nearshore stations north of the discharge dike, both thermal (Stations 13, 14, and 17) as well as those most affected by the CFBC and the Withlacoochee River (Stations 1, 2, 4-7). Stations with elevated pH values were those nearshore in both thermal and nonthermal areas (Stations 27-34, 38, and 39). Although both temperature and salinity contribute to observed pH variations, the controlling influence on pH values appears to be a biological system other than phytoplankton that affects the carbonate - bicarbonate - carbon dioxide equilibria.

Photometry

Extinction coefficients were computed from submersible photometer readings using the equation:

$$K = (\ln (Iz / Io)) / - Z$$

where K = extinction coefficient in ft^{-1}

Io = light below the water surface

Iz = light at depth

Z = depth in feet

Measurements made at secchi depth (12 inch diameter) and surface were used to calculate a KS, and at bottom and surface to calculate a KB. When secchi depths were greater than the water column depth, no KS was calculated. Analyses of variance with independent variables of quarter, storm (quarter), station, depth, and turbidity were performed. All input variables were found to be highly significant.

Seasonal growth patterns of phytoplankton are possibly responsible for the significance of the quarter term in the models generated. The mean KS and KB of all stations during Quarter III was the lowest of any of the five quarters sampled (highest clarity waters). This coincides with temperature and chlorophyll concentration minima.

The storms were identified from the intermittent meteorological data and defined as four consecutive days with wind velocities averaging over 7 mph. The shallow waters of Crystal Bay made resuspension of unconsolidated sediments and erosion of the numerous spoil islands extremely likely during periods of prolonged high winds and resultant wave action. Depth of the water column also controlled the amount of resuspension generated by any given wave height. Since only 5 storms were identified, no attempt was made to weight storms for wind direction, velocity and variability.

The amount of light scattered or absorbed by suspended and dissolved materials in the water column (turbidity) will directly decrease the amount of light reaching a given depth. Turbidity accounted for a highly significant amount of the variability of KB and KS, and the distribution of extinction coefficients matched closely with turbidity isopleths.

The significance of the station term indicated that a consistent spatial pattern of light extinction existed. The highest mean values of KB, and therefore, the waters of lowest clarity, were observed at Stations 1, 2, 4, 5, 6, 7, and 8, those stations nearest the CFBC and the Withlacoochee River (Figure 6.1-25). Lowest coefficients were measured at the offshore stations and south of the intake dike.

The Crystal River, with groundwater as its primary source, had much lower color values than a "blackwater" river such as the Withlacoochee (MML, unpublished data) in addition to much lower flows. Suspended load data from the two rivers were quite comparable. The absorption of light by dissolved organics (humic acids), marsh export detritus, or erosional material from the CFBC spoil islands was believed primarily responsible for the differences in KB.

Differences between KS and KB values were examined to determine if salinity or thermal stratification decreased penetrant light. No consistent pattern was observed in quarterly station means for those stations closest to thermal or freshwater sources.

Quarter I, the quarter with the highest mean value of KB, was further analyzed by back calculating from KB the depths to which 10, 5, and 1 percent of the incident light would penetrate (Table 6.1-1). These depths were then compared to the mean depths recorded on station during that quarter. (Summer tides were among the highest predicted and water column depths and extinction coefficients during this quarter represent a worst case situation.) During Quarter I, quite a number of stations had average water column depths in excess of Z(10 percent), the depth at which all but 10 percent of the incident light has been absorbed. None, however, had depths which exceeded Z(1 percent). The average percent of surface radiation that reached the bottom is illustrated in Figure 6.1-26.

Turbidity

Initial GLM procedures on both surface and bottom turbidity data bases produced highly significant models using quarter, storm (quarter), station, depth, salinity, total suspended load, and chlorophyll as independent variables. The rationale for including many of these parameters was entirely analogous to their selection for the analysis of extinction coefficients and storm dates utilized were the same. Suspended loads should influence turbidity values directly and high chlorophyll concentrations would indicate a phytoplankton population that would also produce considerable light scattering and absorption.

Chlorophyll accounted for a significant portion of the variability in turbidity data but its inclusion in the model limited the number of turbidity values analyzed. For this reason, GLM procedures were repeated after replacing chlorophyll with temperature as an independent variable. Waters of extreme temperatures, either high or low, might be expected to have decreased biomass concentrations, and therefore lower turbidities.

The second set of models for turbidity were also highly significant. Temperature (other than that contained in the quarter variable) did not account for a significant portion of the variation in either model. Suspended load accounted for the greatest portion of the variation in the model. As expected, bottom turbidity values were higher overall than surface values, and more variability was observed at the bottom for a given station.

Highest surface and bottom turbidities were observed during the spring, Quarter IV, the period of lowest salinity and highest surface suspended loads. Over half of the stations both north and south of the intake spoil had maxima during this quarter. This quarter marked the resumption of rains after the dry season, and pulses of turbidity were observed coincident with salinity minima.

The storm (quarter) variable was highly significant. Station means for the quarter (with storm events removed) were calculated and subtracted from surface turbidities collected during storms. The increase in turbidity attributable to storm conditions is illustrated for the two most severe storms (Figures 6.1-27 and 6.1-28). Individual stations and the degree to which they were affected were obviously products of wind direction and strength. The small data base for storm conditions and the partial nature of the meteorological data, however, prevented a quantitative assessment of these contributions.

In general, surface turbidity distributions were inversely related to salinity isopleths for the discharges from the CFBC and the Withlacoochee River, decreasing with increasing salinity (Figure 6.1-29). Stations with the highest observed surface turbidities were 1, 4, 5, 6, and 8. A secondary group included 7, 9, and 17. Turbidity at these stations is most likely the result of precipitation of humic substances, export of salt marsh detritus, and erosion of CFBC spoil islands.

Stations lowest in surface turbidity included most of those south of the intake spoil. These were sheltered from the severest northerly winds and salinities were presumably controlled by the low humic waters of Crystal River. The marshes adjacent to Station 31 also appeared to have lower tidal exchange volumes and lower flows with less scouring. Finer grained material within the marsh itself and accumulated algal detritus also indicated more of a depositional environment than the area near Station 17. Less material appears to be exported from this southern marsh and sediment loads in the adjacent basins are correspondingly less (Cottrell 1974).

Suspended Solids

Suspended load analyses also included GLM procedures. Models were produced for surface and bottom total suspended load data as a function of quarter, storm (quarter), station, turbidity, temperature, and salinity. Storm dates were the same as those described in the analyses of extinction coefficients and turbidity.

Models generated were highly significant. ANOVA summaries indicated that turbidity values could account for a majority of the variation in the data. Quarter, storm (quarter), station and turbidity terms were all highly significant for both data sets. Salinity was only significant for surface turbidities. Temperature (beyond the effects accounted for by the quarter and station terms) was insignificant in accounting for suspended load data variation.

The spring quarter had the highest overall surface suspended load recorded. The lowest concentrations were recorded during the winter, Quarter III. This pattern, while compatible with the rainfall and salinity trends discussed earlier is much less clear cut than for turbidity. Bottom loadings were again more variable than surface and seasonal trends were slightly different from surface values. The lowest values recorded for turbidity and extinction coefficients were also during Quarter III. The effect of storms on suspended load was comparable to the effects on turbidity and the individual stations most affected were again dependent on wind strength and direction.

Similar to turbidity distributions, stations with highest overall values of total suspended load were concentrated along the southern side of the CFBC (Figure 6.1-30). Surface loads at Stations 1 and 6-9 were not significantly different from Station 5, which had the highest load over the course of the project. Those stations with the lowest observed surface values are those south of the intake dike and nearshore (Stations 31-33, 48-40) as well as Station 28.

Due to the variability of bottom TSS data, station to station comparisons produced fewer significant differences despite the wide spread in mean suspended load. Highest values were again observed at stations near the CFBC (1, 3-6, 8-10, and 15) and ranged from 29 to 17 mg/l. Those stations with the lowest suspended loads included stations south of the intake (35, 39, 40), offshore (24, 26), and some Level A and B thermal stations (27, 28, 29).

Volatile suspended solids were also analyzed by the GLM procedure. Independent variables of quarter, station, and chlorophyll were applied to surface and bottom data sets. The models produced were highly significant. Quarter and chlorophyll variables accounted for significant portions of data variability. The station term was significant for bottom values but not for surface.

Seasonal distributions of volatile suspended load were comparable to the trends shown by overall chlorophyll data. The lowest levels of suspended volatiles were recorded during the winter, Quarter III. This period coincided with the lowest quarterly means for turbidity, total suspended solids, and extinction coefficients.

Data variability permitted few significant differences to be observed between stations. Station 8 contained the highest average volatile solids (7 mg/l) for the project. This station also appeared to be a depositional area, as not only volatile but also total suspended solids were high here. Percent silt/clay, total organic carbon, and sulfide concentrations in the sediments at this station were among the highest of those observed in the study area, and the mean grain size was one of the smallest. Stations with volatile suspended loads not significantly different from 8 included those immediately south of the CFBC spoil islands and Level A and B thermal stations (13, 17, 20, 21, and 29). Values at Stations 3 and 33 were also high.

Barge Traffic

The effects of barge traffic on suspended load and turbidity were also investigated through GLM analyses. Surface and bottom data sets from Stations 17, 34, 35, 36, and 37 were selected as being those most likely to show any increases as a result of sediment resuspension. Station 17 was included as it receives the most direct exposure to waters that have passed through the plant condensor. Independent variables included quarter, storm (quarter), station, and barge (quarter-station). The degree of barge influence at these stations was selected based on the length of time since traffic had passed or, in the case of 17, the length of time in which a disturbed water mass could be expected to reach that station.

The models produced for surface and bottom turbidities were both highly significant. The quarter term accounted for most of the data variability in both models, and storm (quarter) was significant for the surface turbidities. No other variables were significant. Barge effects were either not apparent at the selected stations during the times sampled or were overridden by those due to wind or wave action. Other obscuring factors may be the transient nature of any disturbance. Velocities in the intake canal would act to rapidly disperse any elevated turbidities.

The model for bottom suspended load data was not significant. In that produced for the surface values, however, again only quarter and storm (quarter) accounted for any significant amount of variability. Barge influences were not apparent.

Chlorophyll

Surface and mid-depth chlorophyll concentrations were analyzed as a single data base by the GLM procedure, using quarter, station, extinction coefficient (KS), secchi depth, salinity, temperature, and volatile suspended solids as independent variables. Of these only temperature and salinity were insignificant and quarter, station, and KS were highly significant.

Highest overall chlorophyll levels were recorded during the second summer. Winter, Quarter III, levels were lowest. This is compatible with the expected seasonal growth patterns of phytoplankton and cold weather reductions in photosynthetic activity.

Station by station comparisons show few differences and data variability for some stations is quite large compared to stations with comparable means. Those stations with the highest levels are generally centered around the CFBC and the Withlacoochee River entrances to the study area (Stations 1, 3, 4, 5, 8, 9, and 15) (Figure 6.3-31). Lowest levels were observed at offshore and southerly stations.

As chlorophyll samples were collected from eight randomly selected stations per week and volatile suspended solids were only collected every other week, the data base for this statistical analysis was limited. The conjunction of these parameters was met for some stations only once during the entire project. When all weekly chlorophyll data was combined without regard to sampling depth, the seasonal and spatial patterns discussed above were confirmed.

6.1.3 Discussion

Water quality stations in the study area were statistically divided into five groups: four of decreasing thermal influence and those unaffected. The groupings were slightly different for surface and bottom waters, more stations being included for the affected surface waters. Stations 13, 17, 18, 19 and 29 in Basins 1, 2 and 3 were those most directly affected by thermal discharge. Little input of heat was observed from either the Cross Florida Barge Canal or the Withlacoochee River. The distribution of the thermal plume, as determined by station mean water temperatures, agreed well with that predicted by the numerical models.

Spatial salinity patterns were complex as the Crystal River, the Withlacoochee River and CFBC, and the plant (discharging offshore water nearshore) all act as inputs to the study area. Seasonal salinity trends were present but were not directly related to rainfall recorded either at the power plant or in the Crystal River/Inglis area. Minimum salinities were recorded during the spring quarter.

Dissolved oxygen levels were strongly and inversely related to temperature; summer minima and winter maxima were recorded. Percent saturation of dissolved oxygen was also lowest during the summer. The station with the lowest mean oxygen level was that with the highest mean temperature. Distribution of macrophytes affected both dissolved oxygen and percent saturation levels, and appeared to be one of the controlling variables in accounting for pH distributions. Chlorophyll levels displayed seasonal trends (winter minima) but did not control either DO or pH values.

Water clarity was most reduced at stations near the CFBC. High extinction coefficients were apparently the product of dissolved humics and particulate matter exported from the Withlacoochee River, the CFBC, and adjacent salt marshes. Erosion of the spoil islands is also indicated. These same factors also influenced the distributions of turbidity and total and volatile suspended loads. Waters of highest clarity were south of the intake spoil and offshore. Light was apparently not a limiting factor at those stations most affected by the thermal discharge.

Storms produced elevated values of extinction coefficients, turbidity, and suspended load. The stations and the degree to which each was affected were the product of wind directions and strengths. Wave and current resuspension of sediments also apparently contribute. The effect of barge traffic on these paramters was not apparent.

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Table 6.1-1 Penetrant Light. Extinction coefficients KS, KB (ft^{-1}); station depths, D (ft); depth to which 1%, 5%, 10% of surface radiation penetrates, Z(1), Z(5), Z(10) (ft); percent surface radiation at bottom, %Io @ B (%).

Station	KS (ft^{-1})	KB (ft^{-1})	D (ft)	Z(1) (ft)	Z(5) (ft)	Z(10) (ft)	%Io @ B
1	0.54	0.53	2.6	8.7	5.7	4.3	25.2
2	0.49	0.48	4.0	9.6	6.2	4.8	14.7
3	0.40	0.42	7.5	11.0	7.1*	5.5*	4.2
4	0.51	0.63	5.8	7.3	4.8*	3.7*	2.6
5	0.47	0.76	5.1	6.1	3.9*	3.0*	2.1
6	0.53	0.54	5.0	8.5	5.5	4.3*	6.7
7	0.60	0.59	5.3	7.8	5.1*	3.9*	4.4
8	0.42	0.55	6.7	8.4	5.4*	4.2*	4.3
9	0.47	0.45	7.5	10.2	6.7*	5.1*	3.4
10	0.38	0.37	9.1	12.5	8.1*	6.2*	3.5
11	0.31	0.29	9.4	15.9	10.3	7.9*	6.5
12	0.23	0.20	14.4	23.0	15.0	11.5*	5.6
13	0.35	0.46	3.0	10.0	6.5	5.0	25.2
14	0.48	0.42	5.1	11.0	7.1	5.5	11.7
15	0.48	0.45	6.3	10.2	6.7	5.1*	5.9
16	0.37	0.39	7.2	11.8	7.7	5.9*	6.0
17	0.50	0.54	2.4	8.5	5.5	4.3	27.4
18	0.42	0.41	5.8	11.2	7.3	5.6*	9.3
19	0.45	0.41	4.8	11.2	7.3	5.6	14.0
20	0.36	0.41	7.4	11.2	7.3*	5.6*	4.8
21	0.43	0.43	8.5	10.7	7.0*	5.4*	2.6
22	0.45	0.39	8.4	11.8	7.7*	5.9*	3.8
23	0.39	0.34	10.6	13.5	8.8*	6.8*	2.7
24	0.29	0.29	9.8	15.9	10.3	7.9*	5.8
25	0.27	0.23	12.1	20.0	13.0	10.0*	6.2
26	0.24	0.23	14.4	20.0	13.0	10.0*	3.6
27	0.43	0.43	4.9	10.7	7.0	5.4	12.2
28	0.43	0.44	6.8	10.5	6.8	5.2*	5.0
29	0.36	0.36	6.2	12.8	8.3	6.4	10.7
30	0.41	0.40	6.4	11.5	7.5	5.8*	7.7
31	0.45	0.31	4.9	14.9	9.7	7.4	21.9
32	0.33	0.30	4.4	15.4	10.0	7.7	26.7
33	0.40	0.31	7.1	14.9	9.7	7.4	11.1
34	0.33	0.26	8.8	17.7	11.5	8.9	10.1
35	0.25	0.25	7.5	18.4	12.0	9.2	15.3
36	0.27	0.23	11.5	20.0	13.0	10.0*	7.1
37	0.21	0.25	13.3	18.4	12.0*	9.2*	3.6
38	0.26	0.34	4.0	13.5	8.8	6.8	25.7
39	0.27	0.27	7.4	17.1	11.1	8.5	13.6
40	0.22	0.20	13.3	23.0	15.0	11.5	7.0

*Calculated depth exceeded water column depth.

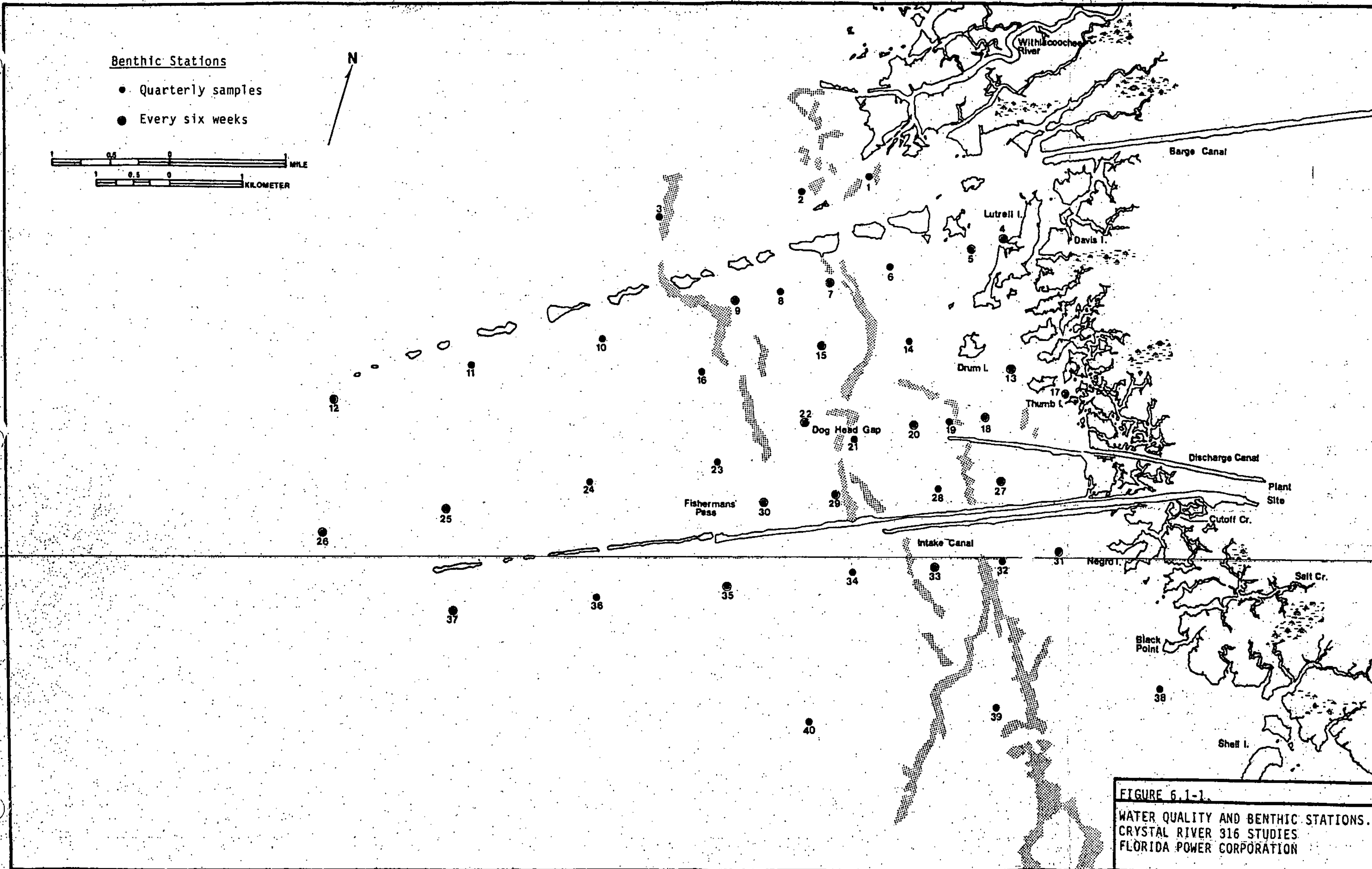

FIGURE 6.1-1.

WATER QUALITY AND BENTHIC STATIONS.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

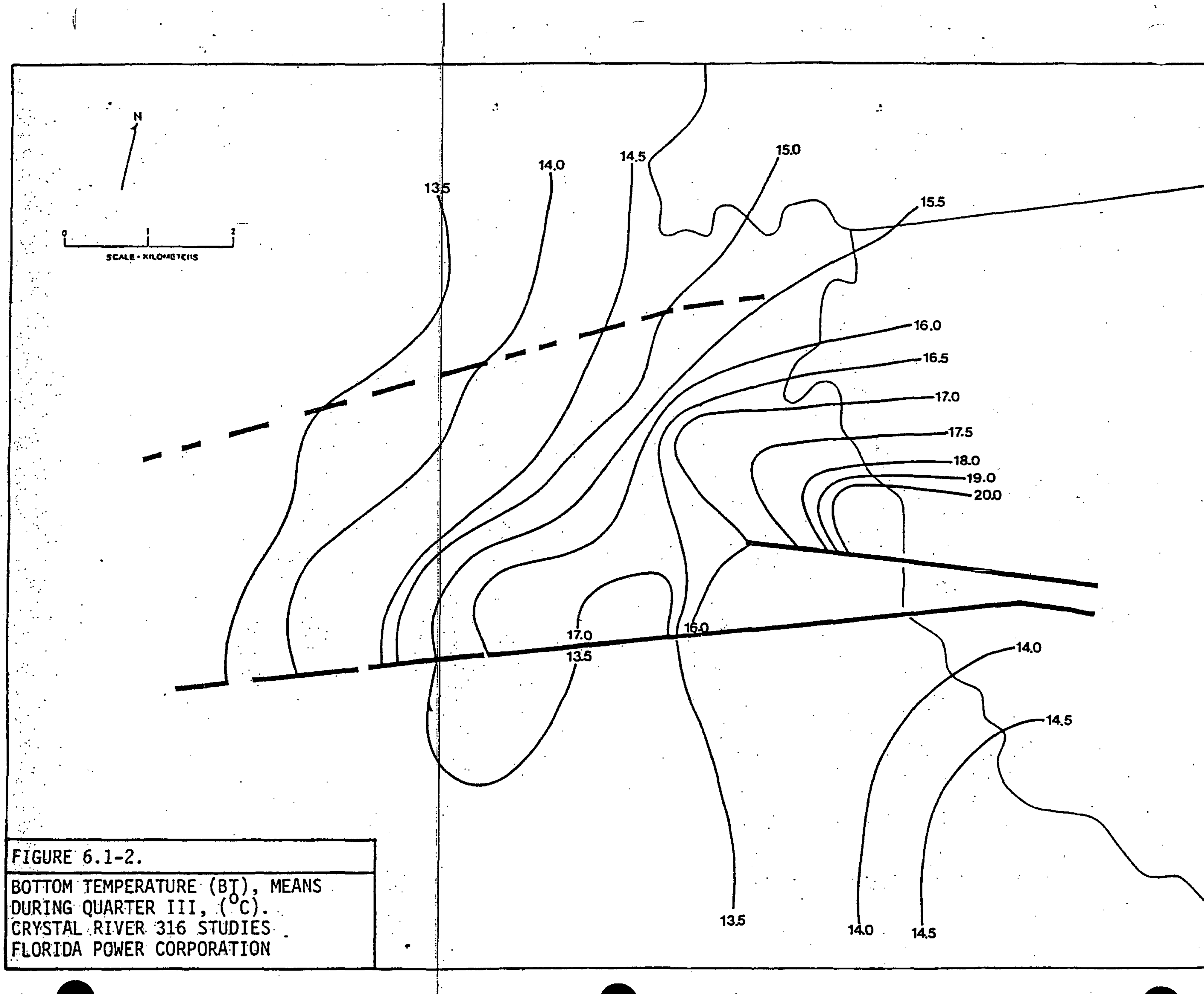

FIGURE 6.1-2.

BOTTOM TEMPERATURE (BT), MEANS DURING QUARTER III, (°C).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

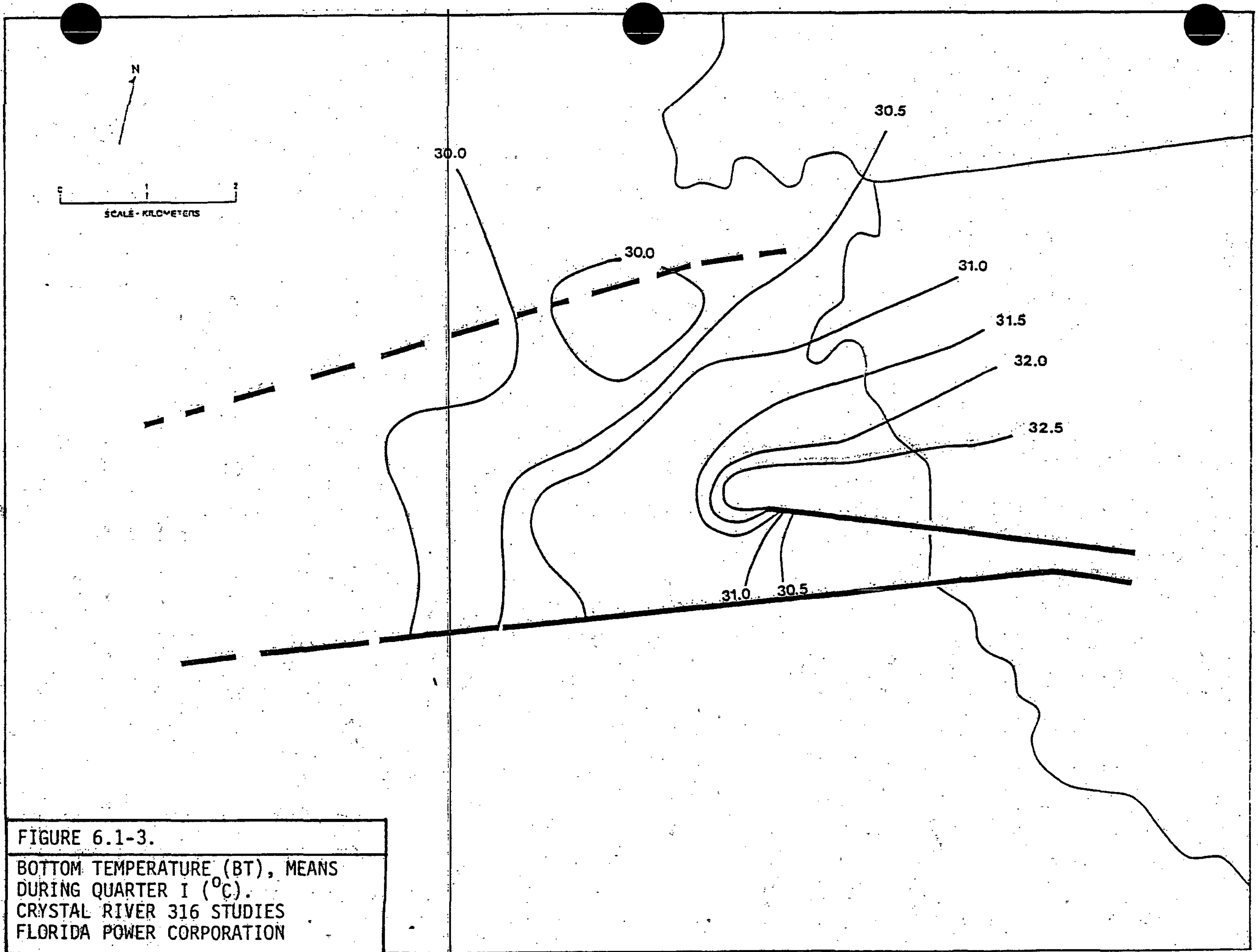

FIGURE 6.1-3.

BOTTOM TEMPERATURE (BT), MEANS DURING QUARTER I (^oC).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

36	37	40	35	31	39	34	32	33	3	26	12	25	38	2	11	10	1	24	8	9	4	6	5	7	15	16	27	14	23	28	22	21	20	30	13	29	18	19	17		
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	17	LEVEL A
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	19	
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	18	
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	
*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	30	LEVEL B
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	20	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	21	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	22	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	28	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	23	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	14	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	27	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	16	LEVEL C
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	15	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	7	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	5	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	6	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	4	LEVEL D
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	9	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	8	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	24	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	1	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	10	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	11	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	2	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	38	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	25	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	12	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	26	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	3	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	33	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	32	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	34	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	39	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	31	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	35	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	40	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	37	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	36	

FIGURE 6.1-4.

SURFACE TEMP. RESULTS OF TUKEY'S TESTS BETWEEN STA. MEANS (* = SIGNIFICANT DIFFERENCES).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

	37	40	36	35	34	39	26	31	33	32	12	25	3	11	10	24	2	38	9	1	8	7	16	6	15	27	23	4	5	22	30	28	21	14	20	29	13	19	18	17	
17	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	LEVEL A
18	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	
19	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	
13	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
29	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
20	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	LEVEL B
14	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	
21	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	LEVEL C
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	LEVEL D
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	

FIGURE 6.1-5.

BOTTOM TEMP. RESULTS OF TUKEY'S TESTS BETWEEN STA. MEANS (* = SIGNIFICANT DIFFERENCES).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

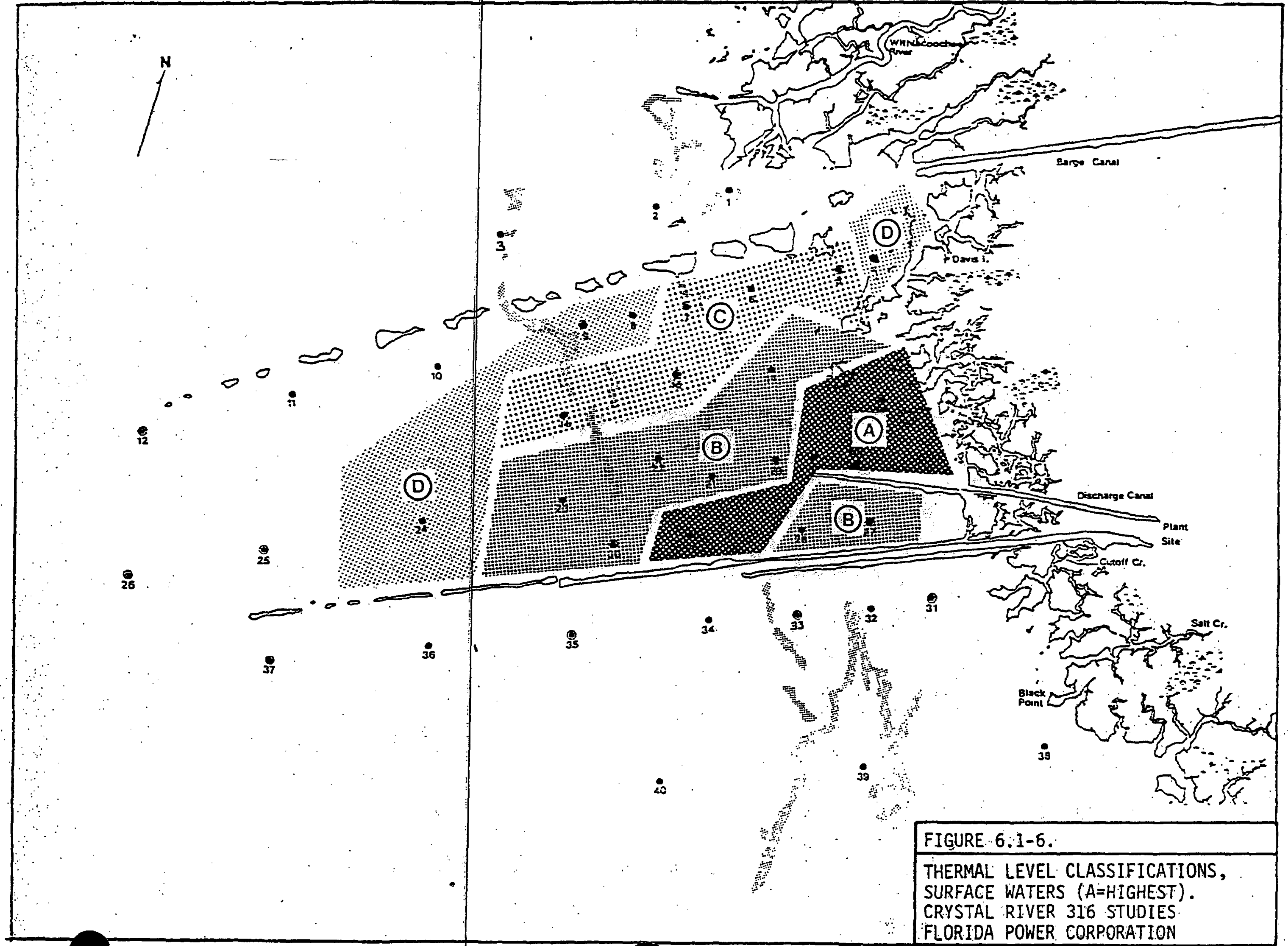

FIGURE 6.1-6.

THERMAL LEVEL CLASSIFICATIONS, SURFACE WATERS (A=HIGHEST). CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION

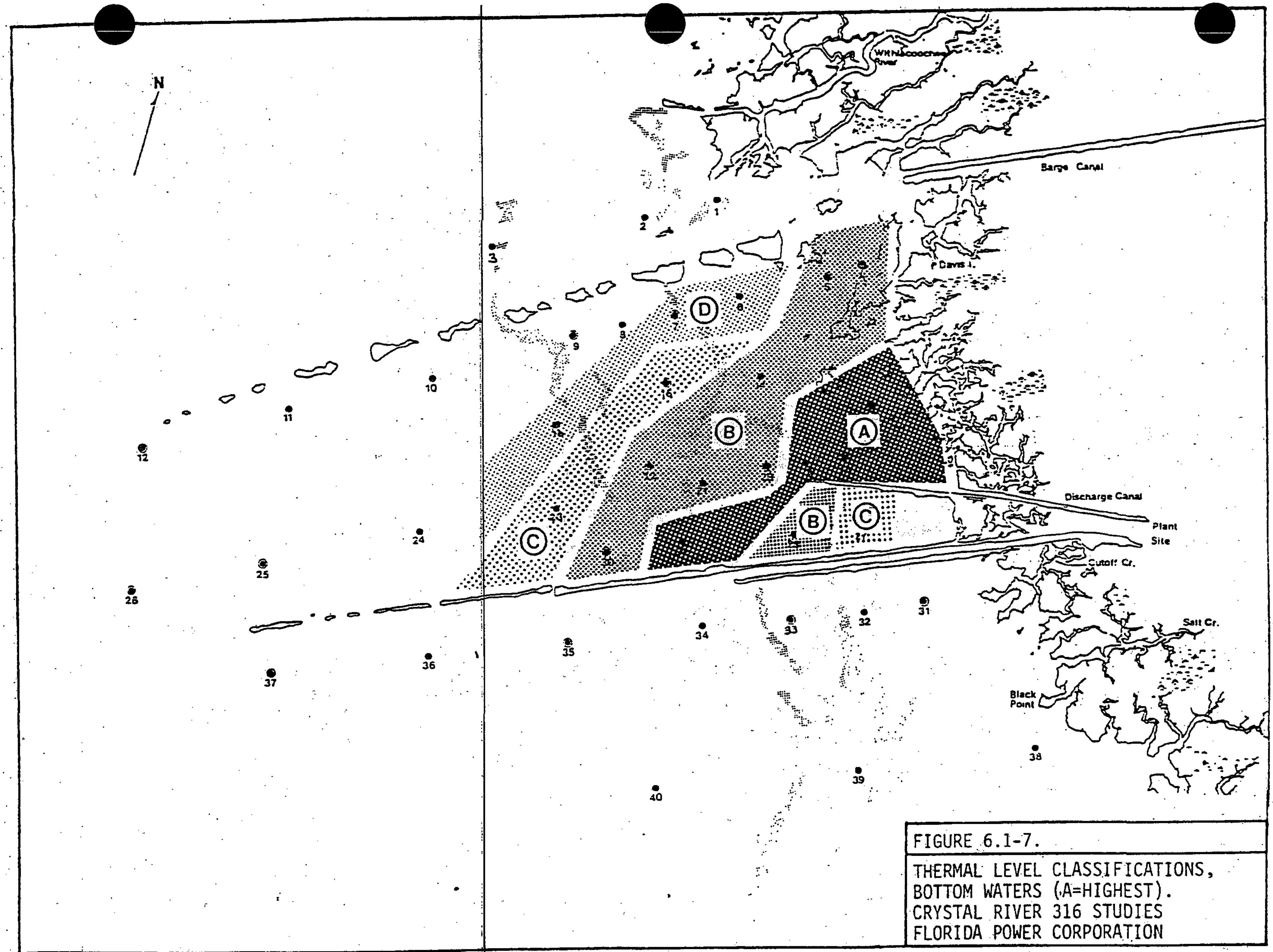

FIGURE 6.1-7.

THERMAL LEVEL CLASSIFICATIONS,
BOTTOM WATERS (A=HIGHEST).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

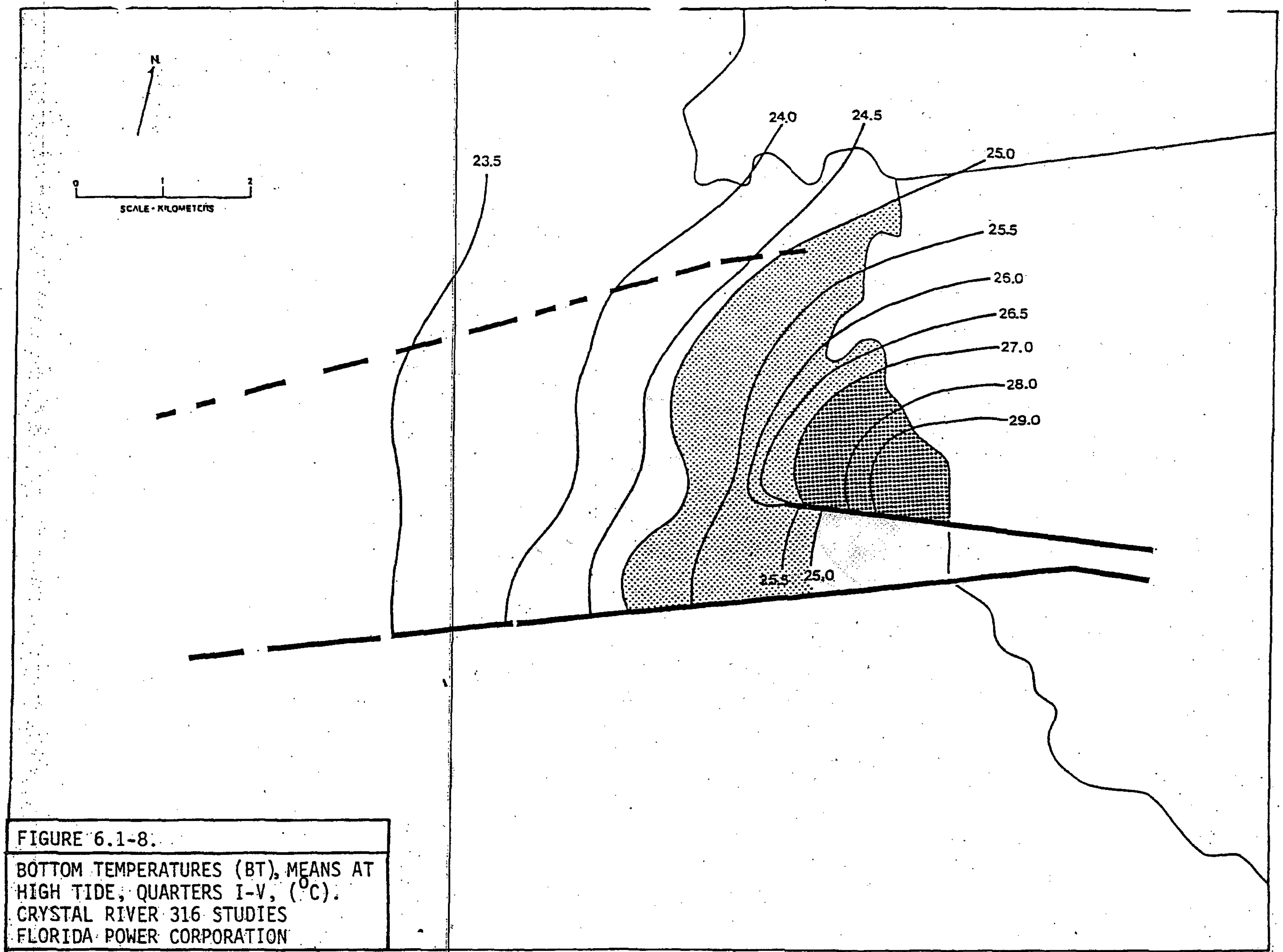

FIGURE 6.1-8.

BOTTOM TEMPERATURES (BT), MEANS AT HIGH TIDE, QUARTERS I-V, (°C).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

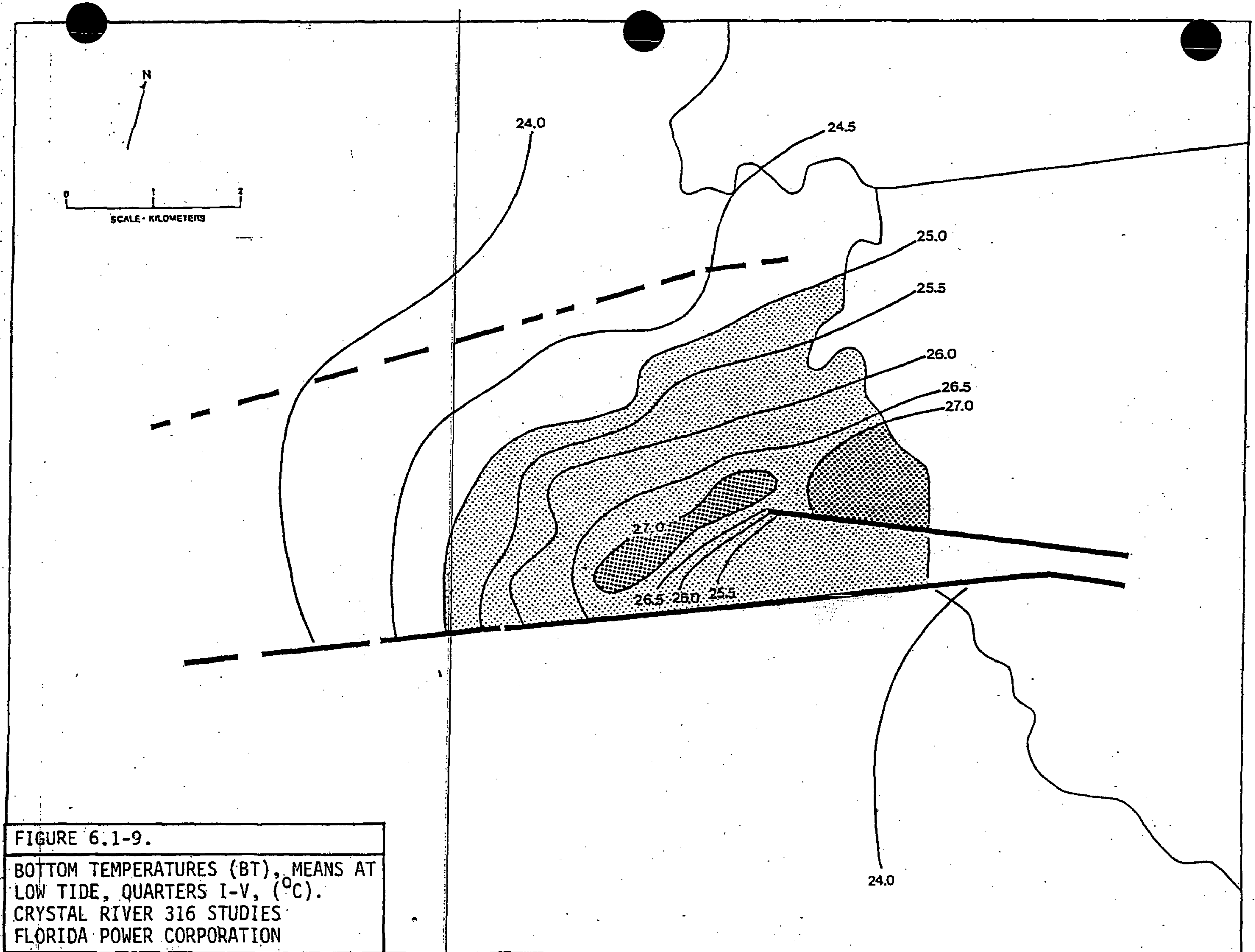

FIGURE 6.1-9.

BOTTOM TEMPERATURES (BT), MEANS AT LOW TIDE, QUARTERS I-V, (^{O}C).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

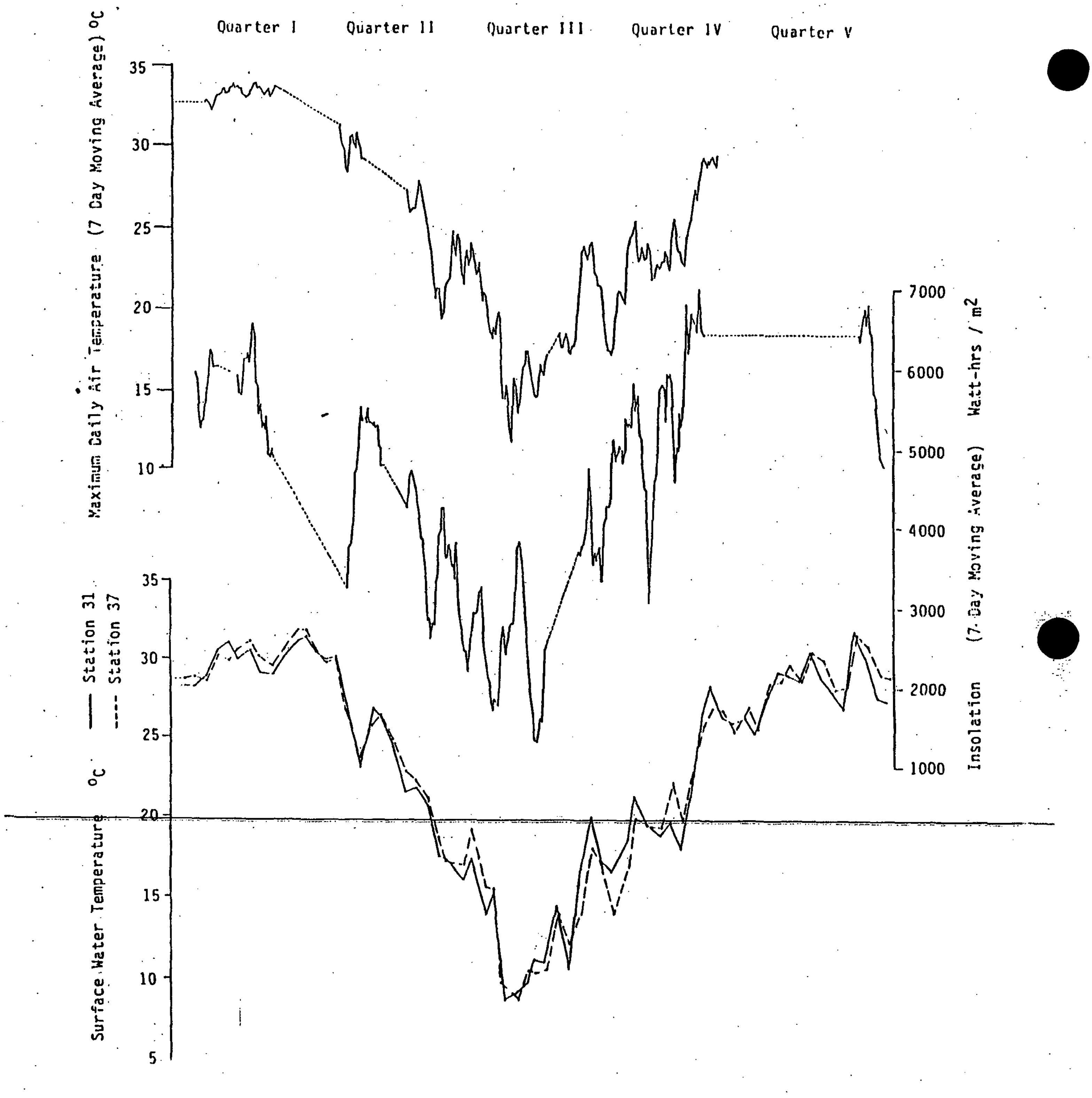

FIGURE 6.1-10.

MAXIMUM DAILY AIR TEMP. INSOLATION
SURFACE WATER TEMPERATURE.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

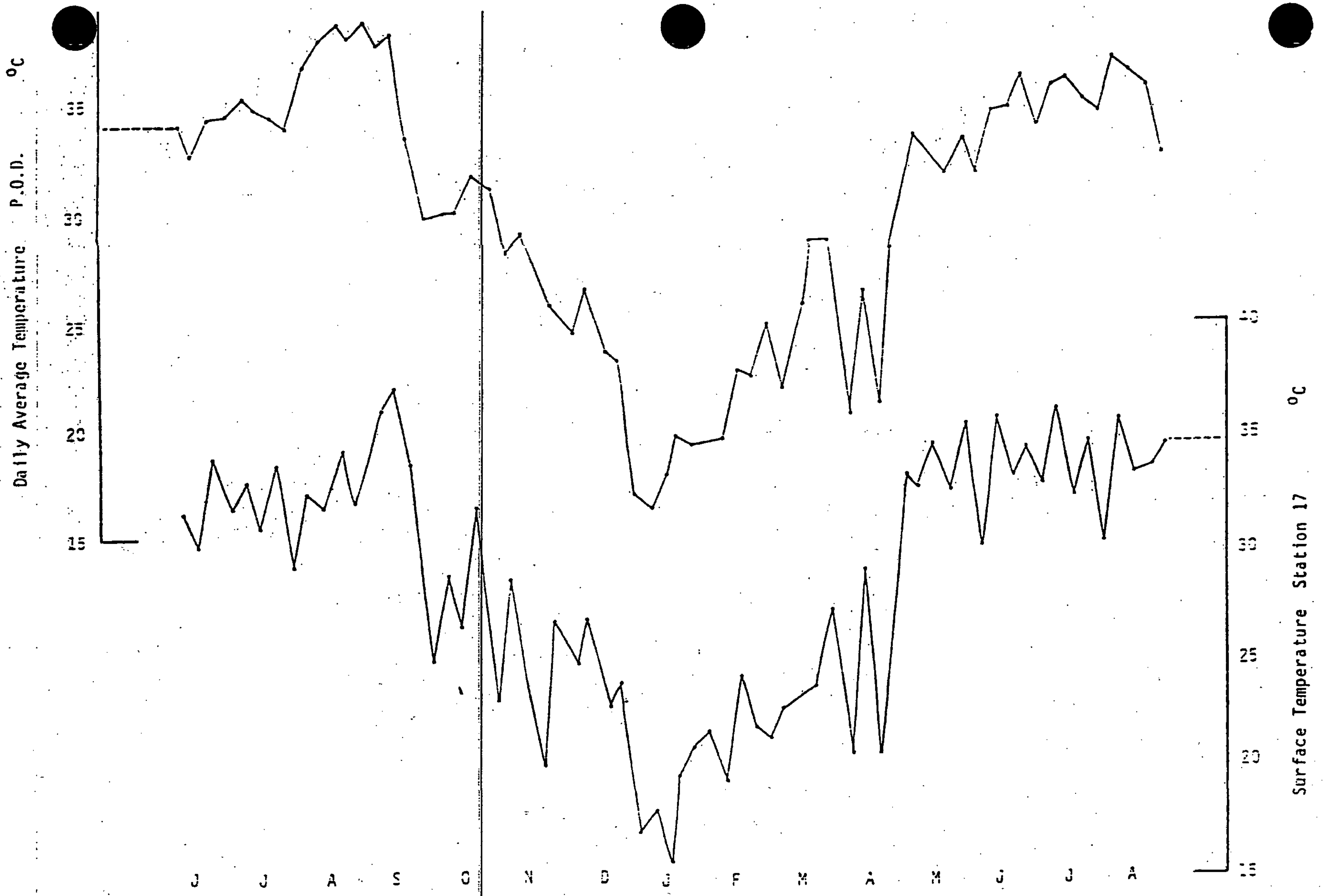

FIGURE 6.1-11.

TEMPERATURES AT P.O.D. AND
STATION 17, SURFACE, (°C).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

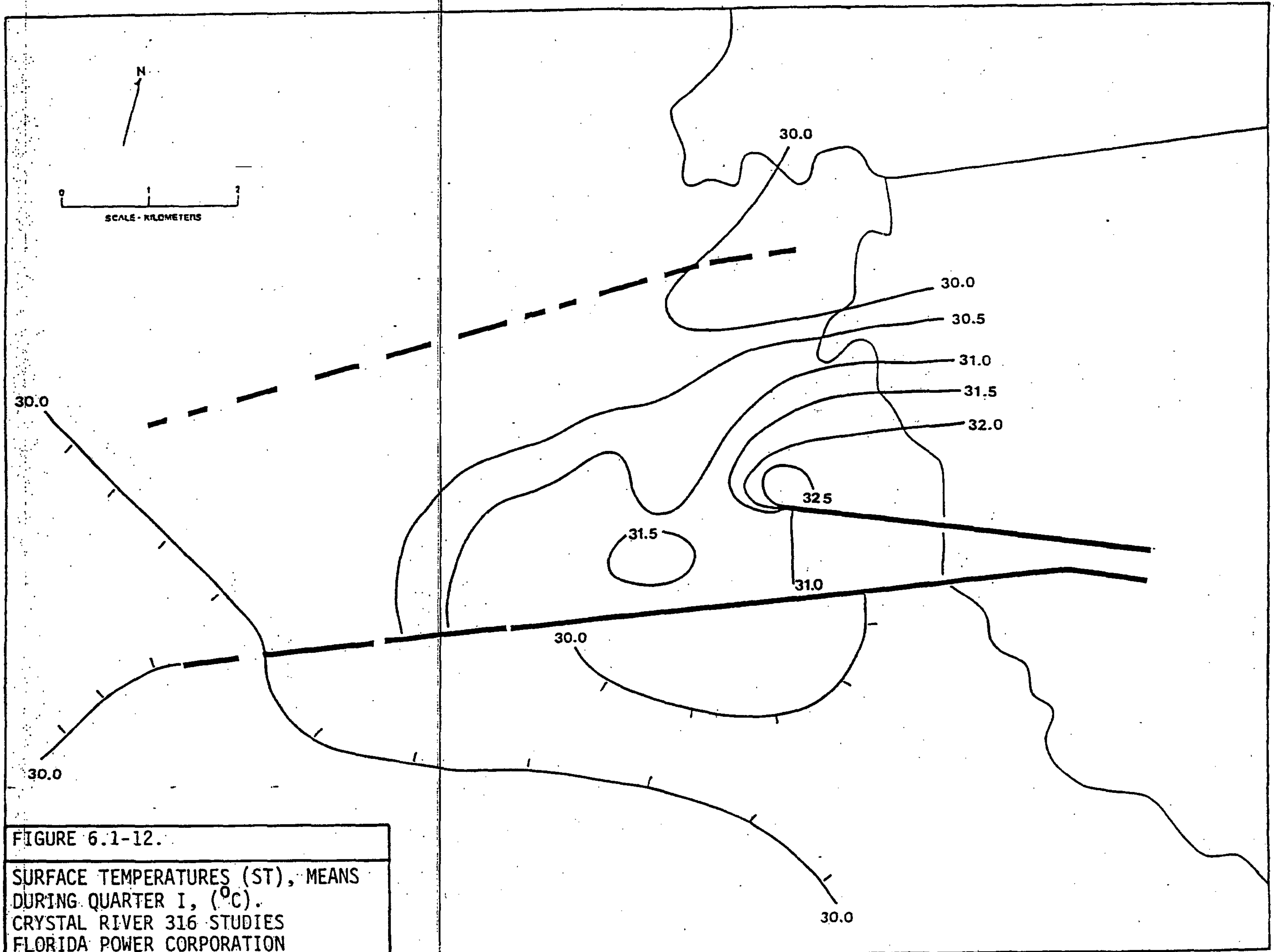

FIGURE 6.1-12.

SURFACE TEMPERATURES (ST), MEANS DURING QUARTER I, (^{o}C).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

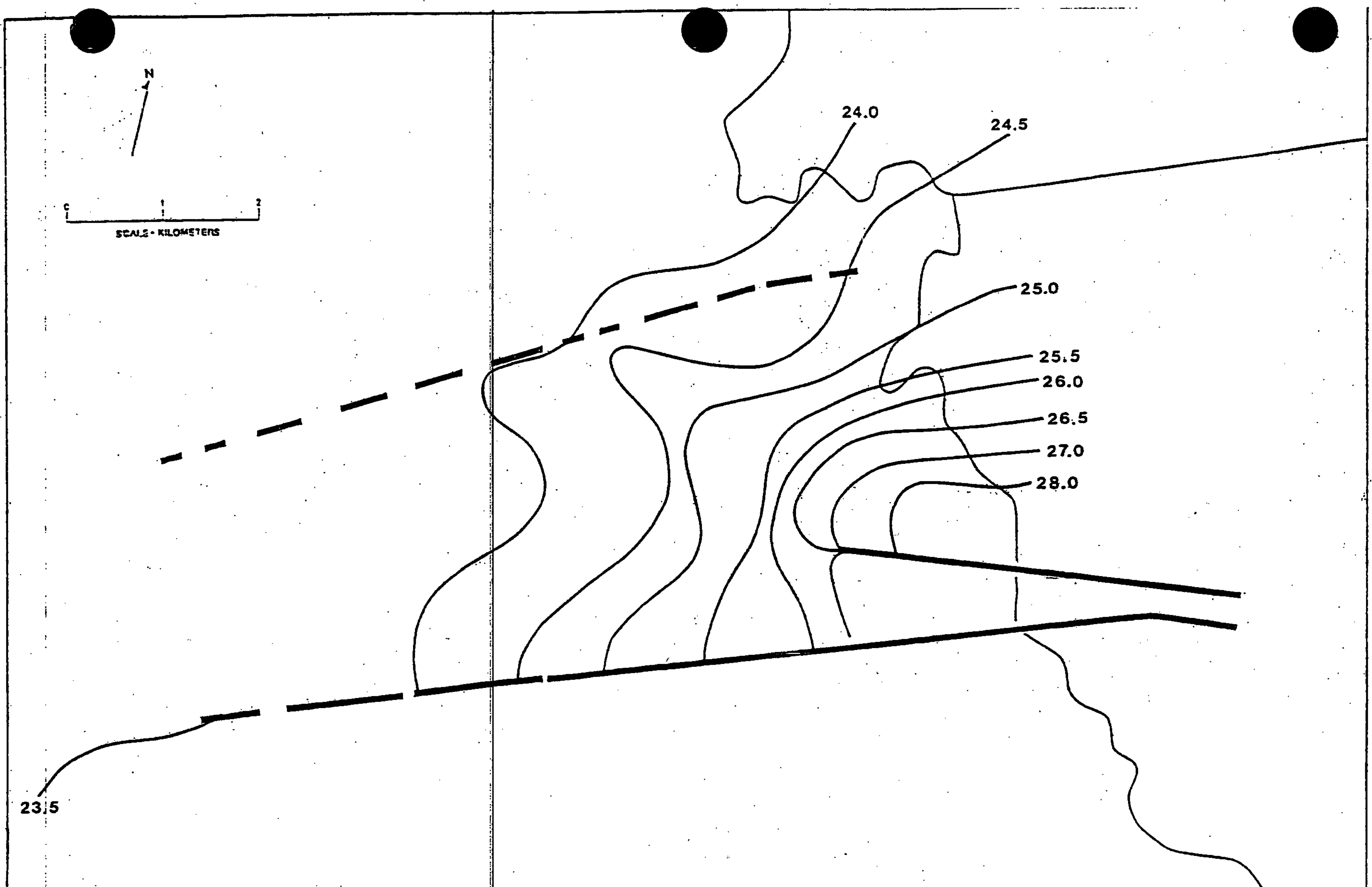

FIGURE 6.1-13.

SURFACE TEMPERATURES (ST) AT HIGH TIDE, QUARTERS I-V, (°C).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

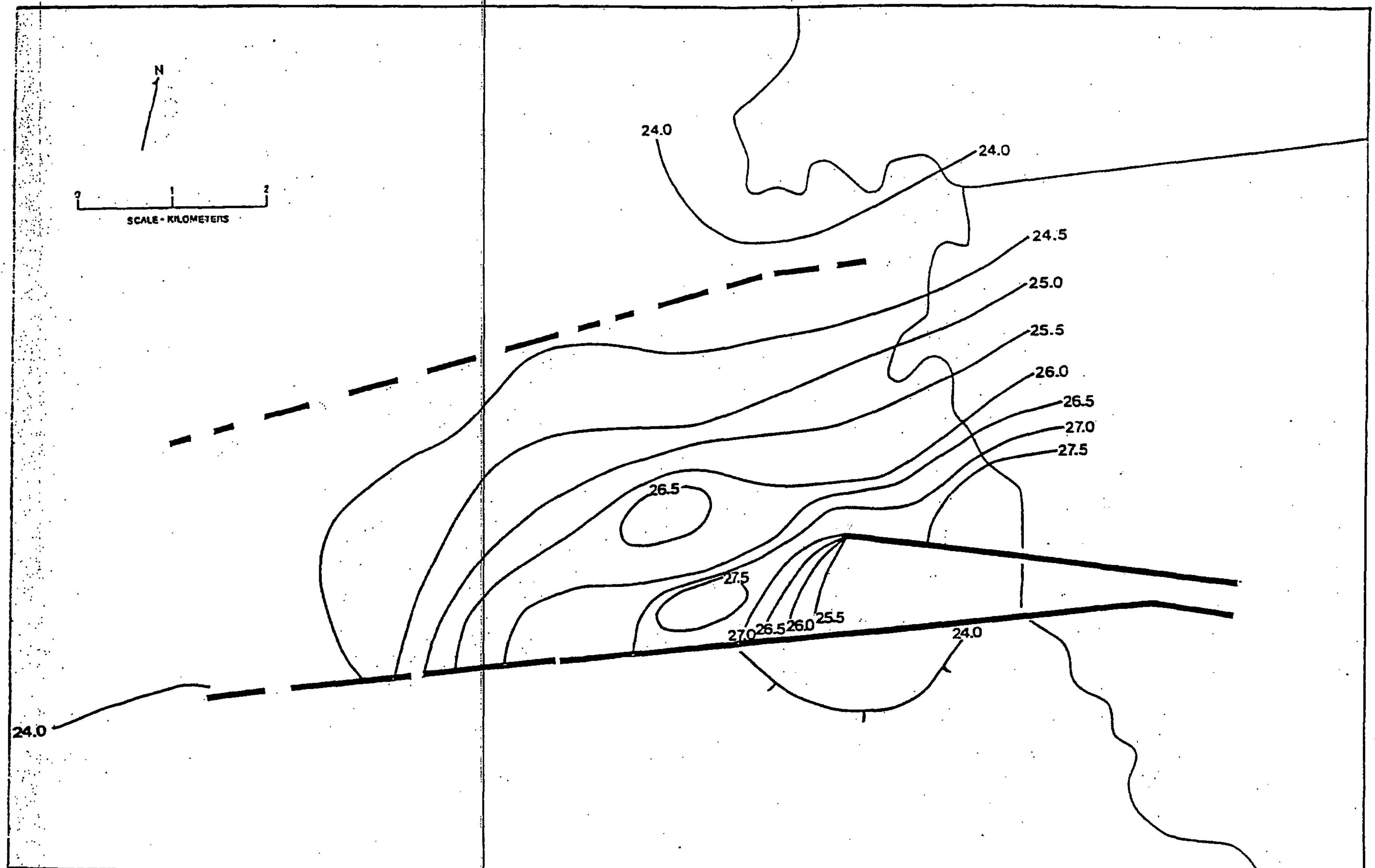

FIGURE 6.1-14.

SURFACE TEMPERATURES (ST), MEANS AT LOW TIDE, QUARTERS I-V, (^{o}C).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

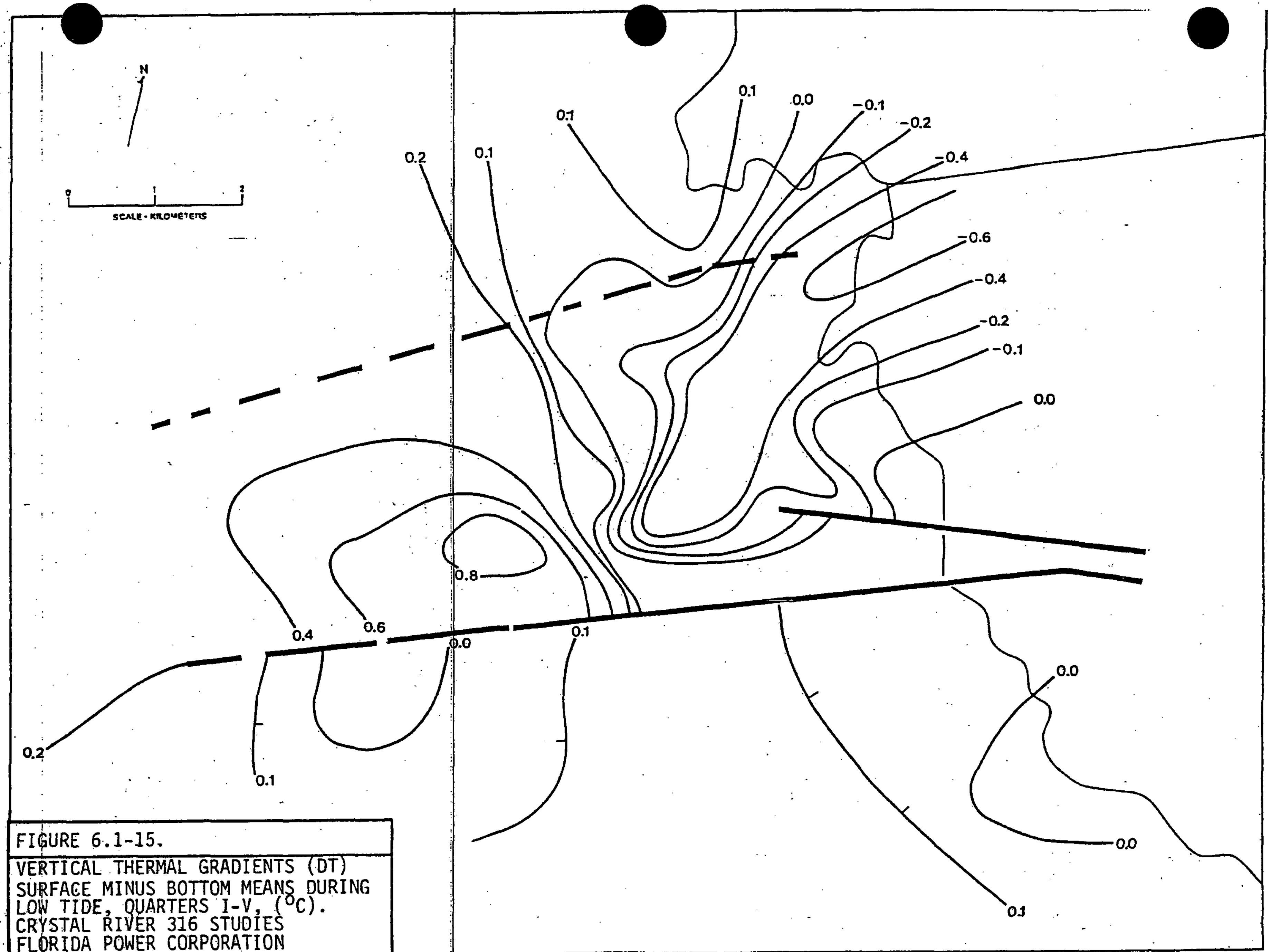

FIGURE 6.1-15.

VERTICAL THERMAL GRADIENTS (DT)
SURFACE MINUS BOTTOM MEANS DURING
LOW TIDE, QUARTERS I-V, (°C).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

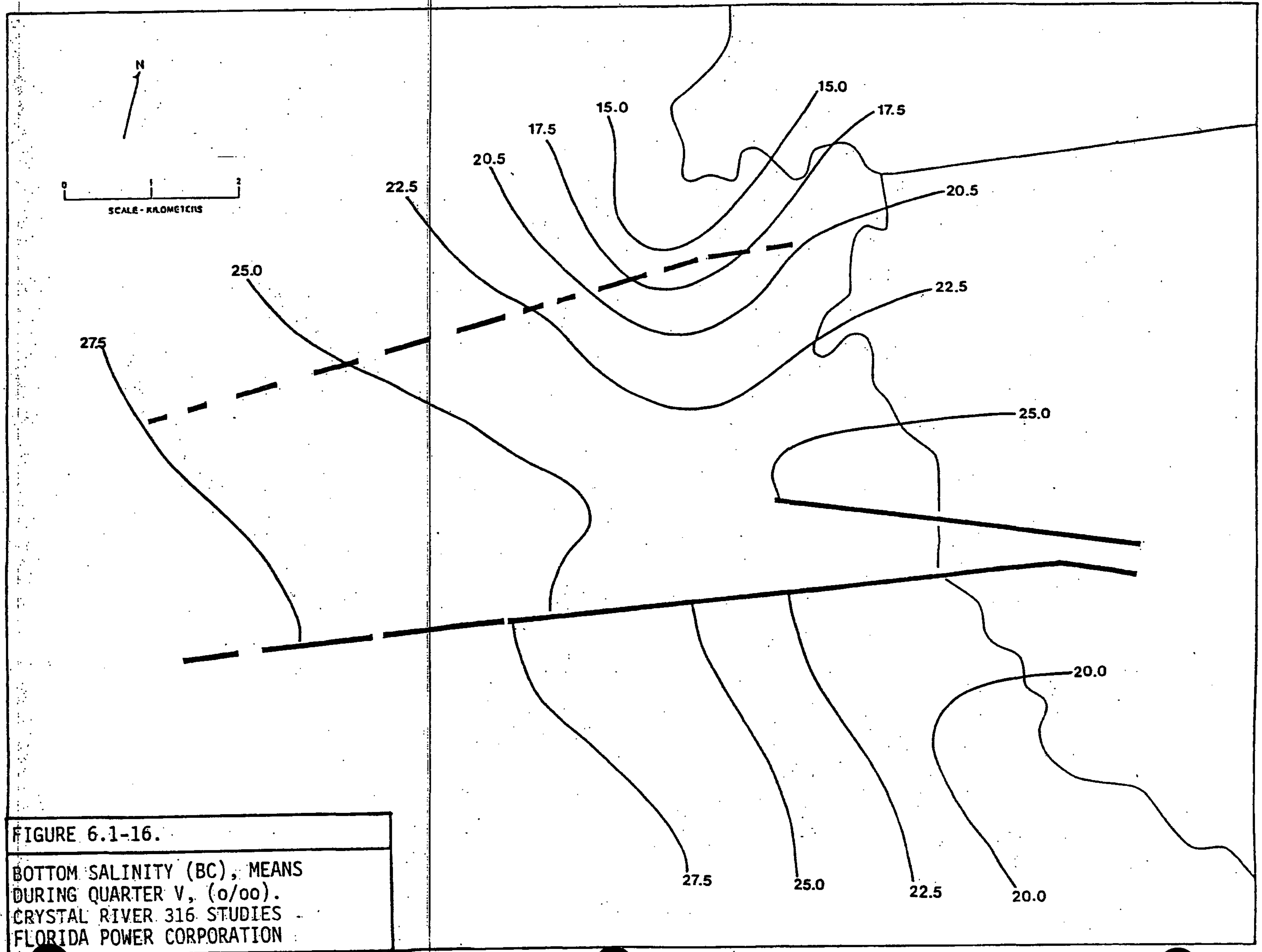

FIGURE 6.1-16.

BOTTOM SALINITY (BC), MEANS
DURING QUARTER V, (o/oo).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

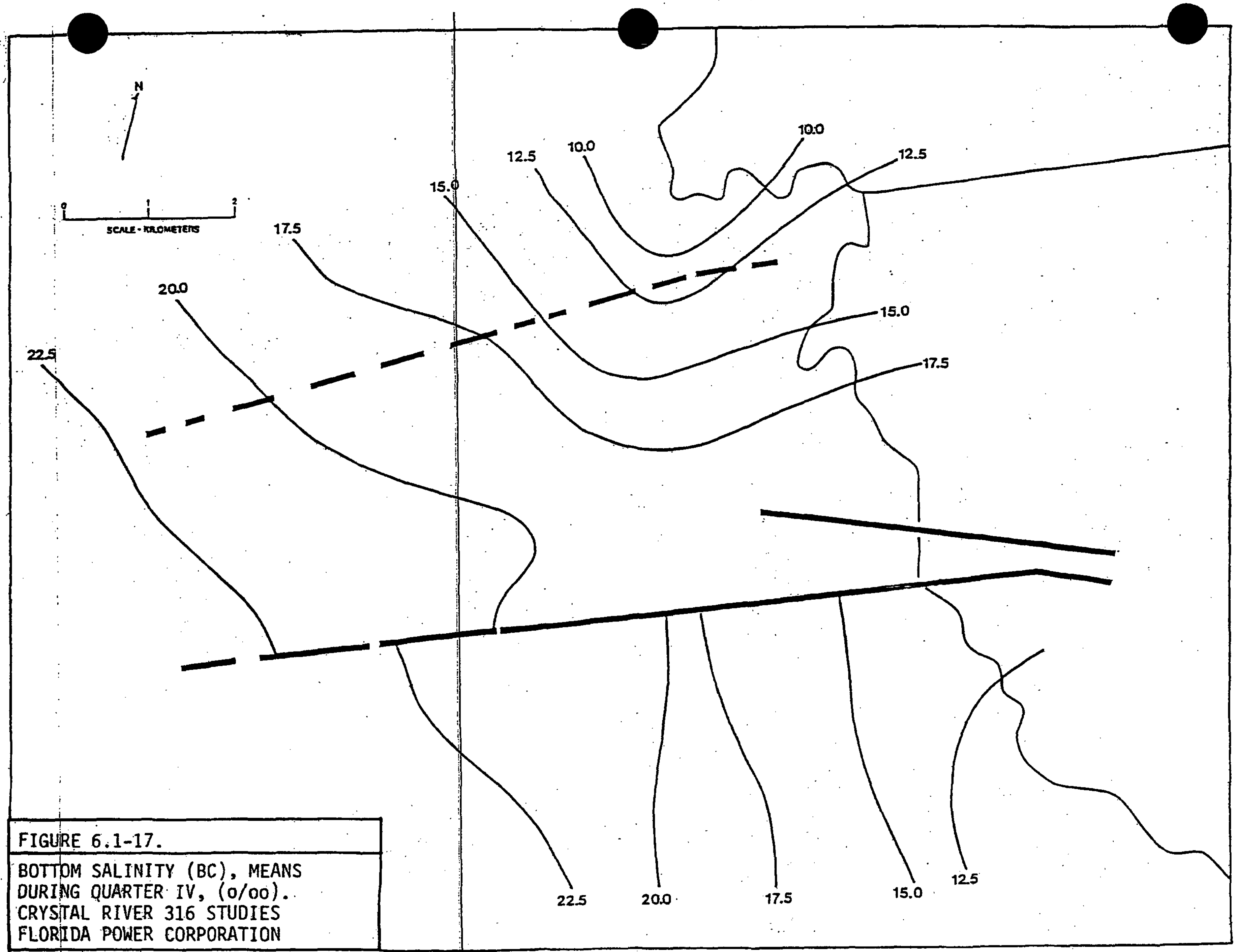

FIGURE 6.1-17.

BOTTOM SALINITY (BC), MEANS DURING QUARTER IV, (o/oo).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

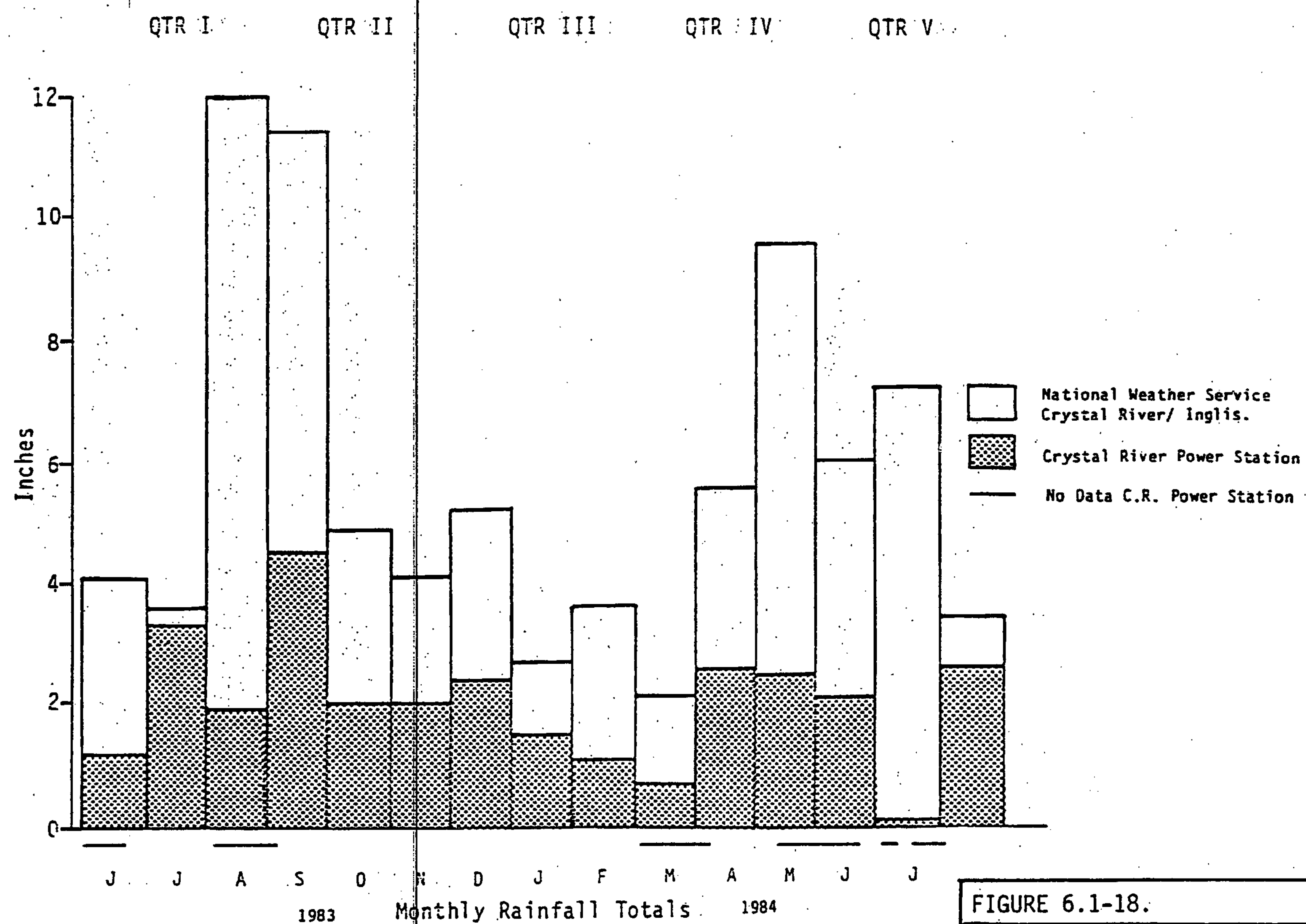

FIGURE 6.1-18.

MONTHLY RAINFALL TOTALS,
CRYSTAL RIVER AREA, (INCHES).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

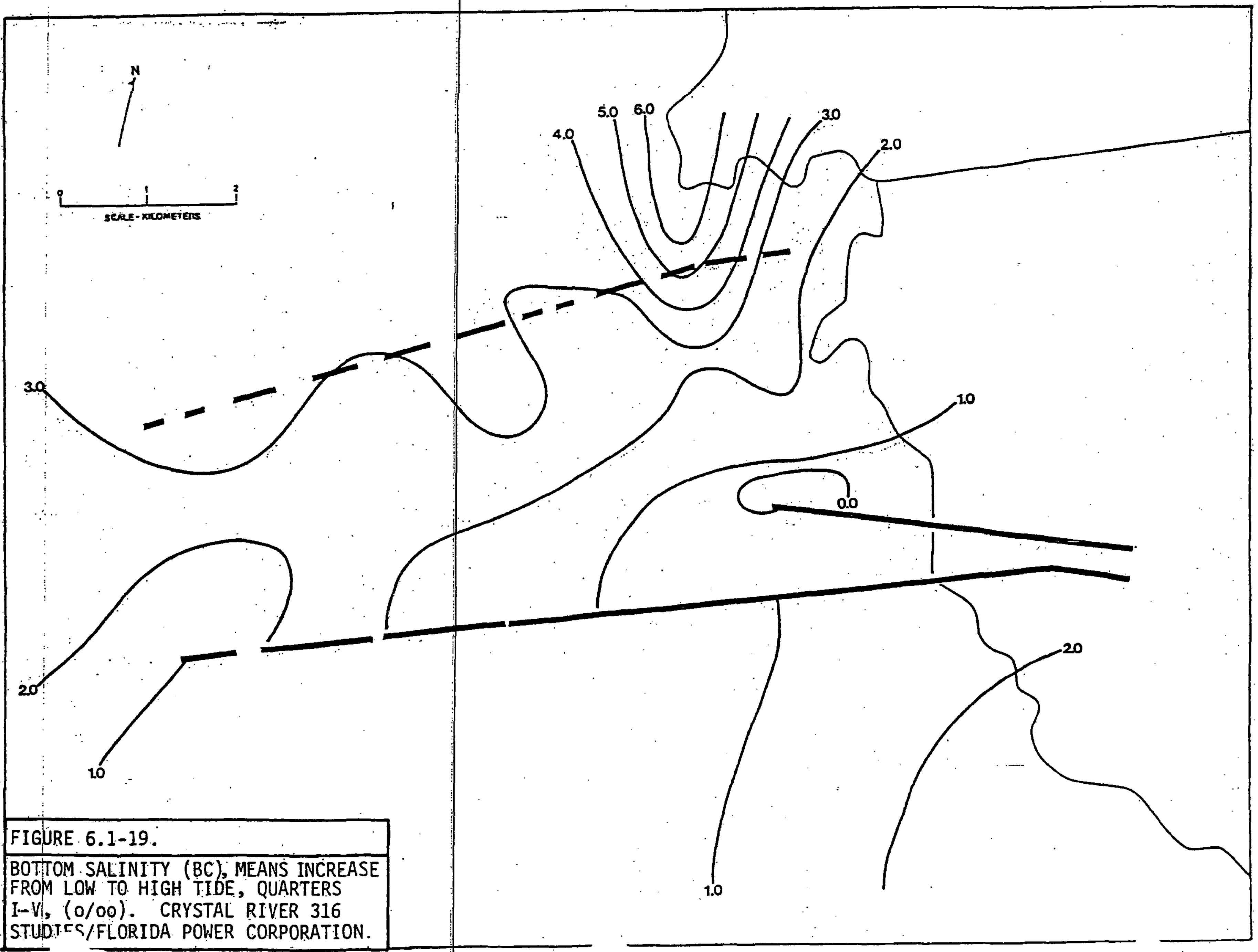

FIGURE 6.1-19.

BOTTOM SALINITY (BC), MEANS INCREASE FROM LOW TO HIGH TIDE, QUARTERS I-V, (o/oo). CRYSTAL RIVER 316 STUDIES/FLORIDA POWER CORPORATION.

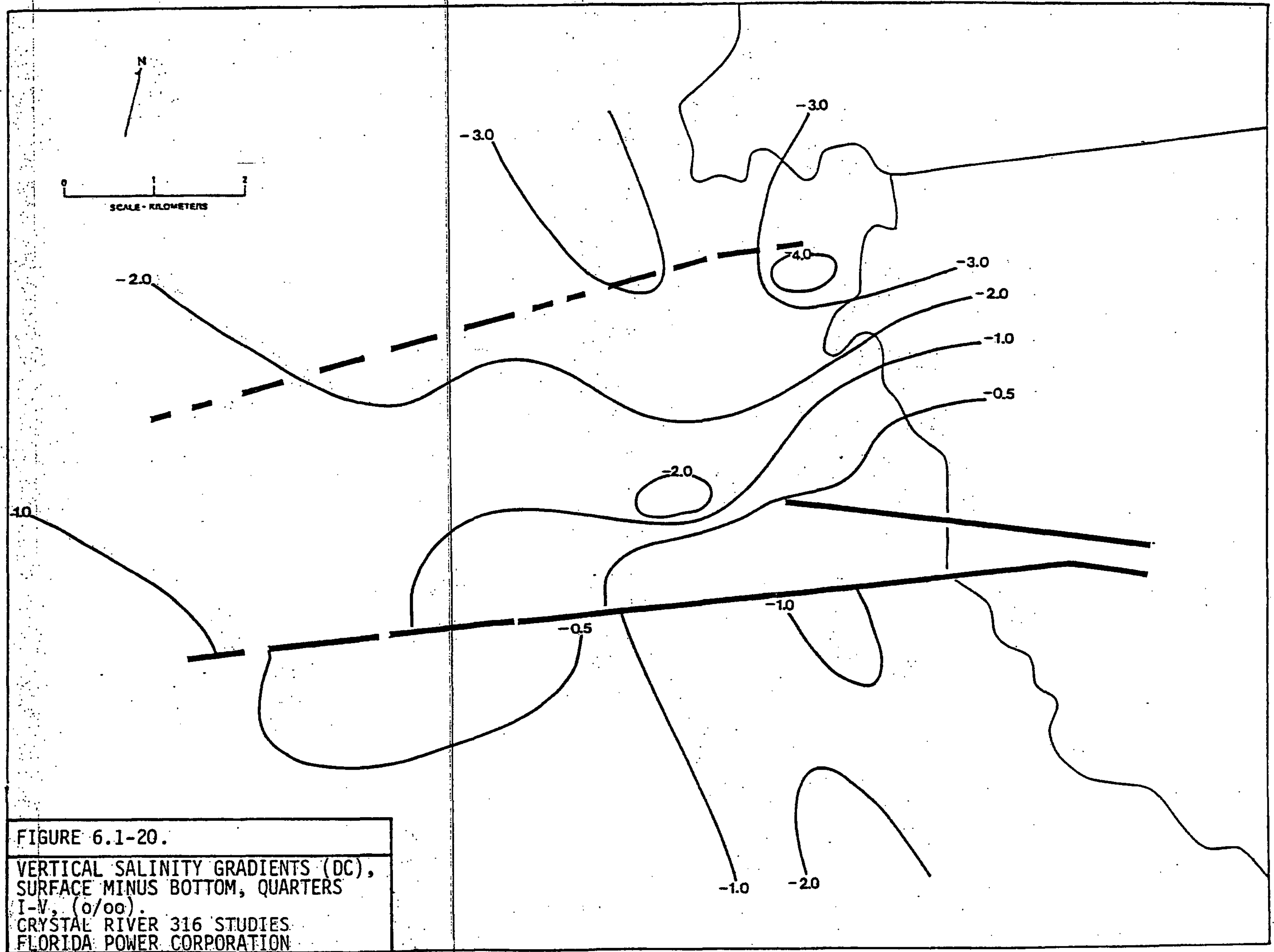

FIGURE 6.1-20.

VERTICAL SALINITY GRADIENTS (DC), SURFACE MINUS BOTTOM, QUARTERS I-V, (o/oo).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

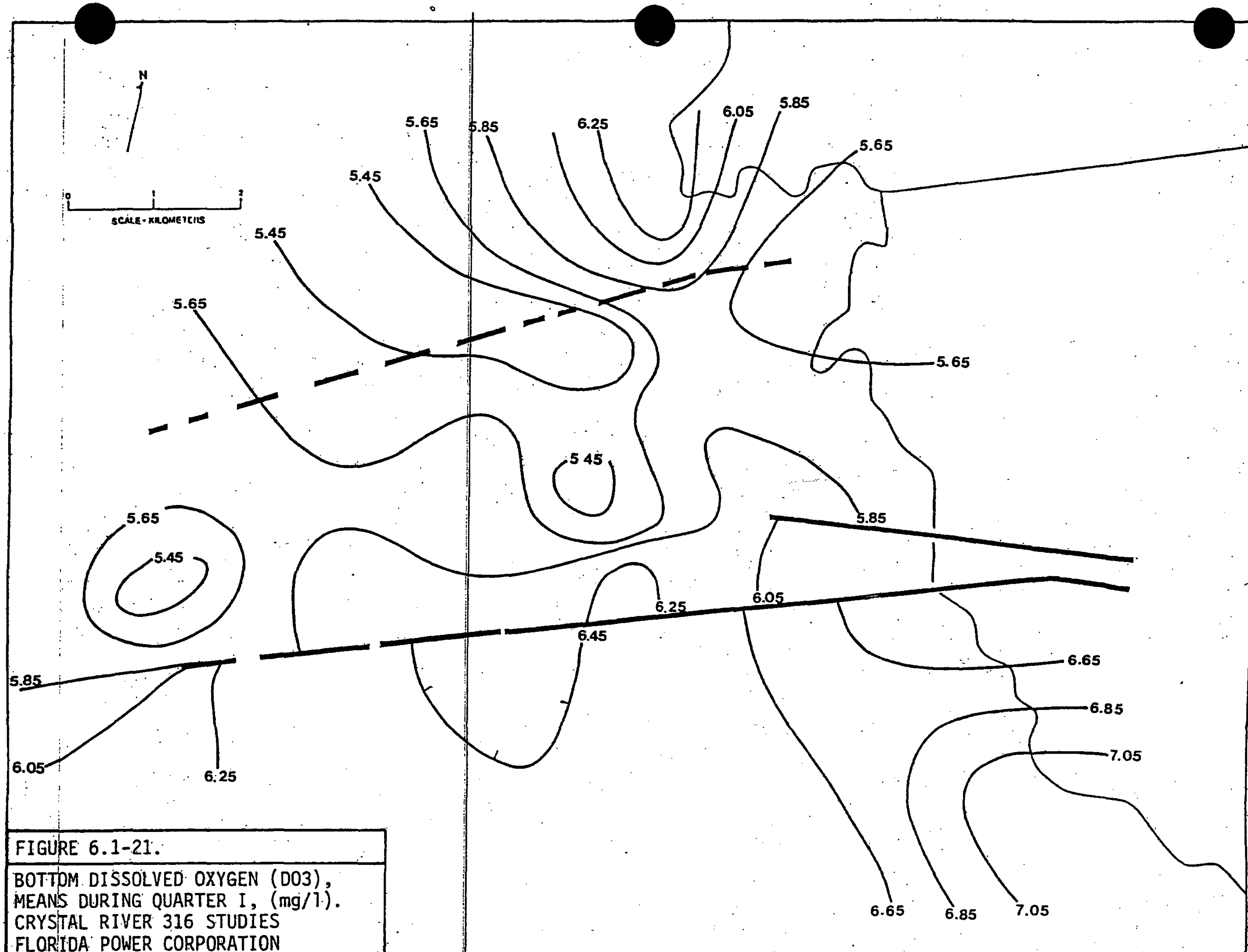

FIGURE 6.1-21.

BOTTOM DISSOLVED OXYGEN (DO3),
MEANS DURING QUARTER I, (mg/l).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

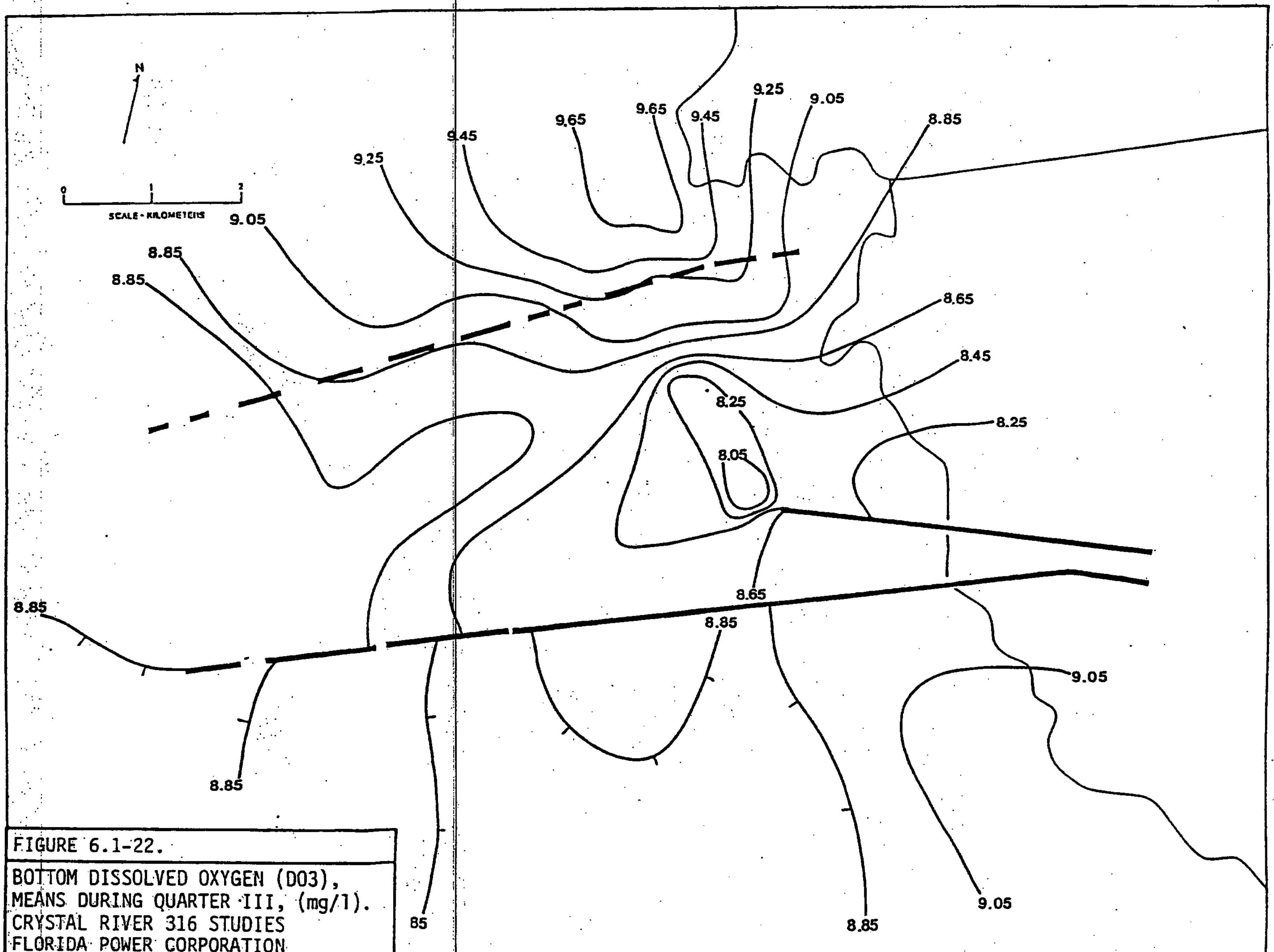

FIGURE 6.1-22.

BOTTOM DISSOLVED OXYGEN (DO3), MEANS DURING QUARTER III, (mg/l). CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION

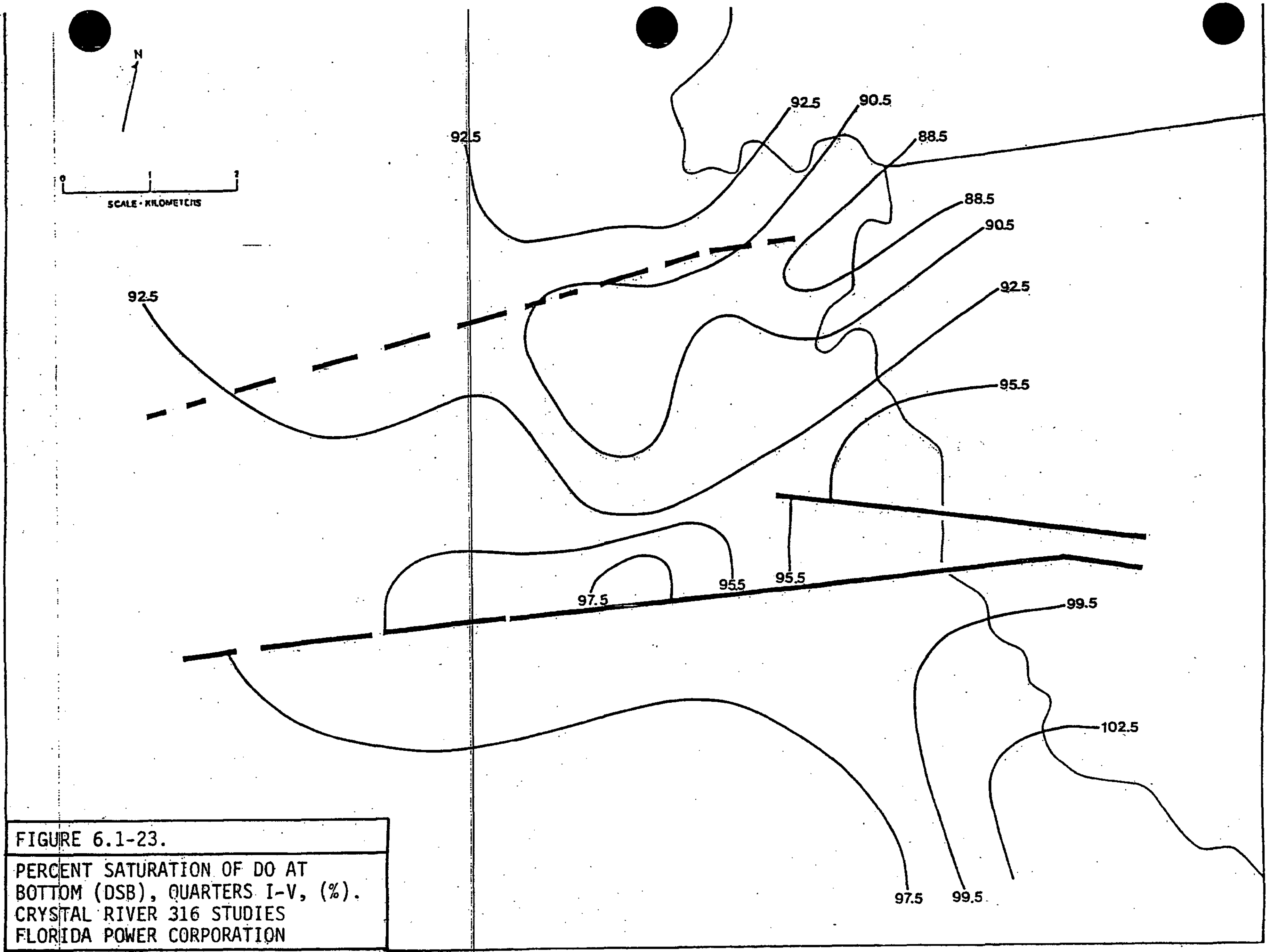

FIGURE 6.1-23.

PERCENT SATURATION OF DO AT BOTTOM (DSB), QUARTERS I-V, (%).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

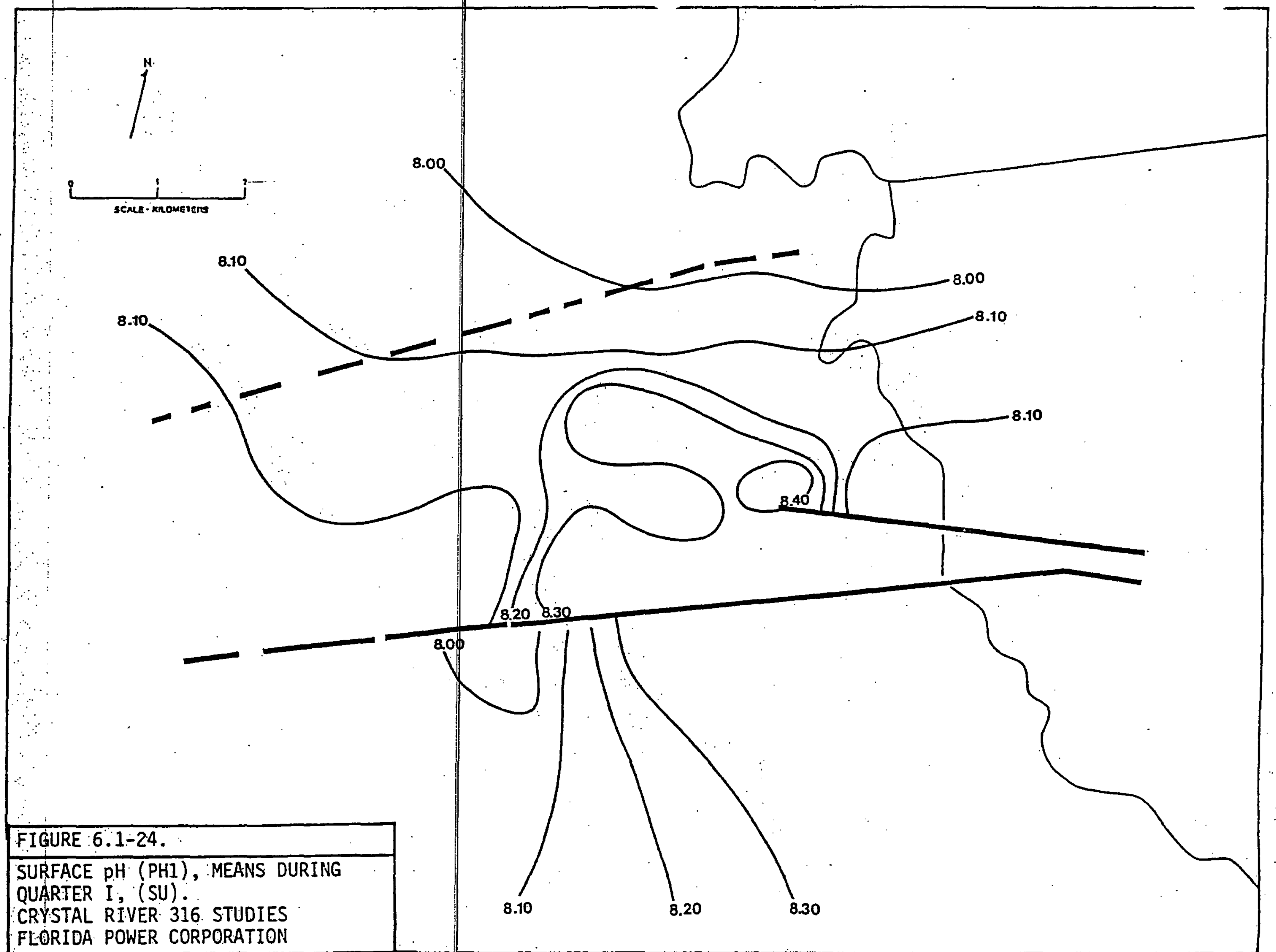

FIGURE 6.1-24.

SURFACE pH (PH1), MEANS DURING QUARTER I, (SU).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

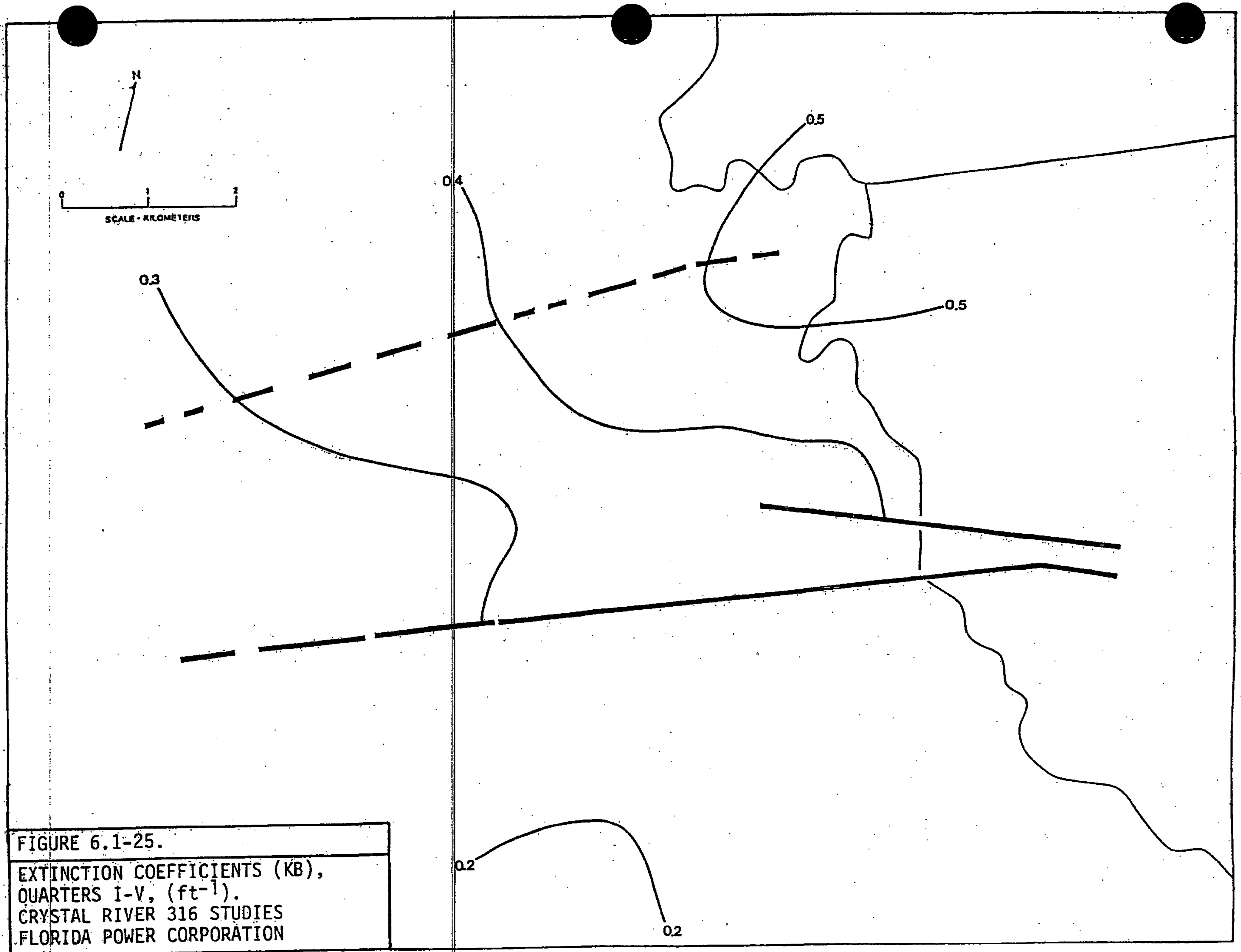

FIGURE 6.1-25.

EXTINCTION COEFFICIENTS (KB), QUARTERS I-V, (ft^{-1}).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

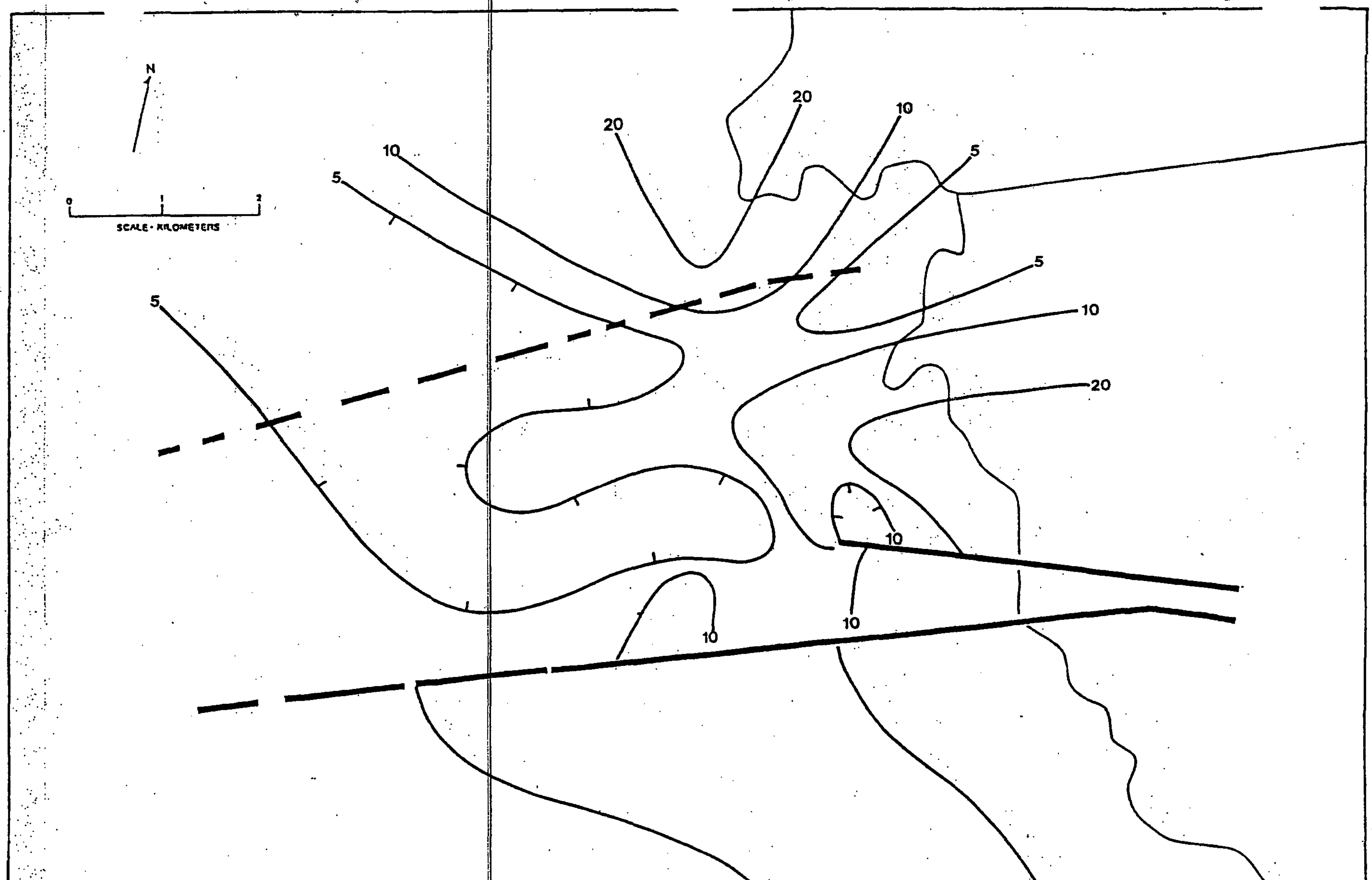

FIGURE 6.1-26.

PERCENT LIGHT AT BOTTOM,
QUARTERS I-V, (%).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

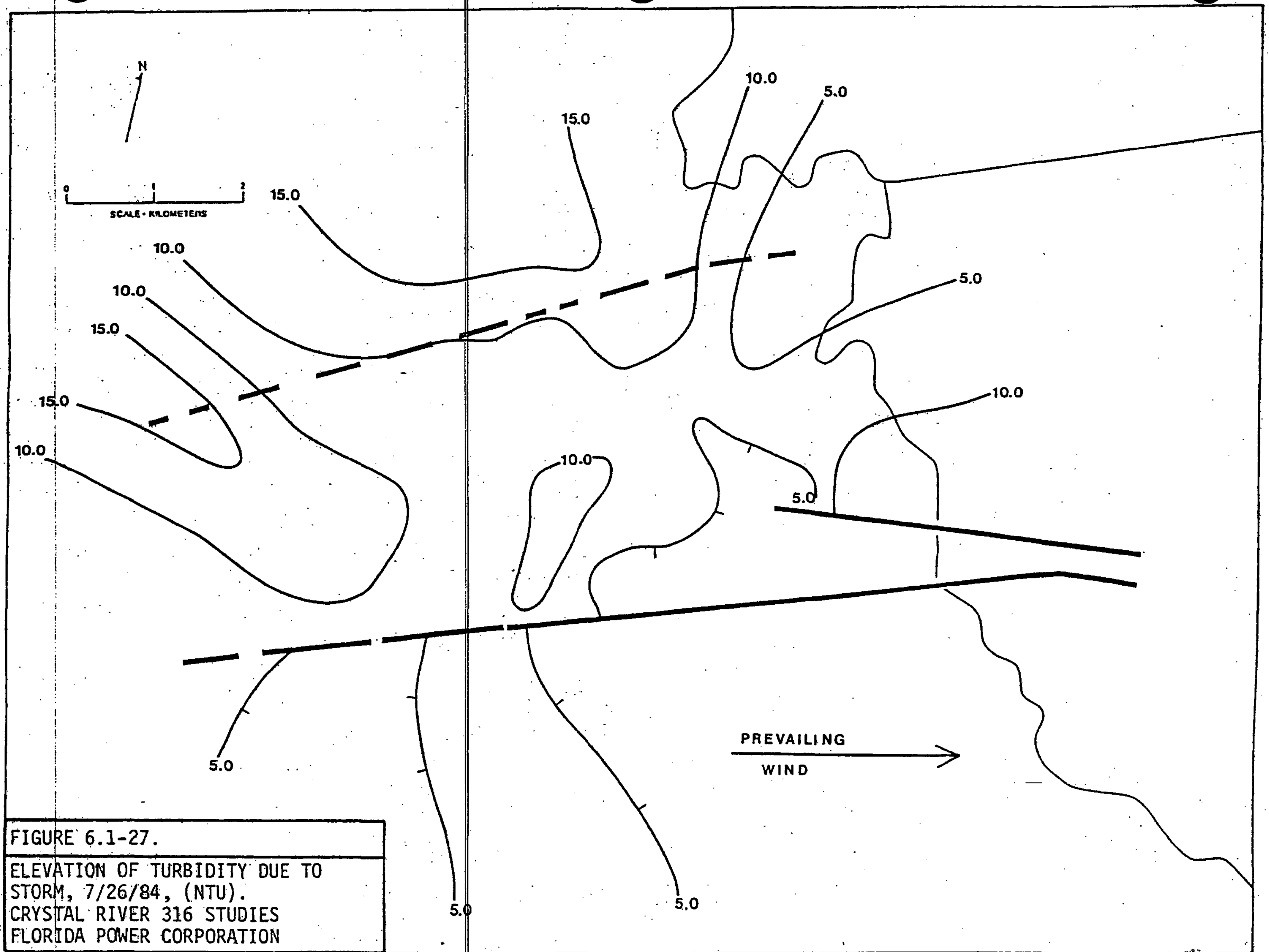

FIGURE 6.1-27.

ELEVATION OF TURBIDITY DUE TO STORM, 7/26/84, (NTU).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

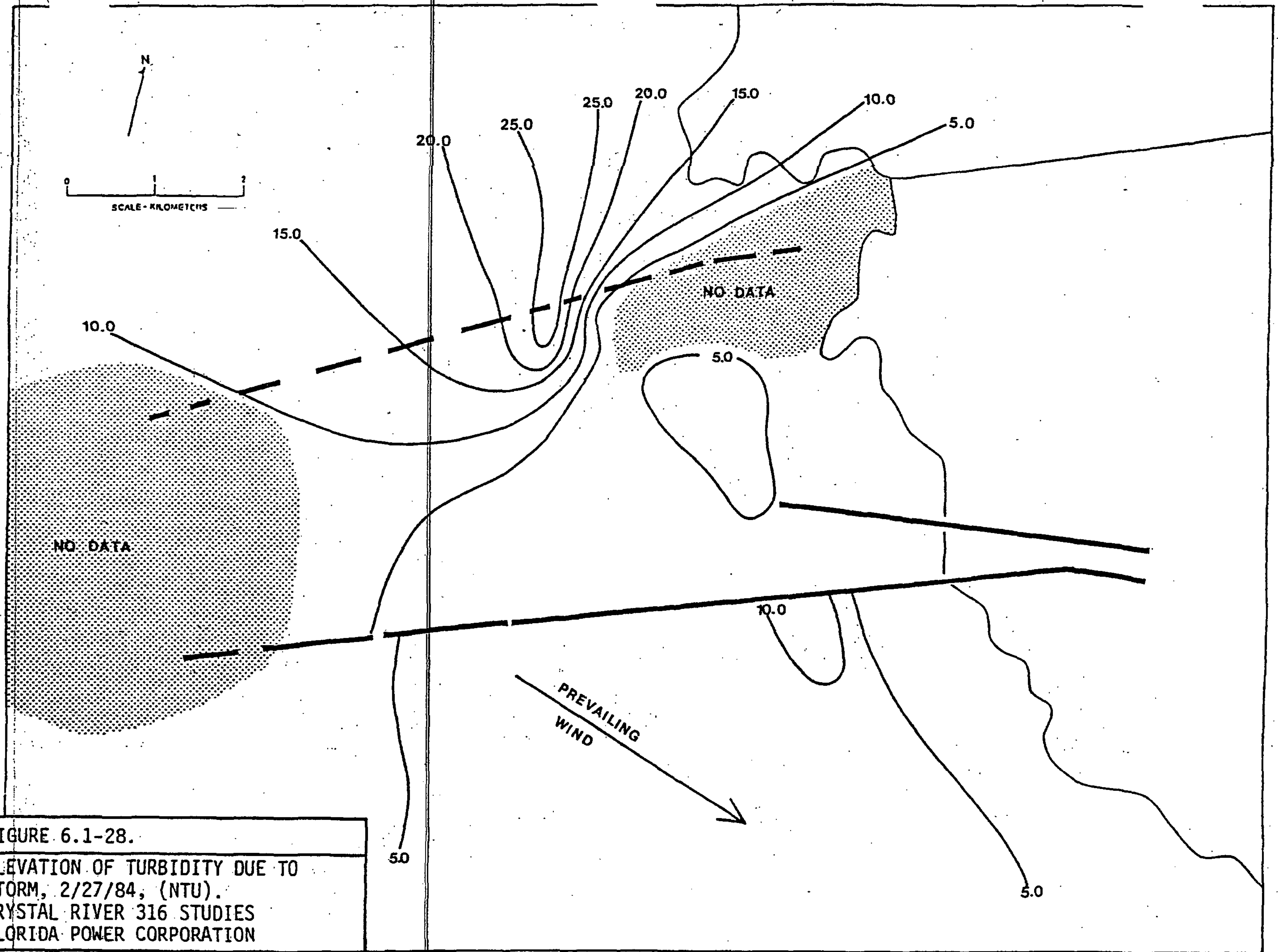

FIGURE 6.1-28.

ELEVATION OF TURBIDITY DUE TO STORM, 2/27/84, (NTU).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

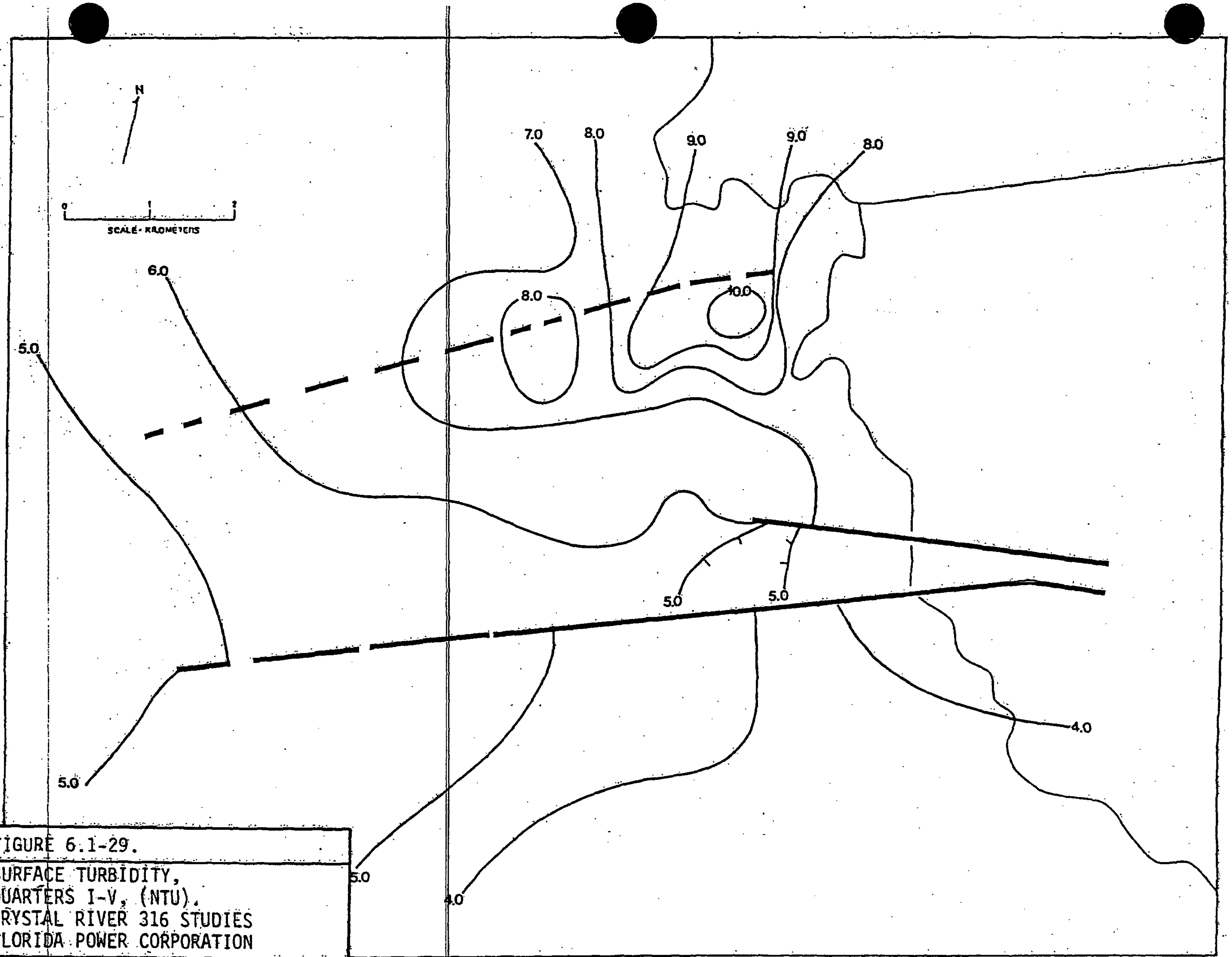

FIGURE 6.1-29.

SURFACE TURBIDITY,
QUARTERS I-V, (NTU).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

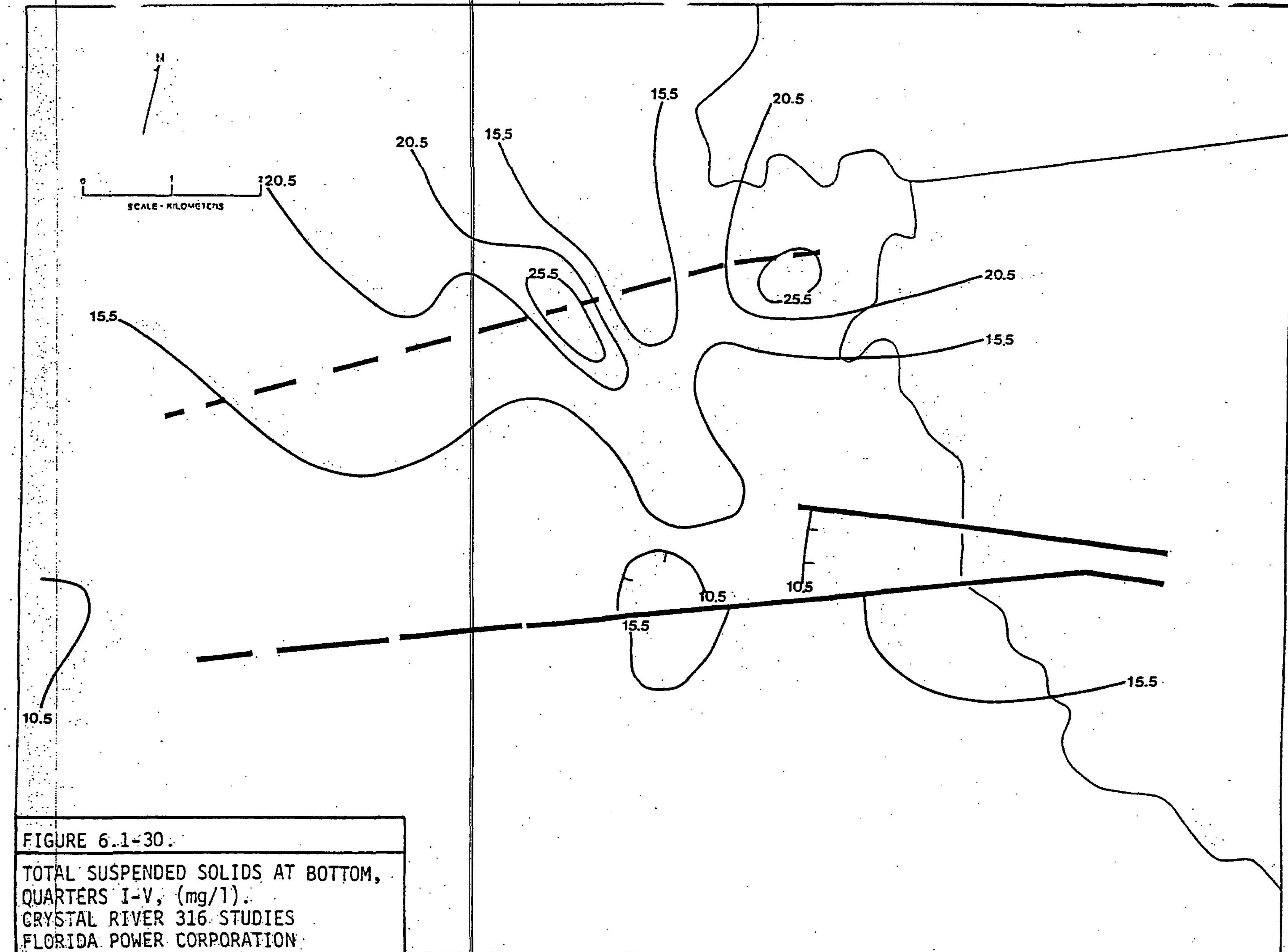

FIGURE 6.1-30.

TOTAL SUSPENDED SOLIDS AT BOTTOM,
QUARTERS I-V, (mg/l).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

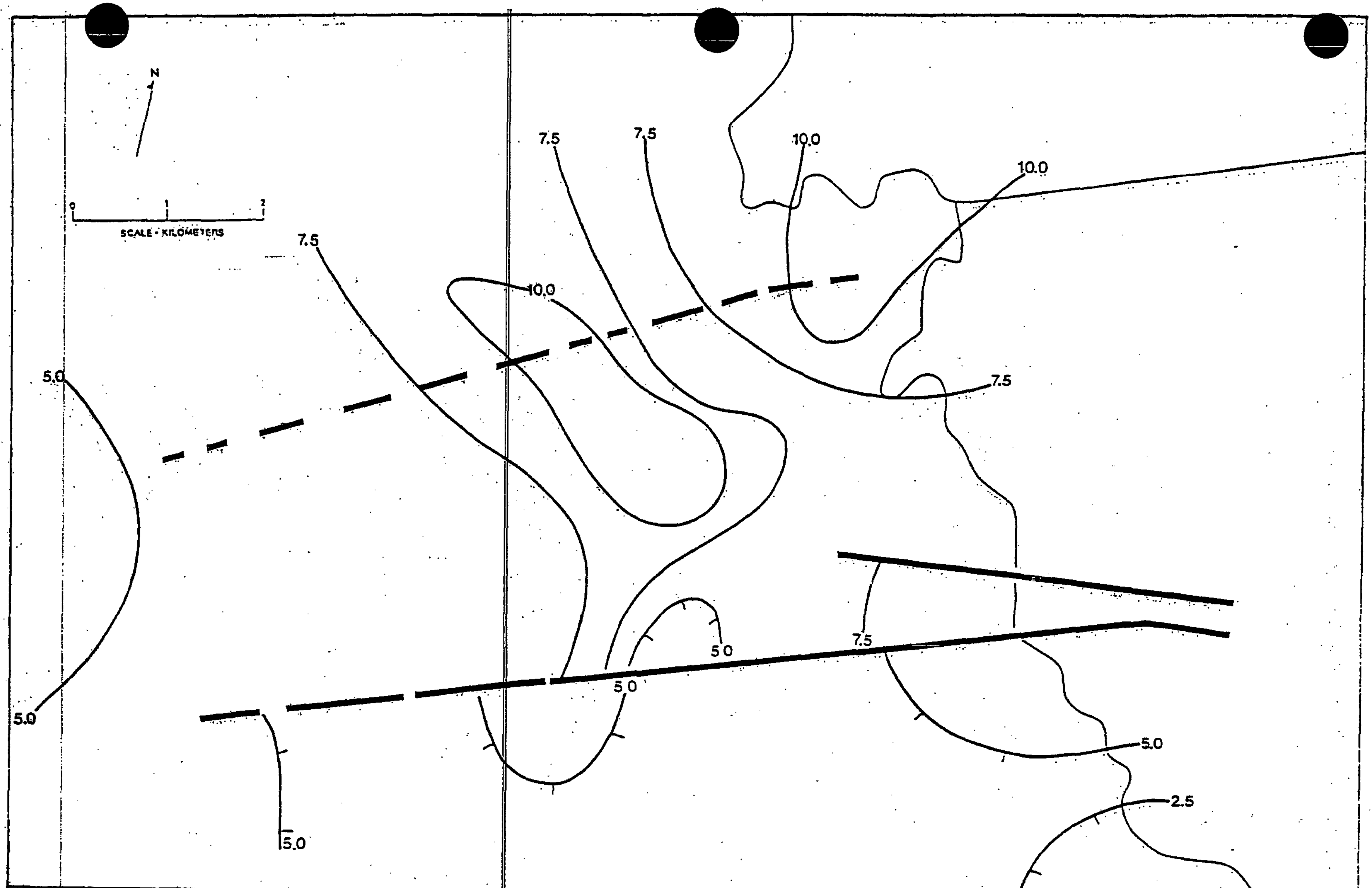

FIGURE 6.1-31.

CHLOROPHYLL 'a', SURFACE AND MID DEPTH, QUARTERS I-V, (mg/m^3).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

6.2 BENTHIC INFAUNA

6.2.1 Sampling and Laboratory Analysis

6.2.1.1 Field Sampling Procedures

Benthic faunal samples were collected at 40 stations (Figure 6.1-1) once a quarter for five quarters, and at 20 of these stations once every 6 weeks for five samplings, to provide quantitative information on the soft bottom macro-infauna of the study area. Samples were collected using benthic faunal box cores constructed after a design originally used by Saloman (1976). Inside core dimensions were 12.5 x 12.5 x 15 cm deep.

Stations locations were established using Loran C. Cores were obtained at each station by divers. The cores were inserted vertically into the substrate. The diver would then remove the sediments on one side of the core and slide a hand across the open end. The core was then inverted and a close weave cotton bag placed over the entire core. A total of eight faunal cores were collected for each station. Six of the cores were processed and two were archived for use if needed. After emptying the core contents into the cotton bag, each bag was submerged in a solution of 15 percent magnesium sulfate solution in seawater for narcotization (Russell 1963).

After narcotization of core samples for a minimum of 30 minutes, samples were washed through a 0.5 mm mesh sieve to remove the finer sediments, preserved in 10 percent formalin seawater and stained with rose bengal stain to facilitate rapid and accurate sorting (Mason and Yevich 1967; Korinkova and Sigmund 1968; Hamilton 1969; Williams and Williams 1974).

Sediment samples were collected each quarter at the 40 benthic faunal stations and analyzed to determine granulometric distribution, total organic carbon (TOC), and free sulfide content. Sediment samples for sulfides were collected from ten stations each day for four consecutive days (40 stations). Samples were collected as early as possible each day and immediately returned to the laboratory for processing. Because sulfides are easily oxidized, the transporting container excluded atmospheric oxygen, was purged with nitrogen after each opening and the entire device was stored and transported on ice.

For collection of the sulfide samples at each station three 3.81 cm (ID) by 15 cm PVC cores were utilized. Cores were collected by a diver. An uncapped core was pushed into the substrate with one hand until the sediment within the core reached the top rim. Cores were then capped on the upper end, sediment was removed from around the outside of the core, the contents of the core were retained by hand, the core was removed from the substrate and the open end capped. Cores were then returned to the support vessel and stored.

Concurrently with the faunal core collection three sediment core samples were collected at each station for granulometry and total organic carbon (TOC). Cores were collected using the method described above. On the surface vessel, the sediment was extruded into a 500 ml plastic sample jar. Each jar was stored on ice until returned to the field facility, where samples were inventoried and frozen. Samples remained frozen until processed.

Also in conjuction with the benthic faunal sampling, sediment temperature and Eh were measured with a Martek Mark VII multiparameter instrument equipped with a specialized sediment probe. Eh readings were taken once every 3 minutes for 25 minutes, while temperature was read with the last Eh reading. Eh and temperature measurements were made once every 6 weeks at the stations sampled for fauna.

6.2.1.2 Laboratory Procedures

After a minimum of 48 hours in 10 percent formalin preservative, benthic faunal samples were transferred to 70 percent isopropyl alcohol. In preparation for rough sorting, faunal samples were decanted into light and heavy fractions. The light fraction contained the majority of fauna and was sorted under a Unitron ZSB stereozoom binocular microscope. The heavy fraction, containing primarily molluscs and larger animals, was sorted with the unaided eye in the white background pan. Each sample was rough sorted into four major groups: polychaetes; crustaceans; molluscs; and miscellaneous.

Taxonomic identifications were performed under various powers of the binocular stereozoom (.7-40X) or a Nikon or Unitron compound microscope (40-1000X). Identifications of taxa to the lowest practical level were accomplished with the use of descriptive literature, comparison to reference collections, and the use of external consultants for verification of problem identification.

Sulfide cores were analyzed according to procedures described in Method 3-243 (EPA 1981), Method No. 112-71W (Technicon 1973), and Method 427 (APHA 1980). The methods are capable of detecting sulfide levels of 0-0.32 mg/l. Three sulfide cores were analyzed from each benthic station. Sample cores were subsampled, placed onto a prepurged, distillation apparatus, and purged with nitrogen into a cadmium sulfate trapping solution using constant, predetermined purge times and rates and reagent volumes. Samples were analyzed using Technicon's Industrial Method 112.71W and a Technicon AutoAnalyzer II. Sample concentrations were computed based on original sediment weight.

Laboratory methods used for grain size analysis follow the procedures of Folk (1974). In the laboratory, sediment samples were stirred thoroughly and subsamples removed for TOC analysis. The remaining sample was then split into replicate samples. Each aliquot was then washed with distilled water through a 0.063 mm screen to remove as much of the silt/clay fraction as possible. This fraction was collected and dried. The material greater than 0.063 mm was dried and then placed into a Wentworth sieve series of 1 phi intervals (2.0 mm, 1.0 mm, 0.5 mm, 0.25 mm, 0.125 mm, 0.063 mm and less than 0.063 mm catch pan). The material retained on each sieve was weighed (to 0.001 gm). Sediment fraction raw weights were then analyzed to yield the following: size class percentage; cumulative percentage; median phi value, mean grain size (phi); sorting coefficient; graphic skewness and graphic kurtosis. The calculations use equations as cited in Folk (1974).

Total organic carbon analyses were conducted using Method 1 (EPA 1981) and Oceanography International (OI) Corporation's Dry Oxidation Procedure (OI undated). The effective range of this procedure is 0.2 to 40 mgC/g.

Subsamples were weighed and then dried to a constant weight at 70°C and weighed again to calculate percentage solids.

Inorganic carbon was removed from the samples by addition of HCl. Samples were then dried, treated with CuO, purged with O_2 and combusted. Samples were analyzed with an OI TOC analyzer (nondispersive infrared type) and quantified against standards and blanks prepared from known carbon concentrations.

6.2.1.3 Statistical Analyses

All of the benthic core summary statistics were calculated after the data set had been purged of species which were not representatively sampled by the core samplers. SAS procedures were used to calculate all summary statistics. The data were analyzed primarily with summary statistics which characterize the benthic community. Species richness, diversity (as measured by Shannon-Weaver, Pielou 1975), and evenness were calculated for each station and date of sampling. Morisita's index of faunal similarly was also calculated for each pairwise combination of station and sampling date. Faunal density (number per m^2) was the only non-community type metric calculated.

The hundreds of pairwise measures of Morisita's index were summarized using the EAP package (Eco Analysis 1984). The EAP package is a group of SAS style procedures which are serially compiled with the SAS package. This package provided a dendogram display of a group-averaged sorting, cluster analysis. The inverse of the Morisita's value was used as the distance metric. The dendograms were produced for each sampling period and with the species-station date collapsed over all sampling periods to assess spatial similarities among the stations. They were also produced for each station to assess temporal clustering of the community. Finally, cluster dendrograms were produced over all stations and periods to simultaneously assess spatial and temporal similarity clustering.

Abiotic parameters relevant to benthic core sampling were also analyzed using the SAS GLM procedures. Sulfide and Eh valves were analyzed relative to time, station, sediment temperature, and mean and median grain size of the sediments. The analysis of sulfide concentrations also included total organic carbon as a covariate.

6.2.2 Results

Introductory chapters to this report have described the general characteristics of the study site. In terms of the subtidal benthic habitats, the study area may be classified as shallow and heterogeneous. Sediment types range from mud to coarse sand and shell. The area contains limestone outcroppings and associated hard substrate, except in the discharge basin where the bottom consists primarily of fine sand and mud. Extensive oyster reefs and patchy seagrasses south of the intake canal add to the heterogeneity of the substrate in the study area. Depths ranged from less than one meter to slightly over four meters at the forty stations where benthic infauna were sampled (Table 6.2-1). Average depth at the stations was two meters. In general, depth increased gradually offshore.

In order to evaluate the effects of the thermal plume on the benthic communities of the study area, the influence of temperature and other abiotic parameters must be considered in evaluating the distribution of benthic infauna. Section 6.1 provides a detailed description of all water quality parameters (on a quarterly basis); the same data were utilized in this section but as six-week means of only bottom measurements to provide direct comparisons with the infauna.

Abiotic Parameters

Temperature

To compare with benthic infaunal data, distribution of bottom temperature at the site was analyzed from four types of information:

1. Weekly synoptic measurements at the 40 stations (collected in conjunction with photometry measurements);

2. Continuous thermograph measurements at or near the 40 stations;

3. Sediment temperature measurements at the time of benthic sampling;

4. Hydrodynamic model projections of the thermal plume under various tidal and seasonal conditions.

Since infaunal sampling was conducted once every six weeks, temperature data from synoptic sampling and thermographs were summarized as six-week averages at each station. In order to account for short-term fluctuations in temperature, the data were also examined as three-week means. The six-week and three-week averages included the week of benthic sampling. Synoptic data was generally collected on high and low tides during alternate weeks. Therefore, the averages mask tidal influence. Measurements of sediment temperature during the infaunal sampling were not synoptic; in light of the shallow nature of Crystal Bay and solar-induced temperature variations within a particular day, sediment temperature data can be used only to describe general trends.

Synoptic bottom temperature at the forty stations is summarized as six-week averages in Table 6.2-2. The three-week averages exhibited essentially the same trend as six-week averages. Lowest temperatures were during January-February and highest temperatures during July-September. Spatial and temporal trends were essentially similar between the three-week and six-week averages. Certain stations had consistently higher temperatures; those stations were 4 and 5 (northern Control Transect); 13-15 (Thermal Transect A); 17-23 (Thermal Transect B); and 23-30 (Thermal Transect C). Based on six-week averages, nine stations exceeded 32°C during September: 13, 14, 17, 18, 19, 20, 21, 28, and 29. The area enveloped by these stations is shown in Figure 6.2-1.

Utilizing plant intake temperatures as ambient temperature, bottom temperature variation from ambient for the six-week averages is presented in Table 6.2-3. The following groups of thermal stations (Figure 6.2-2) can be recognized from the data:

$1^{o}C - 2^{o}C$:	4, 5, 14, 22, 27, 28, and 30	(Group I)
$2^{o}C - 3^{o}C$:	13, 20, 21, and 29	(Group II)
Greater than $3^{o}C$:	17, 18, and 19	(Group III)

Group I stations may be considered marginally thermal stations (Stations 4 and 5 appear to be influenced by both the barge canal and the thermal effluent, as discussed in Section 6.1, and are not effective controls). Group II and Group III stations can be considered thermal stations which are directly influenced by the effluent. Group III stations can be considered maximally influenced by the effluent, since average temperatures at these stations are substantially higher than intake temperatures. It is interesting to note that Group II and Group III stations exceed $32^{o}C$ (average temperature) during the hottest period of the year (August-September). These groups were somewhat different from those identified with quarterly data in Section 6.1.

Six-week average temperature data from thermographs at or near the forty stations are presented in Table 6.2-4. Compared to the synoptic data, thermograph average temperatures were lower since they included night temperatures. However, the general trends related to bottom temperature distribution at the study site were similar to the trends exhibited by the synoptic data.

Sediment temperatures are summarized in Table 6.2-5. Consistently higher temperatures were measured at Stations 13, 14, 17, 18, 19, 20, 21, 27, 28 and 29. This grouping of highly thermal stations is similar to that derived through the analysis of synoptic and thermograph data.

Predicted thermal plume configurations are shown in Chapter 10.6. The $2^{o}C$ isotherm simulated under full plant load, worst case conditions closely approximates the offshore boundary of the thermal groups defined by the field temperature results (synoptic, thermograph, and sediment temperatures). This general agreement of the results obtained by different means confirms that the areas shown in Figures 6.2-1 and 6.2-2 are where thermal effects, if any, would most likely occur on the benthic communities.

Salinity

Bottom salinity information from the weekly synoptic surveys were analyzed as six-week means for each station, similar to the analysis of temperature data. Summary data are presented in Table 6.2-6. For a majority of the stations, temporal variation in salinity was minimal. In general, offshore stations and Stations 17 and 18 near the point of thermal discharge had a higher salinity, while stations near the two rivers (1, 2, 38) and the barge canal (4, 5, 6) had a much reduced salinity.

Turbidity

Bottom turbidity data from the weekly synoptic surveys were averaged as six-week means for each station; results are presented in Table 6.2-7. In general, turbidity values exhibited considerable variation both temporally and spatially. Offshore stations were less turbid and stations near the barge canal spoil islands (Stations 4, 5, 6, 8, 9, 10) and Stations 15 and 21 were most turbid.

Total Suspended Solids (TSS)

TSS information from the biweekly surveys were averaged as six-week means and results are presented in Table 6.2-8. TSS values varied substantially both in time and space, and as with turbidity, were lower at offshore stations and higher near the barge canal spoil islands.

Dissolved Oxygen (DO)

Bottom DO data from the weekly synoptic surveys were averaged as six-week means for each station; results are presented in Table 6.2-9. In general, DO values were high in the study area. Lowest values were observed during July-September. Anoxic conditions were not observed at any station. Lower DO values were observed at Stations 3, 5, 7, 8, 9, 15, 21, and 22 during August-September (1983).

Based on the results of the water quality parameters (six-week averages/bottom) presented above, thermal station groups identified in Figure 6.2-2 can be subdivided as follows:

Group I ($1^{o}C$-$2^{o}C$ increase):	A: Stations 4 and 5 (lower salinity and DO; higher turbidity and TSS)
	B: Stations 14, 22, 27, 28, and 30.
Group II ($2^{o}C$-$3^{o}C$ increase):	Stations 13, 20, 21, and 29.
Group III (greater than $3^{o}C$ increase):	A: Stations 17 and 18 (higher salinity)
	B: Station 19.

Sediment Characteristics

Granulometry

Mean grain size at the forty stations ranged from a low of -0.27 phi (coarse) at Station 29 to a high of 3.53 phi (very fine) at Station 8. Summarized data for all stations is presented in Table 6.2-10. Based on mean grain size, the following groups of similar stations can be discerned:

Group I	(coarse sand): Stations 19, 29, and 35.
Group II	(medium sand): Stations 2, 3, 11, 12, 15, 23, 25, 26, 30, 32, and 36.
Group III	(very fine sand): Stations 4, 5, 8, 21, and 40.
Group IV	(fine sand): all other stations.

Temporal variations in mean grain size were generally minimal except at Station 29 where sediments changed from coarse sand in June 1983 to fine sand in July 1984.

Slit/Clay Content

Percent of silt/clay content in the sediments at stations is summarized in Table 6.2-11. In general, silt/clay content was high at the study site. Except for Stations 1, 2, 19, 29, and 30, all other nearshore stations had a high content of silts and clays. This was especially true at Stations 4, 5, and 8. In general, offshore stations contained less than 5 percent silt/clay content (except Station 40), while nearshore stations frequently exceeded 15 percent silt/clay content.

Redox Potential (Eh)

Measured sediment Eh at the stations is summarized in Table 6.2-12. In general, high negative values of Eh (reducing environments) were very common in the study area, especially in the nearshore areas and areas near the barge canal and the two rivers. Temporal variability of Eh values were high and did not exhibit any specific seasonal trends.

Total Organic Carbon (TOC)

Sediment TOC values at the stations are summarized in Table 6.2-13. TOC values were generally high at the study area with considerable temporal variation. Lowest values were observed at Stations 1, 3, 11, 16, 24, 26, 29, and 35-37 and during July 1984. Only Station 29 is in the thermal area.

Sulfides

Sediment sulfide content at the stations is summarized in Table 6.2-14. In general, values were low at most stations. Extremely high sulfide content was evident at Stations 8, 17, and 38, followed by Stations 21 and 32. Moderately high values were observed at Stations 4, 5, 7, 37, and 39. Lowest sulfide values were observed at Stations 11, 12, 19, 25, and 26. Sulfide values were generally inconsistent from station to station.

Identification of Controls

Thermal groups identified in Figure 6.2-2 can be further subdivided as follows, based upon sediment characteristics:

Group I ($1^{o}C$-$2^{o}C$ increase):	A: 4 and 5 (very fine sand) B: 14 and 27 (fine sand) C: 22 and 28 (medium to fine sand) D: 30 (medium sand)
Group II ($2^{o}C$-$3^{o}C$ increase):	A: 21 (very fine sand) B: 13 and 20 (fine sand) C: 29 (coarse sand)
Group III (greater than $3^{o}C$ increase)	A: 17 and 18 (fine sand) B: 19 (coarse sand)

Stations 4 and 5 of Group I differ from similar sediment stations of other groups by exhibiting much lower salinities, DO content and higher turbidity and TSS. Stations 17 and 18 differ from Station 19 by exhibiting higher salinities also.

Based on the sediment type and selected water quality parameters, the most appropriate control station(s) for the sets of thermal stations (identified above) are:

IA:	Stations 4 and 5	Control: 1
IB:	Stations 14 and 27	Controls: 6, 7, 33, and 39
IC:	Stations 22 and 28	Controls: 2 and 38
ID:	Station 30	Controls: 2, 3, 12, 25, 26, 32, and 36
IIA:	Station 21	Controls: 8 and 40
IIB:	Stations 13 and 20	Controls: 6, 31, and 33
IIC:	Stations 29	Control: 35
IIIA:	Stations 17 and 18	Controls: 6, 31, and 33
IIIB:	Station 19	Control: 35

Faunal Parameters

Species Composition

A total of 918 taxa were identified from approximately 375,000 individuals collected during this study. Meiofaunal species such as ostracods, nematodes and copepods and species which were taxonomically lumped (oligochaetes, nemertines) and colonial species, although sorted and identified, were not included in the data analyses. Numerous species of polychaetes were frequently common and abundant. In terms of overall abundance, the following species contributed over fifty percent of the total fauna (in order of rank abundance): Fabricia sp. A; Streblospio benedicti; Aricidea philbinae; Tharyx cf. dorsobranchialis; Aricidea taylori; Mediomastus ambiseta; Axiothella mucosa; Mediomastus sp.; Myriochele oculata; Lumbrineris verrilli; Halmyrapseudes cf. cubanensis; and Haploscoloplos foliosus. All of these species with the exception of H. cf. cubanensis, a tanaid, were polychaetes.

Some spatial patterns of the abundant species were as follows: Fabricia sp. A occurred as a dominant species (in terms of temporally combined abundance) at over 50 percent of the stations. It was more abundant south and northwest of the intake dike (Figure 6.2-3). Numerical abundance of Streblospio benedicti was limited to the nearshore areas between the barge canal and the discharge canal (Figure 6.2-4). Aricidea philbinae was generally abundant nearshore (Figure 6.2-5). Tharyx cf. dorsobranchialis was abundant in the nearshore areas adjacent to the discharge spoil and Station 31 (Figure 6.2-6). Dominance of Aricidea taylori was limited to a few stations in Basins 3 and 4 and Station 17 (Figure 6.2-7). Mediomastus ambiseta had a patchy distribution south of the barge canal spoil islands and the intake spoil (Figure 6.2-8), while Mediomastus sp. was abundant mostly at offshore stations (Figure 6.2-9). Myriochele oculata was numerically abundant primarily at offshore stations (Figure 6.2-10). Lumbrineris verrilli was primarily abundant at mid depth stations (Figure 6.2-11). Axiothella mucosa was consistently abundant only at Stations 27, 28, 23, 30, and 35 (Figure 6.2-12). The tanaid, Halmyrapseudes cf. cubanensis was dominant only at Stations 1 and 4 (Figure 6.2-13). Haploscoloplos foliosus was numerically dominant at stations near the barge canal and the nearshore stations at the plant discharge (Figure 6.2-14).

Other dominant species which showed patchy distribution in the study area were as follows: Acteocina canaliculata was abundant in the thermal stations (18, 19, 20, 21, and 28) and Stations south of the intake spoil (31, 32). Ampelisca holmesi was abundant only at Stations 2 and 13. Paraprionospio pinnata, Haploscoloplos fragilis and Mysella planulata exhibited patchy distributions. Laonereis culveri and Neanthes succinea (Figures 6.2-15 and 6.2-16), both considered as thermally tolerant species (Logan and Maurer, 1975) occurred in the thermal areas. Polydora websteri and Heteromastus filiformis, also considered thermophilic, were abundant at nearshore thermal stations. Temporal variations in the abundance of the dominant species listed above were considerable.

The density and percent abundance of the ten most dominant species at each of the 40 stations during each sampling period are provided in Appendix III. Based on species dominance alone, the following four somewhat discrete communities can be recognized in the study area:

Stations 1 and 4:	Halmyrapseudes - Xenanthura - Streblospio community;
Station 3:	Brachidontes - Crepidula community;
Stations 2, 5-8, 13-15, 17-21, 27-33, 38, and 39:	Aricidea - Streblospio - Tharyx - Fabricia community;
Stations 9-12, 16, 23-26, 35-37 and 40:	Mediomastus - Myriochole - Goniadides community.

Each of these communities appears to intermix but still retain a distinct spatial pattern (Figure 6.4-17).

Species composition, especially the dominants, changed through the year. During the hottest period of the year (July-October), analyses of distributional patterns of the numerically abundant species (Appendix III) showed that Tharyx cf. dorsobranchialis, Mediomastus ambiseta, Aricidea philbinae and Aricidea taylori were abundant throughout the study area. Streblospio benedicti was abundant at all thermal and northern stations east of Fisherman's Pass and at Station 31 south of the intake spoil. Paraprionospio pinnata was abundant at all nearshore stations except in the area of thermal discharge (Figure 6.2-18). Myriochele oculata and Lumbrineris verrilli were abundant at all stations except stations nearshore. Haploscoloplos foliosus and H. fragilis were abundant in the summer only at Station 1 and Stations 4 through 9 near the barge canal spoil islands. Thermal indicators Laeonereis culveri and Neanthes succinea were both abundant only at Stations 13 and 17. In addition L. culveri was abundant at Stations 18 and N. succinea was abundant at Station 6 (Figures 6.2-19 and 20). Heteromastus filiformis, also considered a thermal indicator, was most abundant at only Station 17. Polydora websteri, a thermally tolerant species, was abundant at Stations 13, 19, and 29. Polydora websteri is associated with oyster reefs in the study area (see Section 6.5); Stations 19 and 29 were near oyster reefs.

Many of the species which were abundant at a few stations were present in small numbers at almost all of the sampled stations in the area. However, Halmyrapseudes cf. cubanensis did not occur at 17 of the 40 stations and Axiothella mucosa did not occur at 8 of the 40 stations. Also, Capitella capitata did not occur at 6 of the 40 stations (10, 11, 22, 25, 34, and 36). Other abundant species were ubiquitous and occurred at all or at a majority of the stations (Table 6.2-15). Rare or uncommon species were numerous in the southern and offshore areas; many of them did not occur in the thermal areas.

Oligomixity (dominance by one or two species) was generally high in the study area except at the following stations (Figure 6.2-21): 2, 11, 12, and 16 (Northern Control); 22, 24, 25, and 26 (Discharge transect - offshore); 31 through 40 (Southern Control). All stations within the area most probably enveloped by the thermal plume (Figures 6.2-1 and 6.2-2) exhibited a high degree of oligomixity.

In summary, results of the species composition of the infaunal communities in the study area show that:

1. Although the study area was extremely diverse in terms of the total number of species encountered, a few species dominated in terms of abundance.

2. Dominance distributional patterns of the species that were abundant ranged from cosmopolitan to very endemic at a few stations. Streblospio benedicti, an opportunistic species, appears to be most dominant in areas north of the intake dike, while Aricidea spp., Fabricia sp. A, and Tharyx cf. dorsobranchialis are widespread. Mediomastus sp. and Myriochele oculata exhibited highest dominance in the offshore areas. All other dominants were limited in their abundance to a few stations.

3. Four communities were defined from the area.

4. During the hottest period dominant species were abundant in both thermal and non-thermal areas. Neanthes succinea, Laonereis culveri, Heteromastus filiformis and Polydora websteri (thermal indicators) were most abundant at the nearshore thermal stations. Paraprionospio pinnata was least abundant at the thermal stations.

5. A majority of the dominants occurred at almost all stations; however, abundance of these species varied considerably spatially and temporally. Abundance and rank of dominant species changed at a majority of the stations between the common sampling periods (June-July) of the two years (1983-1984) indicating annual variations. Many of the rare species found in the southern area and offshore areas were not found in the thermal areas.

6. Oligomixity was generally high, especially in the nearshore areas north of the intake dike.

Faunal Density

Total faunal density (organisms/m^2) for all stations and sampling periods is summarized in Table 6.2-16. Overall, lowest densities occurred during July-

September and highest densities during April. Mean densities were considerably lower at Stations 5, 8, 18, and 24. Low densities were observed at Stations 2, 6, 7, 9, 14, and 15; high densities were observed at Stations 28, 29, 30, and 35. All other stations had moderate densities; no clear patterns in density related to the thermal areas were evident. Temporal variation in density was exceptionally high (over 200 percent change) at the following stations: 4, 5, 7, 8, 11, and 12 (Northern Transect); 13, 15, 16, 23, 26, 28, 29, and 30 (Thermal Transect); 33, 35, 36, and 37 (Southern Transect). Station 28 exhibited a dramatic increase in density between February and June, 1984 (34,059 to 113,387 organisms/m^2) mainly caused by a super abundance of Fabricia sp. A. Comparison of June/July data between 1983 and 1984 showed that considerable differences in density existed both in thermal and non-thermal areas. Overall, density was higher in June/July 1984 compared to June/July 1983.

Comparison of faunal density at thermal stations with control stations of similar sediment type with a 't' test (95 percent significance level) is shown in Table 6.2-17. In general, thermal stations were not significantly different in densities from corresponding southern stations. Thermal Station 17 was significantly higher in density compared to Control Stations 6 (north) and 31 (south) and was not different in density from Station 33 (south). Thermal Stations 21, 27, and 30 were significantly higher in density compared to northern control stations but were similar in density to southern stations.

When stations were grouped as Thermal (13, 17, 18, 19, 20, 21, and 29), South Control (31, 32, 33, 34, 35, 38, 39 and 40) and North Control (6, 7, 8, 9, 15, 16, and 23), density was significantly different between the North Control and South Control Stations. However, densities at both controls were not significantly different from density at the thermal stations.

Since polychaetes, molluscs and crustaceans were the major groups that dominated the study area, densities of these groups are summarized in Table 6.2-18 (Polychaeta); 6.2-19 (Mollusca); and 6.2-20 (Crustacea). Except for Stations 1 and 4 where crustaceans dominated, and Station 32 where molluscs and crustaceans co-dominated, polychaetes overwhelmingly dominated the faunal composition. Trends in total faunal density, therefore, were generally influenced by the patterns exhibited by the polychaete component.

Species Richness

The number of taxa collected at each station (species richness) during the various sampling periods is summarized in Table 6.2-21. Overall, highest species richness occurred during February and June 1984 and lowest during July and September 1983. Comparison of June/July data between 1983 and 1984 showed that considerable differences in species richness existed both in thermal and control areas. Overall, species richness was higher in 1984. Spatially, lowest species richness occurred at Stations 4 and 5 and highest at Stations 2, 11, 12, 16, 25, 30, 32-37, 39, and 40. In general, species richness increased offshore. Nearshore stations in the thermal area and near the barge canal had lower numbers of species than comparable nearshore stations south of the intake canal. Significant differences in species richness ('t'-test; 95% level) between comparable thermal and control stations are summarized in Table 6.2-22. Thermal Stations 13, 14, 17, 18, and 20 were not significantly different in species richness from corresponding northern control stations but contained a significantly lower number of species when compared to southern control stations. Thermal Stations 21, 22, 27, 28, and 30 were higher (or similar) in species richness compared to corresponding northern control stations but had a significantly lower numbers of species when compared to southern control stations. Thermal Stations 19 and 29 were significantly lower in species richness when compared to southern control Station 35. Thermal Stations 22, 28, and 30 were higher in species richness compared to northern stations but not significantly different from southern stations. Lower salinity thermal Stations 4 and 5 were not significantly different from northern control Station 1.

The Thermal, Northern and Southern station groupings (as for faunal density comparisons; see previous section), were significantly different from each other in species richness. Lowest species richness was encountered in thermal areas; slightly higher values in the northern transect; and highest values on the southern transect. In general, thermal stations were more comparable to the northern transect than to the southern transect (in terms of species numbers).

Species number for the three major components is summarized in Tables 6.2-23 (Polychaeta), 6.2-24 (Mollusca), and 6.2-25 (Crustacea). Unlike faunal density, molluscs contributed a much larger proportion to the total species richness; however, polychaetes provided the majority of the species. Numbers of molluscan species were particularly low at Stations 4, 5, 8, 13, 14, 15, 17, 18, 19, 20, 21, 28, and 29. A majority of these stations are in the thermal area. Lower numbers of crustacean taxa were found at Stations 4, 5, 8, 17, 18, and 20. All these stations, except 8, are in the thermal area. All of the southern stations were rich in crustacean and molluscan taxa.

Species Diversity and Equitability

Values of Shannon-Weaver diversity index and Pielou's equitability index are summarized in Tables 6.2-26 and 6.2-27, respectively. Lowest diversities (associated with both low equitability and species richness) were observed at Stations 1 and 4. Lower diversities were also observed at Stations 5, 6, 8, 14, 15, 17, 18, 19, 20, 21 and 29. A majority of these stations were in the thermal area. In general, diversity and equitability exhibited similar spatial and temporal trends as those exhibited by species richness; 't' tests of significance revealed the same dissimilarities between the compared stations, i.e., northern stations were generally more similar to the thermal stations. Both thermal and northern stations were different when compared to the southern stations.

Log-Normal Curves

Individuals in natural benthic communities are generally distributed in a log normal fashion among species. Variation from this distribution or from the slope of the straight line produced from a log-normal distribution has been reported to be indicative of stress (Gray and Mirza 1979). Polluted communities are purported to either show a break in the straight line or have angles to the x-axis lower than 35°. Log-normal distribution of individuals per species was fitted and curves drawn for each station and sampling period according to the method described by Gray and Mirza (1979). Angles to the x-axis were measured from these curves and data is summarized in Table 6.2-28.

Utilizing mean angles, the information is portrayed graphically in Figure 6.2-22. Stations in the thermal area and the nearshore northern area had the least log-normal angles (30-35°) indicating possible stress conditions. Offshore northern stations and the southern stations had higher log-normal angles (greater than 40°).

Faunal Similarity

Utilizing Morisita's index, faunal similarity between stations for each of the sampling periods was computed and results are presented as trellis diagrams. Also for each of the periods, a cluster analysis was conducted (Morisita's Index, group average sorting) and results are presented as dendrograms.

Faunal similarity trends during each of the sampling periods can be summarized as follows:

June, 1983 (Figures 6.2-23 and 24): Thermal stations 17, 18, 19, and 27 (Rocky Cove) and Station 6 were similar to each other. Also, Thermal Stations 20 and 21 and Stations 15, 22, 28, and 30 were similar to each other. These groups of stations were generally dissimilar to all other stations. Interestingly, Thermal Station 13 was similar to northern Stations 2 and 7, while Thermal Station 14 was similar to southern Stations 31 and 39. Offshore stations were generally similar to each other, while Station 29 (thermal area) was dissimilar from all other stations.

July, 1983 (Figures 6.2-25 and 26): Thermal Stations 17 and 18 were similar to northern Station 5. Also, Thermal Stations 20, 22, and 29 were similar to each other and to Stations 7 and 15. Thermal Station 13 was similar to Station 27 (Rocky Cove) and Station 31 (Southern). Offshore stations were similar to each other. Stations 9 (Northern) and 30 (Thermal) were similar to each other; Station 4 was dissimilar from all other stations.

September, 1983 (Figures 6.2-27 and 28): Thermal Stations 13, 14, and 17 and Stations 20 and 21 were similar to each other. All other thermal stations were similar to each other and to several stations in the northern area. Southern nearshore areas grouped together in similarity, while most offshore stations were similar to each other. Stations 1 and 29 were dissimilar from all stations.

October, 1983 (Figures 6.2-29 and 30): Most Thermal Stations (13, 17, 18, 20, and 27) grouped together in similarity with northern nearshore stations. Thermal Stations 15 and 22 were similar to each other and Station 7 (northern) and 33 (southern). Offshore stations were similar to each other, while Stations 29 and 4 were dissimilar from all stations.

November, 1983 (Figures 6.2-31 and 32): Thermal Stations 13, 14, and 18 were similar to each other and to several northern nearshore stations and the southern Station 38. Thermal Stations 17, 19, and 29 were similar to each other and to the northern Station 3 and southern Station 32. Thermal Stations 20, 21, 28, and 15 were similar to each other, while Thermal Station 22 was similar to offshore Stations 16 and 24 and to Stations 31 (southern) and 2 (northern). Generally, offshore stations were similar to each other. Station 1 was dissimilar from all other stations.

January, 1984 (Figures 6.2-33 and 34): Thermal Stations 13, 18, 20, and 27 were similar to each other and similar to several northern stations. Thermal Station 17 was generally dissimilar from all stations. Most northern and offshore stations grouped together in similarity. Thermal Station 22 was similar to offshore Stations 26 and 37, while Thermal Station 29 was similar to offshore Station 12.

February, 1984 (Figures 6.2-35 and 36): Thermal Stations 14, 18 and 21 were similar to each other and several nearshore northern stations. Thermal Station 17 was similar only to Station 13 (thermal) and 38 (southern nearshore). Thermal Stations 19, 20, 22, 28, and 29 were similar to each other and were similar to Stations 23 (offshore thermal) and 32 (southern nearshore). Thermal Station 27 was similar to northern Station 3. Stations 1 and 11 were dissimilar from all other stations. Offshore stations generally grouped together in similarity.

April, 1984 (Figures 6.2-37 and 38):Thermal Stations 17, 18, 20, 22, and 29 were similar to several northern and some offshore stations. Thermal Station 13 was similar to offshore Stations 30 (thermal) and 35 (southern). Offshore Stations 25, 26, and 37 grouped together in similarity. Station 12 was dissimilar from all other stations.

June, 1984 (Figures 6.2-39 and 40): Thermal Stations 17, 20, 21, 22, and 27 were similar to each other and to Stations 16 (offshore), 2 and 9 (northern). Thermal Station 18 was similar to Stations 5, 7, 8 (northern), and 15 (offshore thermal). Thermal Station 13 exhibited generally low similarity to all stations but grouped closer to Station 38 (southern nearshore). Offshore stations generally were similar to each other. Stations 1 and 4 were similar to each other but dissimilar from all other stations.

July, 1984 (Figures 6.2-41 and 42): Thermal Stations 17, 20, 22, 27, and 29 were similar to each other and to Station 31 (southern nearshore). Thermal Station 18 was similar to northern Station 5 and 7, while Thermal Station 13 was similar to Station 30 (thermal offshore). In general, offshore stations grouped together. Station 4 was dissimilar from all other stations.

Temporal changes in similarity were examined at each of the 40 stations. Mean faunal similarity between sampling periods at each station is summarized in Table 6.2-29. In general, temporal variability in similarity was high at both thermal and non-thermal areas. Greatest variability occurred at Stations 11 and 29. Comparison of faunal similarity between June/July 1983 and 1984 showed that spatial, faunal affinities of thermal and non-thermal stations were somewhat different between years indicating that annual fluctuations may have altered communities in the study area at both thermal and non-thermal stations. Although these changes caused by annual fluctuations were evident, the groupings of stations for 1983 and 1984 were similar in that thermal stations group together and were similar to several northern control stations.

A faunal similarity analysis combining all quarterly data at each station (Figures 6.2-43 and 44) showed that Thermal Stations 13, 14, 17, and 27 were similar to each other and similar to Station 2 (nearshore northern). Thermal Stations 18, 20, and 21 were similar to each other and to northern Stations 5, 6, 7, and 8 and to Station 15 (thermal offshore). Thermal Station 28 was similar to Stations 23, 30 (offshore thermal), 35 and 36 (offshore southern). Thermal Stations 19 and 29 were somewhat similar to northern Station 3. Northern Stations 9 and 22 were similar to southern Stations 31, 32, and 39. Station 1 and 4 near the barge canal were similar to each other but different from all other stations. Offshore stations generally grouped together in similarity.

Utilizing six-week sampling data at 20 stations, a similar analyses provided essentially the same results (Figures 6.2-45 and 46) except that Thermal Stations 17 and 29 exhibited much lower similarities with other thermal and non-thermal stations. Thermal Station 13 was similar to Stations 30 (offshore thermal) and 35 (southern offshore). Thermal Station 18 was similar to northern Stations 5 and 7 and offshore Thermal Station 15, while Thermal Station 20 was similar to offshore Thermal Station 22 and northern Station 9. In examining temporally uncombined data for all stations (i.e., all possible combinations of time and space) with a faunal similarity cluster analysis, the same trends exhibited by the temporally combined data presented above were evident.

In summary, faunal similarity analyses showed that thermal stations were more often similar to each other and to the northern control stations. Certain stations (e.g., 29, 1, and 4) were different than all other stations. Offshore stations were generally similar to each other. Thermal stations most often similar to each other were: 17, 18, 19, 20, 21, and 22.

Biotic/Abiotic Relationships

Potential correlations between various abiotic parameters and faunal density, species richness and species diversity were examined with the use of linear regressions. Faunal density appeared to be correlated with grain size and to a lesser degree with silt/clay and total organic carbon (significant F value at 95 percent level). Faunal density appeared unrelated to other abiotic factors (temperature, salinity, turbidity, TSS and sediment sulfides, sorting and Eh; Table 6.2-30). Species richness appeared to be correlated with temperature and salinity and to a lesser degree with sediment parameters (Table 6.2-31). Similarly, species diversity appeared to be correlated with temperature and salinity and to a lesser degree with sediment parameters (Table 6.2-32).

In terms of sediment preference of the dominant species in the study area, Fabricia sp. A was most abundant at stations with coarser sediments (11, 13, 23, 26, 28, 29, 30, 34, 35, 36, and 38) at least during some times of the year. Streblospio benedicti was most abundant at stations with silty sediments (4, 5, 6, 8, 15, 18, and 21). However, S. benedicti was most abundant at siltier stations offshore and in the southern transects. Aricidea philbinae was abundant in a variety of sediment types and was most abundant in the thermal areas. Other dominant species did not exhibit any clear cut preference for sediments or other abiotic parameters.

In summary, temperature appears to affect species richness and diversity while sediment parameters control faunal density in the study area.

Annual Faunal Fluctuations

Long-term annual fluctuations in benthic communities have been observed by several investigators (Pearson 1975, Santos and Simon 1980; Dugan and Livingston 1982; Mahoney and Livingston 1982). Between June/July of 1983 and 1984 considerable changes in species composition, faunal density and species richness occurred in the study area indicating that annual fluctuations may be extremely important. Thermal effects on various community parameters appear to be similar between the two years. Evaluation of the magnitude of differences in community parameters between thermal and control areas showed: 1) annual fluctuations were clearly evident and 2) thermal effects were exhibited in addition to the annual fluctuations.

6.2.3 Impact Assessment

Introduction

The benthic community is generally considered to be the best faunal group for assessing environmental stress due to its relative lack of mobility and varied sensitivity to physiological stresses (Dills and Rogers 1972). In addition, the relatively long life histories of benthic organisms make them valuable indicators of past and present water quality (Mackenthun 1966; McKee 1966; Cairns and Dickson 1971).

Temperature is a primary environmental factor in the distribution and survival of aquatic organisms. Sediment type is a specific factor affecting the zonation of benthic organisms, particularly the infauna (Peterson 1913; 1915; 1918; Thorson 1957; Sanders 1958; Bloom et al 1972; Pearson 1975). Apart from other biological factors (such as competition, predation, etc.), temperature and sediment type seem to be the major factors in benthic faunal distribution. Since various species tolerate temperature increases to differing degrees and display temperature induced reproduction, increased temperature could have both "positive" and "negative" effects. In theory, when heated effluent is introduced into a benthic environment, the following species-specific processes would occur:

1. Some temperature "sensitive" (stenothermal) species would disappear.

2. Some new species would immigrate into the now warm environment.

3. Some species (eurythermal opportunists) would increase in abundance.

4. Some temperature "sensitive" species would decrease in abundance.

Depending on the balance of (1) and (2), diversity (species richness) of the heated environment would either increase or decrease. Dominance would probably be a prime factor in response to changes in (3) and (4). Seasonal changes would, of course, complicate the process.

In a natural eurythermal environment such as Crystal Bay, a shallow subtropical bay where there is a high incidence of eurythermal species, heated effluents (within lethal limits for individual species) may not have a pronounced or detectable effect on the benthic fauna. On the other hand, synergistic effects and biological changes in the other components of the ecosystem (e.g., plankton) would indirectly affect the composition and structure of benthos. This has been recognized by various authors in the past (Markowski 1960; Pearce 1969; Mackenthun 1969; Virnstein 1972; Davis 1972).

Rowe et al (1972) documented the effects of thermal pollution in the lower Mystic River. They identified zones of extreme stress characterized by low faunal density, biomass and species diversity. An interesting study by Logan and Maurer (1975) on the diversity of marine invertebrates in a thermally affected area of the Indian River (Delaware Bay), identified an extremely high diversity zone in the immediate vicinity of the thermal discharge caused by the existence of "pioneer" communities in a state of "non-active equilibrium" (i.e., a community with low dominance, high equitability and low faunal density). Similar zones were reported earlier by Warinner and Brehmer (1966) and Nauman and Cory (1969). A few opportunistic species (e.g., Nereis succinea, Heteromastus filiformis) have also been suggested by Logan and Maurer (1975) as indicators of thermal effects.

Temporally, the most severe effects of the thermal effluent on the benthic fauna would be expected in the summer (Naylor 1965; Warinner and Brehmer 1966; Pearce 1969; Nauman and Cory 1969). However, disruptions in communities due to "cold shock" in winter (due to variability of power plant operation) cannot be ruled out.

Bamber and Spencer (1984) in a recent study of thermal effects on benthic communities in River Medway Estuary showed that areas most influenced by the discharge are: (1) significantly depressed in species richness; (2) higher in densities caused by a few species, i.e., oligomixity; and (3) dominated by opportunistic species that were tolerant of thermal stress (and not organic stress, such as Capitella capitata). Overall, they concluded that thermal effects were limited to the discharge canal and where the thermal discharge impinged on the bottom.

Previous benthic faunal studies at Crystal River are not directly comparable to the present study because of significant differences in methodology and areas of investigation. Historical benthic information from the study area appears to indicate that thermal effects in the form of depressed species richness and abundance occur in the discharge basin. However, drawbacks in the methods used and the limited area of investigation inhibits any conclusion that can be comprehensive in terms of spatial and temporal thermal effects.

From studies described in literature, some of the expected thermal effects on the benthic infaunal communities in the vicinity of the power plant at Crystal River can be summarized as follows.

1. Reduced species richness;

2. Increased or decreased total abundance (faunal density);

3. Increase in the abundance of some eurythermal and opportunistic species;

4. Immigration and abundance of thermal pollution indicator species;

5. Emigration and/or decrease in the abundance of some stenothermal species;

6. Decreased diversity and equitability;

7. Increased dominance (i.e., oligomixity) of a few species;

8. Alteration of basic community structure;

9. Faunal dissimilarity compared to adjacent natural or undisturbed communities.

To evaluate thermal effects in the study area the nine characteristics listed above are tested as hypotheses statements (below) leading to an impact assessment of benthic communities in the vicinity of the power plant.

Species Richness

In general, all thermal stations were lower in species richness than corresponding southern control stations, but not the northern control stations. Therefore, it appears that the thermal effluent in concert with silty conditions found in the northern areas reduces total species richness in an area bounded by Stations 17, 13, 14, 21, and 27. However, no statistically significant differences in species richness between thermal stations and northern control stations were noted.

Examination of molluscan and crustacean species richness provides stronger evidence of thermal effects. Molluscan species richness was considerably lower at Thermal Stations 13, 14, 17-21, 28, and 29 and Stations 4, 5 (low salinity-thermal regime), 15 (slight thermal), and 8 (northern Control Station). Similarly, crustacean species richness was lower at Thermal Stations 17-20 and Stations 4, 5, and 8. Stations 8 and 15 have slightly higher temperatures than plant intake temperatures (Table 6.2-3). Stations 4, 5, and 8 had a high silt/clay content probably causing the reduced molluscan and crustacean species richness. Therefore, it appears that the thermal effluent reduces the species richness of molluscs and crustaceans primarily in an area bounded by Stations 13, 14, 17, 21, and 29 (Figure 6.2-47). The cause of depressed species richness at Station 15 is unknown.

Faunal Density

In general, faunal density at the thermal stations was not statistically different from densities at both southern and northern control stations. Thermal Stations 17, 21, and 27 were higher in densities when compared with northern control stations, while Station 18 was lower in density compared to its corresponding southern control station. Using either increased or decreased abundance as criteria of adverse thermal effects, it appears that the area bounded by Stations 17, 21, and 27 is adversely affected in terms of abundance (Figure 6.2-48). The change in density does not encompass all stations within this area, and therefore the extent of the thermal effect is not clear.

Eurythermal and Opportunistic Species

Streblospio benedicti, a eurythermal and opportunistic species, was most dominant in the northern nearshore areas, especially at the stations with silty conditions. Thermal Stations 18 and 20 had a greater abundance of *S.*

benedicti than other thermal and southern control stations. Aricidea philbinae was most abundant at Thermal Stations 13, 17, and 27. Tharyx cf. dorsobranchialis was most abundant at Thermal Stations 13, 14, 17, 20, 22, 27, 28, and 29, and appears to prefer areas with a higher temperature regime. Aricidea taylori exhibited increased abundance at Thermal Stations 17, 20, 22, and 27. The species abundance patterns discussed above appear to indicate that the area bounded by Stations 13, 14, 17, 22, and 29 is affected by the thermal effluent in the form of increased abundance of selected eurythermal opportunists (Figure 6.2-49).

Thermal Pollution Indicators

Greatest abundance of thermophilic opportunistic species, Laoenereis culveri and Neanthes succinea were at Stations 13, 17, 18, and 27. N. succinea was abundant also at northern control Stations 2, 3, and 6, Thermal Stations 19 and 29 and southern control Station 32. Heteromastus filiformis, also considered a thermophilic opportunist, was most abundant at Station 17. Polydora websteri was most abundant at Stations 13, 19, and 29. Based on the abundance of indicator species, the area bounded by Stations 17, 13, 19, and 29 appears to be adversely affected by the thermal effluent (Figure 6.2-50).

Stenothermal Species

Higher dominance and lower species richness at the thermal stations and northern control stations appears to have excluded several "rare" species found in the southern control areas. This exclusion of several species may be a response to higher temperatures in the thermal zone, especially during the summer. However, habitat heterogeneity in the southern areas (presence of seagrass beds and less silty conditions) probably plays a much larger role than temperature in determining presence or absence of rare species. In terms of dominant species, Paraprionospio pinnata, was the only species that was widespread among nearshore different habitat types but was least abundant at Thermal Stations (especially during the summer) 13, 14, 17, 18, 19, 27, 28, and 29 (Figure 6.2-18). Mediomastus ambiseta was most abundant at nearshore northern and southern controls but not at the thermal stations (Figure 6.2-8). Haploscoloplos foliosus and H. fragilis similarly appeared to avoid thermal areas, but were also not abundant in southern control areas. The thermal effluent, therefore, appears to adversely affect the distribution of P. pinnata and M. ambiseta and probably the distribution of H. foliosus, H. fragilis, and several rare species. Species which were more abundant offshore, such as Mediomastus sp., Myriochele oculata and Goniadides carolinae are probably stenothermal but do not occur in abundance in either of the nearshore control areas. Since many of the other dominant species (e.g., Fabricia sp. A) remained unaffected, and since the study area is expected to primarily contain eurythermal species (subtropical and shallow), exclusion and reduction in abundance of stenothermal species can be considered minimal.

Species Diversity and Equitability

In general, species diversity and equitability values were lower at Thermal Stations 14, 17-21, and 29 and at Stations 5 (low salinity-thermal), 8, 15 (slightly thermal), and 6 (northern control). Southern control stations were much higher in these parameters than the northern and thermal areas. Therefore, it appears that the area bounded by Stations 17, 14, 21, and 29 is adversely affected in diversity and equitability by the thermal effluent (Figure 6.2-51). Similar low values were found at the northern control stations.

Oligomixity

Dominance of few species (oligomixity) was a common phenomenon in the study area. This phenomenon was especially accentuated in the thermal areas and the northern nearshore control areas (Figure 6.2-21). The striking dissimilarity in oligomixity between the southern/offshore stations and the northern/thermal stations may be indicative of stress conditions imposed by a combination of temperature and silty conditions in the northern and thermal stations.

Community Structure

The study area appears to be composed of four types of communities (Figure 6.2-17). Areas dominated by *Halmyrapseudes* and *Brachidontes* were small. The offshore community dominated by *Mediomastus*, *Myriochele*, and *Goniadides* was distinct and widespread in both northern and southern areas. The nearshore community dominated by *Aricidea*, *Tharyx*, *Streblospio*, and *Fabricia* spanned thermal, northern and southern areas. Therefore, it appears that the basic components of the community remain unchanged by the effects of the thermal effluent. Evaluation of the log-normal distribution (Figure 6.2-22) among the communities at each station, however, shows that thermal areas bounded by Stations 17, 13, 21, and 29, the nearshore northern control stations (6 and 7), and the low salinity/high temperature stations (4 and 5) have an altered intrinsic structure indicating stress conditions (Sensu, Gray and Mirza, 1979). It can be surmised that environmental stress in different forms (silty conditions and/or temperature increases) change the basic log-normal distribution of communities. It appears, therefore, that while stations in the thermal regime are adversely affected by the effluent, stations in the north are adversely affected by silty conditions. The absence of such a change in the southern stations and the apparent gradient (Figure 6.2-22) in log-normal distribution with distance from the point of thermal discharge strengthens this conclusion. Other community structure parameters, such as faunal density, abundance of dominant species, diversity and equitability have been discussed earlier and tend to confirm the alterations to structure caused by the thermal effluent (as shown by the evaluation of log-normal distributions).

Faunal Similarity

Detailed descriptions of faunal similarities between stations are provided in the results section. In general, the area bounded by Stations 17, 13, 14, 21, and 28 exhibited faunal homogeneity (Figure 6.2-52) with some similarities to the northern control stations but was dissimilar from the southern control stations. During September (1983), Station 17 contained a unique species composition: over 75 percent of the total abundance was contributed by three species, *Aricidea taylori*, *A. philbinae*, and *Laeonereis culveri*, probably as a response to elevated temperatures during the summer period. Similar dominance of few species occurred at Stations 18, 19, 20, 21, and to a lesser extent at Stations 13, 14, 15, 27, 28, and 29. *Aricidea taylori*, *A. philbinae*, *L. culveri*, *Tharyx* cf. *dorsobranchialis*, and *Streblospio benedicti* were dominant at these stations. In the winter (January 1984), Thermal Station 17 was dissimilar to all stations by having a super abundance of A. philbinae, probably as a response to elevated temperatures that were optimal for A. philbinae. Overall, the faunal similarity analyses indicated that thermal effects are limited to the area shown in Figure 6.2-52. However, similarity of many of the thermal stations to northern control stations indicate that although changes have occurred in the thermal areas, the significance of the change is questionable.

General Considerations/Summary

As expected, two factors appear to play a major role in the distribution of benthic infauna in the study area: sediment type and temperature. While sediment type seems to control density of organisms, temperature controls species richness and diversity (see Results). Therefore, in examining the effects of the thermal effluent, sediment type is the most important element to keep constant. Salinity plays a controlling role only at a few stations near the Withlacoochee River and the Barge Canal. To discern thermal effects, comparisons were made only between stations which were similar in sediment type. Utilizing this strategy, the examination of various community parameters and hypotheses in relation to the thermal effluent suggests that adverse effects caused by the discharge are generally minimal, because they have not encompassed large areas or caused catastrophic changes. However, there is strong evidence (as discussed earlier) to indicate that subtle adverse changes have occurred in the communities bounded by Stations 17, 13, 14, 21, and 29 (Figure 6.2-47). A lesser degree of change seems to have occurred at Stations 4, 5, 22, and 30. The greatest degree of adverse thermal effects appears to be limited to the area bounded by Stations 13, 17, and 18 (Figure 6.2-53).

Overall, the study area (especially the northern areas) can be classified as a stressed habitat for benthic infaunal communities. Natural perturbations in the form of storms appear to affect bottom conditions because of the shallow nature of the study area. Presence of seagrasses in the southern areas probably limits the perturbation caused by storms. Considering the effect of ~~the storms, and the silty conditions associated with the barge canal spoil~~ islands, benthic infaunal communities in the study area are probably resilient and adapted to disturbances. Characteristic of such communities is a preponderance of opportunists and species which have short lives and high reproductive rates, i.e., an 'r' selected community (sensu MacArthur and Wilson 1967; Pianka 1971). The effect of the thermal effluent on such a community is to further modify its structure toward an even more opportunistic and resilient state until survival is affected. This shift is evident only at Stations 13, 17, and 18; survivability does not seem to be affected.

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Table 6.2-1 Station Depths.

Station	$\bar{x}$ (m)	S.D. (m)	Station	$\bar{x}$ (m)	S.D. (m)
1	0.84	0.34	21	2.31	0.44
2	1.16	0.49	22	2.41	0.39
3	1.81	0.51	23	3.01	0.53
4	1.61	0.45	24	2.95	0.53
5	1.51	0.47	25	3.73	0.60
6	1.46	0.55	26	4.25	0.49
7	1.50	0.47	27	1.35	0.43
8	1.80	0.50	28	2.04	0.49
9	2.21	0.53	29	1.74	0.69
10	2.68	0.42	30	1.88	0.55
11	2.92	0.54	31	1.32	0.41
12	4.27	0.45	32	1.25	0.37
13	0.96	0.39	33	2.07	0.44
14	1.39	0.45	34	2.66	0.41
15	1.83	0.47	35	2.17	0.46
16	2.11	0.45	36	3.45	0.66
17	0.77	0.31	37	3.69	0.56
18	1.60	0.45	38	1.15	0.47
19	1.22	0.50	39	2.19	0.40
20	2.04	0.45	40	3.77	0.47

Table 6.2-2 Synoptic Bottom Temperatures in ^{o}C --- 6 Week Means.

Sta. #	June 1983	July 1983	Sept 1983	Oct 1983	Nov 1983	Jan 1984	Feb 1984	Apr 1984	June 1984	July 1984	Mean	Std. Dev.
1	28.58	30.17	30.43	26.70	21.47	14.81	15.23	20.21	27.03	29.05	24.37	5.99
2	28.42	30.25	30.40	27.08	21.29	14.36	14.07	19.46	26.88	29.50	24.17	6.38
3	27.95	30.11	30.34	26.87	21.12	13.85	13.56	19.20	26.72	29.51	23.92	6.52
4	28.26	30.57	31.67	27.79	22.66	16.03	16.11	20.94	28.13	30.63	25.28	5.93
5	28.26	30.46	31.59	27.70	23.05	16.10	16.11	19.52	28.00	30.47	25.13	5.98
6	23.51	30.34	31.12	27.24	22.00	15.54	15.69	20.35	27.74	29.86	24.34	5.84
7	25.09	30.10	31.05	27.56	22.23	15.01	15.09	19.61	27.50	29.86	24.31	6.05
8	28.11	30.06	30.85	27.32	22.11	14.80	15.18	19.69	27.34	29.76	24.52	6.13
9	27.97	30.12	30.55	27.10	21.73	14.39	14.38	18.96	26.96	29.93	24.21	6.37
10	28.19	30.01	30.43	26.87	21.50	14.44	13.74	19.36	26.82	29.33	24.07	6.36
11	28.33	29.86	30.37	26.82	21.31	14.34	13.25	19.17	26.51	29.16	23.91	6.45
12	28.37	29.92	30.27	26.70	21.35	14.38	12.94	18.90	26.43	29.10	23.84	6.50
13	29.72	31.67	33.10	28.43	24.37	19.29	17.35	22.41	29.96	32.72	26.90	5.68
14	28.72	31.21	32.28	28.10	23.87	17.52	17.15	21.01	28.89	31.21	26.00	5.71
15	28.20	30.41	31.10	27.38	22.12	15.21	15.52	20.15	27.76	30.35	24.82	6.11
16	28.16	30.14	31.08	27.26	22.04	15.05	14.78	19.93	27.03	29.77	24.52	6.16
17	30.80	32.11	33.77	30.58	25.63	22.06	21.09	24.23	32.42	33.60	28.63	4.88
18	30.74	32.56	34.03	29.20	25.25	18.67	17.83	22.78	31.24	32.74	27.51	5.98
19	30.44	32.30	33.64	29.56	25.23	17.46	18.01	22.88	30.56	33.19	27.33	6.08
20	29.48	31.47	32.33	28.32	23.91	16.40	18.28	21.27	30.12	31.91	26.35	5.93
21	29.03	30.98	32.25	28.41	23.85	16.54	17.62	21.07	29.49	31.60	26.09	5.88
22	33.20	30.48	31.09	27.99	23.39	16.47	16.81	20.07	28.34	30.08	25.79	6.15
23	27.85	30.02	30.56	27.46	23.13	16.43	15.84	19.97	26.69	29.67	24.76	5.58
24	27.94	29.89	30.43	26.73	21.41	14.96	13.76	19.28	26.29	29.08	23.98	6.20
25	28.06	29.81	30.29	26.64	21.43	14.42	13.12	19.07	26.23	29.14	23.82	6.40
26	28.06	29.83	30.46	26.62	21.37	14.31	12.90	18.96	26.31	29.06	23.79	6.49
27	28.65	30.36	31.62	27.35	21.97	16.14	15.95	21.21	28.11	30.01	25.14	5.87
28	28.76	31.16	32.15	27.79	23.04	16.80	16.25	22.35	28.84	31.04	25.82	5.87
29	29.17	31.05	32.68	29.06	24.65	17.13	17.44	21.49	29.04	32.05	26.38	5.85
30	28.25	30.41	31.21	27.78	23.75	16.56	16.18	21.07	27.71	30.30	25.32	5.64
31	27.67	29.97	30.37	26.45	20.58	13.65	14.11	19.60	26.57	29.31	23.83	6.38
32	28.04	30.09	30.38	26.40	20.72	13.66	14.18	19.60	26.56	29.35	23.89	6.39
33	27.78	29.95	30.39	26.46	20.93	13.68	13.72	19.16	26.61	29.39	23.81	6.47
34	27.76	30.08	30.26	26.45	20.91	13.84	13.47	19.52	26.05	29.26	23.76	6.42
35	28.38	29.84	30.24	26.35	21.18	13.96	13.43	19.32	26.10	29.18	23.80	6.42
36	28.34	29.49	30.32	26.31	21.20	14.04	13.22	19.22	26.15	29.13	23.74	6.42
37	28.40	29.77	30.30	26.35	22.38	14.38	13.11	19.15	26.17	29.17	23.92	6.38
38	28.38	29.90	30.06	26.90	21.18	14.88	15.23	19.70	26.34	29.49	24.21	5.97
39	27.74	29.86	30.27	26.57	20.81	13.76	13.88	19.27	26.20	29.17	23.75	6.37
40	28.28	29.99	30.33	26.33	20.93	13.91	13.09	19.27	27.83	29.05	23.90	6.60

Table 6.2-3 Synoptic Bottom Temperature Variation from 'Ambient'--6 Week Means.

Sta. #	June 1983	July 1983	Sept 1983	Oct 1983	Nov 1983	Jan 1984	Feb 1984	Apr 1984	June 1984	July 1984	Mean	Std. Dev.
1	0.70	-0.03	0.30	0.06	0.04	0.19	0.56	0.64	0.70	-0.08	0.31	0.32
2	0.54	0.05	0.27	0.44	-0.14	-0.26	-0.60	-0.11	0.55	0.37	0.11	0.39
3	0.07	-0.09	0.21	0.23	-0.31	-0.77	-1.11	-0.37	0.39	0.38	-0.14	0.50
4	0.38	0.37	1.54	1.15	1.23	1.41	1.44	1.37	1.80	1.50	1.22	0.48
5	0.38	0.26	1.46	1.06	1.62	1.48	1.44	-0.05	1.67	1.34	1.07	0.63
6	-4.37	0.14	0.99	0.60	0.57	0.92	1.02	0.78	1.41	0.73	0.28	1.67
7	-2.79	-0.10	0.92	0.92	0.80	0.39	0.42	0.04	1.17	0.73	0.25	1.14
8	0.23	-0.14	0.72	0.68	0.68	0.18	0.51	0.12	1.01	0.63	0.46	0.35
9	0.09	-0.08	0.42	0.46	0.30	-0.23	-0.29	-0.61	0.63	0.80	0.15	0.45
10	0.31	-0.19	0.30	0.23	0.07	-0.18	-0.93	-0.21	0.49	0.20	0.01	0.41
11	0.45	-0.34	0.24	0.18	-0.12	-0.28	-1.42	-0.40	0.18	0.03	-0.15	0.53
12	0.49	-0.28	0.14	0.06	-0.08	-0.24	-1.73	-0.67	0.10	-0.03	-0.22	0.61
13	1.84	1.47	2.97	1.79	2.94	4.67	2.68	2.84	3.63	3.59	2.84	0.98
14	0.84	1.01	2.15	1.46	2.44	2.90	2.48	1.44	2.56	2.08	1.94	0.70
15	0.32	0.21	0.97	0.74	0.69	0.59	0.85	0.58	1.43	1.22	0.76	0.38
16	0.28	-0.06	0.95	0.62	0.61	0.43	0.11	0.36	0.70	0.64	0.46	0.30
17	2.92	1.91	3.64	3.94	4.20	7.44	6.42	4.66	6.09	4.47	4.57	1.67
18	2.86	2.36	3.90	2.56	3.82	4.05	3.16	3.21	4.91	3.61	3.44	0.77
19	2.56	2.10	3.51	2.92	3.80	2.84	3.34	3.31	4.23	4.06	3.27	0.67
20	1.60	1.27	2.20	1.68	2.48	1.78	3.61	1.70	3.79	2.78	2.29	0.87
21	1.15	0.78	2.12	1.77	2.42	1.92	2.95	1.50	3.16	2.47	2.02	0.76
22	5.32	0.28	0.96	1.35	1.96	1.85	2.14	0.50	2.01	0.95	1.73	1.42
23	-0.03	-0.18	0.43	0.82	1.70	1.81	1.17	0.40	0.36	0.54	0.70	0.67
24	0.06	-0.31	0.30	0.09	-0.02	0.34	-0.91	-0.29	-0.04	-0.05	-0.08	0.36
25	0.18	-0.39	0.16	0.00	0.00	-0.20	-1.55	-0.50	-0.10	0.01	-0.24	0.51
26	0.18	-0.37	0.33	-0.02	-0.06	-0.31	-1.77	-0.61	-0.02	-0.07	-0.27	0.59
27	0.77	0.16	1.49	0.71	0.54	1.52	1.28	1.64	1.78	0.88	1.08	0.54
28	0.88	0.96	2.02	1.15	1.61	2.18	1.58	2.78	2.51	1.91	1.76	0.64
29	1.29	0.85	2.55	2.42	3.22	2.51	2.77	1.92	2.71	2.92	2.32	0.75
30	0.37	0.21	1.08	1.14	2.32	1.94	1.51	1.50	1.38	1.17	1.26	0.64
31	-0.21	-0.23	0.24	-0.19	-0.85	-0.97	-0.56	0.03	0.24	0.18	-0.23	0.44
32	0.16	-0.11	0.25	-0.24	-0.71	-0.96	-0.49	0.03	0.23	0.22	-0.16	0.43
33	-0.10	-0.25	0.26	-0.18	-0.50	-0.94	-0.95	-0.41	0.28	0.26	-0.25	0.46
34	-0.12	-0.12	0.13	-0.19	-0.52	-0.78	-1.20	-0.05	-0.28	0.13	-0.30	0.42
35	0.50	-0.36	0.11	-0.29	-0.25	-0.66	-1.24	-0.25	-0.23	0.05	-0.27	0.46
36	0.46	-0.71	0.19	-0.33	-0.23	-0.58	-1.45	-0.35	-0.18	0.00	-0.32	0.53
37	0.52	-0.43	0.17	-0.29	0.95	-0.24	-1.56	-0.42	-0.16	0.04	-0.14	0.66
38	0.50	-0.30	-0.07	0.26	-0.25	0.26	0.56	0.13	0.01	0.36	0.15	0.30
39	-0.14	-0.34	0.14	-0.07	-0.62	-0.86	-0.79	-0.30	-0.13	0.04	-0.31	0.35
40	0.40	-0.21	0.20	-0.31	-0.50	-0.71	-1.58	-0.30	1.50	-0.08	-0.16	0.79

Table 6.2-4 Thermograph Temperatures in ^{o}C --- 6 Week Means.

Sta. #	June 1983	July 1983	Sept 1983	Oct 1983	Nov 1983	Jan 1984	Feb 1984	Apr 1984	June 1984	July 1984	Mean	Std. Dev.
1	*	28.42	28.28	26.37	20.87	13.65	15.17	18.42	25.00	26.60	22.53	5.68
2	*	28.42	28.28	26.37	20.87	13.65	15.17	18.42	25.00	26.60	22.53	5.68
3	*	28.72	28.83	23.73	20.35	14.65	13.60	18.40	24.62	27.27	22.24	5.80
4	26.50	28.53	29.12	26.25	21.25	15.52	15.32	19.17	25.30	27.50	23.44	5.24
5	*	29.60	28.83	26.17	21.97	16.17	14.90	19.50	24.12	26.90	23.13	5.36
6	*	28.90	29.50	26.32	21.57	15.77	15.40	17.58	24.87	25.90	22.87	5.49
7	*	29.42	29.80	26.97	21.83	17.96	14.32	18.47	25.23	27.00	23.44	5.53
8	*	28.40	28.35	26.12	21.15	16.10	14.93	18.57	25.53	27.50	22.96	5.36
9	*	28.40	28.35	26.12	21.15	16.10	14.93	18.57	25.53	27.50	22.96	5.36
10	*	29.10	29.38	26.12	19.85	14.98	*	18.03	24.42	*	23.13	5.60
11	*	27.70	27.15	26.57	20.80	14.92	15.53	17.93	24.58	26.50	22.41	5.19
12	*	28.58	28.78	25.55	21.02	17.25	12.88	17.55	23.75	*	21.92	5.75
13	30.10	31.38	31.92	28.47	23.47	18.28	17.90	20.38	27.87	29.55	25.93	5.44
14	27.60	29.65	30.58	27.38	23.04	16.77	15.58	17.87	25.98	28.00	24.25	5.58
15	*	29.42	29.80	26.97	21.83	17.96	14.32	18.47	25.23	27.00	23.44	5.53
16	*	27.92	30.72	25.95	20.78	14.37	14.13	18.27	25.38	27.00	22.73	6.06
17	29.00	30.28	32.27	29.95	*	21.70	18.95	22.90	28.78	31.45	27.25	4.79
18	30.10	31.80	34.35	31.03	26.83	20.43	19.02	*	30.28	32.15	28.44	5.34
19	30.80	31.50	31.42	29.02	26.10	21.95	18.92	21.65	28.77	30.90	27.10	4.68
20	29.30	30.76	32.72	28.62	24.20	18.53	17.55	21.22	27.90	30.50	26.13	5.40
21	28.50	30.12	31.20	26.33	23.18	17.37	18.10	18.50	27.35	30.55	25.12	5.44
22	27.30	29.07	29.68	26.97	21.06	15.48	14.93	18.85	26.25	27.90	23.75	5.65
23	*	29.04	*	25.78	21.52	15.90	14.98	19.65	24.92	26.67	22.31	5.15
24	*	28.63	28.98	26.20	20.72	15.48	14.17	17.78	24.27	*	22.03	5.84
25	*	28.48	28.45	25.13	21.08	14.12	13.95	16.63	24.55	26.57	22.11	5.89
26	*	29.18	29.54	26.17	20.72	14.65	13.62	18.00	24.85	27.07	22.64	6.10
27	*	*	*	*	*	*	*	*	*	*	*	*
28	28.40	29.75	30.70	27.52	22.53	16.28	16.18	20.40	26.82	28.80	24.74	5.49
29	28.90	30.10	30.97	25.87	22.58	16.80	16.23	19.13	26.12	28.60	24.53	5.52
30	*	30.07	29.93	27.42	21.28	16.35	15.53	18.78	24.43	25.45	23.25	5.54
31	*	*	29.42	26.22	19.90	14.18	14.83	18.92	24.67	26.53	21.84	5.69
32	*	*	29.42	26.22	19.90	14.18	14.83	18.92	24.67	26.53	21.84	5.69
33	*	*	29.42	26.22	19.90	14.18	14.83	18.92	24.67	26.53	21.84	5.69
34	*	28.82	29.04	26.57	19.76	14.18	14.60	17.88	24.85	26.50	22.47	5.93
35	*	28.97	29.32	26.15	20.23	14.43	13.27	17.62	24.50	26.10	22.29	6.10
36	*	28.75	29.08	24.23	21.25	14.25	13.55	16.33	25.28	26.75	22.16	6.10
37	*	28.35	29.80	25.63	20.30	14.55	13.28	17.52	24.27	26.13	22.20	6.03
38	*	*	29.42	26.22	19.90	14.18	14.83	18.92	*	26.53	21.43	6.02
39	*	28.83	*	25.50	19.72	14.35	13.23	18.28	24.55	26.05	21.31	5.76
40	*	28.83	*	25.50	19.72	14.35	13.23	18.28	24.55	26.05	21.31	5.76

* = Missing data.

Table 6.2-5 Mean Sediment Temperature in C°.

Sta. #	June 1983	Sept 1983	Nov 1983	Feb 1984	June 1984	Mean	Std. Dev.
1	27.99	27.17	19.57	17.01	26.28	23.60	4.97
2	27.57	27.92	18.48	17.22	26.68	23.57	5.26
3	27.44	27.77	18.30	17.52	26.55	23.52	5.14
4	27.60	29.83	19.70	17.78	28.84	24.75	5.58
5	27.49	29.90	18.84	18.96	28.63	24.76	5.42
6	27.08	28.81	18.67	17.86	28.52	24.19	5.45
7	27.70	29.36	19.66	18.15	27.35	24.44	5.14
8	27.60	29.19	19.24	18.06	26.92	24.20	5.15
9	27.46	28.96	18.99	17.78	26.73	23.98	5.19
10	27.39	28.83	18.65	17.67	26.09	23.73	5.18
11	27.48	28.81	18.16	17.65	25.58	23.54	5.27
12	27.52	28.95	17.73	17.42	25.58	23.44	5.49
13	27.18	31.61	23.38	19.18	31.12	26.49	5.27
14	28.11	31.25	19.08	19.87	30.09	25.68	5.78
15	27.82	29.49	20.48	18.35	27.60	24.75	4.98
16	27.44	29.08	19.38	18.05	26.64	24.12	5.03
17	29.21	35.49	*	20.26	31.79	29.19	6.49
18	28.62	31.48	22.76	20.37	30.74	26.79	4.96
19	28.65	32.69	22.43	22.43	30.62	27.36	4.73
20	28.46	30.34	22.93	19.96	32.34	26.81	5.19
21	28.38	30.03	22.52	21.01	31.12	26.61	4.56
22	27.54	29.27	21.70	18.04	26.86	24.68	4.66
23	27.52	29.21	18.83	17.66	26.30	23.90	5.28
24	27.45	28.97	17.97	18.92	25.89	23.84	5.06
25	27.58	29.00	17.72	17.84	25.66	23.56	5.41
26	27.58	28.89	17.73	17.43	25.55	23.44	5.48
27	28.01	30.82	20.49	18.76	28.89	25.39	5.40
28	28.54	30.58	18.99	19.07	30.25	25.49	5.94
29	27.69	30.02	21.75	19.49	30.44	25.88	4.98
30	27.26	29.38	20.23	18.45	26.38	24.34	4.73
31	26.51	28.96	18.72	17.57	25.90	23.53	5.07
32	26.63	28.05	18.26	17.34	26.14	23.28	5.07
33	27.33	28.83	18.14	17.20	25.98	23.50	5.42
34	27.53	28.50	17.81	17.27	26.15	23.45	5.46
35	27.01	28.30	17.47	17.15	25.69	23.12	5.39
36	27.12	28.43	17.50	16.67	25.68	23.08	5.57
37	27.35	28.21	17.45	16.74	25.50	23.05	5.53
38	27.13	28.52	18.30	18.28	26.16	23.68	4.99
39	27.12	28.58	17.63	17.45	25.47	23.25	5.33
40	27.11	28.47	17.45	16.55	25.52	23.02	5.60

* = Missing data.

Table 6.2-6 Bottom Salinity in o/oo -- 6 Week Means.

Sta. #	June 1983	July 1983	Sept 1983	Oct 1983	Nov 1983	Jan 1984	Feb 1984	Apr 1984	June 1984	July 1984	Mean	Std. Dev.
1	14.31	13.48	12.00	12.76	12.88	11.35	8.56	8.70	8.04	12.39	11.45	2.23
2	16.55	18.11	19.67	21.27	18.84	14.38	14.78	13.53	14.30	18.88	17.03	2.68
3	21.01	22.88	22.89	21.82	21.69	18.59	19.32	16.28	17.45	23.77	20.57	2.53
4	19.25	18.46	16.86	19.00	18.80	18.04	17.00	13.28	14.83	19.83	17.54	2.09
5	19.40	19.36	17.77	18.27	19.25	17.87	16.25	12.33	15.15	18.89	17.45	2.28
6	20.51	19.35	16.85	18.04	18.16	16.01	16.35	12.42	15.76	18.89	17.24	2.29
7	23.10	21.13	20.26	22.00	22.50	18.73	19.93	15.17	17.07	20.81	20.07	2.48
8	21.32	21.93	22.09	21.06	21.95	18.69	19.58	16.19	17.35	22.42	20.26	2.20
9	22.06	23.26	21.93	20.98	22.53	20.57	19.21	17.15	18.48	23.55	20.97	2.12
10	24.12	25.92	25.84	24.53	24.91	22.55	23.70	20.02	20.22	25.19	23.70	2.14
11	24.81	26.68	27.00	25.82	26.68	24.29	24.02	21.80	23.22	27.10	25.14	1.81
12	25.29	29.91	28.79	28.37	28.39	26.05	26.12	22.85	25.12	28.53	26.94	2.19
13	20.88	23.22	22.33	23.31	24.01	24.15	21.09	17.21	19.48	24.10	21.98	2.30
14	19.95	22.97	22.10	21.42	22.81	21.92	19.42	14.27	18.18	21.33	20.44	2.65
15	21.30	24.92	22.92	22.69	22.43	20.23	19.05	15.73	18.82	22.64	21.07	2.66
16	23.58	25.01	24.98	24.27	24.57	22.46	20.44	18.85	20.66	24.84	22.97	2.24
17	22.63	26.07	24.87	26.01	26.33	24.79	23.47	19.90	21.27	25.18	24.05	2.18
18	22.32	23.86	24.04	25.49	25.86	23.50	22.83	18.56	20.81	24.35	23.16	2.19
19	22.41	24.71	23.65	25.12	25.38	23.43	21.80	18.23	20.02	23.60	22.84	2.29
20	22.35	24.93	23.85	24.68	24.57	22.74	22.19	18.12	20.20	23.85	22.75	2.18
21	20.06	24.70	24.63	24.71	24.52	23.56	22.02	18.04	20.17	24.08	22.65	2.43
22	20.90	25.27	25.41	24.47	24.64	23.40	21.72	19.22	20.63	24.73	23.04	2.23
23	22.96	25.34	26.10	25.97	25.35	24.17	22.17	19.91	21.14	25.03	23.81	2.16
24	21.49	26.74	27.23	26.50	26.19	25.03	20.55	21.30	22.87	26.90	24.48	2.64
25	25.31	28.17	28.53	28.07	27.85	25.63	25.53	22.87	24.39	28.11	26.45	1.96
26	26.35	30.56	29.12	28.62	28.80	27.32	25.99	23.07	25.42	28.92	27.42	2.22
27	20.60	24.87	22.76	24.10	23.56	22.78	21.90	18.59	19.39	22.27	22.08	2.02
28	21.47	24.44	23.31	24.32	24.57	23.51	22.31	18.59	19.71	24.05	22.63	2.09
29	22.36	25.14	24.29	25.81	25.22	23.87	22.13	19.24	19.87	24.13	23.21	2.26
30	22.18	25.17	25.13	25.20	25.13	23.20	22.16	19.85	20.76	24.68	23.35	2.02
31	20.77	21.73	20.02	22.75	22.24	19.86	21.21	15.83	15.86	20.82	20.11	2.42
32	20.53	22.57	21.04	22.57	23.59	21.00	20.93	16.92	16.54	21.14	20.69	2.30
33	22.64	24.39	23.95	25.07	25.16	22.49	23.14	18.66	18.52	24.57	22.86	2.44
34	24.24	25.94	25.57	25.81	26.47	23.51	23.42	19.90	21.18	26.62	24.27	2.29
35	24.67	27.64	26.78	26.71	27.45	25.49	24.23	22.01	23.10	27.23	25.53	1.97
36	25.11	28.41	28.13	27.73	27.83	26.26	24.71	22.64	24.08	28.01	26.29	2.04
37	26.41	29.07	29.14	28.52	28.07	25.61	25.64	23.04	25.35	28.79	26.97	2.06
38	16.14	18.85	16.22	15.10	17.18	14.97	12.90	12.96	12.28	17.30	15.39	2.16
39	21.87	24.00	21.94	22.78	22.26	19.38	20.01	15.98	18.96	24.18	21.14	2.55
40	26.53	28.14	25.77	27.84	27.21	24.29	24.63	22.05	23.55	28.01	25.80	2.10

Table 6.2-7 Bottom Turbidity in N.T.U.'s --- 6 Week Means.

Sta. #	June 1983	July 1983	Sept 1983	Oct 1983	Nov 1983	Jan 1984	Feb 1984	Apr 1984	June 1984	July 1984	Mean	Std. Dev.
1	8.10	7.87	8.33	8.07	7.38	7.30	4.53	13.53	12.28	9.93	8.73	2.59
2	4.95	7.85	8.27	5.95	8.13	3.78	3.03	13.82	6.77	8.78	7.13	3.06
3	10.00	9.77	10.68	9.40	4.85	4.88	3.82	20.63	9.00	9.52	9.23	4.65
4	15.55	8.63	22.82	15.82	8.55	8.98	4.55	13.63	13.73	22.50	13.48	6.02
5	9.90	7.70	13.33	28.73	9.78	26.58	5.72	19.10	13.22	9.98	14.40	7.89
6	10.40	9.37	36.08	20.92	11.24	7.88	4.13	12.72	9.40	9.37	13.15	9.12
7	9.90	8.43	11.27	16.37	9.03	6.52	3.83	13.92	6.18	13.07	9.85	3.87
8	7.70	10.93	15.45	14.72	11.95	7.70	4.30	14.18	11.30	11.62	10.99	3.52
9	15.55	8.00	11.00	9.82	5.65	8.07	4.43	42.02	11.60	16.97	13.31	10.83
10	8.50	18.02	10.42	9.65	5.08	5.38	4.48	23.32	10.92	17.58	11.33	6.33
11	5.05	5.53	7.75	7.53	5.53	5.10	4.86	20.93	7.38	6.13	7.58	4.82
12	5.30	5.58	5.02	6.08	4.52	4.20	5.30	14.43	7.98	4.25	6.27	3.07
13	6.35	6.47	8.88	8.30	6.25	4.85	4.83	9.18	8.12	7.70	7.09	1.57
14	6.00	7.98	10.97	9.53	7.30	5.98	5.25	10.13	7.12	8.90	7.92	1.92
15	6.80	11.12	11.37	11.87	9.70	10.30	5.70	17.88	14.38	17.33	11.64	3.99
16	12.00	8.38	10.77	9.85	4.40	4.40	3.15	14.83	10.17	8.95	8.69	3.71
17	10.50	8.08	9.97	6.52	5.37	5.78	4.75	10.28	16.10	8.15	8.55	3.38
18	12.95	6.42	8.73	7.00	11.02	4.95	4.45	9.38	8.22	6.80	7.99	2.64
19	9.35	5.18	10.23	7.60	4.48	3.92	3.62	9.93	7.12	5.65	6.71	2.51
20	9.95	8.37	16.15	8.77	5.05	5.53	4.45	11.57	12.45	9.63	9.19	3.64
21	13.00	8.85	31.73	8.85	30.77	5.62	5.38	14.13	12.77	12.27	14.34	9.41
22	6.75	10.28	13.45	8.12	5.50	7.38	2.65	14.83	8.67	9.50	8.71	3.59
23	8.85	8.60	23.50	8.00	4.47	4.28	3.83	10.93	7.68	6.23	8.64	5.70
24	5.90	6.33	5.08	6.92	4.78	4.75	2.97	14.02	9.07	5.87	6.57	3.06
25	5.25	6.95	6.96	8.18	5.28	5.30	3.83	16.58	10.05	6.32	7.47	3.65
26	3.60	5.03	3.90	6.20	4.27	4.00	3.33	17.22	7.05	3.48	5.81	4.19
27	8.70	9.53	11.42	9.58	5.23	3.57	2.27	6.60	3.82	7.88	6.86	3.05
28	9.20	9.25	8.47	10.17	4.20	3.23	2.65	11.08	4.78	5.02	6.80	3.13
29	8.10	4.68	6.80	13.45	4.45	3.67	3.27	13.55	6.97	6.18	7.22	3.91
30	8.00	8.90	10.03	8.18	4.50	3.99	3.47	12.02	7.13	10.78	7.70	2.94
31	7.20	14.55	2.90	5.17	3.18	3.93	4.28	6.97	3.53	26.78	7.85	7.49
32	5.75	5.22	2.82	4.15	4.10	2.43	3.93	9.22	3.32	6.83	4.78	2.06
33	14.95	10.27	5.88	23.52	5.73	5.58	2.88	13.32	4.90	8.40	9.54	6.24
34	8.90	5.98	5.22	6.50	4.80	4.33	2.08	12.65	17.33	5.13	7.29	4.54
35	5.50	4.58	5.05	5.85	5.20	3.75	2.68	13.18	7.07	5.18	5.87	2.84
36	5.10	3.29	5.47	5.03	5.45	3.03	2.72	15.53	7.98	5.55	5.92	3.71
37	4.80	5.49	6.87	7.10	5.27	3.33	3.00	17.30	9.33	5.08	6.76	4.14
38	3.50	5.43	4.93	3.25	3.50	5.33	2.82	6.78	4.22	9.23	4.90	1.95
39	7.15	3.02	4.58	23.90	4.62	3.48	3.33	9.17	5.75	7.88	7.29	6.19
40	4.35	3.61	6.08	6.78	4.22	2.70	2.38	12.43	8.03	4.43	5.50	3.01

Table 6.2-8 Mean Total Suspended Solids in mg/l.

Sta. #	June 1983	July 1983	Sept 1983	Oct 1983	Nov 1983	Jan 1984	Feb 1984	Apr 1984	June 1984	July 1984	Mean	Std. Dev.
1	10.00	11.00	13.67	14.00	11.33	10.00	6.67	14.67	18.00	25.00	13.43	5.12
2	8.00	11.00	9.00	7.33	5.67	7.00	5.33	10.00	7.00	9.67	8.00	1.88
3	16.00	59.67	15.00	9.33	5.33	10.33	5.67	27.00	8.33	17.00	17.37	16.22
4	19.00	15.67	38.33	15.00	9.00	11.67	9.67	18.67	33.00	15.00	18.50	9.73
5	23.00	38.00	17.00	23.00	19.33	13.00	17.67	15.00	29.67	13.33	20.90	7.89
6	16.00	29.33	18.00	23.33	20.67	14.33	6.33	12.67	10.00	13.00	16.37	6.74
7	36.00	13.00	12.00	16.67	9.67	23.33	6.00	15.33	9.00	10.00	15.10	8.80
8	247.00	15.67	31.00	14.67	17.00	10.67	6.00	16.33	14.33	14.67	38.73	73.45
9	55.00	18.67	15.33	9.33	8.33	10.33	7.67	16.67	12.33	20.33	17.40	13.93
10	127.00	23.67	14.33	14.00	7.33	9.33	8.33	21.67	13.67	25.00	26.43	35.89
11	11.00	10.00	10.00	11.33	8.00	12.00	7.00	33.33	10.33	10.33	12.33	7.53
12	13.00	6.00	9.00	12.67	10.33	9.33	8.00	23.67	10.67	9.33	11.20	4.84
13	10.00	10.00	13.67	15.67	9.33	8.33	6.67	10.33	9.67	13.33	10.70	2.71
14	9.00	8.00	22.33	11.00	7.67	9.00	13.00	12.33	11.00	11.00	11.43	4.22
15	26.00	11.67	13.00	15.00	13.00	20.33	7.00	27.33	23.33	19.67	17.63	6.72
16	24.00	15.33	15.33	15.00	7.33	8.67	7.00	11.67	16.33	11.00	13.17	5.16
17	10.00	9.67	14.00	11.00	8.33	11.00	7.33	17.33	17.33	12.67	11.87	3.46
18	10.00	10.67	16.67	11.00	12.00	9.33	8.67	13.00	10.67	10.00	11.20	2.29
19	15.00	11.00	11.33	13.00	8.33	8.67	7.33	14.33	11.00	9.00	10.90	2.61
20	15.00	13.00	19.67	12.00	7.67	10.00	11.67	14.00	11.00	33.33	14.73	7.28
21	18.00	17.33	52.33	13.33	8.00	13.00	9.67	12.33	16.33	10.67	17.10	12.81
22	10.00	17.33	16.00	14.67	9.00	15.33	7.33	15.00	11.33	11.00	12.70	3.38
23	19.00	9.00	18.00	10.00	7.00	10.00	6.00	11.67	21.33	13.00	12.50	5.26
24	13.00	12.00	10.33	10.33	6.00	11.00	6.00	14.67	11.00	9.67	10.40	2.74
25	15.00	8.67	11.33	14.33	7.33	12.33	7.67	13.33	12.33	9.67	11.20	2.74
26	7.00	8.33	10.67	9.00	6.00	10.00	6.67	18.67	10.33	9.00	9.57	3.57
27	28.00	8.33	12.33	13.00	6.67	6.67	5.67	9.33	6.67	9.67	10.63	6.58
28	41.00	18.00	14.33	9.00	7.00	6.00	6.33	9.67	6.33	9.33	12.70	10.67
29	13.00	9.00	10.00	22.33	10.00	8.33	6.67	9.33	10.33	10.67	10.97	4.32
30	17.00	16.67	17.00	12.67	5.67	7.67	10.00	11.67	9.00	9.67	11.70	4.07
31	12.00	78.33	11.67	7.33	4.67	7.33	8.00	10.00	6.00	7.33	15.27	22.28
32	12.00	28.67	10.33	8.00	7.00	5.67	7.00	8.33	6.67	6.00	9.97	6.86
33	12.00	24.67	11.00	8.67	10.00	6.00	7.33	14.33	8.33	9.67	11.20	5.29
34	14.00	9.67	12.00	12.67	5.67	7.33	6.00	13.33	78.33	9.00	16.80	21.83
35	12.00	7.00	11.67	11.33	7.33	7.00	8.33	17.67	14.67	8.33	10.53	3.60
36	12.00	8.00	12.00	8.67	10.00	7.00	9.33	20.67	10.00	9.67	10.73	3.83
37	15.00	11.67	15.67	9.00	7.33	7.67	7.67	25.00	15.00	9.33	12.33	5.53
38	7.00	14.00	5.33	6.67	9.33	4.50	12.67	11.00	7.67	14.00	9.22	3.53
39	16.00	10.00	12.33	6.67	9.67	7.33	7.67	11.67	13.67	11.33	10.63	2.97
40	7.00	9.33	18.67	14.33	8.00	6.33	6.33	14.00	9.67	8.00	10.17	4.14

Table 6.2-9 Dissolved Oxygen in mg/l --- 6 Week Means.

Sta. #	June 1983	July 1983	Sept 1983	Oct 1983	Nov 1983	Jan 1984	Feb 1984	Apr 1984	June 1984	July 1984	Mean	Std. Dev.
1	7.00	6.55	5.80	7.20	7.45	9.55	9.70	9.17	6.95	6.02	7.54	1.43
2	6.80	6.50	5.18	6.33	7.02	9.58	9.23	8.53	7.12	6.18	7.25	1.42
3	5.70	5.88	4.95	6.03	7.20	9.18	8.90	8.12	6.83	6.33	6.91	1.42
4	6.05	5.35	5.15	5.48	6.68	9.18	8.60	8.67	6.28	5.25	6.67	1.56
5	5.95	6.07	5.00	5.85	6.57	9.53	8.88	8.67	6.28	5.50	6.83	1.59
6	5.95	6.05	5.33	6.18	7.12	9.28	8.82	8.58	6.77	5.88	7.00	1.41
7	5.60	6.05	4.55	5.95	7.15	9.18	8.90	8.02	6.58	5.82	6.78	1.51
8	5.15	5.82	4.38	5.93	7.08	9.10	8.70	8.22	6.67	5.98	6.70	1.56
9	6.15	5.78	5.05	6.42	7.23	8.90	8.63	8.12	6.78	6.15	6.92	1.28
10	5.55	5.77	5.45	6.33	7.33	8.97	8.50	8.03	6.65	6.33	6.89	1.26
11	6.35	5.88	5.63	6.30	7.03	8.78	9.13	7.67	6.83	6.37	7.00	1.18
12	6.40	5.83	5.62	6.13	6.98	8.60	9.13	7.85	6.68	6.37	6.96	1.19
13	6.05	5.90	5.73	5.53	6.72	8.32	8.55	7.72	6.23	5.33	6.61	1.18
14	6.75	6.10	5.20	5.93	6.78	8.08	8.28	8.17	6.23	5.97	6.75	1.08
15	6.65	5.72	4.75	5.57	6.58	8.78	8.72	7.70	5.93	6.08	6.65	1.35
16	6.50	6.03	5.37	6.25	7.05	8.78	9.03	8.02	6.93	6.28	7.02	1.21
17	6.00	5.90	5.55	5.88	6.36	8.30	8.17	7.73	6.52	5.78	6.62	1.04
18	6.50	6.35	5.98	5.88	6.67	8.53	8.40	7.57	6.15	5.67	6.77	1.04
19	6.35	6.20	6.02	6.00	6.84	8.50	8.00	7.65	6.10	6.08	6.77	0.93
20	6.35	6.00	5.38	5.75	7.03	8.48	8.03	7.50	6.12	6.18	6.68	1.03
21	6.65	6.07	5.00	5.90	6.95	8.53	8.12	7.62	6.17	6.18	6.72	1.09
22	6.65	5.50	4.88	6.03	6.95	8.26	8.37	7.72	6.32	6.03	6.67	1.16
23	0.00	6.18	5.37	6.18	7.02	8.52	8.83	7.90	6.25	6.32	6.95	1.20
24	6.30	6.02	6.05	6.47	7.00	8.52	9.22	8.03	6.78	6.40	7.08	1.12
25	6.50	6.02	5.73	6.35	7.08	8.53	9.18	7.80	6.40	6.30	6.99	1.15
26	6.70	5.88	5.57	6.32	7.12	8.38	9.12	7.87	6.53	6.33	6.98	1.14
27	7.10	6.07	5.98	6.45	7.22	9.22	8.53	8.35	7.23	5.93	7.21	1.16
28	6.45	6.13	5.70	6.33	7.10	8.65	8.43	8.10	7.10	5.98	7.00	1.07
29	7.10	6.10	6.10	6.43	7.17	8.62	8.45	8.15	6.67	6.10	7.09	0.99
30	7.00	6.07	5.75	6.55	7.12	8.47	8.62	8.26	6.88	6.27	7.10	1.03
31	7.60	6.70	6.20	6.18	7.37	9.55	8.52	8.20	7.12	7.62	7.50	1.05
32	7.45	7.08	6.45	6.17	7.37	9.37	8.52	8.32	7.73	7.18	7.56	0.96
33	7.35	6.43	6.30	6.30	7.22	9.08	8.50	8.18	7.35	7.12	7.38	0.95
34	7.00	6.68	5.88	6.42	7.22	9.00	9.17	8.18	6.88	6.48	7.29	1.12
35	7.15	6.47	6.02	6.48	7.17	8.80	8.85	8.03	7.05	6.67	7.27	0.98
36	7.25	6.52	5.98	6.40	7.13	8.83	8.92	8.03	6.83	6.62	7.25	1.02
37	7.05	6.28	5.92	6.10	6.95	8.53	8.93	8.02	6.52	6.67	7.10	1.05
38	8.65	7.15	6.60	6.27	8.22	9.50	8.95	8.67	7.43	7.33	7.88	1.07
39	8.35	6.37	5.98	6.60	7.27	9.03	8.63	7.95	7.13	6.57	7.39	1.05
40	6.70	6.55	6.27	6.27	6.92	8.63	8.53	8.03	6.52	6.32	7.07	0.95

Table 6.2-10 Mean Grain Size in Phi Units.

Sta. #	June 1983	Sept 1983	Nov 1983	Feb 1984	June 1984	Mean	Std. Dev.
1	2.65	2.51	2.75	2.71	2.61	2.65	0.09
2	2.71	1.61	1.49	2.59	1.47	1.97	0.62
3	1.03	1.17	1.03	1.70	1.52	1.29	0.30
4	3.05	2.97	3.29	3.25	3.12	3.14	0.13
5	3.27	3.13	3.21	3.08	3.19	3.18	0.07
6	2.56	2.58	2.74	2.98	2.27	2.63	0.26
7	3.01	2.91	1.68	1.52	2.95	2.41	0.75
8	2.91	3.53	2.57	3.14	3.12	3.05	0.35
9	2.06	1.72	2.78	3.00	1.42	2.20	0.68
10	2.80	2.91	2.37	2.60	2.50	2.64	0.22
11	2.21	2.21	1.94	1.71	1.83	1.98	0.23
12	1.77	0.78	1.70	1.45	1.28	1.40	0.40
13	2.97	2.86	2.52	2.31	1.51	2.43	0.58
14	2.56	2.06	2.67	2.61	2.14	2.53	0.22
15	1.57	1.32	1.80	1.91	3.19	1.96	0.73
16	2.37	2.31	1.84	1.97	2.08	2.11	0.22
17	3.09	3.07	1.87	2.87	2.06	2.59	0.58
18	2.79	2.58	2.72	2.44	2.36	2.58	0.18
19	1.38	0.24	0.82	0.97	0.38	0.76	0.46
20	2.71	2.76	2.62	2.09	2.68	2.57	0.27
21	3.33	3.05	3.11	2.91	3.15	3.11	0.15
22	2.27	2.55	2.64	0.85	2.51	2.16	0.75
23	1.74	1.96	1.41	3.08	1.32	1.90	0.71
24	2.24	2.19	2.51	2.57	2.57	2.42	0.19
25	1.73	1.72	1.30	1.96	1.10	1.56	0.35
~~26~~	~~1.36~~	~~1.62~~	~~1.30~~	~~1.88~~	~~1.74~~	~~1.58~~	~~0.25~~
27	2.50	2.41	1.97	2.44	2.91	2.45	0.33
28	2.58	1.60	2.87	1.45	1.95	2.09	0.62
29	-0.46	-0.60	-0.27	0.61	2.30	0.32	1.20
30	1.94	1.63	1.89	1.01	2.00	1.69	0.41
31	2.86	2.72	2.35	2.95	1.97	2.57	0.41
32	1.04	1.89	2.03	2.20	2.36	1.90	0.51
33	3.00	2.78	2.54	2.30	2.69	2.66	0.26
34	2.40	1.65	1.88	2.45	1.71	2.02	0.38
35	1.18	0.94	0.81	0.81	0.76	0.90	0.17
36	2.50	2.28	1.73	0.63	2.72	1.97	0.84
37	2.06	2.47	2.14	2.69	2.12	2.30	0.27
38	2.22	2.01	2.80	2.38	1.41	2.16	0.51
39	2.16	2.18	2.55	2.85	2.94	2.54	0.36
40	3.03	3.06	3.05	2.62	3.02	2.95	0.18

Table 6.2-11 Percent Silt and Clay in Sediment.

Sta. #	June 1983	Sept 1983	Nov 1983	Feb 1984	June 1984	Mean	Std. Dev.
1	2.19	3.97	4.86	4.49	2.13	3.53	1.29
2	8.32	5.65	6.61	4.25	4.52	5.87	1.66
3	2.54	3.30	3.33	2.13	1.71	2.60	0.71
4	20.03	23.63	35.92	29.71	21.80	26.22	6.54
5	27.60	30.92	41.70	28.72	26.81	31.15	6.10
6	23.16	17.30	21.42	18.05	8.48	17.68	5.68
7	18.34	16.40	3.35	3.69	12.88	10.93	7.04
8	30.17	44.02	23.71	27.03	22.68	29.52	8.62
9	14.79	13.08	28.78	30.77	10.90	19.66	9.36
10	14.32	17.63	8.92	26.52	6.30	14.74	7.94
11	4.69	5.37	4.33	4.31	3.06	4.35	0.84
12	10.33	7.32	8.18	4.41	4.26	6.90	2.59
13	11.72	10.36	4.74	5.65	17.74	10.04	5.23
14	8.54	7.73	17.58	7.82	9.42	10.22	4.17
15	12.48	7.88	14.71	30.75	27.83	18.73	10.00
16	5.96	6.15	3.83	3.87	2.80	4.52	1.47
17	19.44	17.58	13.62	9.94	9.49	14.01	4.45
18	17.26	14.43	17.30	14.00	12.88	15.17	2.00
19	8.72	3.88	7.06	6.75	3.61	6.00	2.20
20	15.66	20.85	17.44	18.60	15.54	17.62	2.21
21	26.60	21.96	21.10	21.56	22.43	22.73	2.22
22	15.14	17.51	20.68	13.61	15.24	16.44	2.75
23	12.88	9.94	13.30	20.12	7.34	12.72	4.79
24	3.13	6.22	4.41	3.24	7.54	4.91	1.93
25	11.96	12.14	8.39	11.30	5.26	9.81	2.96
~~26~~	~~6.55~~	~~5.52~~	~~4.71~~	~~4.60~~	~~5.08~~	~~5.29~~	~~0.79~~
27	16.25	15.01	5.71	15.20	11.61	12.76	4.31
28	11.21	9.84	10.01	8.57	13.85	10.70	2.00
29	1.46	3.25	6.32	7.80	9.88	5.74	3.40
30	8.03	12.23	10.61	5.64	4.85	8.27	3.16
31	10.61	17.01	15.68	10.31	14.90	13.70	3.06
32	13.23	10.97	13.44	12.69	11.68	12.40	1.05
33	19.64	17.64	13.39	16.62	23.24	18.11	3.65
34	15.88	13.92	12.03	14.91	7.86	12.92	3.17
35	2.96	3.37	2.15	2.48	2.71	2.73	0.46
36	4.87	3.74	6.93	3.62	5.43	4.92	1.36
37	5.55	4.12	7.12	7.04	4.74	5.71	1.35
38	6.98	10.79	13.48	16.79	9.63	11.53	3.75
39	7.12	8.50	9.18	14.92	16.35	11.21	4.13
40	13.35	14.53	10.43	7.10	12.95	11.67	2.96

Table 6.2-12 Sediment Eh Levels in millivolts.

Sta. #	June 1983	Sept 1983	Nov 1983	Feb 1984	June 1984	Mean	Std. Dev.
1	-177	-113	-171	-85	-189	-147	45
2	-131	-32	-3	-98	-49	-63	51
3	-35	-146	52	-16	-29	-35	71
4	-208	-255	-315	-167	-185	-226	60
5	-242	-265	-279	-190	-235	-242	34
6	-214	-201	-209	-191	-213	-206	10
7	-105	-328	27	-174	-260	-168	138
8	-235	-345	-205	-191	-238	-243	61
9	-122	26	-209	-195	-47	-109	100
10	-51	-205	-143	-123	-203	-145	64
11	87	-187	76	136	-26	17	128
12	80	21	73	92	34	60	31
13	-229	-169	-163	18	-20	-113	106
14	-249	-126	-221	-167	-45	-162	81
15	15	-220	-145	-206	-337	-179	129
16	34	-145	46	-21	-3	-18	76
17	-293	-167	*	-101	-251	-162	117
18	-131	8	-170	-69	-42	-81	71
19	89	11	33	-79	-32	4	64
20	-156	-298	-9	-108	-215	-157	109
21	-207	-262	-179	-137	-213	-200	46
22	-240	-144	-131	18	-62	-112	96
23	68	-3	77	-141	23	5	88
24	130	-21	63	20	-148	9	104
25	67	-158	64	-145	*	34	110
26	11	-111	76	-171	-9	41	99
27	-336	18	22	17	-241	-104	172
28	-103	-72	-168	25	3	-63	79
29	-15	35	-8	10	-120	-20	59
30	-166	8	25	28	-79	-37	84
31	-266	-261	-77	-112	-189	-181	86
32	-47	-5	-19	*	-29	-20	19
33	-223	-302	-9	2	-181	-143	134
34	-146	-184	37	-83	21	-71	98
35	106	-139	72	46	79	33	98
36	68	-294	106	7	25	-18	159
37	85	-270	81	-53	-79	-47	145
38	-110	-242	-163	*	-21	-107	100
39	-115	-250	-187	-151	-231	-187	56
40	-83	-163	-30	-37	-99	-82	54

Table 6.2-13 Sediment Total Organic Carbon in mg/g.

Sta. #	June 1983	Sept 1983	Nov 1983	Feb 1984	June 1984	Mean	Std. Dev.
1	1.87	2.97	4.17	5.30	2.07	3.28	1.45
2	5.50	4.80	6.70	3.53	2.13	4.53	1.77
3	3.80	3.00	3.43	4.90	1.40	2.51	1.28
4	15.43	10.93	14.03	10.67	4.83	11.18	4.09
5	17.50	13.67	19.53	27.40	6.63	16.95	7.64
6	15.47	8.17	12.27	16.33	2.57	10.96	5.68
7	7.17	7.60	3.87	11.37	3.80	6.76	3.13
8	20.43	19.73	11.73	13.13	5.57	14.12	6.15
9	8.73	5.40	13.70	13.67	5.10	9.32	4.23
10	6.60	7.87	5.13	5.43	3.17	5.64	1.75
11	3.97	3.53	3.77	3.80	2.07	3.43	0.78
12	6.77	4.47	5.00	6.53	3.33	5.22	1.44
13	6.40	5.37	2.87	4.57	6.43	5.13	1.48
14	2.30	4.83	4.13	11.57	2.47	5.06	3.80
15	6.73	5.13	5.50	24.23	9.00	10.12	8.03
16	3.97	5.23	2.23	3.60	1.37	3.28	1.51
17	8.23	11.40	2.37	6.07	2.93	6.20	3.76
18	11.23	7.03	2.90	9.33	4.27	6.95	3.45
19	6.30	4.23	2.57	7.23	2.57	4.58	2.13
20	6.27	8.93	4.87	8.37	5.73	6.83	1.74
21	15.03	9.57	10.37	12.43	7.50	10.98	2.87
22	10.17	5.80	10.13	11.97	3.90	8.39	3.39
23	8.00	6.07	5.63	9.37	3.60	6.53	2.23
24	0.93	4.27	1.53	1.10	2.13	1.99	1.36
25	4.23	5.27	4.97	6.47	2.60	4.71	1.43
26	2.87	3.73	3.10	3.67	1.80	3.03	0.78
27	8.80	10.10	3.07	10.43	2.93	7.07	3.76
28	5.40	4.73	3.57	6.83	5.07	5.12	1.18
29	4.43	3.53	5.03	2.90	2.67	3.71	1.00
30	3.10	7.80	7.27	3.13	2.43	4.75	2.57
31	3.50	8.53	5.40	11.93	7.17	7.31	3.20
32	11.03	7.43	4.93	14.63	3.60	8.32	4.52
33	10.07	8.43	4.70	11.97	4.30	7.89	3.34
34	7.77	5.47	6.23	10.20	3.33	6.60	2.57
35	2.50	3.30	2.83	6.27	2.03	3.39	1.68
36	2.13	2.50	6.63	2.87	0.60	2.95	2.23
37	4.60	1.97	3.57	4.30	1.67	3.22	1.34
38	5.63	7.37	9.87	11.50	4.97	7.87	2.78
39	5.90	5.57	4.90	11.40	4.40	6.43	2.84
40	6.07	5.70	6.90	8.53	3.60	6.16	1.80

Table 6.2-14 Sediment Sulfide Levels in ug/g.

Sta. #	June 1983	Sept 1983	Nov 1983	Feb 1984	June 1984	Mean	Std. Dev.
1	0.001	0.008	0.028	0.026	0.013	0.015	0.012
2	0.013	0.042	0.080	0.016	0.036	0.037	0.027
3	0.003	0.047	0.008	0.018	0.000	0.015	0.019
4	0.234	0.172	0.022	0.045	0.029	0.100	0.097
5	0.117	0.245	0.034	0.031	0.024	0.090	0.095
6	0.012	0.045	0.026	0.077	0.039	0.040	0.024
7	0.197	0.072	0.026	0.014	0.112	0.084	0.074
8	0.240	0.780	0.185	0.029	0.051	0.257	0.306
9	0.007	0.144	0.058	0.021	0.080	0.062	0.054
10	0.052	0.050	0.017	0.035	0.080	0.047	0.023
11	0.001	0.009	0.006	0.005	0.000	0.004	0.004
12	0.000	0.008	0.018	0.004	0.003	0.007	0.007
13	0.068	0.031	0.011	0.024	0.031	0.033	0.021
14	0.061	0.078	0.013	0.037	0.005	0.039	0.031
15	0.167	0.260	0.015	0.097	0.089	0.125	0.093
16	0.004	0.039	0.016	0.010	0.002	0.014	0.015
17	0.423	0.361	0.350	0.086	0.139	0.272	0.149
18	0.001	0.180	0.036	0.019	0.019	0.051	0.073
19	0.000	0.021	0.004	0.002	0.000	0.005	0.009
20	0.031	0.045	0.009	0.022	0.042	0.030	0.015
21	0.018	0.003	0.559	0.038	0.188	0.161	0.234
22	0.015	0.096	0.135	0.012	0.000	0.052	0.060
23	0.011	0.102	0.021	0.032	0.005	0.034	0.039
24	0.031	0.069	0.019	0.019	0.000	0.028	0.026
25	0.012	0.006	0.018	0.010	0.000	0.009	0.007
~~26~~	~~0.013~~	~~0.003~~	~~0.006~~	~~0.001~~	~~0.000~~	~~0.005~~	~~0.005~~
27	0.430	0.021	0.011	0.027	0.111	0.120	0.178
28	0.077	0.007	0.008	0.042	0.009	0.029	0.031
29	0.019	0.008	0.028	0.008	0.000	0.013	0.010
30	0.084	0.006	0.018	0.004	0.009	0.024	0.034
31	0.043	0.127	0.043	0.011	0.068	0.058	0.043
32	0.044	0.171	0.137	0.067	0.360	0.156	0.125
33	0.042	0.004	0.041	0.028	0.022	0.027	0.016
34	0.034	0.164	0.005	0.022	0.013	0.048	0.066
35	0.038	0.005	0.006	0.002	0.062	0.023	0.026
36	0.044	0.108	0.008	0.004	0.161	0.065	0.068
37	0.037	0.421	0.001	0.003	0.012	0.095	0.183
38	0.052	0.892	0.147	0.120	0.045	0.251	0.361
39	0.090	0.121	0.100	0.064	0.028	0.081	0.036
40	0.053	0.046	0.003	0.012	0.043	0.031	0.022

Table 6.2-15. Abundant species occurring at all or at a majority of stations.

SPECIES OCCURRING AT ALL STATIONS	
Tharyx cf. *dorsobranchialis*	
Aricidea philbinae	
Aricidea taylori	
Lumbrineris verrilli	
Haploscoloplos foliosus	
Acetocina canaliculata	

SPECIES OCCURRING AT ALL BUT ONE STATION	STATION WHERE ABSENT
Fabricia sp. A	18
Mediomastus ambiseta	35
Mediomastus sp.	38
Ampelisca holmesi	19
Mysella planulata	1
Chone americana	1
Scolelepis texana	40
Mitrella lunata	4
Scoloplos rubra	1

SPECIES OCCURRING AT ALL BUT FOUR OR LESS STATIONS	STATIONS WHERE ABSENT
~~*Paraprionospio pinnata*~~	~~1, 35~~
Streblospio benedicti	4, 25
Myriochele oculata	4, 6, 14, 38
Sphaerosyllis taylori	1, 8
Grandidierella bonneroides	4, 5
Erichthonius brasiliensis	18, 24, 38
Haploscoloplus fragilis	1, 34
Cirrophorus cf. *furcatus*	1, 6, 32
Ampelisca abdita	19, 20, 21
Spiophanes bombyx	1, 5, 13, 32
Paracaprella tenuis	1, 8, 38

Table 6.2-16 Total Faunal Density by Date and Station.

BENTHIC CORE FAUNAL DENSITY BY DATE AND STATION

STATION	JUNE 1983	JULY 1983	SEPTEMBER 1983	OCTOBER 1983	NOVEMBER 1983	JANUARY 1984	FEBRUARY 1984	APRIL 1984	JUNE 1984	JULY 1984	MEAN	STANDARD DEVIATION
1	7915	.	9515	.	16320	.	18667	.	4597	.	11403	5895
2	9728	.	4181	.	8768	.	13621	.	6763	.	8612	3515
3	13035	.	10784	.	27189	.	17163	.	24000	.	18434	7017
4	11147	26507	5067	4331	2059	4928	12544	9653	24395	1941	10257	8801
5	4395	3019	4843	3360	2848	7381	15456	3957	3840	2272	5137	3892
6	5771	.	2901	.	6677	.	12171	.	9611	.	7426	3573
7	3723	4181	3861	2869	11285	16181	8544	12523	3488	3371	7003	4792
8	1973	.	5045	.	3317	.	11627	.	3424	.	5077	3820
9	5579	7893	7669	1717	4299	8683	9312	7851	11243	9429	7367	2787
10	8757	.	9248	.	21429	.	8747	.	8811	.	11398	5611
11	4597	.	4747	.	24299	.	30443	.	16075	.	16032	11555
12	5611	2635	5280	11968	15381	12192	17536	21653	19925	6965	11915	6642
13	12267	2272	4811	2283	5184	11488	17621	57227	18613	14560	14633	16144
14	5803	.	2144	.	5312	.	11904	.	15179	.	8068	5317
15	4288	2880	10549	4299	12160	15093	18261	7360	4587	2656	8213	5510
16	4075	.	4128	.	32469	.	10421	.	11168	.	12452	11683
17	17269	14304	7883	9163	6144	18304	17387	33280	17035	11520	15229	7712
18	2827	2731	5835	4619	9323	11381	13856	6752	4800	4395	6652	3723
19	9429	.	6059	.	14859	.	11776	.	20320	.	12489	5435
20	5429	6645	10784	5248	6955	15573	17184	10048	9888	9216	9697	4041
21	6325	.	11531	.	10613	.	20107	.	9301	.	11575	5159
22	4320	5077	6688	3883	11328	13163	18187	9259	11947	6411	9026	4612
23	6464	.	3947	.	29419	.	9269	.	23861	.	14592	11330
24	3179	.	3104	.	5013	.	8064	.	15307	.	6933	5095
25	7093	8149	9803	8960	12789	12928	8971	14624	17899	7093	10831	3586
26	8235	4928	8960	12512	27659	7893	17696	14027	21845	6155	12991	7406
27	8395	7531	7659	11968	11616	14411	16224	20448	19093	13813	13116	4572
28	10059	.	14325	.	3445	.	34059	.	113387	.	35055	45251
29	30880	6069	44981	42091	63840	17941	20587	11477	24107	6037	26801	18776
30	8245	2912	22795	27563	28533	23851	41749	31349	69131	14251	27038	18667
31	3755	10016	5621	8683	8096	7957	13824	20171	15765	6283	10017	5086
32	23819	.	5664	.	12011	.	13579	.	31083	.	17231	10120
33	4320	9088	6869	3872	5376	26816	32608	21099	20149	4960	13516	10665
34	6496	.	15019	.	21152	.	14005	.	31947	.	17724	9503
35	7136	6379	9077	23712	46688	38965	61771	58752	30197	12875	29555	21198
36	4651	.	3403	.	42816	.	36971	.	5899	.	18748	19434
37	5536	5611	2240	14091	8096	12565	14571	16587	10165	5856	9532	4780
38	11584	.	5771	.	5216	.	5237	.	16352	.	8832	4987
39	8171	.	18667	.	8128	.	17045	.	5675	.	11537	5884
40	9056	.	6965	.	14005	.	21312	.	9781	.	12224	5688
MEANS	8033	6941	8461	10369	15303	14885	18002	19405	18516	7503		
STD DEV	5535	5516	7357	10188	13414	7814	10754	15315	19321	4050		

Table 6.2-17 Faunal density comparisons between thermal and control stations ('t' test; 95% significance level).

THERMAL STATIONS \ CONTROL STATIONS	1	2	3	6	7	8	12	25	26	31	32	33	35	36	38	39	40
4	--																
5	--																
13				--						--		--					
14				--	--							--				--	
17				X						X		--					
18				--						--		o					
19													--				
20				--						--		--					
21						X											--
22		--													--		
27				X	X							--				--	
28		X													--		
29													--				
30		--	--				X	X	X		--			--			

Key: X = Thermal station significantly higher (95% level of certainty).
o = Thermal station significantly lower.
-- = No significant difference.

Table 6.2-18 BENTHIC CORE POLYCHAETA DENSITY BY DATE AND STATION

STATION	JUNE 1983	JULY 1983	SEPTEMBER 1983	OCTOBER 1983	NOVEMBER 1983	JANUARY 1984	FEBRUARY 1984	APRIL 1984	JUNE 1984	JULY 1984	MEAN	STANDARD DEVIATION
1	1291	.	779	.	1077	.	3637	.	1035	.	1564	1173
2	3093	.	3904	.	7104	.	8395	.	5237	.	5547	2199
3	2763	.	5259	.	12981	.	8277	.	6464	.	7149	3827
4	2336	2976	4160	4181	1984	4448	10411	5461	5120	1067	4214	2599
5	3723	2667	4704	3296	2656	7083	13440	3701	3019	1835	4612	3420
6	3637	.	2709	.	6389	.	10731	.	7093	.	6112	3165
7	1707	3392	3221	2293	10656	15072	7381	11477	2464	2432	6010	4805
8	1472	.	4768	.	2912	.	10699	.	2837	.	4538	3638
9	2784	6560	5451	1141	3243	8160	7573	7211	8661	6581	5737	2528
10	6272	.	5312	.	18667	.	7029	.	5973	.	8651	5633
11	2475	.	3136	.	17237	.	15957	.	10581	.	9877	6926
12	1515	1888	3029	8299	7701	9088	13259	15829	13621	5003	7923	5109
13	6763	1728	4373	1600	3808	9664	15947	45952	13856	10784	11447	13090
14	4693	.	1803	.	4779	.	11051	.	12640	.	6993	4623
15	3147	2613	9376	3360	11285	14453	10827	6187	3499	2229	6698	4426
16	1963	.	2987	.	24757	.	8971	.	8309	.	9397	9133
17	16117	13536	7541	8939	5216	17205	16203	31349	13173	9771	13905	7332
18	2475	2485	5803	4224	6912	10016	10581	5813	3509	3243	5506	2931
19	6709	.	4597	.	9867	.	8096	.	13312	.	8516	3302
20	4779	6421	10251	4981	5867	12309	13664	8032	8800	8277	8338	3015
21	6133	.	11328	.	9355	.	13643	.	8213	.	9734	2883
22	2592	4779	5867	3125	10453	9963	14837	7307	8523	4917	7236	3786
23	3755	.	3221	.	23029	.	7371	.	16981	.	10871	8755
24	1749	.	1621	.	3627	.	6475	.	9888	.	4672	3514
25	4576	6496	7349	5653	9696	9067	6144	12053	11531	5611	7818	2617
26	4128	3755	6144	8171	19381	4800	13504	10645	14683	4053	8927	5429
27	6283	5568	5739	6016	9088	12949	11552	12160	12085	10496	9194	3022
28	7904	.	12907	.	3040	.	26336	.	98421	.	29722	39376
29	3776	5440	20341	36555	31808	14912	17461	9237	19765	5056	16435	11221
30	5621	2315	15008	19616	24405	19936	31989	23147	48821	8629	19949	13653
31	2421	5920	2400	4096	5355	5803	5813	7637	9504	3691	5264	2230
32	12373	.	2731	.	7787	.	8928	.	10432	.	8450	3630
33	2901	5376	4363	2475	3957	21237	27093	14709	13931	3552	9959	8783
34	4267	.	11765	.	17141	.	10699	.	16469	.	12068	5195
35	4224	4000	7072	14304	33248	30635	57227	52032	16779	6464	22598	19807
36	1675	.	2197	.	30837	.	29301	.	3157	.	13434	15205
37	3467	4149	1259	9909	6016	6880	11072	13387	5344	3691	6517	3826
38	8203	.	3744	.	4075	.	3520	.	10624	.	6033	3208
39	5675	.	9728	.	4864	.	9963	.	3296	.	6705	2993
40	6443	.	4779	.	10912	.	16960	.	7819	.	9382	4797
MEANS	4447	4603	5818	7612	10829	12184	13550	15166	12387	5369		
STD DEV	2965	2646	4073	8185	8716	6448	9626	13279	15985	2919		

Table 6.2-19 BENTHIC CORE MOLLUSCA DENSITY BY DATE AND STATION

STATION	JUNE 1983	JULY 1983	SEPTEMBER 1983	OCTOBER 1983	NOVEMBER 1983	JANUARY 1984	FEBRUARY 1984	APRIL 1984	JUNE 1984	JULY 1984	MEAN	STANDARD DEVIATION
1	1355	.	885	.	459	.	5621	.	565	.	1777	2177
2	1248	.	149	.	1173	.	2187	.	459	.	1043	792
3	9109	.	4853	.	10965	.	2816	.	12523	.	8053	4100
4	491	53	128	21	32	256	448	235	149	64	188	169
5	384	117	32	53	32	267	1035	128	256	203	251	299
6	1237	.	53	.	203	.	928	.	555	.	595	493
7	843	331	363	352	203	576	288	128	651	448	418	217
8	85	.	171	.	96	.	768	.	203	.	265	286
9	2048	1003	1312	309	757	363	1067	395	1035	1707	999	578
10	1963	.	3104	.	2112	.	1099	.	2059	.	2067	712
11	1504	.	811	.	1856	.	2069	.	2571	.	1762	657
12	3125	341	1120	1536	3371	1259	1845	2720	2581	1291	1919	986
13	1045	160	149	107	235	587	501	1291	437	2528	704	752
14	619	.	267	.	288	.	576	.	1301	.	610	419
15	736	53	501	704	277	245	3893	459	651	171	769	1122
16	1269	.	960	.	2805	.	725	.	1173	.	1387	820
17	352	181	96	32	235	491	480	224	1131	1067	429	383
18	117	107	11	363	2133	693	1568	555	811	1003	736	683
19	405	.	1024	.	480	.	1248	.	4832	.	1598	1843
20	267	96	437	181	1024	3200	2635	1237	405	693	1018	1073
21	53	.	85	.	1024	.	3328	.	459	.	990	1364
22	1024	117	416	427	448	1824	2443	885	1877	939	1040	766
23	2112	.	565	.	4213	.	1141	.	5067	.	2620	1949
24	992	.	789	.	693	.	1003	.	3968	.	1489	1392
25	1760	683	1248	1141	1269	1717	1920	2080	3392	533	1574	816
26	2763	544	1557	1707	3424	1237	2101	2517	3403	1088	2034	981
27	907	395	757	2635	1408	789	1867	1408	2741	1803	1471	795
28	1163	.	512	.	203	.	5653	.	4512	.	2409	2498
29	24704	107	21163	3563	16149	1824	1952	1333	2421	683	7390	9433
30	1419	341	5909	5611	2432	2432	5152	3787	9611	2133	3883	2737
31	395	1760	2613	4043	1835	1589	4811	2368	3157	1419	2399	1312
32	7808	.	1728	.	2144	.	2315	.	12864	.	5372	4876
33	405	1472	1323	875	747	2944	2827	3925	2144	757	1742	1169
34	1568	.	1291	.	1696	.	2048	.	6944	.	2709	2383
35	2293	704	864	6848	5717	1813	1387	4448	8821	2325	3522	2794
36	2144	.	608	.	5707	.	1856	.	2016	.	2466	1913
37	1173	565	491	2357	832	3328	1653	2336	3008	885	1663	1034
38	555	.	1163	.	789	.	619	.	789	.	783	236
39	1045	.	6635	.	1952	.	4597	.	896	.	3025	2505
40	1856	.	1077	.	1621	.	1621	.	1141	.	1463	338
MEANS	2109	457	1681	1643	2076	1372	2052	1623	2839	1087		
STD DEV	4072	476	3498	1978	3077	1004	1453	1348	3201	712		

Table 6.2-20 BENTHIC CORE CRUSTACEA DENSITY BY DATE AND STATION

STATION	JUNE 1983	JULY 1983	SEPTEMBER 1983	OCTOBER 1983	NOVEMBER 1983	JANUARY 1984	FEBRUARY 1984	APRIL 1984	JUNE 1984	JULY 1984	MEAN	STANDARD DEVIATION
1	5248	.	7840	.	14741	.	9408	.	2997	.	8047	4473
2	5237	.	117	.	363	.	2923	.	960	.	1920	2157
3	1024	.	576	.	2944	.	5771	.	4875	.	3038	2290
4	8299	23456	768	128	43	224	1685	3957	18923	96	5758	8594
5	288	224	107	11	149	32	960	107	149	171	220	273
6	864	.	96	.	85	.	501	.	1419	.	593	563
7	1024	405	224	128	331	352	608	757	288	192	431	283
8	395	.	64	.	213	.	139	.	277	.	218	127
9	693	288	800	160	85	64	501	213	875	1035	471	357
10	245	.	299	.	405	.	363	.	597	.	382	135
11	512	.	533	.	4693	.	12288	.	2816	.	4169	4864
12	853	352	971	1877	3915	1472	2112	2773	3307	597	1823	1203
13	4448	373	277	565	1120	1205	1163	9963	4320	1237	2467	3036
14	448	.	53	.	235	.	213	.	1195	.	429	451
15	384	192	672	117	555	277	3456	373	288	160	647	1002
16	789	.	139	.	4661	.	459	.	1483	.	1506	1833
17	747	587	245	192	693	533	672	1664	2688	672	869	753
18	181	117	21	21	256	651	1685	341	448	117	384	498
19	2304	.	437	.	4491	.	2421	.	2165	.	2364	1439
20	341	128	43	64	43	43	725	651	544	85	267	276
21	117	.	107	.	171	.	2656	.	544	.	719	1098
22	533	181	203	160	331	1323	843	533	715	181	500	377
23	533	.	117	.	1899	.	213	.	1653	.	883	834
24	352	.	395	.	576	.	331	.	928	.	516	250
25	576	672	1099	1813	1429	1856	352	416	2645	651	1151	763
26	1269	565	1003	2283	4256	1717	1824	715	3435	800	1787	1228
27	1131	1461	1013	3232	789	437	2709	6635	3637	1088	2213	1900
28	949	.	896	.	139	.	1536	.	10261	.	2756	4225
29	2272	501	3221	1792	15627	1077	1077	864	1888	192	2851	4577
30	1184	224	1824	1973	1408	1344	4469	3989	10549	3392	3036	2963
31	768	2197	597	256	608	192	587	10059	2752	533	1855	3004
32	3509	.	1163	.	1952	.	1995	.	7424	.	3209	2505
33	768	1333	1003	320	469	1600	1813	2005	3573	523	1341	979
34	373	.	1856	.	2037	.	448	.	8235	.	2590	3248
35	448	1547	1003	1995	7264	6251	2720	1696	4352	3563	3084	2266
36	768	.	544	.	5856	.	3776	.	619	.	2313	2402
37	683	768	363	1493	1056	1963	1589	704	1707	928	1125	529
38	2816	.	811	.	320	.	1045	.	4939	.	1986	1901
39	1259	.	1813	.	896	.	1408	.	1109	.	1297	345
40	640	.	672	.	1088	.	2368	.	533	.	1060	761
MEANS	1382	1779	850	929	2205	1131	2045	2421	3053	811		
STD DEV	1718	5134	1304	1004	3520	1373	2425	3075	3665	982		

Table 6.2-21 BENTHIC CORE SPECIES RICHNESS BY DATE AND STATION

STATION	JUNE 1983	JULY 1983	SEPTEMBER 1983	OCTOBER 1983	NOVEMBER 1983	JANUARY 1984	FEBRUARY 1984	APRIL 1984	JUNE 1984	JULY 1984	MEAN	STANDARD DEVIATION
1	36	.	33	.	32	.	48	.	28	.	35	8
2	67	.	40	.	81	.	71	.	71	.	66	15
3	83	.	92	.	123	.	130	.	125	.	111	21
4	33	41	23	23	19	31	44	41	39	26	32	9
5	28	28	18	16	26	19	45	21	45	33	28	10
6	57	.	23	.	31	.	38	.	70	.	44	19
7	54	57	37	54	68	67	61	63	59	41	56	10
8	29	.	25	.	36	.	40	.	39	.	34	7
9	75	81	76	39	49	50	68	48	100	110	70	24
10	72	.	64	.	88	.	73	.	102	.	80	15
11	90	.	74	.	147	.	156	.	128	.	119	36
12	102	64	82	127	135	109	134	167	143	101	116	31
13	71	35	41	43	52	60	79	73	49	69	57	15
14	60	.	22	.	38	.	48	.	81	.	50	22
15	77	36	55	52	70	54	88	61	57	36	59	16
16	74	.	64	.	144	.	98	.	101	.	96	31
17	58	36	20	24	34	33	55	44	70	45	42	16
18	43	31	13	24	45	31	58	52	60	42	40	15
19	50	.	29	.	59	.	72	.	77	.	57	19
20	46	33	23	39	40	46	65	71	63	53	48	15
21	44	.	35	.	48	.	82	.	79	.	58	21
22	80	54	60	61	83	95	97	85	92	77	78	15
23	87	.	51	.	108	.	79	.	122	.	89	27
24	75	.	76	.	81	.	90	.	112	.	87	15
25	97	79	122	109	116	116	101	119	167	101	113	23
26	114	84	118	143	180	121	145	131	157	101	129	28
27	78	63	64	69	62	71	78	85	91	81	74	10
28	70	.	63	.	41	.	104	.	119	.	79	32
29	57	46	75	102	78	99	91	81	84	52	77	19
30	96	50	116	128	123	112	124	132	154	129	116	28
31	65	102	68	85	89	64	79	99	101	71	82	15
32	124	.	93	.	105	.	115	.	126	.	113	14
33	81	117	97	80	88	120	139	127	131	74	105	24
34	110	.	114	.	130	.	114	.	169	.	127	24
35	103	104	109	123	148	145	145	160	169	174	138	27
36	71	.	77	.	179	.	170	.	79	.	115	54
37	109	105	59	133	96	134	132	121	120	96	111	23
38	55	.	67	.	49	.	58	.	69	.	60	8
39	95	.	120	.	95	.	126	.	105	.	108	14
40	87	.	85	.	102	.	126	.	87	.	97	17
MEANS	73	62	63	74	83	79	92	89	96	76		
STD DEV	24	28	32	42	43	39	36	41	38	37		

Table 6.2-22 Species richness comparisons between thermal and control stations ('t' test; 95% confidence level).

THERMAL STATIONS \ CONTROL STATIONS	1	2	3	6	7	8	12	25	26	31	32	33	35	36	38	39	40
4	--																
5	--																
13				--						o		o					
14				--	--							o				o	
17				--						o		o					
18				--						o		o					
19													o				
20				--						o		o					
21						X											o
22		X													--		
27				X	X							o				o	
28		X													--		
29													o				
30		X	--				--	--	--		--			--			

Key: X = Thermal station significantly higher (95% level of certainty).
o = Thermal station significantly lower.
-- = No significant difference.

Table 6.2-23 BENTHIC CORE POLYCHAETA RICHNESS BY DATE AND STATION

STATION	JUNE 1983	JULY 1983	SEPTEMBER 1983	OCTOBER 1983	NOVEMBER 1983	JANUARY 1984	FEBRUARY 1984	APRIL 1984	JUNE 1984	JULY 1984	MEAN	STANDARD DEVIATION
1	13	.	12	.	13	.	21	.	13	.	14	4
2	25	.	25	.	44	.	28	.	35	.	31	8
3	40	.	42	.	60	.	71	.	60	.	55	13
4	15	21	12	16	12	18	19	21	16	13	16	3
5	14	15	9	13	15	12	24	13	26	17	16	5
6	21	.	12	.	19	.	18	.	25	.	19	5
7	23	25	18	33	37	37	34	42	25	18	29	8
8	18	.	15	.	18	.	20	.	22	.	19	3
9	36	52	38	22	27	29	32	29	53	54	37	12
10	30	.	32	.	46	.	40	.	43	.	38	7
11	43	.	39	.	74	.	83	.	65	.	61	19
12	39	35	37	55	56	51	64	83	65	39	52	15
13	32	20	27	21	32	34	50	37	25	39	32	9
14	29	.	11	.	21	.	29	.	40	.	26	11
15	42	24	28	25	42	31	43	36	31	15	32	9
16	29	.	30	.	72	.	53	.	61	.	49	19
17	29	25	13	15	23	24	35	26	36	30	26	8
18	21	18	10	17	29	22	37	29	29	18	23	8
19	25	.	17	.	40	.	49	.	43	.	35	13
20	30	22	12	24	29	31	40	42	34	32	30	9
21	31	.	23	.	29	.	37	.	38	.	32	6
22	38	40	35	34	54	52	55	49	52	39	45	8
23	40	.	27	.	52	.	47	.	65	.	46	14
24	34	.	37	.	45	.	49	.	58	.	45	10
25	48	46	64	65	55	54	61	69	87	60	61	12
26	46	52	54	61	83	55	66	66	78	45	61	13
27	33	32	25	26	31	37	36	30	37	38	33	5
28	39	.	35	.	27	.	55	.	62	.	44	14
29	29	28	43	57	51	67	53	47	43	32	45	13
30	52	29	63	48	62	57	64	63	69	52	56	12
31	35	45	27	51	47	34	40	34	44	32	39	8
32	55	.	41	.	46	.	53	.	49	.	49	6
33	40	64	48	38	44	54	71	59	61	40	52	12
34	58	.	53	.	63	.	60	.	78	.	62	9
35	54	49	58	64	67	68	66	83	80	77	67	11
36	30	.	37	.	71	.	87	.	38	.	53	25
37	55	60	28	65	57	54	69	75	59	53	58	13
38	23	.	31	.	25	.	23	.	34	.	27	5
39	49	.	53	.	46	.	62	.	46	.	51	7
40	47	.	42	.	48	.	63	.	45	.	49	8
MEANS	35	35	32	38	43	41	48	47	47	37		
STD DEV	12	15	15	19	18	16	18	21	19	17		

Table 6.2-24 BENTHIC CORE MOLLUSCA RICHNESS BY DATE AND STATION

STATION	JUNE 1983	JULY 1983	SEPTEMBER 1983	OCTOBER 1983	NOVEMBER 1983	JANUARY 1984	FEBRUARY 1984	APRIL 1984	JUNE 1984	JULY 1984	MEAN	STANDARD DEVIATION
1	11	.	9	.	8	.	13	.	7	.	10	2
2	16	.	7	.	19	.	20	.	14	.	15	5
3	24	.	26	.	30	.	29	.	33	.	28	4
4	5	4	4	1	3	5	9	10	8	4	5	3
5	7	4	3	2	3	4	7	5	7	6	5	2
6	16	.	3	.	5	.	8	.	18	.	10	7
7	15	14	5	9	12	19	11	8	15	13	12	4
8	5	.	3	.	6	.	13	.	6	.	7	4
9	21	15	18	9	9	13	18	11	21	30	17	7
10	25	.	17	.	22	.	16	.	29	.	22	5
11	27	.	16	.	31	.	27	.	24	.	25	6
12	28	14	22	37	29	22	28	41	30	30	28	8
13	16	6	9	9	5	11	12	17	10	16	11	4
14	14	.	5	.	8	.	7	.	20	.	11	6
15	21	5	13	14	10	12	16	13	8	9	12	4
16	25	.	20	.	33	.	19	.	21	.	24	6
17	11	4	4	3	4	4	7	6	13	8	6	3
18	8	5	1	4	9	4	8	7	16	14	8	5
19	6	.	5	.	7	.	10	.	10	.	8	2
20	8	4	5	7	7	9	10	11	16	11	9	3
21	5	.	6	.	9	.	19	.	18	.	11	7
22	22	7	12	14	15	19	16	15	20	16	16	4
23	24	.	14	.	25	.	14	.	24	.	20	6
24	25	.	16	.	20	.	21	.	26	.	22	4
25	24	14	22	17	24	23	22	29	33	14	22	6
26	31	10	29	33	38	22	30	32	28	25	28	8
27	18	11	14	17	13	14	16	22	21	22	17	4
28	13	.	14	.	5	.	22	.	18	.	14	6
29	13	6	9	14	10	14	15	13	20	12	13	4
30	20	11	27	40	31	26	26	30	40	27	28	9
31	14	25	22	18	24	19	21	25	28	17	21	4
32	31	.	29	.	28	.	27	.	41	.	31	6
33	16	23	22	20	16	32	26	35	34	16	24	7
34	26	.	25	.	35	.	30	.	44	.	32	8
35	25	23	26	24	35	35	31	33	36	36	30	5
36	25	.	17	.	56	.	35	.	18	.	30	16
37	22	18	13	30	13	44	29	23	26	17	24	9
38	17	.	21	.	11	.	17	.	15	.	16	4
39	20	.	37	.	26	.	31	.	28	.	28	6
40	23	.	20	.	25	.	25	.	17	.	22	3
MEANS	18	11	15	16	18	18	19	19	22	17		
STD DEV	8	7	9	12	12	11	8	11	10	9		

Table 6.2-25 BENTHIC CORE CRUSTACEA RICHNESS BY DATE AND STATION

STATION	JUNE 1983	JULY 1983	SEPTEMBER 1983	OCTOBER 1983	NOVEMBER 1983	JANUARY 1984	FEBRUARY 1984	APRIL 1984	JUNE 1984	JULY 1984	MEAN	STANDARD DEVIATION
1	10	.	11	.	10	.	14	.	8	.	11	2
2	22	.	7	.	13	.	19	.	17	.	16	6
3	16	.	20	.	29	.	24	.	29	.	24	6
4	12	14	6	6	4	8	16	10	11	7	9	4
5	7	8	6	1	7	3	13	2	10	8	7	4
6	18	.	6	.	7	.	11	.	24	.	13	8
7	12	13	11	8	16	8	13	10	15	5	11	3
8	4	.	5	.	8	.	5	.	7	.	6	2
9	16	11	14	5	4	5	11	5	18	21	11	6
10	10	.	9	.	14	.	12	.	21	.	13	5
11	13	.	12	.	34	.	38	.	34	.	26	13
12	27	12	17	27	42	28	31	33	37	27	28	9
13	22	8	4	12	13	14	16	18	14	13	13	5
14	15	.	4	.	8	.	8	.	18	.	11	6
15	12	5	14	9	15	7	26	6	12	10	12	6
16	18	.	11	.	30	.	17	.	13	.	18	7
17	16	7	8	6	7	4	11	10	19	6	9	5
18	11	7	2	2	5	3	11	14	13	8	8	5
19	18	.	7	.	10	.	12	.	23	.	14	6
20	6	7	4	6	2	4	9	14	9	7	7	3
21	6	.	5	.	7	.	22	.	18	.	12	8
22	15	7	7	8	10	21	22	14	13	13	13	5
23	19	.	7	.	24	.	12	.	27	.	18	8
24	11	.	16	.	13	.	13	.	23	.	15	5
25	17	12	31	18	28	29	13	18	34	20	22	8
26	32	19	27	38	48	38	39	26	40	24	33	9
27	23	18	20	23	14	14	22	28	26	16	20	5
28	15	.	13	.	6	.	21	.	34	.	18	11
29	12	11	19	24	14	13	20	19	20	6	16	5
30	22	8	21	31	21	27	28	30	37	45	27	10
31	9	27	18	11	16	9	12	36	26	15	18	9
32	33	.	21	.	28	.	29	.	33	.	29	5
33	17	24	21	18	21	28	34	26	31	15	24	6
34	18	.	32	.	24	.	16	.	42	.	26	11
35	18	29	19	27	40	34	36	34	47	52	34	11
36	13	.	19	.	45	.	35	.	17	.	26	14
37	22	23	14	28	21	30	29	16	30	19	23	6
38	14	.	12	.	11	.	15	.	20	.	14	4
39	21	.	26	.	19	.	23	.	27	.	23	3
40	13	.	15	.	23	.	27	.	19	.	19	6
MEANS	16	14	13	15	18	16	20	18	23	17		
STD DEV	6	7	8	11	12	12	9	10	10	13		

Table 6.2-26 BENTHIC CORE SHANNON INDEX BY DATE AND STATION

STATION	JUNE 1983	JULY 1983	SEPTEMBER 1983	OCTOBER 1983	NOVEMBER 1983	JANUARY 1984	FEBRUARY 1984	APRIL 1984	JUNE 1984	JULY 1984	MEAN	STANDARD DEVIATION
1	2.1167	.	1.1917	.	0.8181	.	1.9343	.	2.3835	.	1.6889	0.6579
2	2.6381	.	2.4542	.	3.3648	.	3.4679	.	3.2763	.	3.0403	0.4607
3	2.8281	.	3.3462	.	3.3637	.	3.4872	.	3.6275	.	3.3305	0.3027
4	1.7580	1.0867	1.7500	1.4600	1.7504	2.1684	2.0314	2.4935	1.2545	2.1647	1.7918	0.4386
5	2.1243	2.0240	1.3759	1.5522	2.2082	1.7352	2.0038	2.0771	2.5872	2.6772	2.0365	0.4104
6	2.7203	.	1.9802	.	2.0737	.	1.5741	.	3.0286	.	2.2754	0.5884
7	3.2475	2.9446	2.4215	3.2805	2.8259	2.3340	2.8687	3.1288	3.2683	2.8827	2.9203	0.3346
8	2.6881	.	1.3015	.	2.2992	.	1.9456	.	2.7518	.	2.1972	0.5968
9	3.5291	3.1633	3.3151	3.1894	2.5800	2.4003	2.6113	2.2466	3.6563	3.7869	3.0478	0.5501
10	2.7856	.	2.7937	.	2.8473	.	2.9545	.	3.7163	.	3.0195	0.3953
11	3.7598	.	3.6037	.	3.7809	.	3.3858	.	3.8171	.	3.6694	0.1783
12	3.8381	3.5378	3.6083	3.5343	3.9314	3.8667	3.5968	3.7337	3.5383	2.6971	3.5883	0.3467
13	3.0426	2.7745	2.4119	3.0829	3.1177	2.6813	3.1657	2.4632	2.5144	3.0387	2.8293	0.2948
14	2.7035	.	2.3129	.	2.4865	.	2.2243	.	2.7632	.	2.4981	0.2355
15	3.6684	2.6316	2.2081	2.7994	2.5499	1.9543	2.4826	2.8768	3.2376	2.6026	2.7011	0.4888
16	3.7309	.	3.1976	.	3.6608	.	3.5112	.	3.7786	.	3.5758	0.2343
17	2.5616	1.7293	1.7387	2.0222	2.6048	1.7429	2.1896	1.9708	2.6669	2.4636	2.1690	0.3801
18	2.6678	2.5017	1.1560	1.8203	2.3879	1.4466	2.5896	2.5484	3.3332	2.8395	2.3291	0.6622
19	2.6334	.	2.1611	.	2.8584	.	3.1995	.	2.7203	.	2.7145	0.3771
20	2.2281	2.0518	1.2269	2.0797	2.5946	2.5823	2.6692	2.9761	2.5447	2.2838	2.3237	0.4809
21	2.2325	.	1.4280	.	2.4540	.	2.8943	.	2.7849	.	2.3587	0.5831
22	3.6235	2.8410	2.8396	3.1994	3.1594	3.4643	3.4095	3.4959	3.1724	3.3429	3.2548	0.2650
23	3.5974	.	2.7520	.	2.8672	.	3.0954	.	3.4451	.	3.1514	0.3635
24	3.9419	.	3.7930	.	3.5319	.	3.4830	.	3.5747	.	3.6649	0.1949
25	3.3313	3.2588	3.6494	3.9080	3.6384	3.9771	3.7731	3.6498	4.1563	3.3753	3.6717	0.2926
26	3.7922	3.6956	3.7636	4.0392	3.8551	4.0280	3.4761	3.7446	3.8032	3.8905	3.8088	0.1633
27	3.0516	3.2138	2.9844	3.1755	2.8990	2.8128	3.2589	3.2890	3.2916	2.7727	3.0749	0.1988
28	3.1854	.	2.7169	.	2.9229	.	3.3660	.	1.9408	.	2.8264	0.5535
29	1.6356	2.5310	2.0223	2.3531	2.7904	3.4138	3.2840	3.0860	2.2869	2.9214	2.6324	0.5699
30	3.7223	3.2915	3.4474	3.2414	3.0317	2.9647	2.7767	3.1925	2.6137	3.7326	3.2014	0.3703
31	3.5742	3.8429	3.2023	3.0192	3.7524	3.0078	3.0820	3.5395	3.7146	3.2299	3.3965	0.3226
32	3.7326	.	3.9488	.	3.8381	.	3.7769	.	3.7010	.	3.7995	0.0981
33	3.7647	3.9503	3.8664	3.7209	3.6954	3.4799	3.2003	3.7088	3.9326	3.5350	3.6854	0.2291
34	3.8962	.	2.9350	.	3.2430	.	3.4956	.	4.0496	.	3.5239	0.4587
35	3.3420	3.8287	3.7535	3.3561	2.9745	2.5067	1.8817	2.2108	3.6639	4.4445	3.1962	0.7998
36	3.7029	.	3.3231	.	3.5276	.	3.1715	.	3.6147	.	3.4680	0.2175
37	3.8539	4.0192	3.7334	3.7007	3.8330	3.9592	3.7589	3.8636	3.8063	3.9065	3.8435	0.1000
38	2.4385	.	3.3500	.	2.6105	.	2.9548	.	2.8593	.	2.8426	0.3491
39	3.7739	.	3.6399	.	3.9102	.	3.9376	.	4.0446	.	3.8612	0.1569
40	3.5333	.	3.5271	.	3.1565	.	3.5519	.	3.2540	.	3.4046	0.1854
MEANS	3.1249	2.9459	2.7558	2.9267	2.9949	2.8263	2.9880	3.0148	3.2044	3.1294		
STD DEV	0.6553	0.7976	0.8786	0.7811	0.6701	0.8090	0.6199	0.6201	0.6398	0.6100		

Table 6.2-27 BENTHIC CORE FAUNAL EQUITABILITY BY DATE AND STATION

STATION	JUNE 1983	JULY 1983	SEPTEMBER 1983	OCTOBER 1983	NOVEMBER 1983	JANUARY 1984	FEBRUARY 1984	APRIL 1984	JUNE 1984	JULY 1984	MEAN	STANDARD DEVIATION
1	0.5907	.	0.3408	.	0.2361	.	0.4997	.	0.7153	.	0.4765	0.1916
2	0.6274	.	0.6653	.	0.7657	.	0.8135	.	0.7686	.	0.7281	0.0782
3	0.6400	.	0.7400	.	0.6990	.	0.7164	.	0.7513	.	0.7093	0.0438
4	0.5028	0.2926	0.5581	0.4656	0.5945	0.6315	0.5368	0.6715	0.3424	0.6644	0.5260	0.1289
5	0.6375	0.6074	0.4760	0.5598	0.6778	0.5893	0.5264	0.6822	0.6797	0.7657	0.6202	0.0860
6	0.6728	.	0.6315	.	0.6039	.	0.4327	.	0.7129	.	0.6108	0.1078
7	0.8141	0.7283	0.6706	0.8224	0.6697	0.5551	0.6978	0.7552	0.8015	0.7763	0.7291	0.0832
8	0.7983	.	0.4043	.	0.6416	.	0.5274	.	0.7511	.	0.6246	0.1616
9	0.8174	0.7198	0.7655	0.8706	0.6629	0.6136	0.6189	0.5803	0.7939	0.8056	0.7249	0.1006
10	0.6514	.	0.6717	.	0.6359	.	0.6886	.	0.8035	.	0.6902	0.0664
11	0.8355	.	0.8373	.	0.7576	.	0.6705	.	0.7867	.	0.7775	0.0687
12	0.8299	0.8507	0.8188	0.7296	0.8015	0.8242	0.7344	0.7295	0.7130	0.5844	0.7616	0.0802
13	0.7138	0.7804	0.6495	0.8197	0.7890	0.6549	0.7245	0.5741	0.6461	0.7177	0.7070	0.0765
14	0.6603	.	0.7483	.	0.6836	.	0.5746	.	0.6288	.	0.6591	0.0644
15	0.8445	0.7344	0.5510	0.7085	0.6002	0.4899	0.5545	0.6998	0.8008	0.7263	0.6710	0.1164
16	0.8668	.	0.7689	.	0.7366	.	0.7658	.	0.8187	.	0.7914	0.0515
17	0.6309	0.4826	0.5804	0.6363	0.7387	0.4985	0.5464	0.5208	0.6277	0.6472	0.5909	0.0798
18	0.7093	0.7285	0.4507	0.5728	0.6273	0.4213	0.6378	0.6450	0.8141	0.7597	0.6366	0.1272
19	0.6731	.	0.6418	.	0.7010	.	0.7481	.	0.6262	.	0.6781	0.0486
20	0.5820	0.5868	0.3913	0.5677	0.7034	0.6745	0.6394	0.6982	0.6142	0.5752	0.6033	0.0902
21	0.5899	.	0.4016	.	0.6339	.	0.6568	.	0.6374	.	0.5839	0.1048
22	0.8269	0.7122	0.6936	0.7783	0.7150	0.7607	0.7453	0.7869	0.7016	0.7696	0.7490	0.0432
23	0.8055	.	0.6999	.	0.6124	.	0.7084	.	0.7171	.	0.7087	0.0686
24	0.9130	.	0.8758	.	0.8037	.	0.7740	.	0.7576	.	0.8248	0.0669
25	0.7282	0.7458	0.7597	0.8330	0.7654	0.8366	0.8175	0.7637	0.8121	0.7313	0.7793	0.0416
26	0.8007	0.8341	0.7889	0.8139	0.7424	0.8399	0.6985	0.7681	0.7522	0.8430	0.7882	0.0477
27	0.7004	0.7757	0.7176	0.7500	0.7024	0.6599	0.7480	0.7403	0.7297	0.6310	0.7155	0.0439
28	0.7498	.	0.6558	.	0.7871	.	0.7248	.	0.4061	.	0.6647	0.1523
29	0.4045	0.6611	0.4684	0.5088	0.6405	0.7429	0.7280	0.7023	0.5161	0.7394	0.6112	0.1255
30	0.8155	0.8414	0.7252	0.6680	0.6300	0.6283	0.5760	0.6538	0.5189	0.7680	0.6825	0.1038
31	0.8562	0.8309	0.7589	0.6796	0.8360	0.7232	0.7054	0.7703	0.8049	0.7577	0.7723	0.0591
32	0.7744	.	0.8712	.	0.8247	.	0.7960	.	0.7553	.	0.8063	0.0429
33	0.8567	0.8295	0.8452	0.8491	0.8253	0.7269	0.6486	0.7656	0.8067	0.8213	0.7975	0.0659
34	0.8289	.	0.6197	.	0.6662	.	0.7381	.	0.7894	.	0.7285	0.0860
35	0.7211	0.8244	0.8001	0.6974	0.5952	0.5037	0.3781	0.4356	0.7142	0.8615	0.6531	0.1678
36	0.8687	.	0.7650	.	0.6800	.	0.6175	.	0.8273	.	0.7517	0.1033
37	0.8215	0.8636	0.9156	0.7567	0.8398	0.8084	0.7698	0.8056	0.7950	0.8559	0.8232	0.0473
38	0.6085	.	0.7967	.	0.6708	.	0.7277	.	0.6753	.	0.6958	0.0705
39	0.8287	.	0.7603	.	0.8586	.	0.8142	.	0.8691	.	0.8262	0.0430
40	0.7912	.	0.7939	.	0.6825	.	0.7344	.	0.7286	.	0.7461	0.0469
MEANS	0.7347	0.7215	0.6769	0.7044	0.6959	0.6592	0.6690	0.6874	0.7130	0.7401		
STD DEV	0.1140	0.1417	0.1476	0.1201	0.1065	0.1245	0.1066	0.0967	0.1132	0.0835		

Table 6.2-28 Log normal plot angles.

Station	June 1983	Sept. 1983	Nov. 1983	Feb. 1984	June 1984	Mean $\bar{x}$	S.D.
1	33	33	43	31	35	35	4.690
2	44	37	35	37	43	39	4.025
3	46	39	33	32	52	40.4	8.561
4	30	32	26	32	24	28.8	3.633
5	30	20	27	25	25	25.4	3.647
6	30	27	24	20	37	27.6	6.427
7	37	25	29	29	30	30	4.359
8	38	39	35	39	29	36	4.243
9	39	37	38	38	42	38.8	1.923
10	44	39	32	41	41	39.4	4.506
11	48	45	46	43	40	44.4	3.050
12	46	45	38	34	43	41.2	5.070
13	37	27	36	32	24	31.2	5.630
14	43	37	51	29	35	39	8.367
15	46	46	34	39	43	41.6	5.128
16	49	35	37	40	43	40.8	5.495
17	28	21	33	32	35	29.8	5.541
18	36	33	30	32	35	33.2	2.387
19	30	30	33	28	27	29.6	2.302
20	31	24	23	25	31	26.8	3.900
21	31	29	26	23	35	28.8	4.604
22	38	35	33	40	40	37.2	3.114
23	45	32	29	35	32	34.6	6.189
24	57	54	49	43	36	47.8	8.468
25	49	49	47	39	41	45	4.690
26	46	46	43	38	42	43	3.317
27	45	42	32	31	30	36	6.964
28	40	39	38	33	32	36.4	3.650
29	39	32	23	35	39	27.6	1.424
30	37	37	34	35	36	35.8	1.304
31	47	38	42	35	39	40.2	4.550
32	33	46	40	46	40	41	5.385
33	49	47	49	31	37	42.6	8.173
34	45	46	35	40	32	39.6	6.107
35	49	48	37	39	40	42.6	5.505
36	50	50	36	37	43	43.2	6.760
37	47	52	45	45	50	47.8	3.114
38	39	38	34	48	35	38.8	5.541
39	49	35	47	40	42	42.6	5.595
40	39	47	38	39	42	41	3.674

Table 6.2-29 Mean faunal similarity (Morisita's Index) for each station.

Station	Mean of 10 Periods	Station	Mean of 5 Periods
4	.38	1	.52
5	.61	2	.37
7	.61	3	.37
9	.33	6	.55
12	.29	8	.62
13	.50	10	.45
15	.54	11	.19
17	.66	14	.41
18	.48	16	.37
20	.54	19	.32
22	.55	21	.58
25	.57	23	.26
26	.40	24	.43
27	.42	28	.36
29	.19	32	.40
30	.56	34	.46
31	.40	36	.25
33	.52	38	.27
35	.40	39	.52
37	.47	40	.66

Table 6.2-30 Linear regression (R^2 values) for Faunal Density as the dependent variable (Y).

Independent Variable (X)	June 1983	July 1983	Sept. 1983	Oct. 1983	Nov. 1983	Jan. 1984	Feb. 1984	Apr. 1984	June 1984	July 1984
Synoptic Temperature	.0225	.0004	.0254	.0025	.0019	.0071	.0170	.0459	.0019	.0361
Thermographs	.0043	.0925	.0238	.0563	.0123	.0081	.0162	.0162	.0003	.0177
Sediment Temperature	.0002	.0461	.0005	.0329	.0082	.0272	.0331	.3440	.0100	.0067
Salinity	.0164	.1247	.0065	.1894	.1308	.1004	.0972	.0963	.0141	.0897
Turbidity	.0070	.0575	.0190	.0455	.0471	.0980	.0608	.1134	.0690	.0916
Total Suspended Solids	.0351	.0200	.0041	.0437	.0464	.0491	.0007	.0260	.0004	.0003
Mean Grain Size	.2939		.2884		.5548		.2946		.0723	
Median Grain Size	.3658		.2898		.5525		.2669		.0368	
Sorting Coefficient	.0066		.0622		.0918		.1186		.1498	
Silt-Clay	.0604		.0252		.2300		.1064		.0146	
Total Organic Carbon	.0082		.0168		.0821		.0459		.0026	
Sulfide	.0092		.0377		.0502		.0768		.0086	
Eh	.0000	.0040	.0631	.0809	.3067	.0530	.2464	.0598	.1252	.0000

Table 6.2-31 Linear regressions (R^2 values) for <u>Species Richness</u> as the dependent variable (Y).

Independent Variable (X)	June 1983	July 1983	Sept. 1983	Oct. 1983	Nov. 1983	Jan. 1984	Feb. 1984	Apr. 1984	June 1984	July 1984	Means
Synoptic Temperature	.0084	.5101	.3754	.3516	.2389	.2807	.3772	.2289	.2496	.2727	.3394
Thermographs	.0026	.3405	.1503	.3149	.2016	.3843	.2598	.3337	.1809	.2240	.2935
Sediment Temperature	.1950	.4559	.2377	.4751	.2547	.4113	.2199	.2858	.2589	.2656	.3110
Salinity	.3219	.1514	.2249	.5533	.3711	.4402	.3931	.6082	.3657	.4090	.0998
Turbidity	.2057	.0026	.2947	.1596	.1296	.2762	.1828	.0277	.0534	.1216	.3150
Total Suspended Solids	.0817	.0616	.1706	.0848	.2012	.1001	.0572	.0226	.0120	.0922	.1385
Mean Grain Size	.2086		.1569		.2792		.2805		.2456		.2636
Median Grain Size	.1592		.0766		.1581		.2115		.2057		.1805
Sorting Coefficient	.1895		.1597		.0761		.0708		.1341		.0846
Silt-Clay	.1926		.1611		.3272		.2293		.2217		.3361
Total Organic Carbon	.2019		.1761		.1496		.1602		.1566		.3157
Sulfide	.0586		.0520		.0823		.1662		.0124		.1559
Eh	.2140	.4024	.0228	.5039	.5704	.0213	.3366	.3974	.3225	.2153	.5179

Table 6.2-32 Linear regressions (R^2 values) for <u>Species Diversity</u> (Shannon's Index) as the dependent variable (Y).

Independent Variable (X)	June 1983	July 1983	Sept. 1983	Oct. 1983	Nov. 1983	Jan. 1984	Feb. 1984	Apr. 1984	June 1984	July 1984
Synoptic Temperature	.0184	.3985	.4315	.4715	.1613	.2643	.1977	.2579	.3512	.2983
Thermographs	.0040	.1151	.1986	.2494	.1401	.4115	.0879	.2647	.1653	.3274
Sediment Temperature	.1851	.2749	.2039	.5266	.1715	.3368	.0494	.2011	.4361	.2817
Salinity	.3201	.3526	.2420	.3567	.4327	.3471	.2156	.2488	.1943	.3053
Turbidity	.1174	.0036	.3004	.1119	.1571	.2152	.2173	.0354	.0373	.0772
Total Suspended Solids	.0093	.0162	.2547	.2034	.2500	.0898	.1302	.0062	.0002	.1758
Mean Grain Size	.0138		.0785		.1191		.0711		.0513	
Median Grain Size	.0025		.0286		.0561		.0451		.0396	
Sorting Coefficient	.0722		.0671		.0270		.0180		.0124	
Silt-Clay	.0799		.2412		.2268		.1653		.1141	
Total Organic Carbon	.1389		.2380		.1786		.1654		.0837	
Sulfide	.0387		.0216		.0273		.0873		.0061	
Eh	.1696	.5337	.0258	.3436	.4145	.0017	.1835	.3030	.0703	.1578

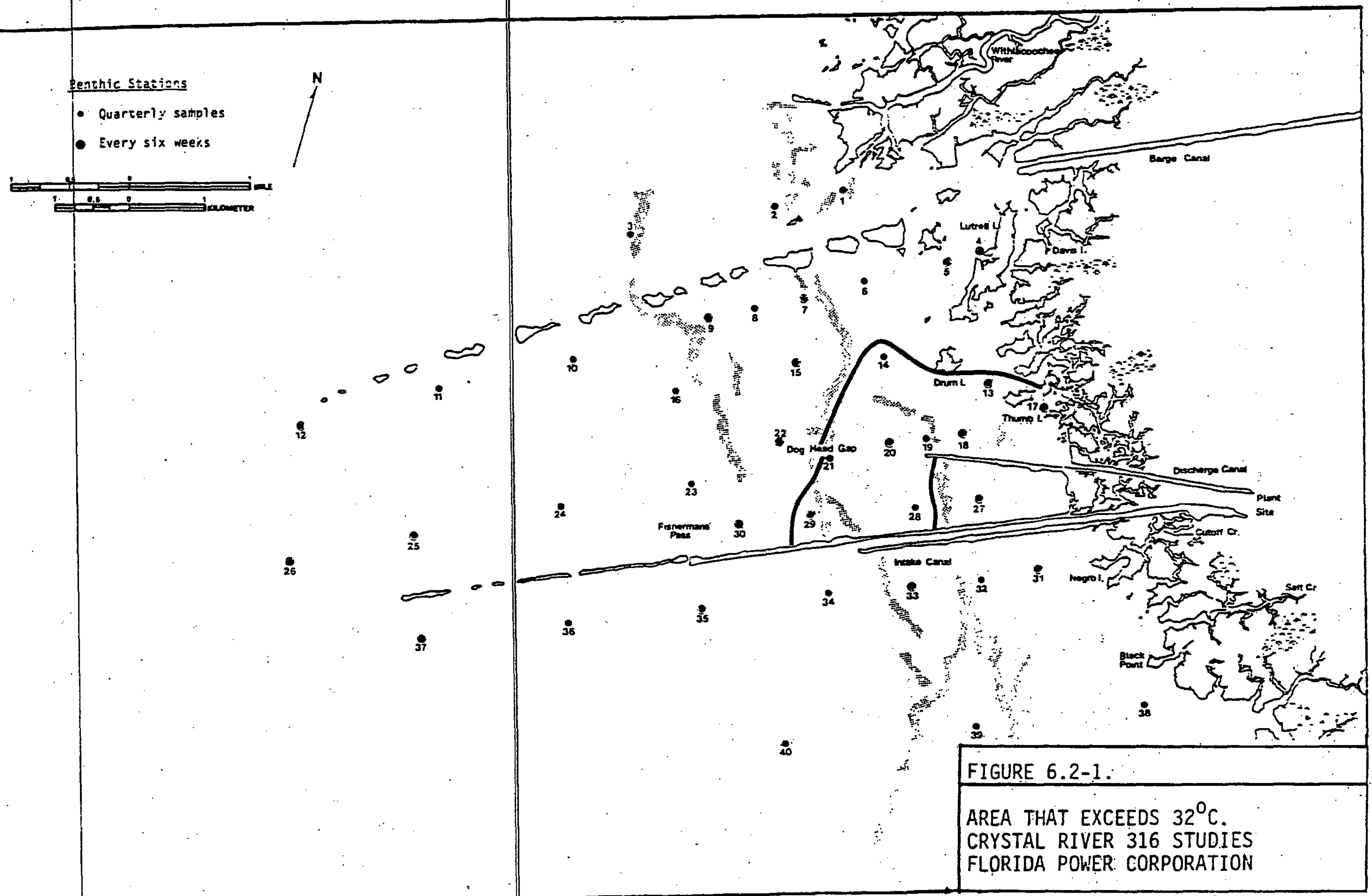

FIGURE 6.2-1.

AREA THAT EXCEEDS 32°C.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

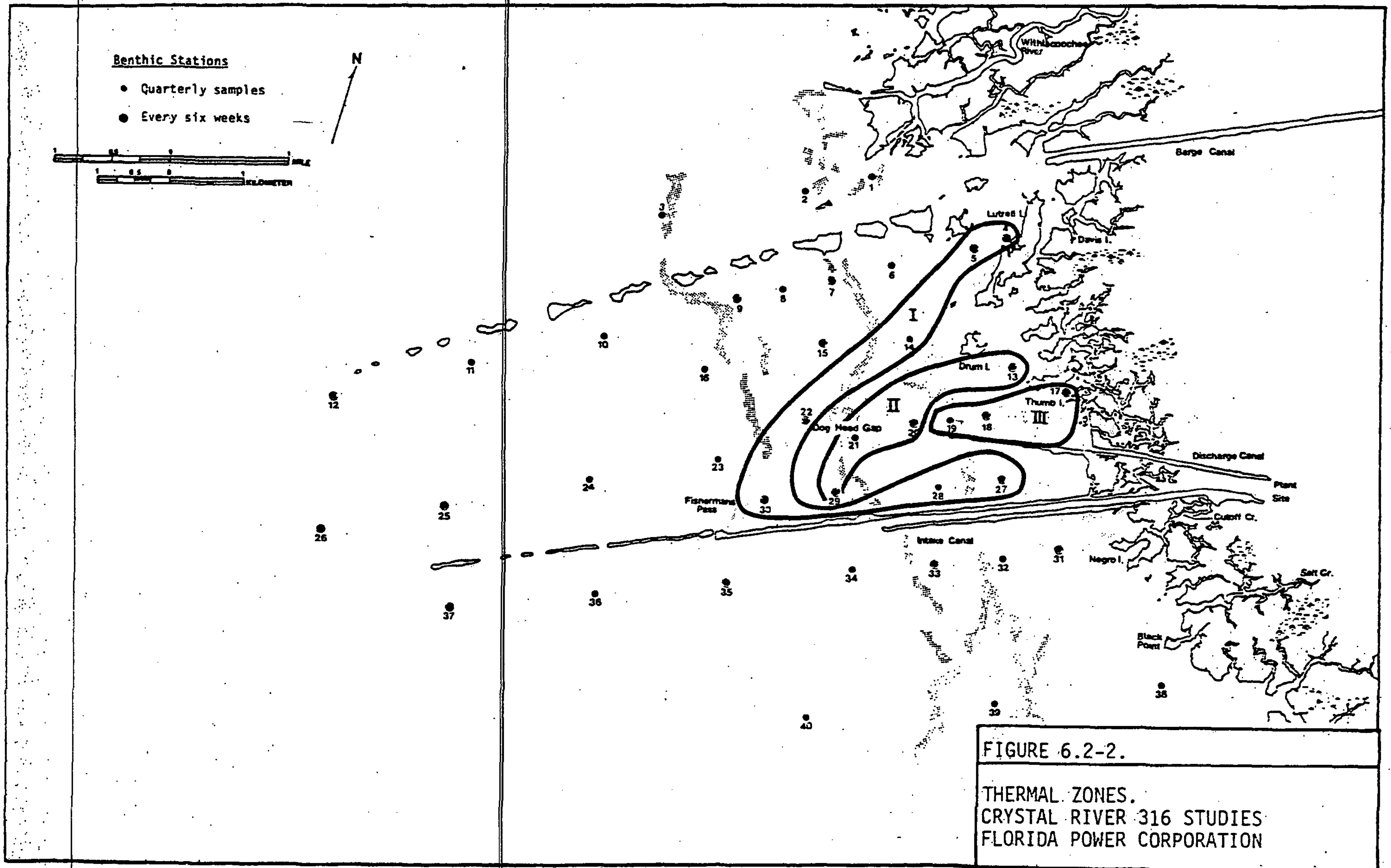

FIGURE 6.2-2.

THERMAL ZONES.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

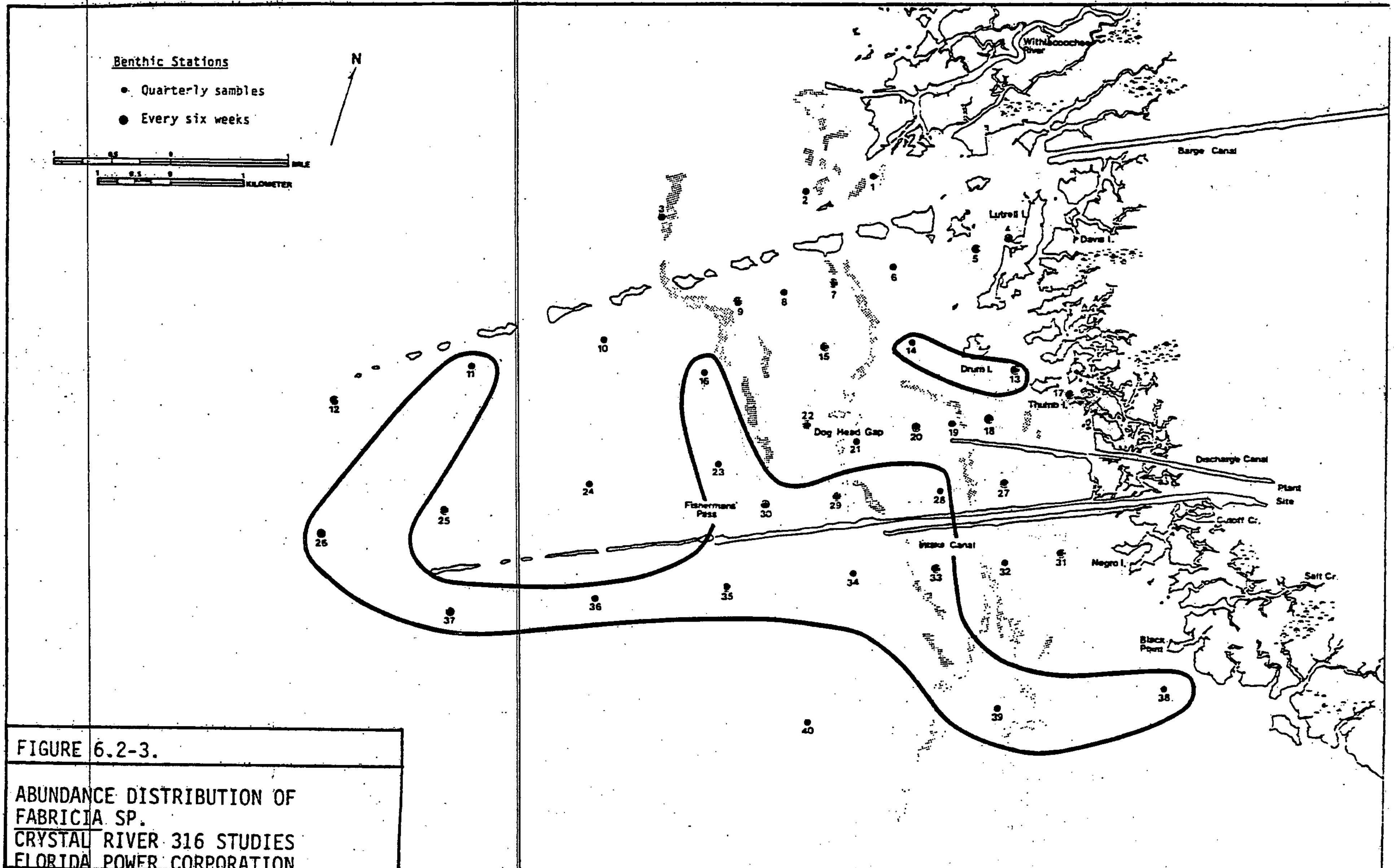

FIGURE 6.2-3.

ABUNDANCE DISTRIBUTION OF
FABRICIA SP.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

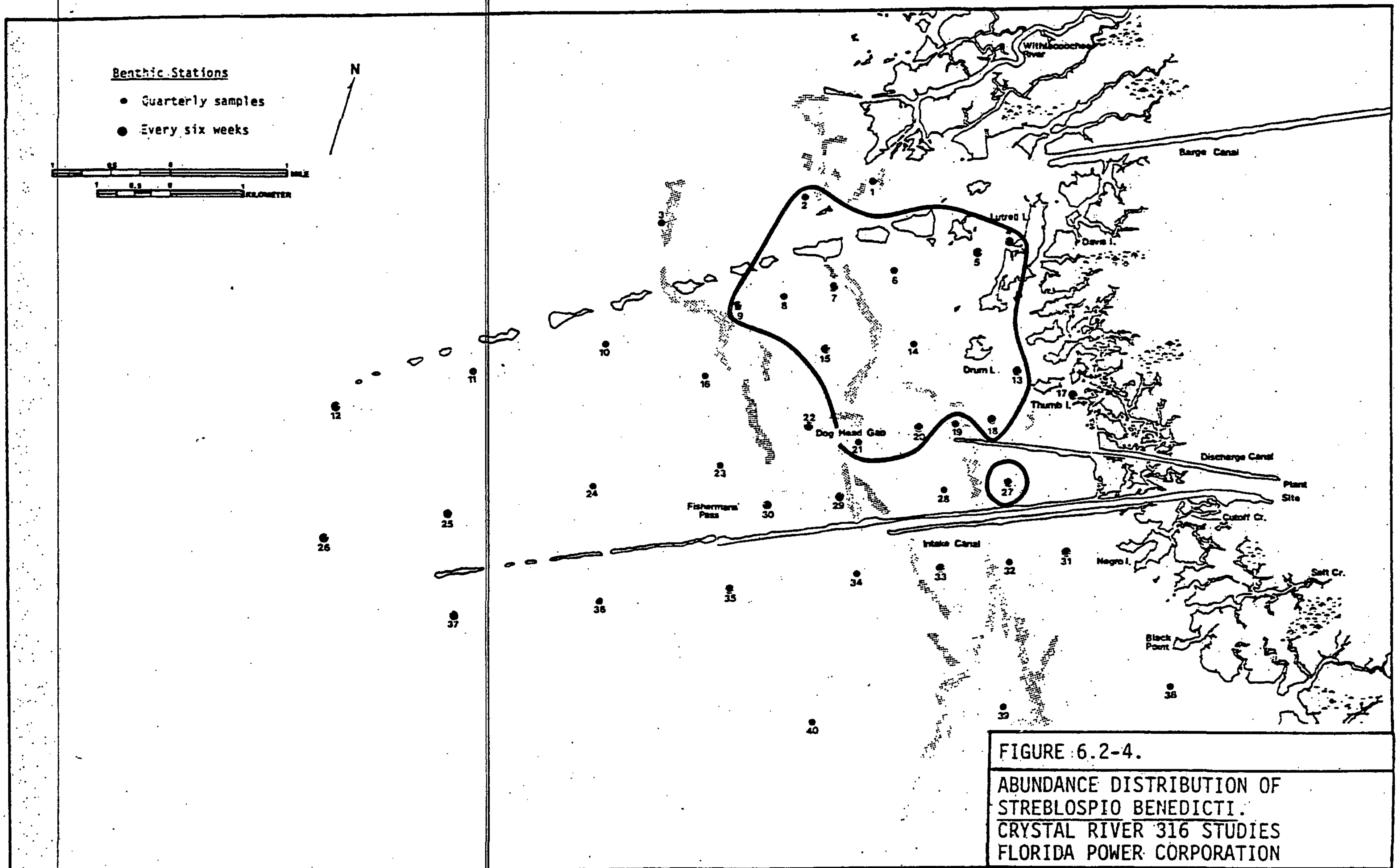

FIGURE 6.2-4.

ABUNDANCE DISTRIBUTION OF STREBLOSPIO BENEDICTI.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

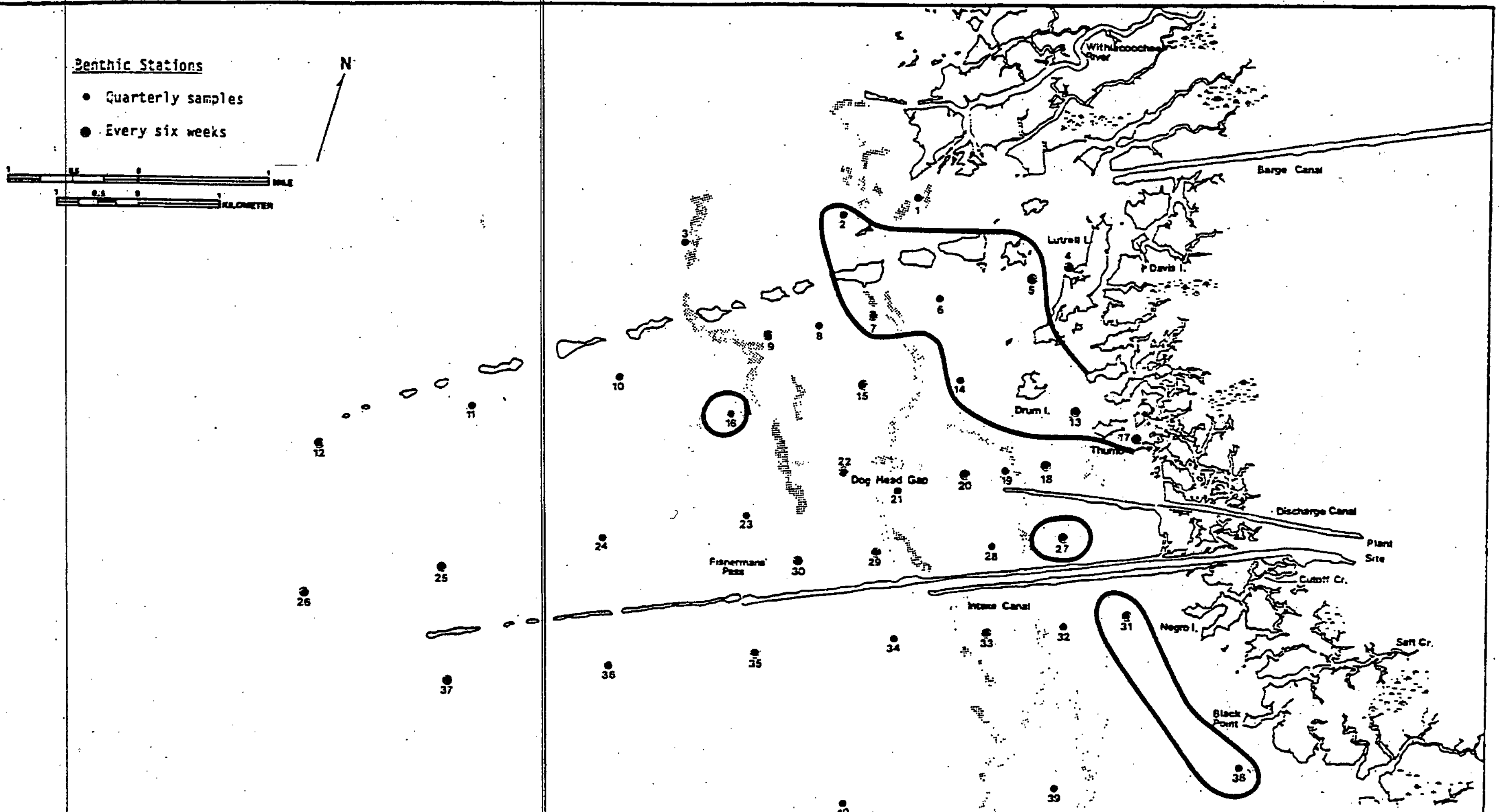

FIGURE 6.2-5.

ABUNDANCE DISTRIBUTION OF *ARICIDEA PHILBINAE*.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

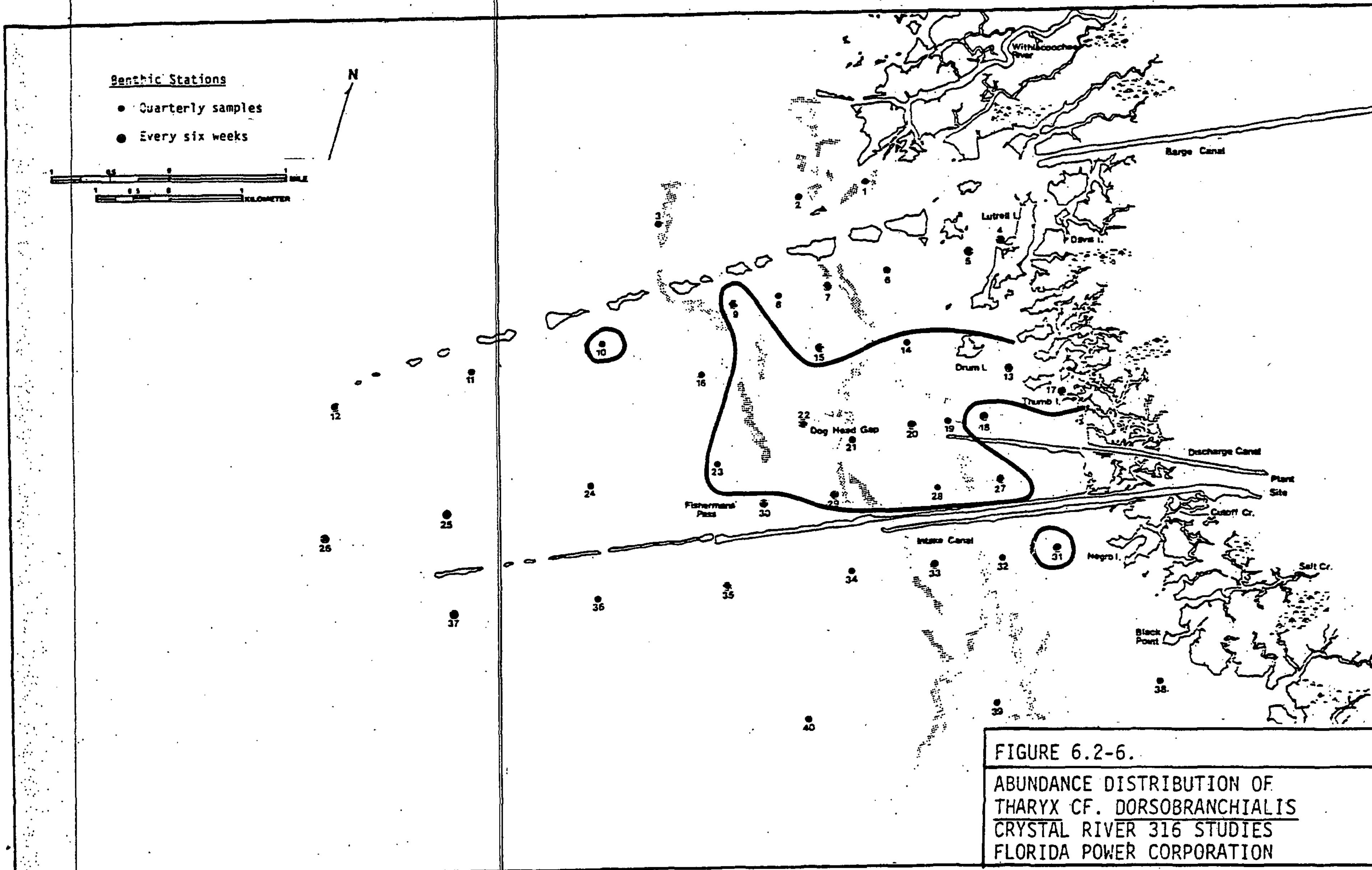

FIGURE 6.2-6.

ABUNDANCE DISTRIBUTION OF
THARYX CF. DORSOBRANCHIALIS
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

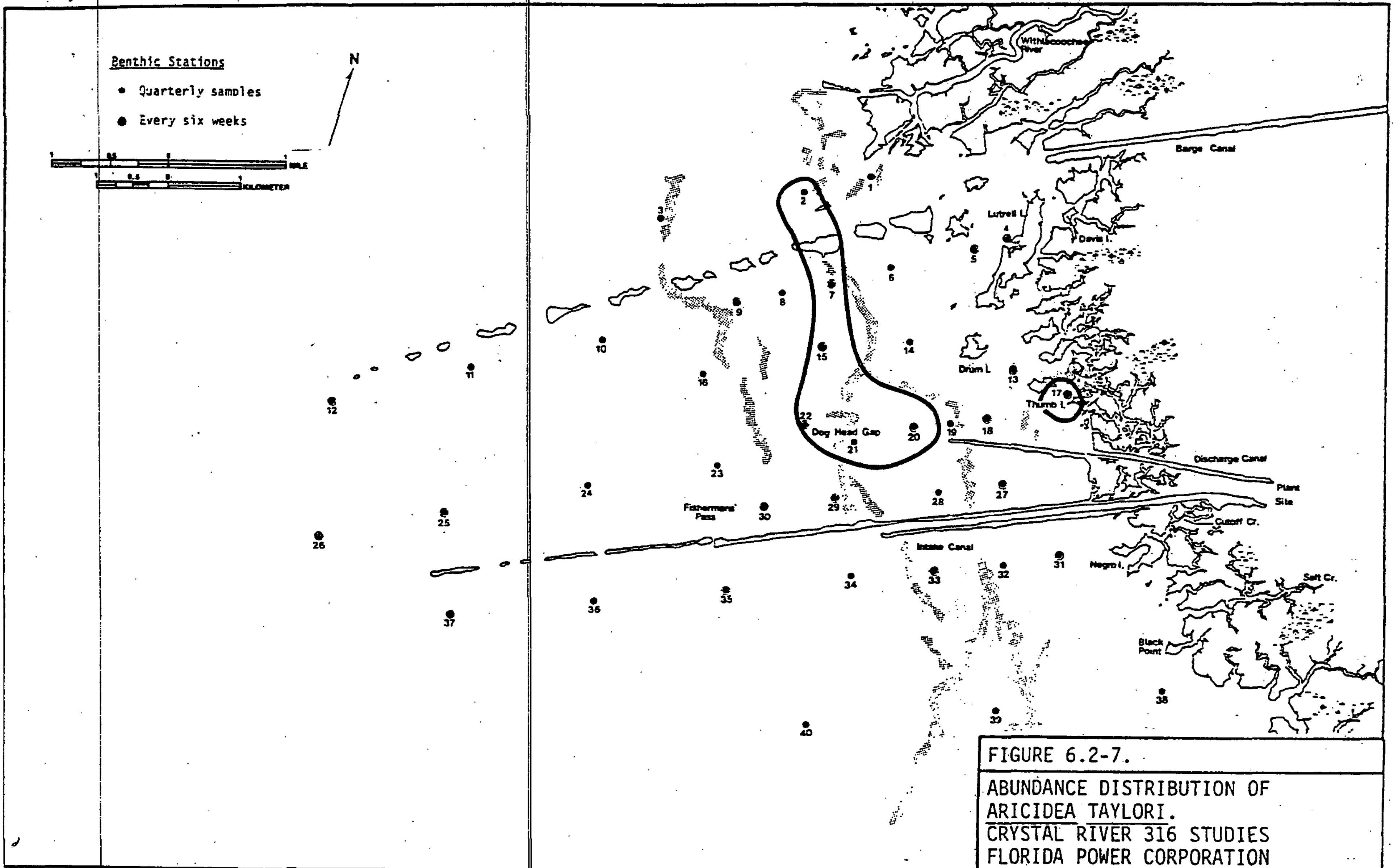

FIGURE 6.2-7.

ABUNDANCE DISTRIBUTION OF
ARICIDEA TAYLORI.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

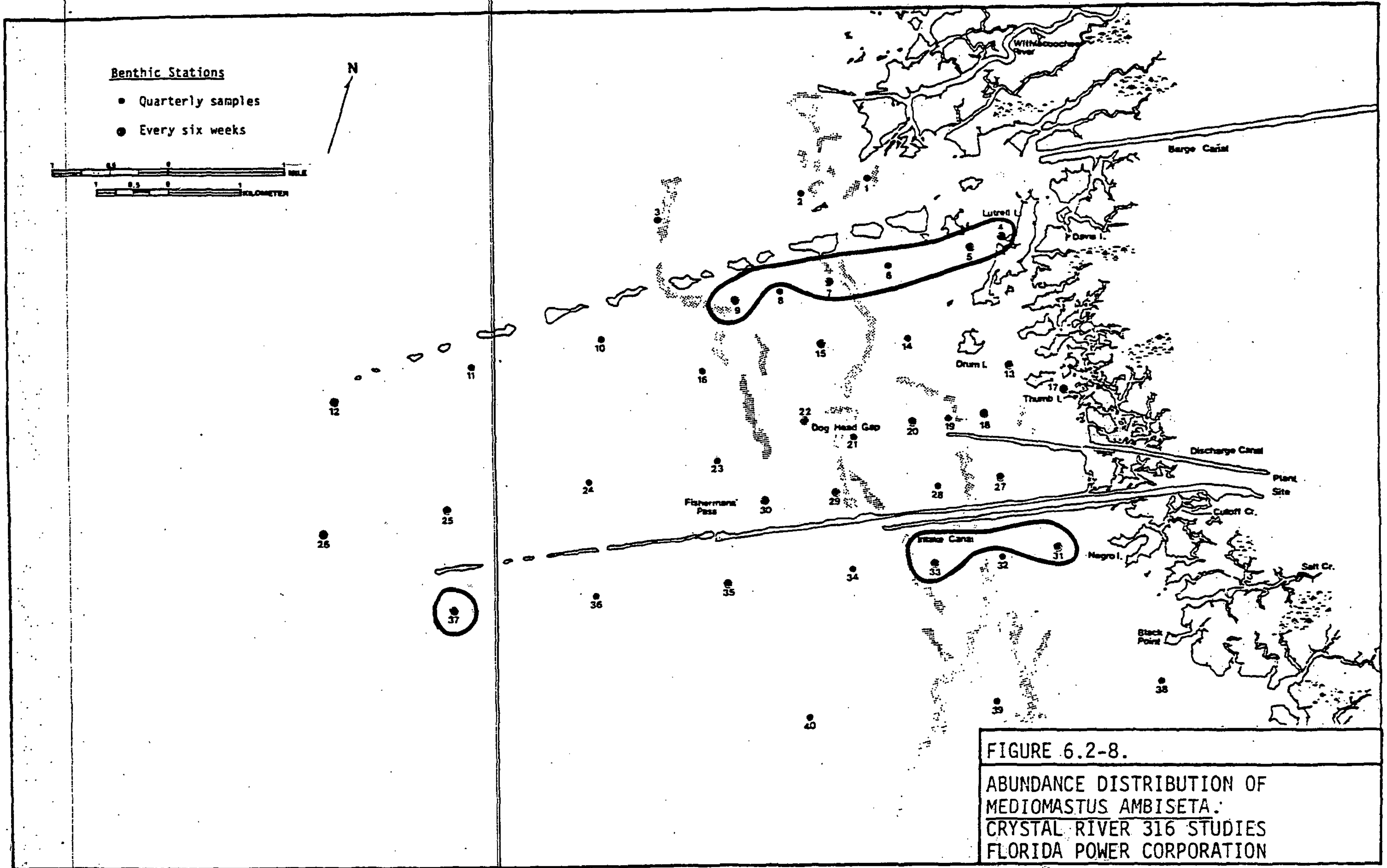

FIGURE 6.2-8.

ABUNDANCE DISTRIBUTION OF MEDIOMASTUS AMBISETA.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

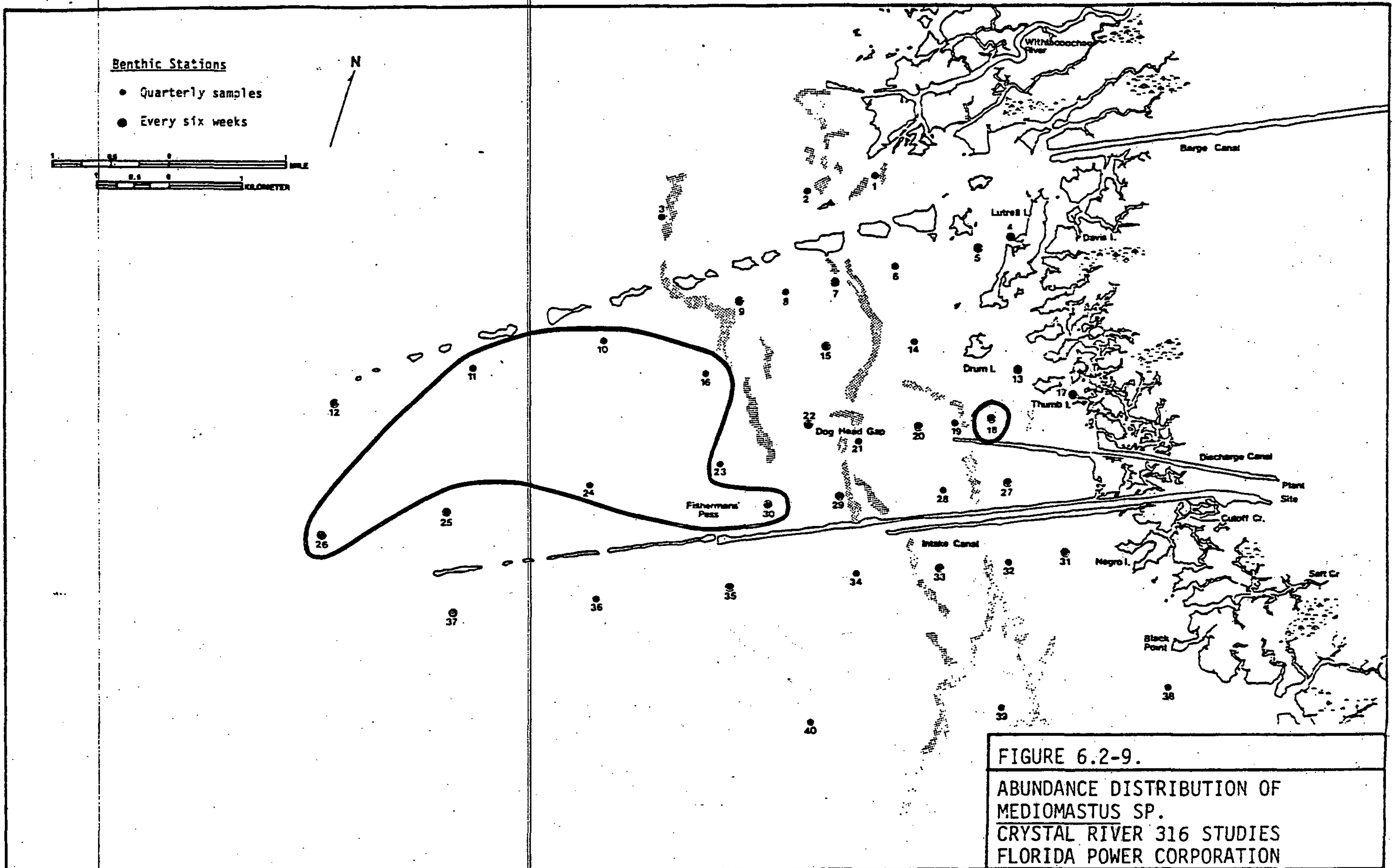

FIGURE 6.2-9.

ABUNDANCE DISTRIBUTION OF
MEDIOMASTUS SP.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

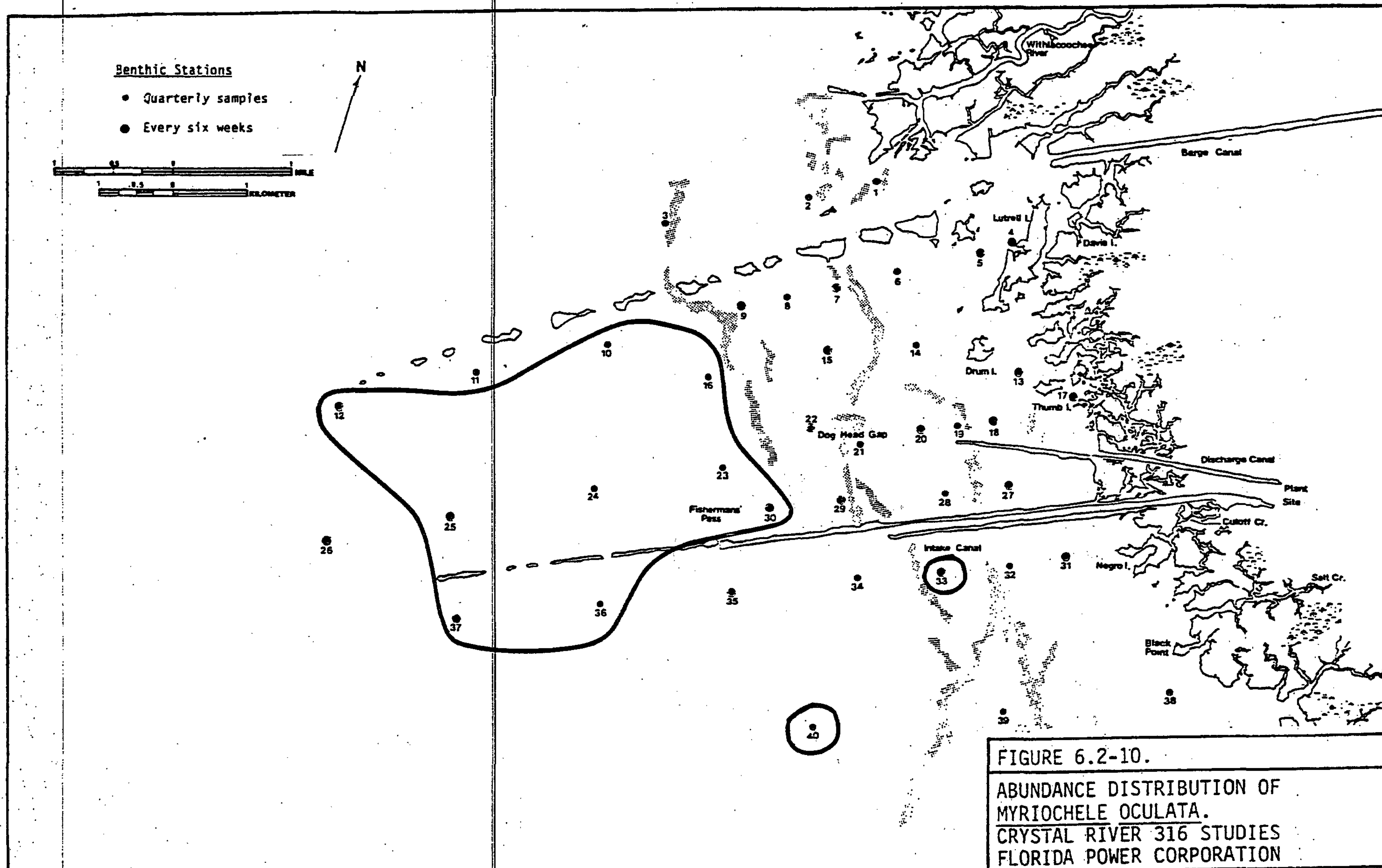

FIGURE 6.2-10.

ABUNDANCE DISTRIBUTION OF *MYRIOCHELE OCULATA*.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

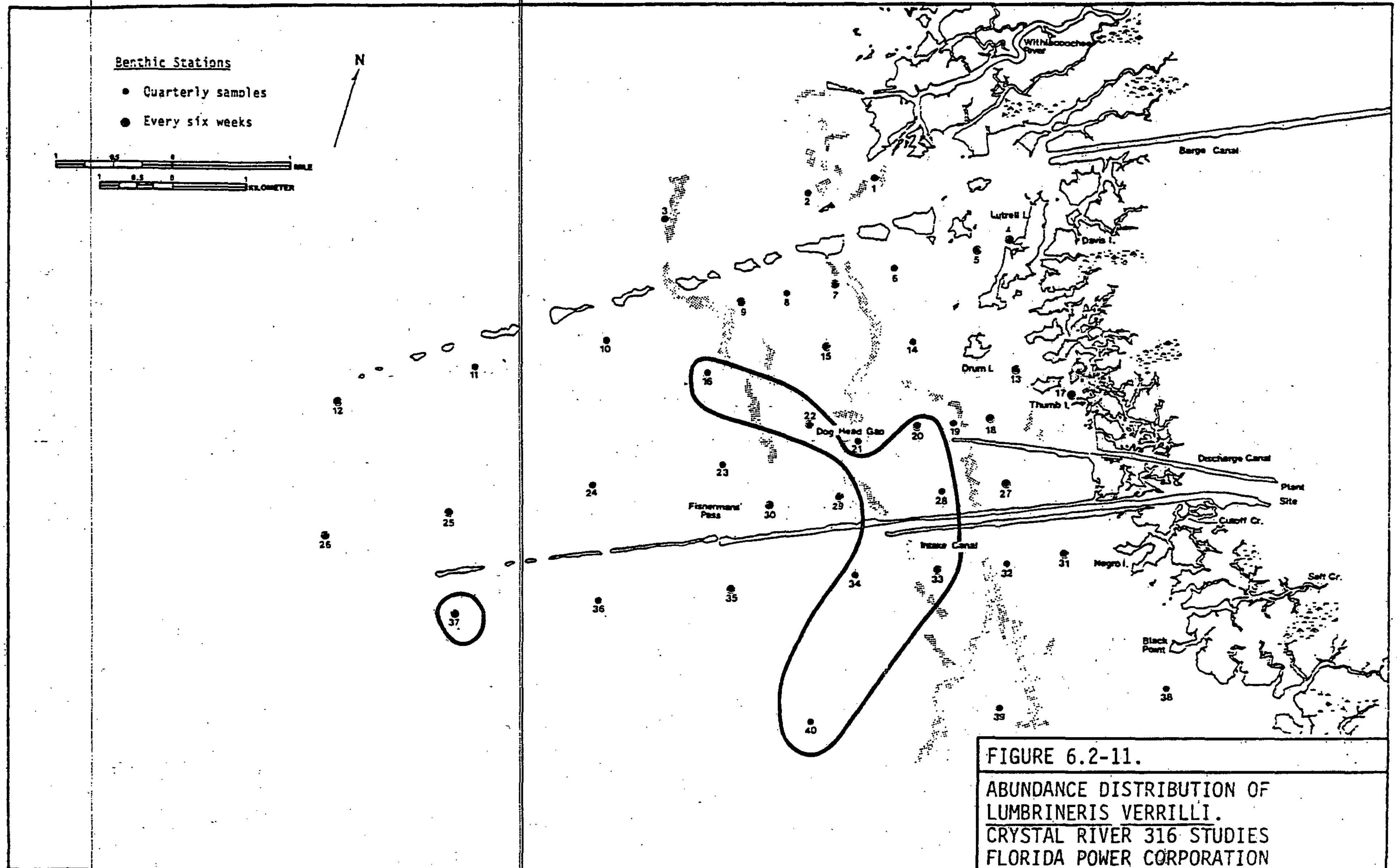

FIGURE 6.2-11.

ABUNDANCE DISTRIBUTION OF
LUMBRINERIS VERRILLI.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

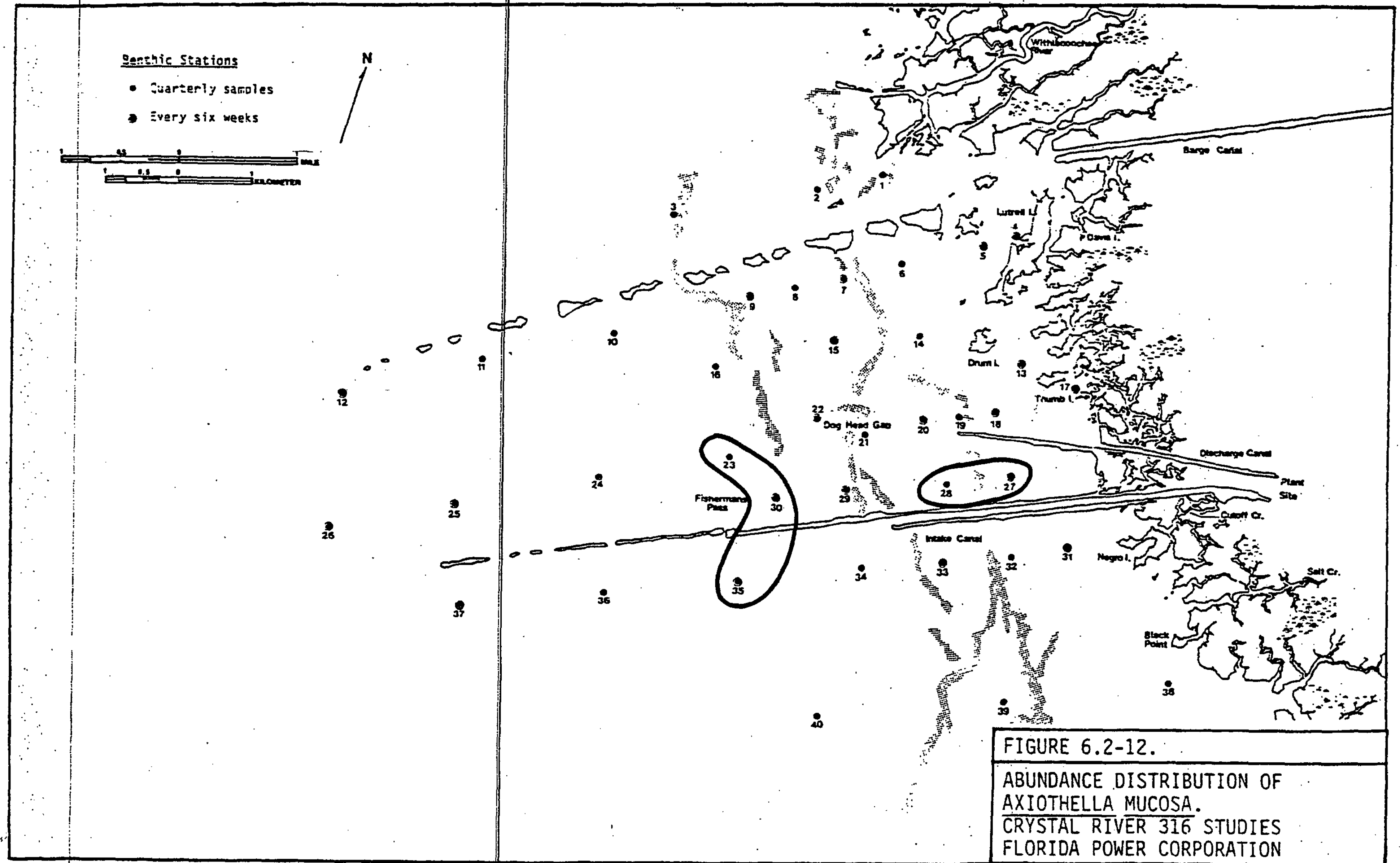

FIGURE 6.2-12.

ABUNDANCE DISTRIBUTION OF
AXIOTHELLA MUCOSA.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

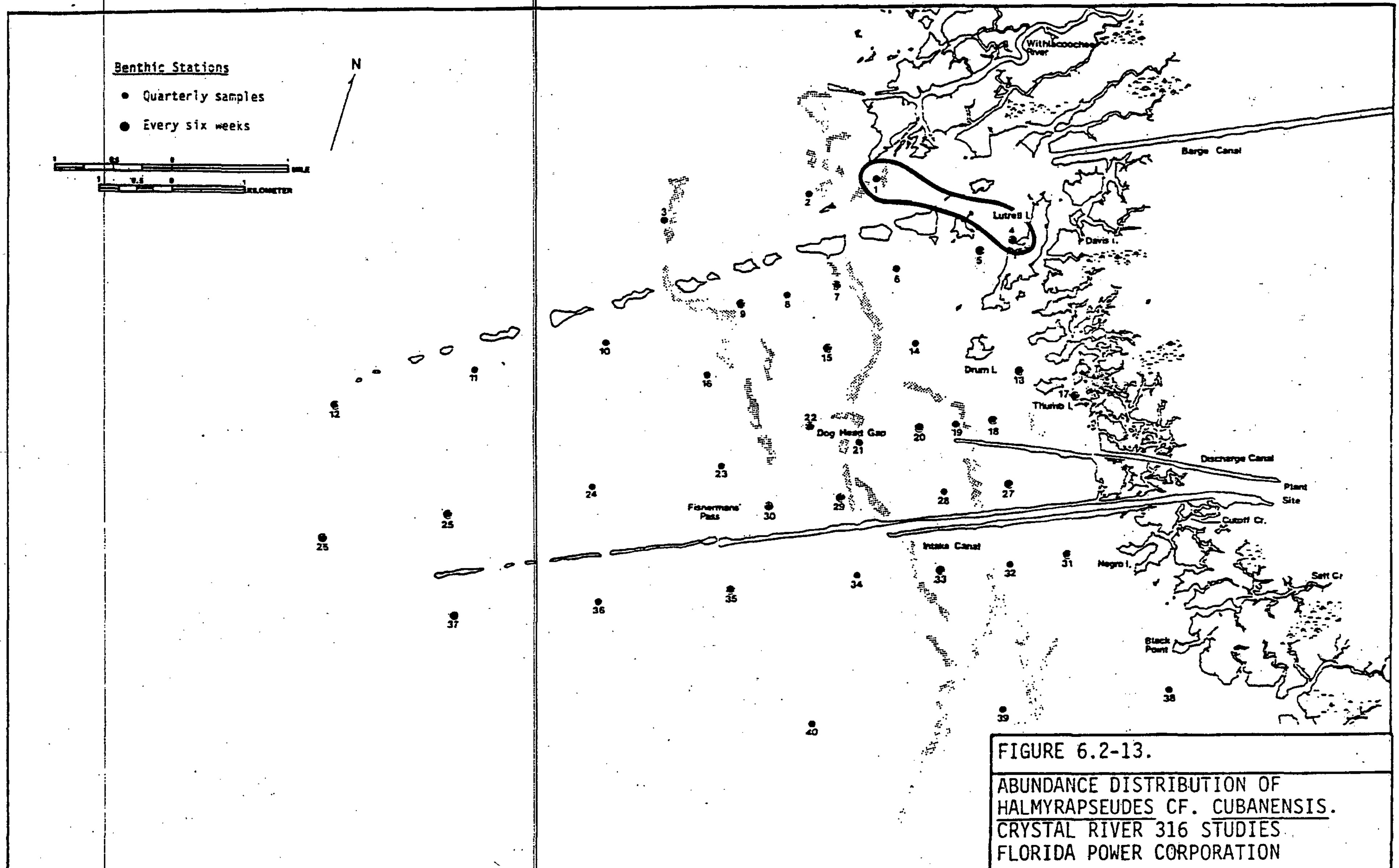

FIGURE 6.2-13.

ABUNDANCE DISTRIBUTION OF HALMYRAPSEUDES CF. CUBANENSIS.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

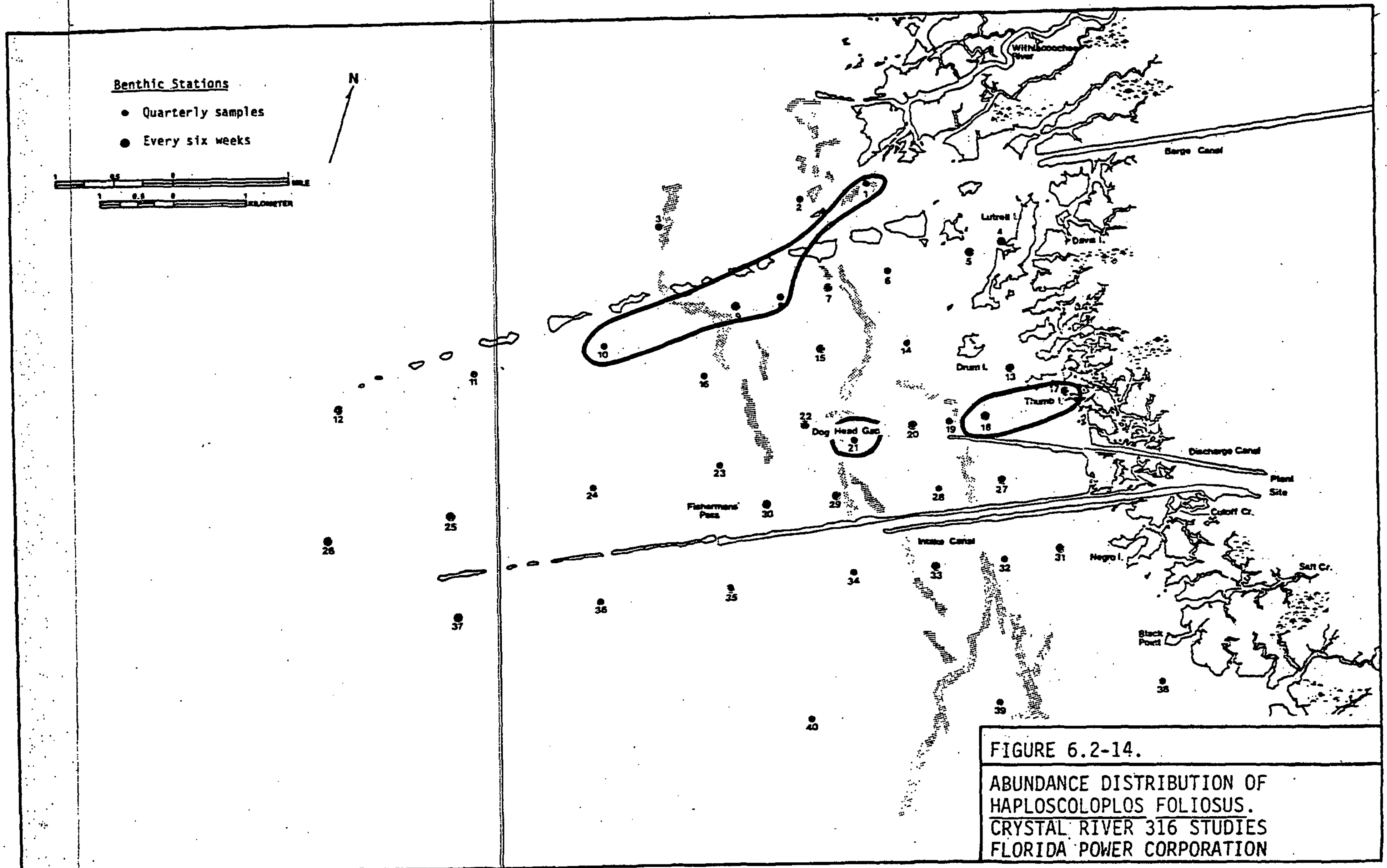

FIGURE 6.2-14.

ABUNDANCE DISTRIBUTION OF HAPLOSCOLOPLOS FOLIOSUS. CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION

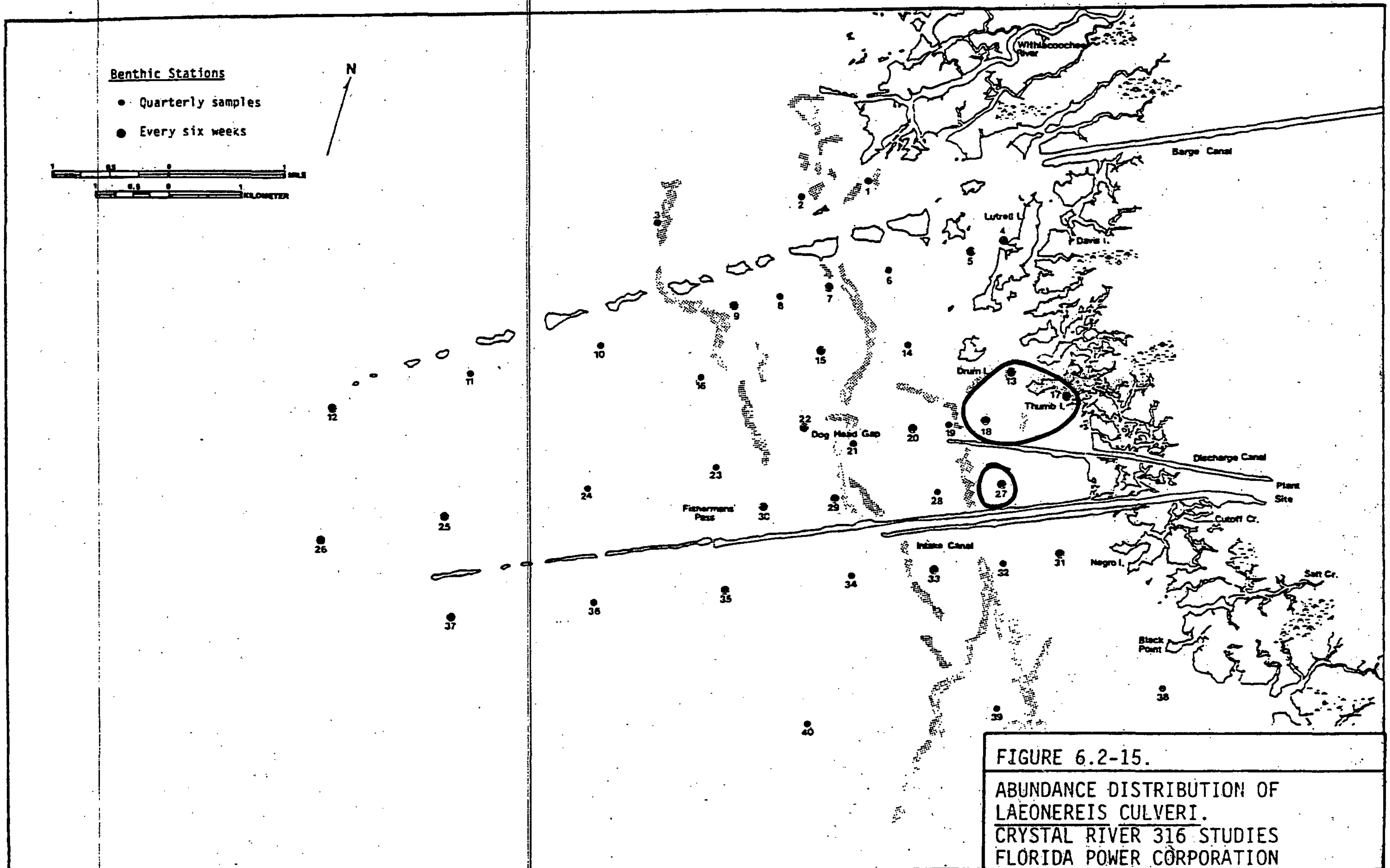

FIGURE 6.2-15.

ABUNDANCE DISTRIBUTION OF LAEONEREIS CULVERI.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

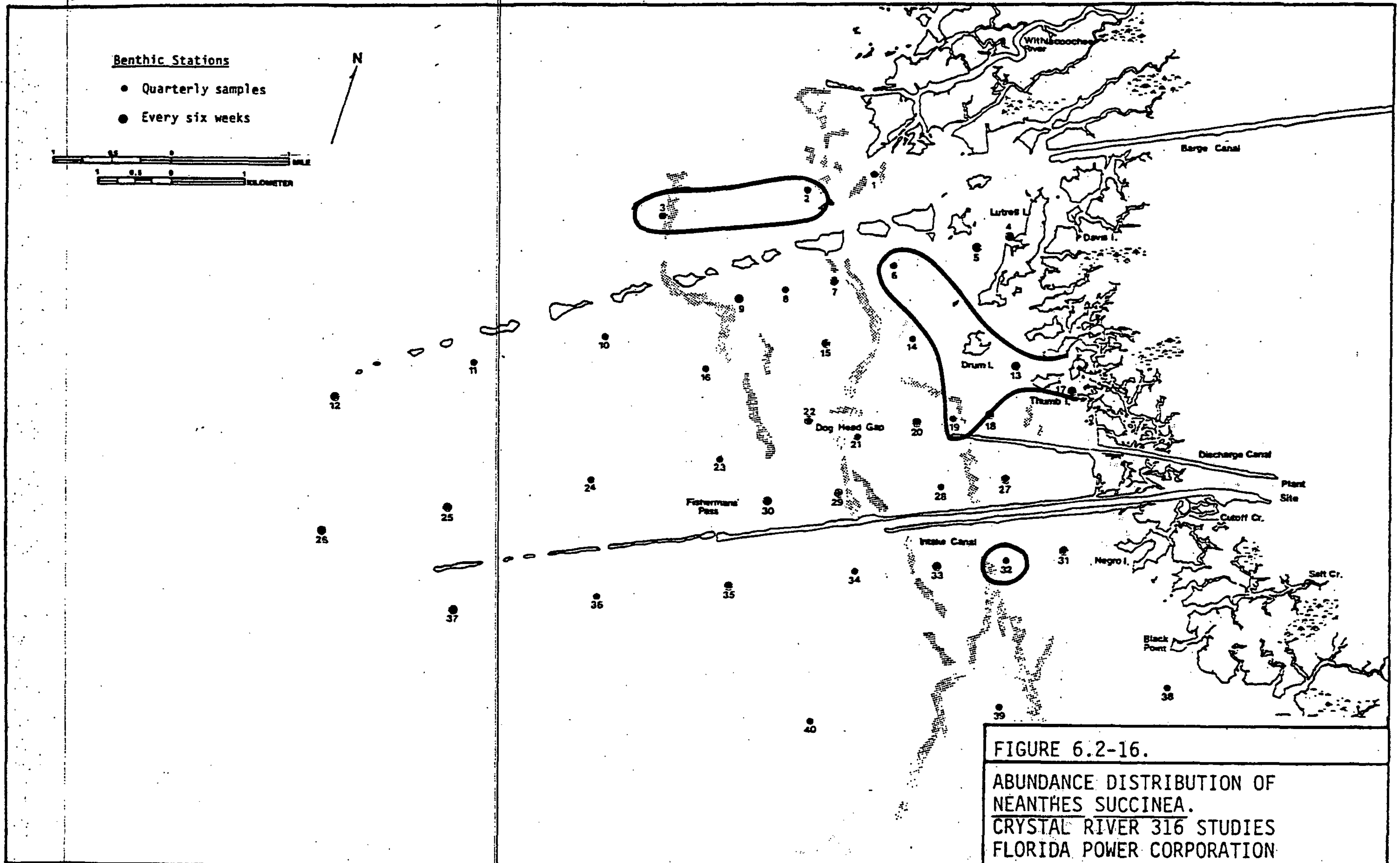

FIGURE 6.2-16.

ABUNDANCE DISTRIBUTION OF NEANTHES SUCCINEA.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

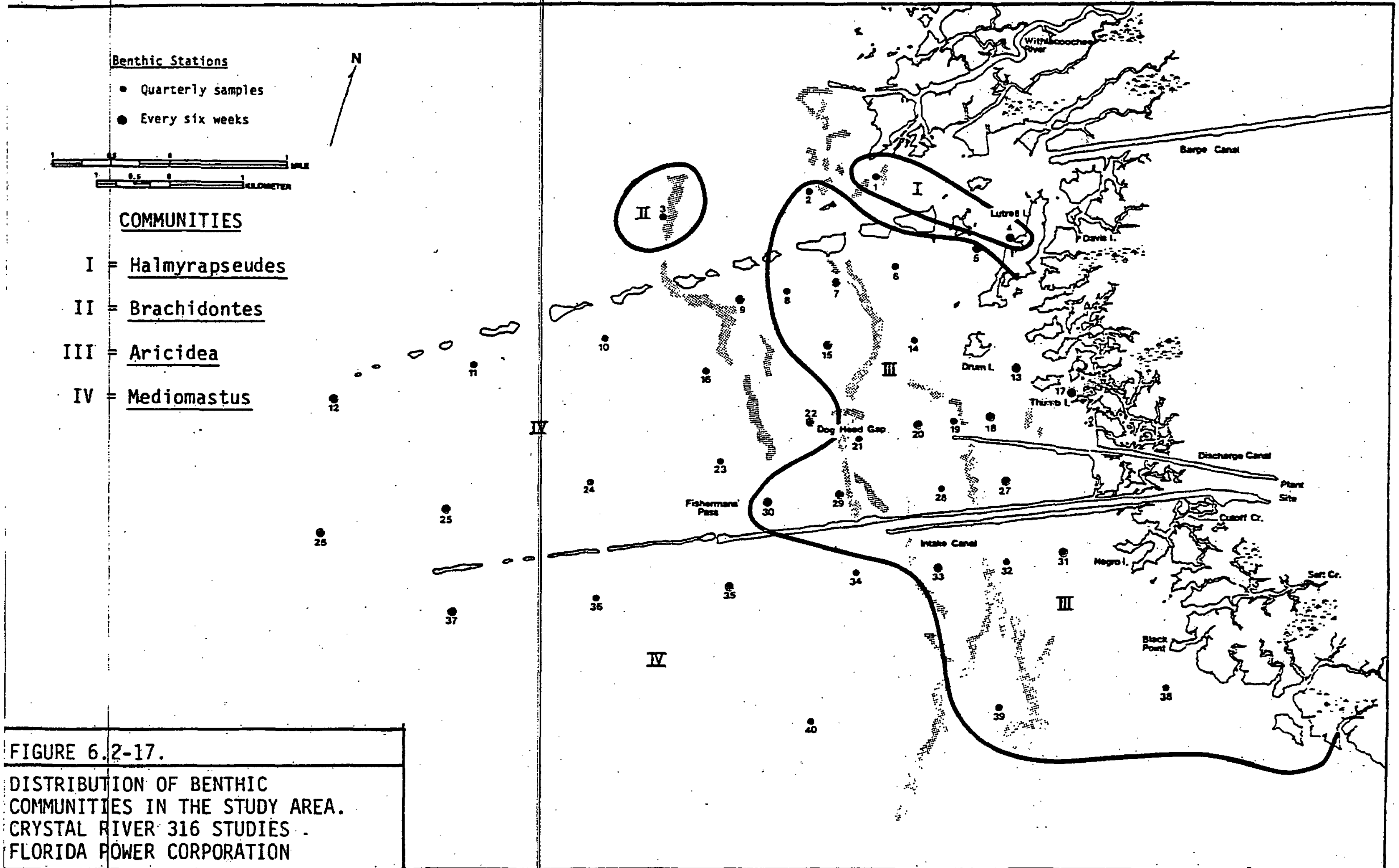

FIGURE 6.2-17.

DISTRIBUTION OF BENTHIC COMMUNITIES IN THE STUDY AREA.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

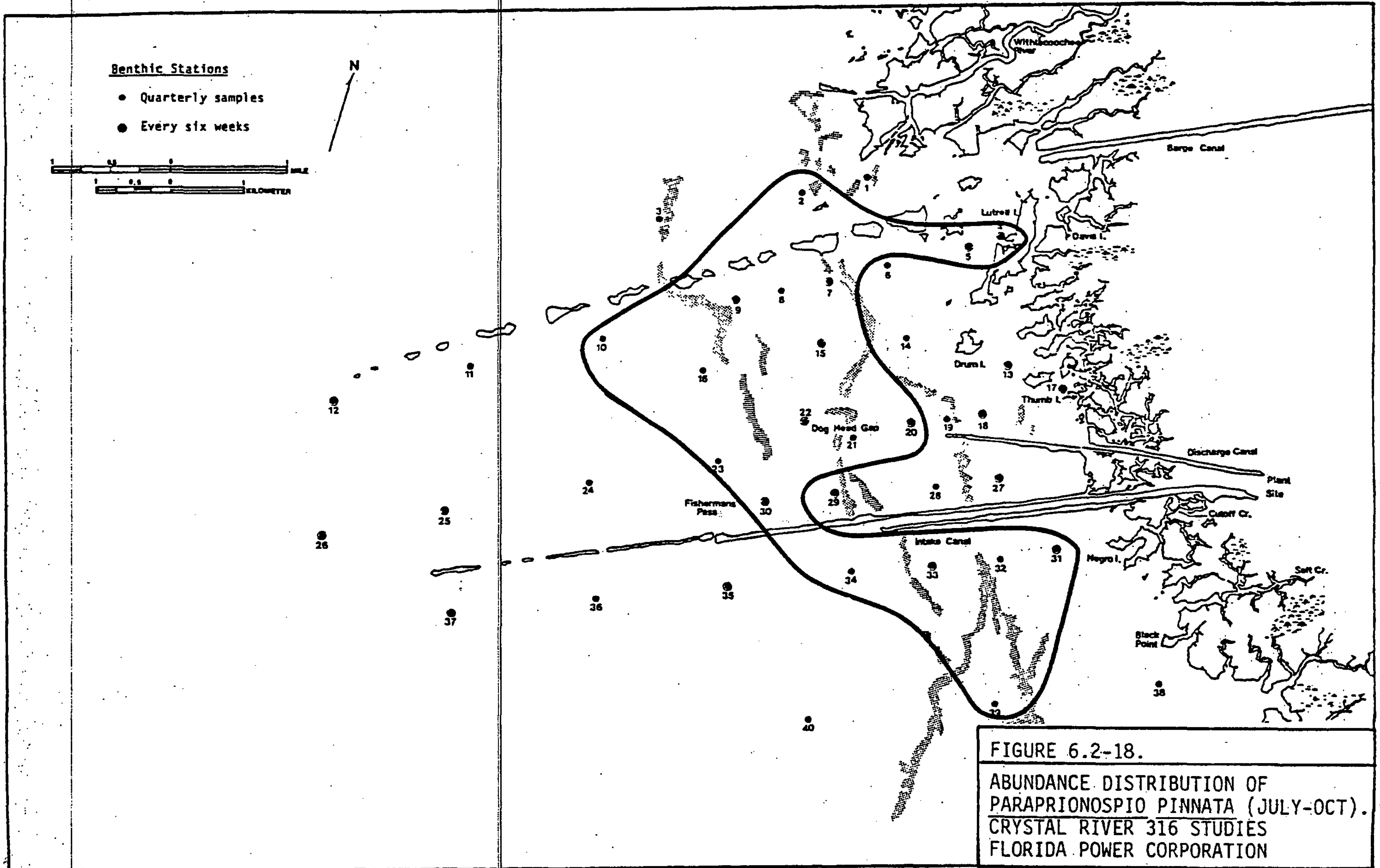

FIGURE 6.2-18.

ABUNDANCE DISTRIBUTION OF PARAPRIONOSPIO PINNATA (JULY-OCT).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

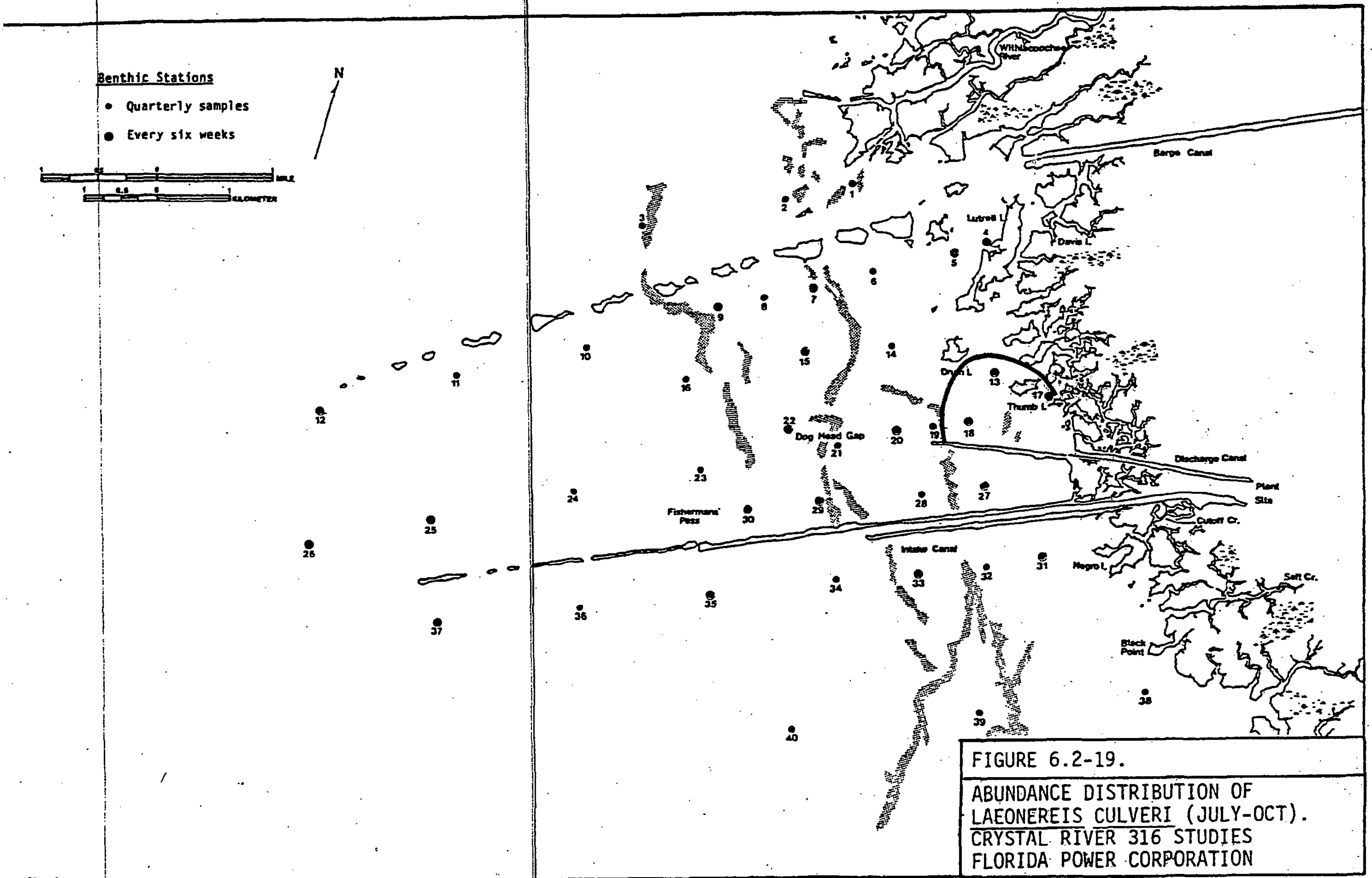

FIGURE 6.2-19.

ABUNDANCE DISTRIBUTION OF
LAEONEREIS CULVERI (JULY-OCT).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

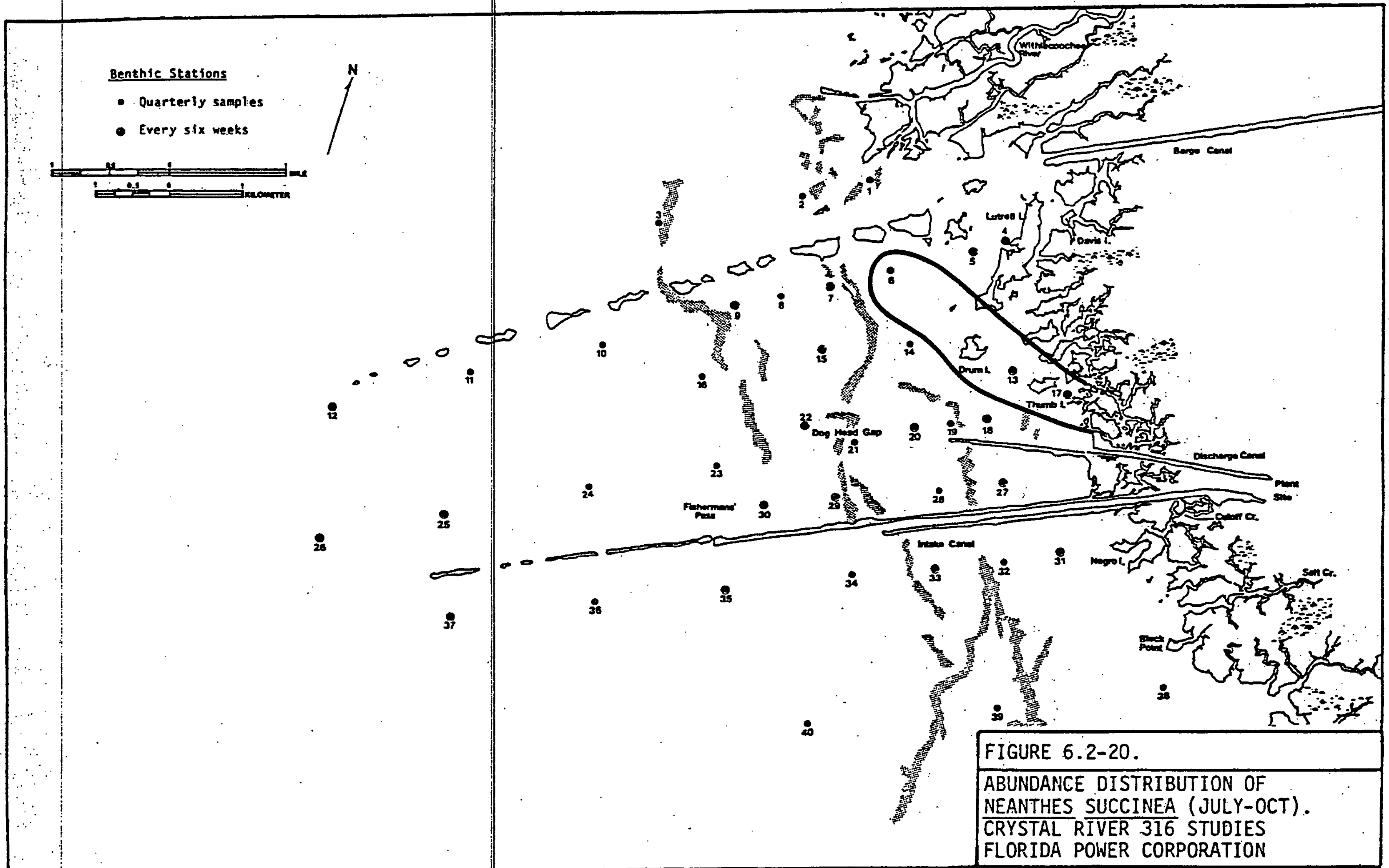

FIGURE 6.2-20.

ABUNDANCE DISTRIBUTION OF
NEANTHES SUCCINEA (JULY-OCT).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

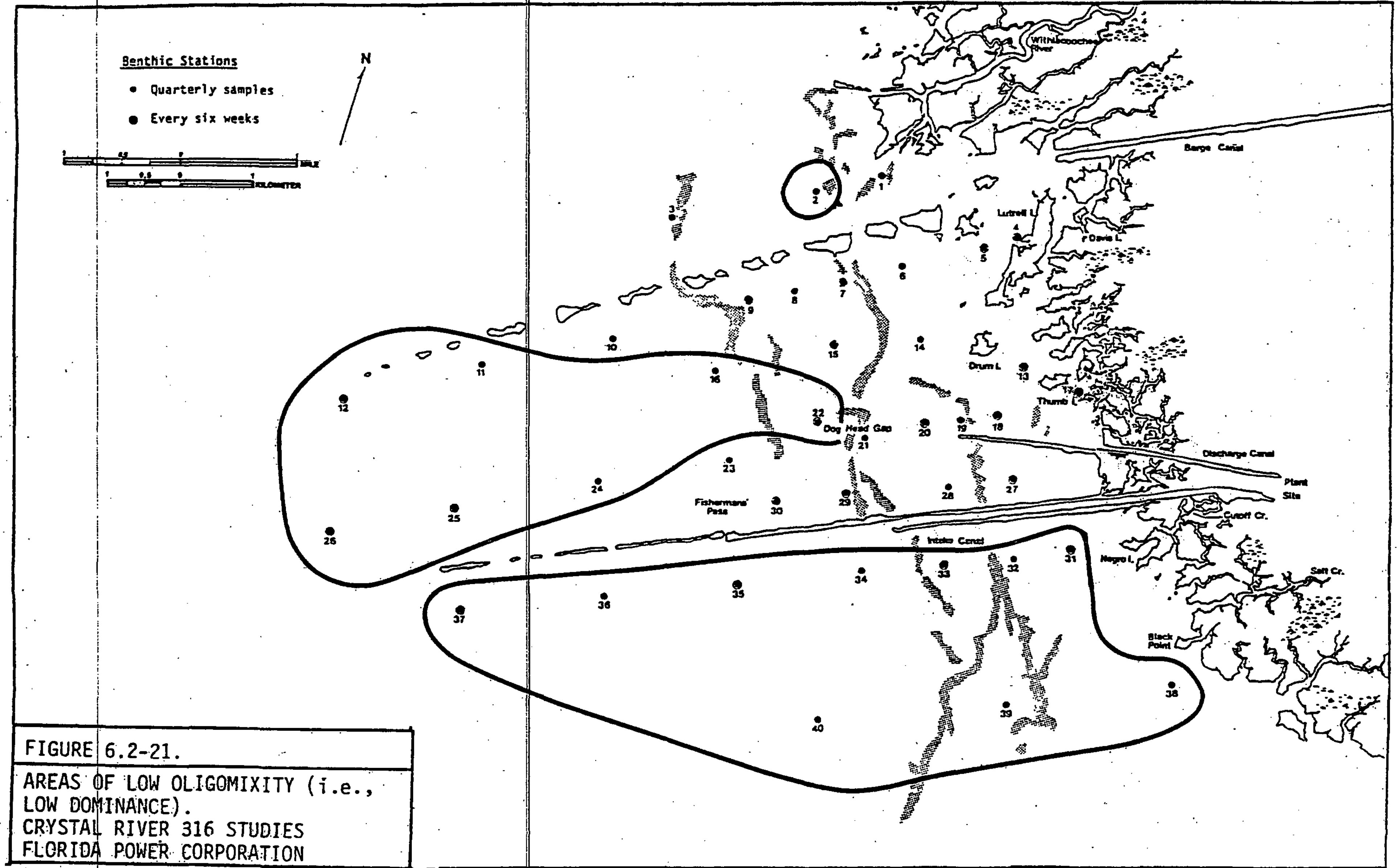

FIGURE 6.2-21.

AREAS OF LOW OLIGOMIXITY (i.e., LOW DOMINANCE).
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

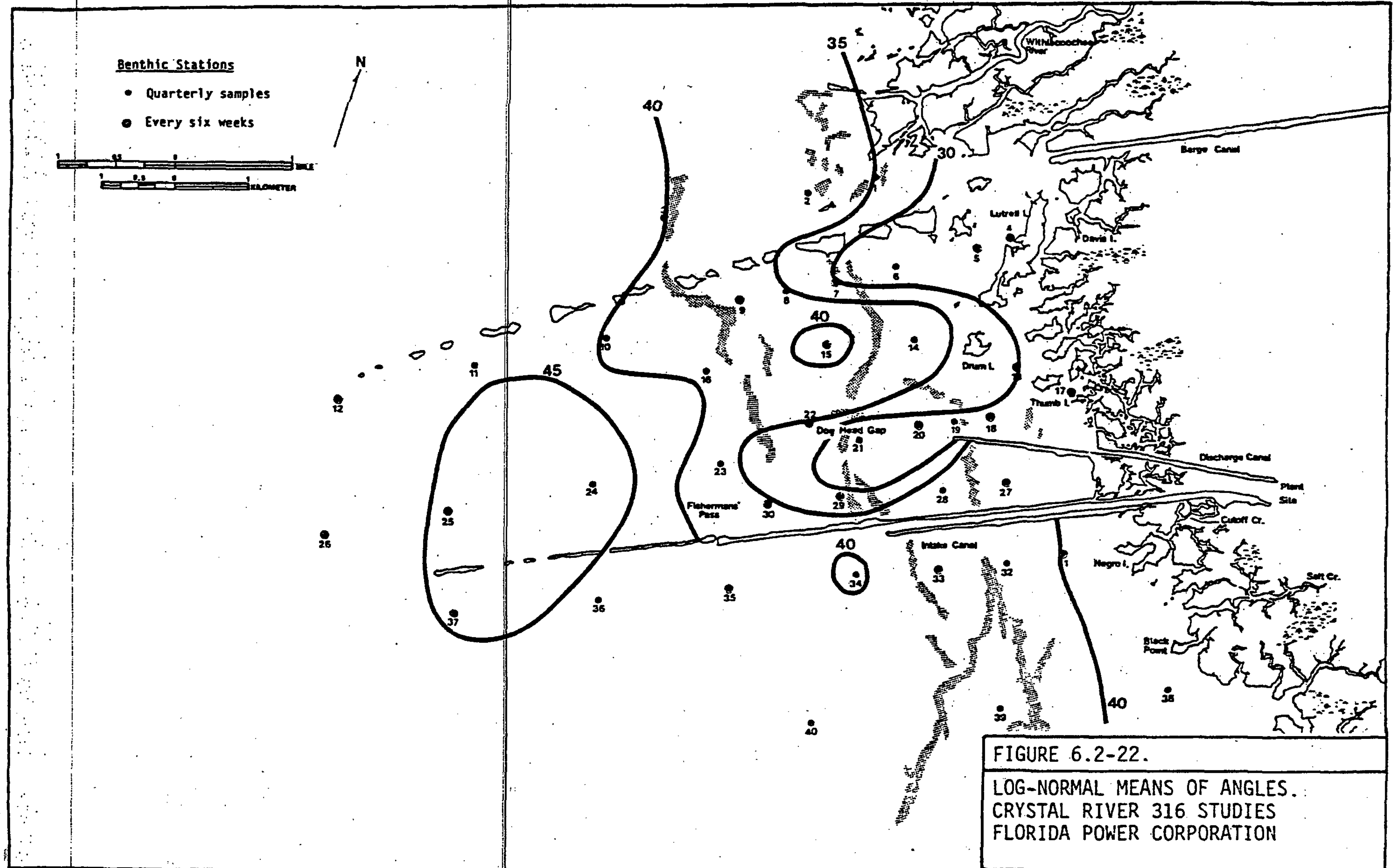

FIGURE 6.2-22.

LOG-NORMAL MEANS OF ANGLES.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

MORISITA'S INDEX OF FAUN[redacted]IMILARITY (X100)

JUNE 1983

STATIONS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1																																								
2	2																																							
3	4	7																																						
4	20	8	1																																					
5	3	9	2	19																																				
6	2	15	9	17	65																																			
7	1	66	6	8	20	29																																		
8	2	13	3	10	70	41	39																																	
9	2	16	44	4	12	15	41	18																																
10	1	6	3	1	4	4	16	13	36																															
11	18	8	18	5	15	17	21	15	62	23																														
12	2	1	5	1	3	4	5	4	20	14	51																													
13	3	72	4	16	24	33	65	23	20	8	13	8																												
14	1	22	3	9	36	49	34	33	26	52	16	4	36																											
15	3	16	16	4	14	18	47	27	74	39	49	15	34	44																										
16	1	10	23	5	17	30	33	19	77	36	60	25	26	25	69																									
17	3	19	2	10	39	62	39	37	12	17	4	5	59	64	40	20																								
18	2	15	1	13	61	78	27	46	4	2	4	3	40	45	19	17	76																							
19	6	16	4	11	44	73	33	33	15	6	14	3	40	48	39	24	74	80																						
20	1	18	4	4	15	19	37	25	24	14	13	3	28	35	56	20	51	30	47																					
21	1	19	3	5	26	23	40	33	25	19	16	4	29	41	59	21	54	33	49	98																				
22	1	10	10	2	5	7	33	16	61	49	38	14	28	36	78	64	29	9	20	39	39																			
23	2	10	36	7	21	34	24	20	63	26	61	21	26	42	50	51	35	27	34	20	24	37																		
24	1	9	6	2	7	10	31	17	43	26	59	44	15	21	43	46	12	8	11	14	14	50	30																	
25	1	4	4	2	8	8	9	5	19	16	46	33	7	6	16	19	3	2	5	6	9	14	15	20																
26	2	5	6	3	9	9	12	8	30	12	70	62	15	9	28	31	9	5	10	10	13	21	27	45	81															
27	3	23	2	13	48	74	42	42	11	14	6	4	48	63	39	21	90	84	82	55	58	23	35	13	3	7														
28	1	18	6	2	11	11	34	19	48	27	33	10	53	42	71	49	45	20	28	43	42	79	34	36	11	22	28													
29	0	0	4	0	1	1	0	0	2	0	2	1	0	0	6	1	0	0	2	0	1	0	2	0	6	1	0	0												
30	8	30	12	6	17	27	51	23	53	24	52	16	51	35	74	57	44	30	43	44	46	75	48	41	20	31	44	66	1											
31	1	42	3	3	16	21	52	35	29	37	22	6	52	64	45	25	40	24	22	16	19	39	34	32	7	12	39	46	0	44										
32	7	4	37	1	5	12	8	7	22	18	11	8	18	28	24	23	22	14	14	4	6	18	31	9	3	8	14	23	4	21	30									
33	2	13	4	3	7	11	25	17	25	18	16	10	20	24	35	25	19	12	16	20	21	34	18	26	6	10	22	46	0	34	32	11								
34	2	9	21	4	18	20	22	22	63	40	65	25	19	35	56	59	21	15	20	17	21	61	72	48	19	32	22	43	1	66	41	28	41							
35	1	1	13	0	0	1	2	1	10	2	28	20	2	1	6	8	2	2	3	3	3	5	19	9	87	61	2	5	5	8	3	12	3	12						
36	1	15	4	1	3	4	22	10	26	19	53	74	19	11	25	30	5	2	5	8	8	26	17	72	25	58	7	20	0	27	25	6	27	28	10					
37	2	6	6	4	13	14	17	13	44	17	76	47	12	14	41	47	4	3	10	13	16	33	30	43	73	82	5	30	1	46	18	6	16	44	52	45				
38	1	17	4	2	4	6	14	4	11	0	5	5	55	6	16	15	38	6	8	5	3	20	12	3	5	10	6	47	0	21	14	12	6	7	2	4	6			
39	1	12	16	2	3	5	25	16	38	36	17	12	39	40	52	37	35	9	12	16	18	57	31	28	9	17	20	61	1	46	53	39	39	47	10	19	17	36		
40	1	9	2	0	1	2	15	9	29	51	27	22	12	13	30	36	7	3	5	11	12	54	15	45	16	20	7	30	0	39	20	7	62	48	6	45	25	3	34	

FIGURE 6.2-23.

MORISITA'S INDEX FOR JUNE 1983.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

CLUSTER DENDROGRAM FOR JUNE 1983.

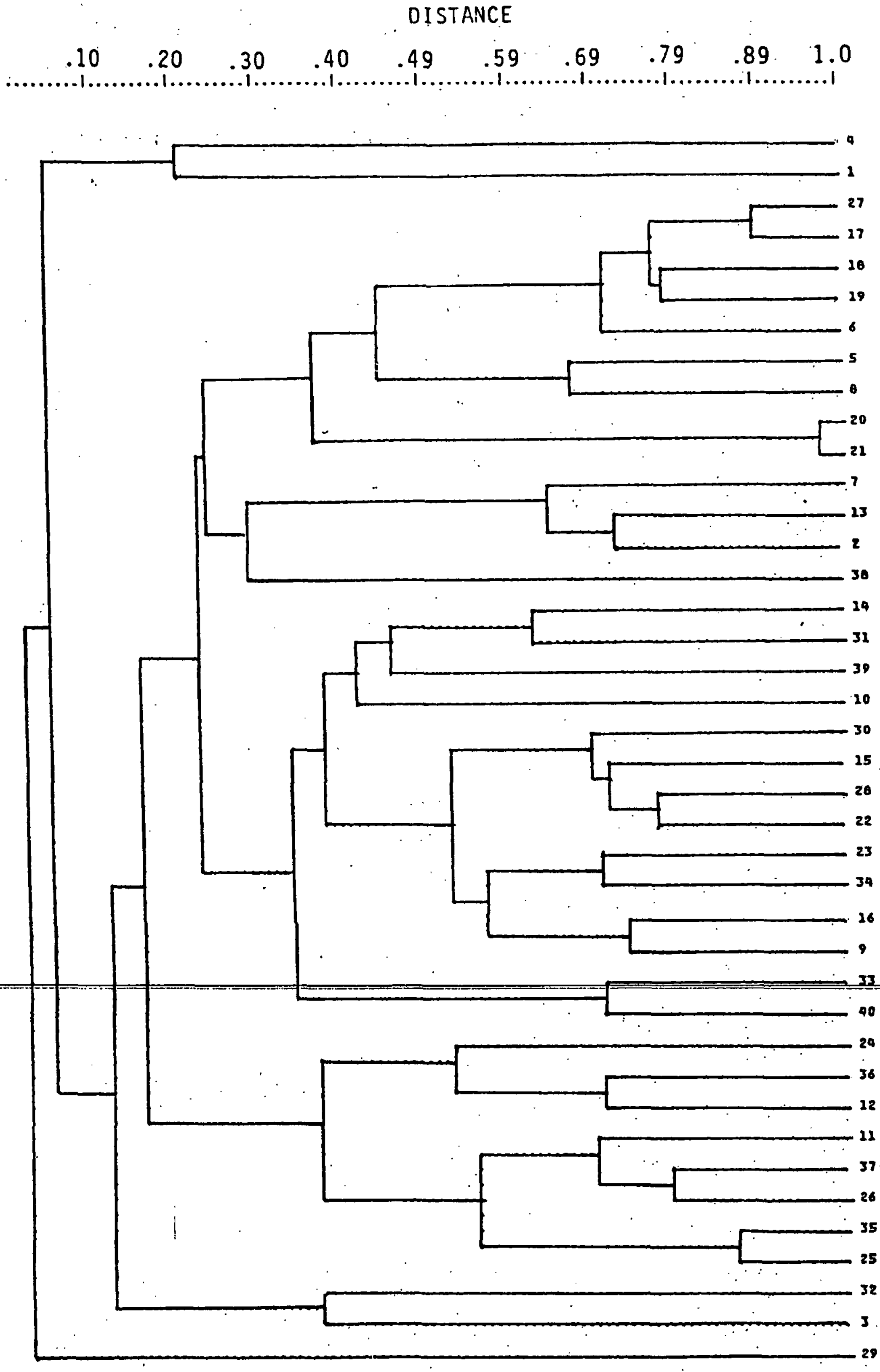

FIGURE 6.2-24.

CLUSTER DENDROGRAM FOR JUNE 1983.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

MORISITA'S INDEX OF FAUNAL SIMILARITY (X100)

JULY 1983

STATIONS	4	5	7	9	12	13	15	17	18	20	22	25	26	27	29	30	31	33	35	37
4		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	7		☼	◆	•	◆	◆	◆	☼	◆	◆	•	•	◆	•	◆	•	•	•	•
7	4	58		◆	•	•	✱	◆	☼	☼	☼	•	•	◆	◆	◆	◆	◆	•	◆
9	4	46	39		◆	•	☼	•	◆	◆	☼	◆	☼	•	◆	✱	•	•	•	☼
12	2	19	19	48		•	◆	•	•	•	◆	☼	✱	•	•	◆	•	◆	✱	✱
13	1	27	24	12	8		•	◆	◆	•	•	•	•	☼	◆	•	◆	•	•	•
15	4	43	86	57	30	13		◆	◆	☼	☼	◆	◆	•	◆	☼	•	◆	•	◆
17	2	49	49	14	8	29	40		☼	☼	☼	•	•	☼	☼	•	◆	◆	•	•
18	4	72	60	44	14	35	36	65		☼	☼	•	•	☼	☼	◆	◆	◆	•	◆
20	3	34	73	32	8	15	63	55	69		☼	•	•	◆	☼	◆	•	•	•	•
22	3	36	60	72	33	21	67	56	70	70		◆	◆	◆	✱	☼	◆	☼	•	☼
25	1	13	17	34	65	8	26	14	13	10	30		☼	•	•	◆	•	•	◆	☼
26	2	23	22	55	86	16	30	8	22	16	39	69		•	•	◆	•	◆	☼	✱
27	3	44	40	14	12	63	22	56	59	26	36	11	16		◆	◆	☼	◆	•	•
29	2	6	39	42	14	30	41	51	58	73	85	17	21	29		◆	•	◆	•	◆
30	7	39	38	84	50	24	53	21	49	32	74	36	49	27	46		◆	☼	•	☼
31	2	18	27	15	19	32	22	36	27	13	32	14	15	55	25	27		•	•	•
33	1	9	16	24	13	8	18	19	18	13	33	11	12	17	23	28	19		•	◆
35	2	5	9	16	77	11	9	4	8	8	14	49	64	14	11	18	23	5		◆
37	2	20	25	62	81	15	33	8	28	18	50	55	84	14	30	70	21	17	50	

FIGURE 6.2-25.

MORISITA'S INDEX FOR JULY 1983.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

CLUSTER DENDROGRAM FOR JULY 1983
DISTANCE

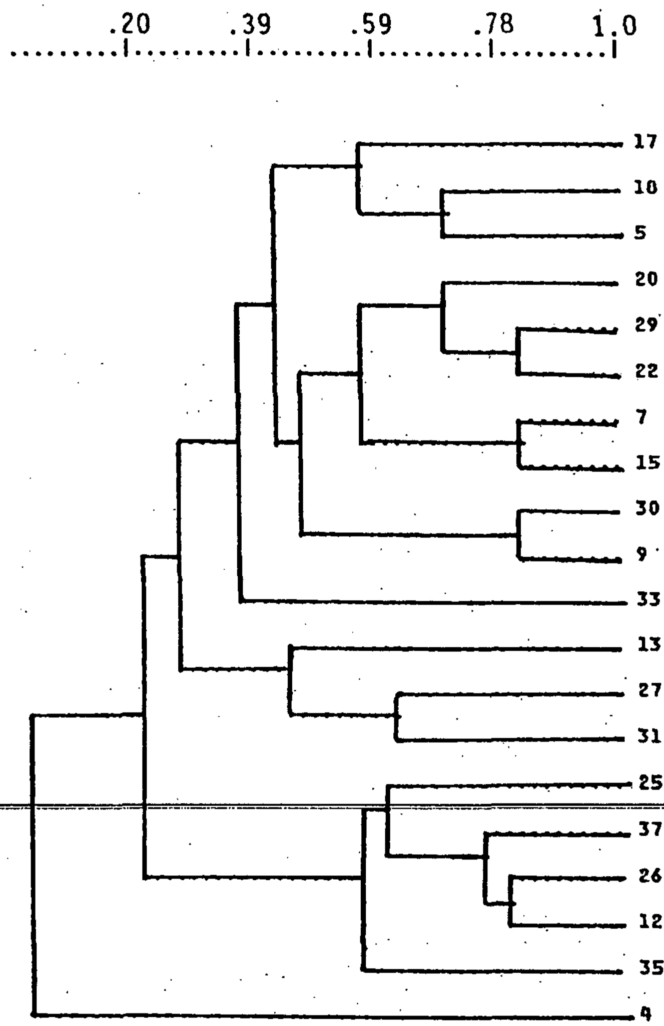

FIGURE 6.2-26.

CLUSTER DENDROGRAM FOR JULY 1983.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

MORISITA'S INDEX OF FAUNAL SIMILARITY (X100)

OCTOBER 1983

STATIONS	4	5	7	9	12	13	15	17	18	20	22	25	26	27	29	30	31	33	35	37
4		✦	·	·	·	·	·	·	✦	✦	·	·	·	·	·	·	·	·	·	·
5	32		✦	✦	·	✦	✦	☼	☼	✱	·	·	·	✦	·	·	·	·	·	✦
7	13	37		☼	·	✦	✱	☼	✦	✦	✱	·	·	✦	·	·	·	☼	·	·
9	8	29	53		·	·	☼	·	·	✦	☼	·	·	·	·	·	·	✦	·	·
12	0	1	8	4		·	·	·	·	·	·	·	☼	·	·	·	·	·	·	·
13	15	38	31	17	3		·	✦	✦	✦	·	·	·	✦	·	✦	·	·	·	·
15	14	37	83	62	7	25		✦	✦	☼	✱	·	·	✦	·	·	·	☼	·	·
17	25	53	52	22	4	45	46		☼	✦	✦	·	·	✦	·	·	·	·	·	·
18	29	67	32	24	2	31	35	67		✱	·	·	·	✦	·	·	·	·	·	·
20	32	82	43	39	2	33	54	48	81		✦	·	·	✦	·	·	·	·	·	·
22	4	20	85	66	9	10	87	37	21	35		·	·	·	·	·	✦	☼	·	·
25	1	10	20	15	24	5	13	4	2	6	23		☼	·	·	·	·	✦	✦	☼
26	0	1	9	7	54	22	6	2	1	3	10	53		·	·	✦	·	·	✦	✦
27	14	32	31	21	2	41	33	35	28	32	14	3	3		·	·	·	✦	·	·
29	1	3	5	2	3	3	5	4	3	4	4	2	6	2		·	·	·	·	·
30	1	18	17	12	10	39	17	5	2	11	17	19	46	8	4		·	✦	✦	✦
31	5	13	22	18	3	10	24	9	18	19	33	9	4	9	2	6		✦	·	·
33	4	14	60	39	11	22	53	21	4	16	62	28	21	27	2	28	28		·	✦
35	0	6	5	4	16	17	3	1	0	2	4	36	35	3	2	27	5	8		·
37	1	29	23	18	19	17	12	6	2	14	24	58	33	4	1	40	10	50	25	

FIGURE 6.2-29.

MORISITA'S INDEX FOR
OCTOBER 1983.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

CLUSTER DENDROGRAM FOR OCTOBER 1983

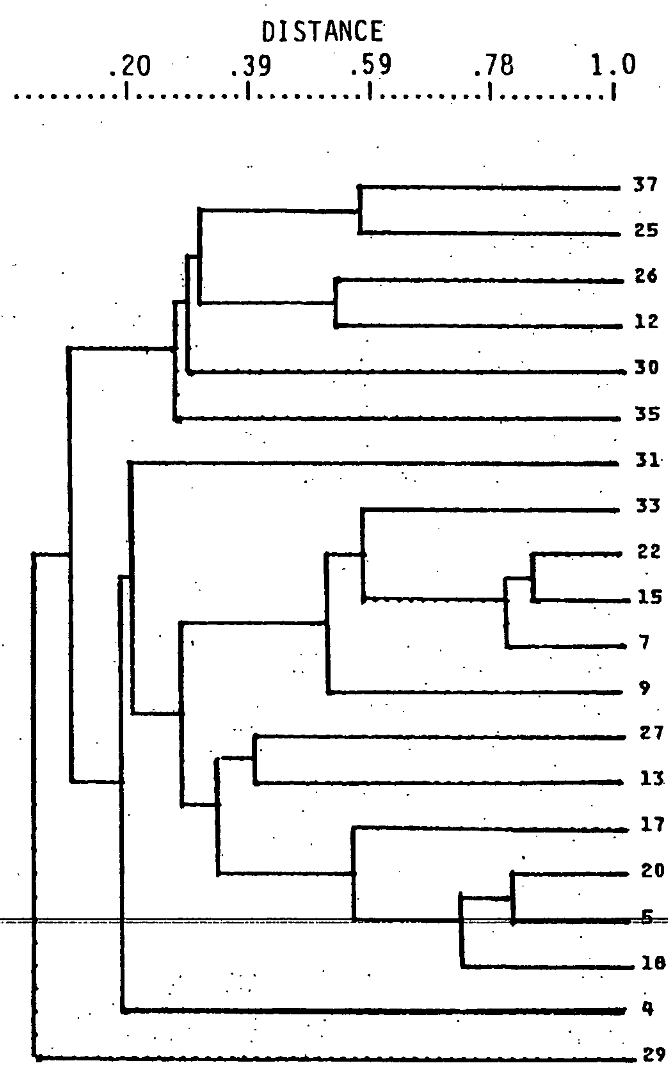

FIGURE 6.2-30.

CLUSTER DENDROGRAM FOR OCTOBER 1983.

CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

MORISITA'S INDEX OF FAUNAL SIMILARITY (X100)

NOVEMBER 1983

STATIONS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1																																								
2	2																																							
3	0	27																																						
4	3	42	1																																					
5	3	49	2	98																																				
6	2	49	2	99	100																																			
7	1	78	8	70	78	79																																		
8	1	44	3	60	66	60	48																																	
9	0	28	14	3	9	6	17	27																																
10	0	22	8	10	13	10	26	9	16																															
11	0	18	16	5	5	5	13	1	3	30																														
12	0	14	6	4	4	4	12	1	2	24	57																													
13	1	56	12	52	59	58	65	33	11	5	17	8																												
14	2	56	13	82	90	90	81	62	19	4	3	1	63																											
15	1	59	9	70	74	75	72	52	21	8	4	4	55	77																										
16	0	57	24	14	17	17	47	16	9	50	63	41	23	16	14																									
17	1	46	31	43	48	49	54	24	21	3	8	2	57	69	42	16																								
18	1	52	3	80	83	81	68	53	4	18	9	8	59	76	66	23	35																							
19	0	14	14	10	12	12	12	9	5	1	13	4	44	16	16	6	30	17																						
20	0	53	23	30	36	35	40	53	20	13	9	4	31	53	58	24	44	51	17																					
21	2	48	7	31	30	32	38	34	18	20	10	8	23	25	70	22	13	36	11	62																				
22	1	57	18	23	26	25	47	32	56	53	27	24	22	24	42	59	22	31	8	42	55																			
23	0	11	34	1	2	1	3	1	2	24	70	25	16	10	3	44	26	5	14	20	3	9																		
24	0	37	11	11	13	12	33	11	20	66	35	29	13	7	10	70	5	23	3	23	25	67	12																	
25	0	14	6	4	5	5	13	4	9	42	43	37	5	2	9	33	3	8	2	8	12	31	17	41																
26	0	15	10	5	5	5	13	1	2	20	56	47	8	2	5	39	6	8	5	6	9	24	31	28	42															
27	0	26	6	32	36	35	35	20	1	9	26	15	39	37	29	23	25	34	15	18	9	8	40	10	8	13														
28	1	53	9	37	43	41	50	47	24	21	13	8	38	44	59	29	23	44	12	64	56	53	5	35	19	9	19													
29	0	6	45	2	3	3	2	2	1	0	5	2	5	13	3	5	30	3	12	20	1	2	22	1	1	5	3	1												
30	0	22	13	10	10	10	18	5	4	41	76	34	20	5	7	63	9	15	9	9	12	29	87	34	25	37	44	14	3											
31	0	56	11	13	15	16	38	15	14	28	54	39	30	17	14	69	26	31	19	33	23	49	35	49	24	33	33	29	5	51										
32	4	34	34	2	4	4	13	13	20	7	30	19	23	21	16	26	51	12	34	48	21	29	35	12	10	16	17	22	30	19	55									
33	0	36	14	7	11	11	27	9	35	48	29	24	20	18	17	44	26	13	5	34	19	55	17	55	36	15	11	39	0	24	44	32								
34	0	11	14	2	5	2	6	3	8	71	57	23	11	3	4	43	7	5	6	10	8	24	67	36	37	22	25	12	2	70	25	13	48							
35	0	5	21	0	0	0	1	0	1	6	62	23	14	2	1	33	7	0	7	4	1	3	80	5	25	34	51	3	8	80	31	15	5	48						
36	0	8	20	1	2	1	3	0	3	42	73	39	15	7	2	45	21	2	12	15	3	11	80	20	37	38	25	6	14	74	29	28	33	79	63					
37	0	14	19	2	4	3	9	4	12	33	35	35	16	12	10	29	26	3	6	28	10	23	29	41	69	26	15	26	14	23	22	32	57	42	21	47				
38	1	65	4	65	71	74	80	44	21	4	2	1	64	79	58	20	66	61	12	37	22	24	3	8	4	1	34	34	2	8	37	18	31	4	1	2	10			
39	0	42	11	3	7	7	18	25	37	17	27	27	19	15	23	31	15	14	7	43	30	45	20	23	15	14	18	40	1	24	54	47	62	21	17	26	32	24		
40	0	5	10	0	4	1	3	2	13	78	29	13	5	4	5	30	7	5	3	20	12	28	38	45	36	11	15	20	3	39	14	11	64	86	18	59	49	4	24	

FIGURE 6.2-31.

MORISITA'S INDEX FOR
NOVEMBER 1983.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

CLUSTER DENDROGRAM FOR NOVEMBER 1983

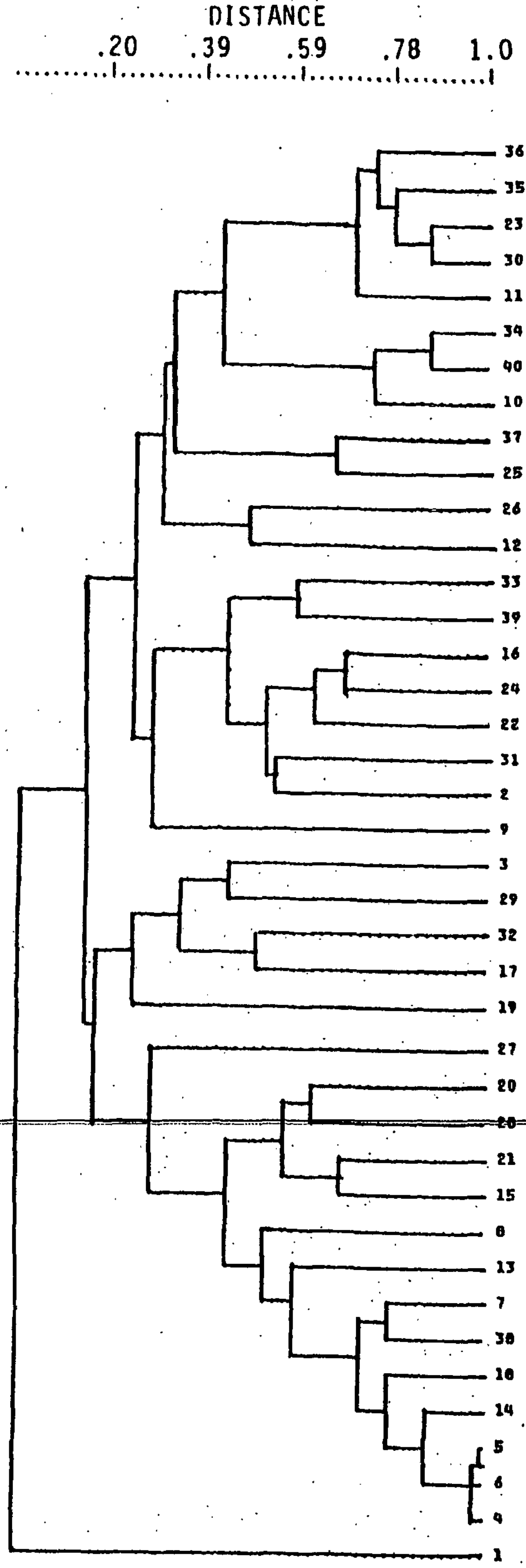

FIGURE 6.2-32.

CLUSTER DENDROGRAM FOR NOVEMBER 1983, CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION

MORISITA'S INDEX OF F[illegible]L SIMILARITY (X100)

JANUARY 1984

STATIONS	4	5	7	9	12	13	15	17	18	20	22	25	26	27	29	30	31	33	35	37
4		✱	✱	☼	·	☼	✱	·	✱	☼	·	·	·	☼	·	·	◇	·	·	·
5	97		✱	☼	·	☼	✱	◇	✱	☼	·	·	·	☼	·	·	◇	·	·	·
7	87	90		◇	·	☼	✱	·	✱	☼	·	·	·	☼	·	·	·	·	·	·
9	59	56	46		·	◇	◇	·	◇	◇	·	·	·	◇	·	·	◇	·	·	·
12	6	4	10	8		·	·	·	·	·	·	☼	◇	·	◇	◇	·	◇	·	◇
13	66	67	71	29	15		☼	◇	☼	☼	·	·		☼	·	☼	·	◇	☼	◇
15	85	90	97	49	6	65		·	✱	☼	·	·	·	☼	·	·	·	·	·	·
17	22	32	24	9	2	34	15		·	·	·	·	·	◇	·	·	◇	·	·	·
18	81	88	87	27	3	61	91	14		☼	·	·	·	◇	·	·	·	·	·	·
20	55	53	64	37	17	54	60	20	51		◇	·	·	◇	◇	·	◇	·	·	·
22	9	6	9	16	22	25	8	5	6	30		·	☼	·	◇	·	·	◇	·	☼
25	18	14	3	20	52	15	3	4	5	12	21		◇	·	·	◇	◇	☼	·	◇
26	2	1	2	3	50	21	1	3	1	6	54	36		·	·	·	·	·	·	✱
27	56	56	58	35	13	63	53	28	46	48	22	15	7		·	◇	·	·	·	·
29	10	8	21	8	47	25	14	4	9	47	42	19	23	17		◇	·	◇	·	◇
30	4	4	7	5	30	54	3	6	2	15	25	31	23	28	42		·	☼	✱	◇
31	37	33	12	34	14	20	8	34	13	33	20	46	6	21	22	18		☼	·	·
33	18	15	5	17	30	30	3	13	6	20	36	64	25	25	29	57	57		◇	◇
35	0	0	0	0	17	52	0	0	0	0	17	19	19	22	17	87	4	36		◇
37	4	3	2	7	41	29	1	6	1	8	60	49	77	15	29	43	12	48	34	

FIGURE 6.2-33.

MORISITA'S INDEX FOR
JANUARY 1984.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

CLUSTER DENDROGRAM FOR JANUARY 1984

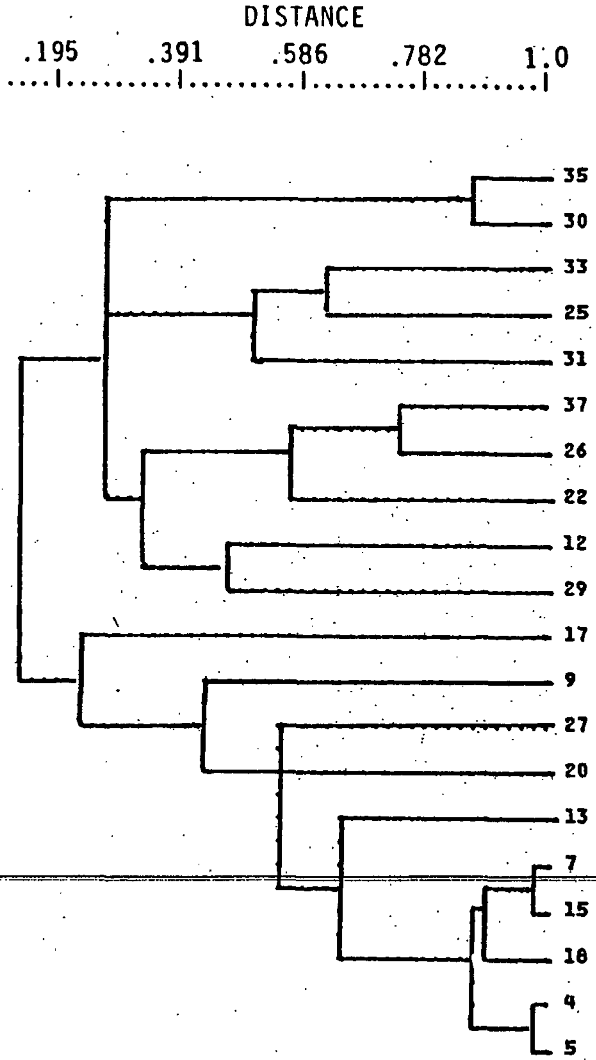

FIGURE 6.2-34.
CLUSTER DENDROGRAM FOR JANUARY 1984.
CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION

MORISITA'S INDEX OF [illegible]L SIMILARITY (X100)

FEBRUARY 1984

STATIONS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1																																							
2	8																																						
3	2	40																																					
4	22	41	13																																				
5	18	45	16	97																																			
6	18	32	6	96	93																																		
7	15	70	32	77	83	66																																	
8	19	34	6	76	77	73	59																																
9	14	27	11	38	43	33	36	84																															
10	7	16	10	8	12	5	13	48	75																														
11	1	5	17	1	3	1	5	3	5	9																													
12	1	21	33	7	9	2	23	2	7	8	14																												
13	6	42	22	27	33	24	46	22	16	13	10	17																											
14	18	43	7	91	90	90	78	75	39	16	2	3	34																										
15	18	40	18	92	89	90	72	70	30	4	8	2	24	90																									
16	2	51	45	13	21	5	55	10	23	32	12	42	36	13	3																								
17	6	33	2	21	33	22	35	24	22	16	2	1	56	28	14	28																							
18	17	44	11	76	76	69	70	77	54	28	4	6	17	80	76	13	27																						
19	2	21	22	8	9	6	20	6	9	18	6	11	15	21	10	22	8	31																					
20	5	32	23	26	30	21	45	22	23	30	4	20	34	46	24	42	15	47	58																				
21	12	52	20	44	48	38	54	59	60	48	17	13	28	53	41	35	22	69	37	60																			
22	3	34	33	14	16	9	34	13	17	31	10	30	28	21	12	49	9	33	39	59	42																		
23	4	21	9	8	11	6	21	25	41	69	5	8	23	32	8	34	13	24	46	72	47	43																	
24	1	31	23	9	12	4	40	8	11	18	14	21	13	13	5	75	12	14	12	22	18	27	23																
25	1	14	16	3	4	1	13	3	8	44	12	29	9	5	1	45	3	5	13	20	14	42	40	39															
26	0	3	26	1	1	0	5	1	2	4	50	47	34	1	1	17	1	2	3	5	5	21	4	8	15														
27	5	26	35	13	16	11	23	24	31	31	14	13	37	20	21	19	22	29	25	27	30	24	28	8	8	17													
28	3	18	34	11	12	9	24	12	13	18	15	29	52	22	14	29	9	33	40	54	35	58	36	15	17	45	47												
29	1	25	31	5	7	3	23	7	9	20	15	27	41	20	5	40	13	33	49	68	40	70	47	34	24	34	28	72											
30	0	2	34	1	1	0	8	1	2	4	20	22	43	2	3	17	2	6	8	11	5	26	5	6	6	65	21	60	45										
31	3	37	15	16	19	13	28	18	18	15	5	11	23	21	15	29	24	33	21	39	48	20	27	27	11	3	14	25	32	4									
32	1	24	49	5	7	2	19	9	14	15	14	30	35	7	6	35	13	30	34	39	26	63	16	23	16	23	39	54	70	33	28								
33	1	16	46	6	10	2	25	1	6	11	18	37	47	4	2	50	6	8	13	27	14	38	14	26	21	58	21	60	49	79	16	41							
34	0	20	42	5	8	2	23	1	6	30	21	37	41	5	2	59	8	9	15	29	22	53	28	39	56	51	19	58	49	58	25	40	79						
35	0	0	22	0	0	0	5	0	1	1	14	22	34	0	0	11	0	1	1	3	1	11	1	2	2	52	14	45	27	87	2	17	65	43					
36	0	3	31	1	1	0	9	1	2	5	20	42	44	1	1	21	1	6	5	11	5	24	4	7	12	71	19	59	43	92	4	32	81	64	84				
37	1	36	55	13	20	4	43	3	12	15	19	58	28	4	3	80	11	7	15	34	21	44	15	43	42	31	14	29	36	27	21	38	58	63	19	33			
38	0	34	15	9	16	9	25	8	11	19	3	11	59	21	4	28	54	20	38	48	22	34	42	12	11	6	30	37	43	10	25	37	14	15	3	9	15		
39	1	25	30	3	5	2	15	7	11	18	14	22	29	7	3	39	9	19	19	29	35	38	25	34	35	32	21	50	51	33	47	46	47	61	23	36	34	15	
40	0	10	24	2	4	1	12	1	4	33	17	26	23	3	2	44	5	5	9	15	11	38	29	38	70	30	14	40	31	31	12	25	50	81	24	37	45	12	52

FIGURE 6.2-35.

MORISITA'S INDEX FOR FEBRUARY 1984.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

CLUSTER DENDROGRAM FOR FEBRUARY 1984

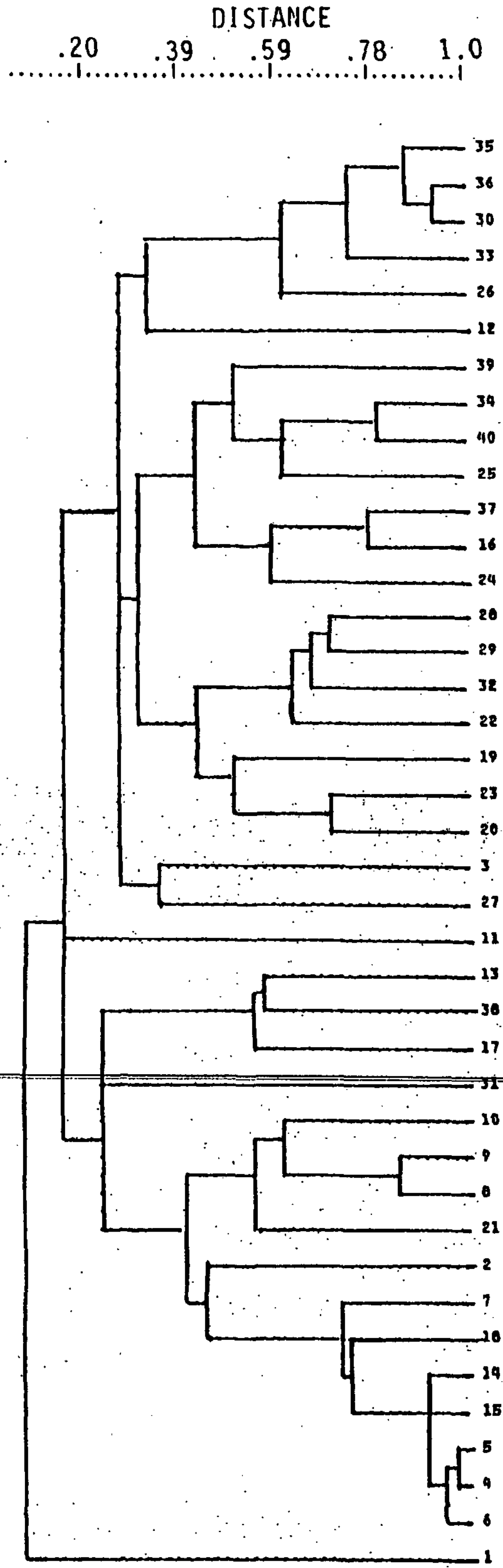

FIGURE 6.2-36.

CLUSTER DENDROGRAM FOR FEBRUARY 1984.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

APRIL 1984

STATIONS	4	5	7	9	12	13	15	17	18	20	22	25	26	27	29	30	31	33	35	37
4		✧	✧	·	·	·	✧	·	·	·	·	·	·	·	·	·	·	·	·	·
5	38		☼	✧	·	·	✱	✧	☼	·	✧	·	·	·	·	·	·	·	·	·
7	33	51		·	·	·	☼	✧	✧	✧	✧	·	·	✧	✧	·	·	·	·	✧
9	22	33	18		·	·	☼	·	✱	·	✧	·	·	·	·	·	·	·	·	·
12	1	1	4	2		·	·	·	·	·	·	·	✧	·	·	·	·	·	·	·
13	5	9	15	8	12		·	·	·	·	·	·	✧	✧	·	✱	·	☼	✱	·
15	40	80	54	60	2	8		·	☼	✧	☼	·	·	·	✧	·	·	·	·	·
17	12	38	49	11	1	18	16		·	·	·	·	·	·	·	·	·	·	·	·
18	21	55	37	86	2	13	72	21		✧	✧	·	·	·	✧	·	·	·	·	·
20	10	21	37	23	2	11	48	17	32		✱	✧	·	✧	☼	·	·	✧	·	·
22	17	26	36	40	3	10	57	13	46	80		☼	✧	✧	☼	·	·	☼	·	✧
25	1	1	10	9	12	21	5	4	13	29	53		✱	·	·	✧	·	☼	·	☼
26	2	3	8	12	34	39	7	4	16	23	43	81		·	·	✧	·	☼	✧	☼
27	11	24	32	2	6	32	24	24	12	26	31	12	17		✧	✧	✱	✧	·	·
29	11	8	32	22	5	16	31	13	33	61	63	25	17	36		·	·	✧	·	·
30	6	3	10	5	14	92	5	5	8	13	16	33	46	30	18		·	☼	✱	·
31	8	9	22	1	11	16	9	13	8	16	18	6	9	80	23	10		·	·	·
33	4	5	15	14	12	54	12	8	21	30	51	70	67	29	32	70	12		✧	✧
35	0	0	2	0	11	91	0	1	1	1	2	20	32	20	3	86	4	46		·
37	23	9	33	14	21	11	18	8	15	18	34	58	56	10	17	17	14	39	11	

FIGURE 6.2-37.

MORISITA'S INDEX FOR APRIL 1984.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

CLUSTER DENDROGRAM FOR APRIL 1984

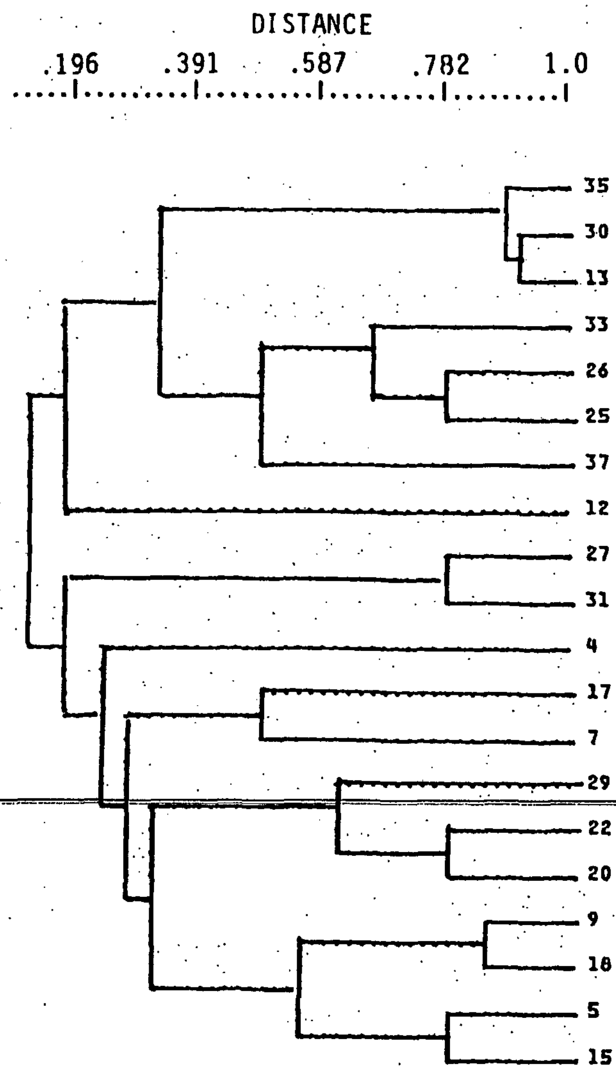

FIGURE 6.2-38.

CLUSTER DENDROGRAM FOR APRIL 1984.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

STATIONS

STATIONS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2	4																			
3	1	18																		
4	59	2	1																	
5	6	24	3	8																
6	8	48	11	8	55															
7	15	45	8	3	63	45														
8	8	34	3	7	77	53	85													
9	6	71	19	2	19	28	33	32												
10	3	38	23	2	10	23	20	23	75											
11	2	14	18	1	5	11	10	9	32	45										
12	1	8	8	0	3	1	5	5	35	69	49									
13	3	28	10	1	9	15	22	19	21	9	5	5								
14	2	72	14	1	10	18	24	17	55	26	10	13	39							
15	12	59	5	3	52	30	89	75	58	30	9	7	27	38						
16	4	76	18	1	14	29	36	21	79	58	35	30	17	50	49					
17	20	76	4	3	23	44	37	23	52	25	8	4	17	53	47	63				
18	11	48	9	5	64	48	73	69	49	37	19	13	14	28	70	52	43			
19	1	11	24	0	2	4	6	2	12	6	2	1	14	11	9	11	11	6		
20	5	62	3	2	31	17	36	35	62	29	6	7	16	46	67	51	63	44	12	
21	4	58	3	3	47	19	46	46	58	26	7	9	16	42	74	47	58	52	11	96
22	3	72	7	0	8	5	24	19	78	45	10	14	24	69	56	66	62	36	13	78
23	2	40	26	1	4	7	12	6	37	32	29	34	29	70	12	36	15	12	6	10
24	2	26	7	2	7	14	14	15	49	71	35	59	5	17	22	46	19	26	5	22
25	2	16	18	1	4	5	11	8	40	64	74	68	5	13	12	44	9	25	3	10
26	2	10	7	0	2	3	7	4	17	16	79	27	3	7	9	22	7	14	3	8
27	2	77	6	1	17	25	38	25	68	33	6	4	22	60	61	66	68	44	13	67
28	1	27	11	0	2	2	6	3	15	6	8	12	28	69	6	14	10	4	2	8
29	2	43	13	1	4	6	12	8	29	15	11	14	33	83	17	26	22	11	5	24
30	1	28	15	1	3	6	7	4	14	8	11	16	28	69	4	14	7	4	2	3
31	3	74	16	4	25	64	42	36	60	42	16	7	9	50	45	65	60	51	9	34
32	3	29	21	2	9	26	24	12	22	17	8	6	0	27	19	23	18	22	10	12
33	2	37	14	2	12	28	23	16	45	61	33	46	0	29	21	52	28	35	4	21
34	1	23	29	1	5	13	12	6	35	45	55	39	9	20	12	37	14	18	10	9
35	1	13	55	0	1	2	6	1	14	14	29	16	8	19	4	15	4	5	26	2
36	0	15	11	0	5	5	14	7	16	28	20	20	2	7	10	29	11	19	2	8
37	2	17	10	2	7	17	13	14	39	72	59	74	3	8	11	43	9	30	2	9
38	4	31	13	2	12	38	20	14	15	6	6	7	6	38	13	17	15	12	5	8
39	6	40	13	1	10	14	32	22	52	43	17	19	8	23	42	56	27	41	5	37
40	0	11	3	0	5	4	10	7	18	28	14	23	2	7	10	25	10	15	2	14

STATIONS	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
21																				
22	70																			
23	11	27																		
24	21	38	19																	
25	12	15	36	56																
26	8	7	20	12	56															
27	64	79	14	23	8	7														
28	7	19	68	3	10	5	9													
29	22	38	77	10	13	7	23	94												
30	4	15	77	5	13	7	5	97	95											
31	32	46	29	27	14	8	66	14	25	16										
32	12	16	24	12	11	6	47	14	19	18	45									
33	21	28	38	45	50	16	28	16	23	22	49	23								
34	9	14	40	28	57	40	15	14	18	18	26	23	42							
35	3	5	34	5	27	24	10	18	19	21	20	17	15	35						
36	9	23	12	40	33	13	13	2	6	3	14	8	38	15	11					
37	9	14	25	62	77	29	8	5	9	9	22	11	51	38	13	34				
38	8	14	33	4	7	4	19	30	33	32	35	30	15	11	10	2	5			
39	35	45	13	39	28	10	42	5	13	6	39	31	57	22	6	33	32	12		
40	13	21	8	34	21	5	13	2	4	2	10	4	43	12	10	69	24	2	31	

FIGURE 6.2-39.

MORISITA'S INDEX FOR JUNE 1984.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

CLUSTER DENDROGRAM FOR JUNE 1984

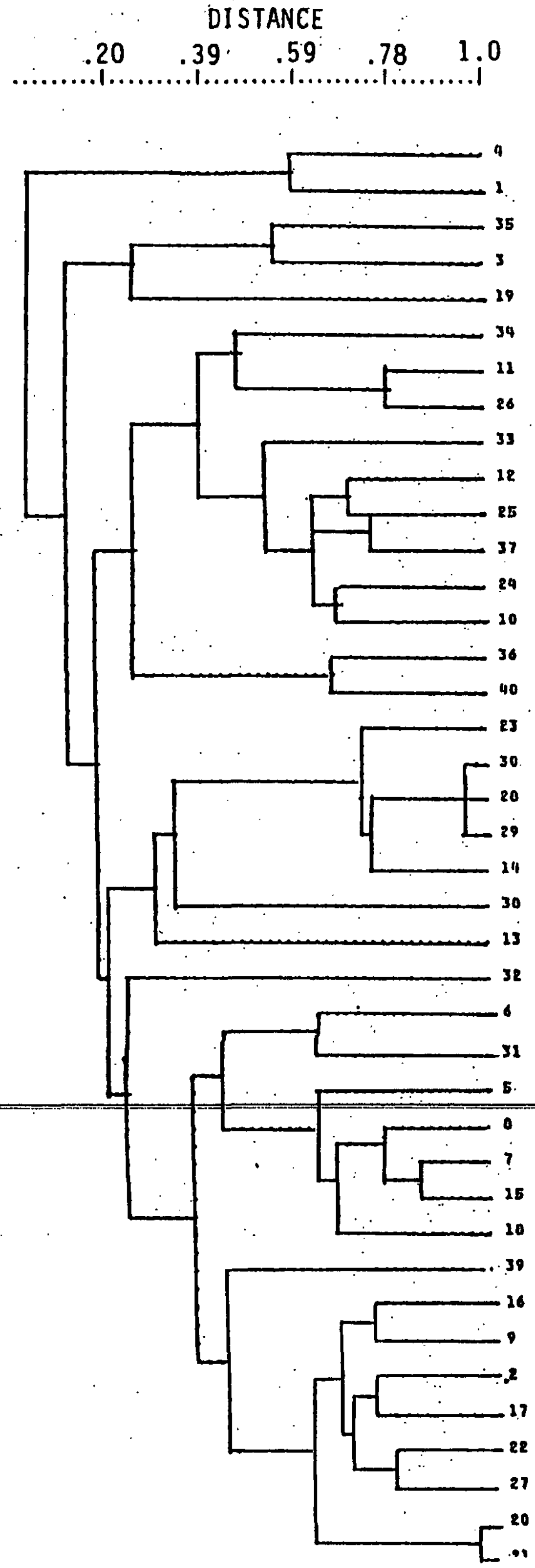

FIGURE 6.2-40.

CLUSTER DENDROGRAM FOR JUNE 1984.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

JULY

STATIONS	4	5	7	9	12	13	15	17	18	20	22	25	26	27	29	30	31	33	35	37
4		✦	✦	·	·	·	✦	·	·	·	·	·	·	·	·	·	·	·	·	·
5	40		☼	·	·	·	☼	✦	☼	✦	·	·	·	✦	·	·	✦	·	·	·
7	31	74		·	·	·	☼	✦	✱	☼	✦	·	·	✦	✦	·	✦	·	·	·
9	3	19	19		·	✦	·	✦	·	·	✦	·	·	·	✦	☼	✦	✦	☼	·
12	2	0	1	8		·	·	·	·	·	·	☼	·	·	·	✦	·	✦	✦	·
13	3	12	13	37	2		·	✦	·	·	✦	·	·	✦	✦	☼	✦	·	·	·
15	30	52	55	11	1	14		✦	✦	☼	✦	·	·	✦	✦	·	✦	·	·	·
17	7	27	34	26	2	47	38		✦	☼	☼	·	·	✱	☼	·	☼	✦	·	·
18	22	56	83	24	1	18	48	39		☼	✦	·	·	✦	✦	·	✦	✦	·	·
20	12	26	52	17	1	22	59	69	63		☼	·	·	✱	☼	·	✦	✦	·	·
22	10	25	38	45	15	31	49	64	44	67		·	✦	☼	✱	·	☼	☼	✦	✦
25	2	3	4	17	62	6	5	8	7	7	24		·	·	·	✦	·	✦	✦	✦
26	12	5	9	20	10	12	19	18	12	18	28	19		·	·	·	·	✦	✦	✦
27	9	28	42	22	1	38	46	92	47	82	71	8	19		✱	·	☼	✦	·	·
29	10	22	33	44	1	41	43	74	49	73	82	11	19	81		·	✱	✦	✦	✦
30	4	8	7	55	28	70	6	19	6	7	25	34	20	11	19		·	·	✦	·
31	9	28	38	36	2	36	32	62	43	45	66	11	16	68	78	13		✦	✦	✦
33	6	20	21	23	23	17	21	30	24	25	61	32	31	33	38	23	38		✦	✦
35	2	11	14	56	26	16	10	22	13	15	43	35	32	21	29	41	29	33		✦
37	3	7	12	22	17	20	11	21	14	15	37	49	39	23	30	18	34	35	33	

FIGURE 6.2-41.

MORISITA'S INDEX FOR JULY 1984.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

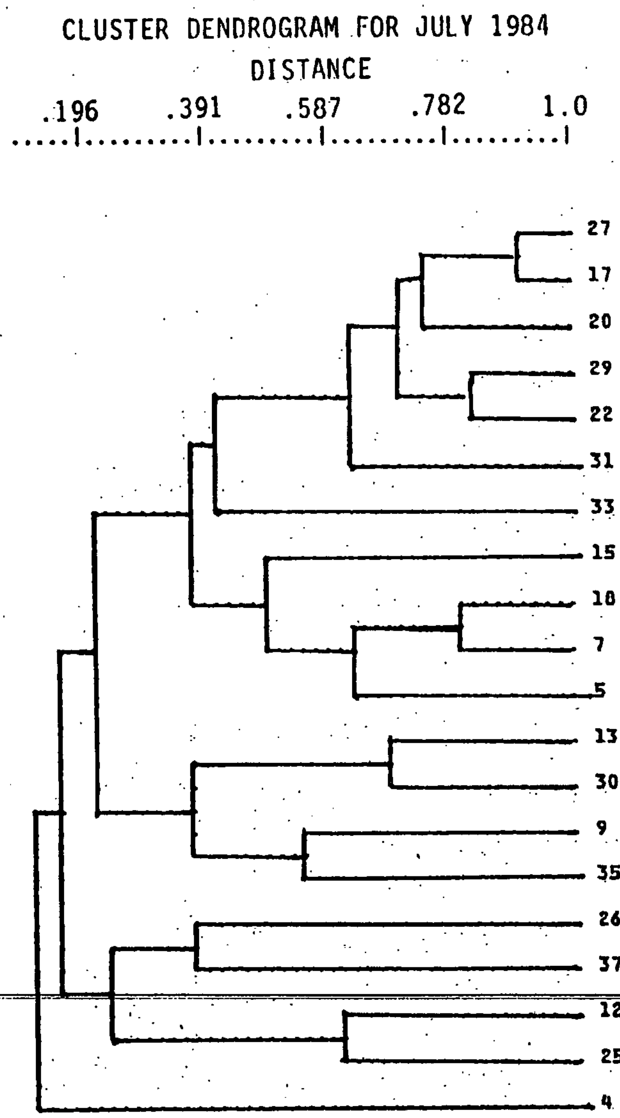

FIGURE 6.2-42.

CLUSTER DENDROGRAM FOR JULY 1984.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

MORISITA'S INDEX OF [illegible]NAL SIMILARITY (X100)

ALL QUARTERL[illegible]ATES COMBINED

STATIONS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1																																								
2	4																																							
3	1	27																																						
4	86	20	6																																					
5	7	45	11	45																																				
6	7	53	11	42	96																																			
7	5	75	16	33	78	85																																		
8	8	39	7	37	82	80	71																																	
9	5	52	33	16	39	38	54	47																																
10	4	21	13	4	9	8	21	14	55																															
11	1	16	25	3	6	6	13	4	30	32																														
12	1	13	17	3	6	5	11	3	27	51	55																													
13	3	62	19	16	38	47	56	32	40	15	25	16																												
14	4	59	16	26	61	67	74	59	59	28	18	12	68																											
15	7	51	14	37	83	85	82	84	40	11	6	4	42	72																										
16	1	47	32	7	18	21	45	13	51	53	55	48	41	37	15																									
17	4	55	9	13	35	49	53	21	28	15	9	6	57	56	34	34																								
18	7	49	10	36	81	84	80	83	43	14	7	7	44	68	89	21	34																							
19	1	26	23	4	12	16	22	7	21	11	10	6	43	28	16	19	32	19																						
20	4	59	16	23	53	54	68	54	58	27	10	10	46	74	73	29	51	67	28																					
21	5	55	12	23	53	54	67	60	52	22	10	9	39	59	74	24	49	68	23	92																				
22	2	52	24	10	23	24	48	26	76	57	32	30	45	64	37	58	40	35	29	74	60																			
23	1	22	41	4	9	9	17	8	38	37	54	45	50	45	10	56	21	12	16	22	15	44																		
24	1	30	17	4	10	9	27	7	46	70	40	50	16	21	9	69	14	12	11	23	18	55	31																	
25	0	15	16	2	4	4	12	4	28	53	47	83	10	10	6	46	8	7	7	13	12	36	33	65																
26	0	14	20	2	4	3	10	2	19	17	76	66	23	17	4	41	10	6	9	10	9	23	49	25	60															
27	3	62	19	14	37	47	60	32	51	23	20	15	63	68	46	40	60	45	36	54	46	57	34	20	12	17														
28	1	13	15	3	7	8	12	8	17	9	31	19	44	45	11	29	18	11	10	16	11	23	72	7	9	29	22													
29	1	14	34	2	4	5	9	4	18	9	21	13	29	22	7	23	12	7	31	16	10	28	42	10	15	23	16	29												
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35	0	7	23	0	1	1	4	0	9	5	36	30	37	30	2	28	10	1	6	3	2	13	76	4	20	39	21	88	29	90	15	22	52	36						
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40	0	12	12	1	4	4	9	3	31	71	34	50	16	15	6	47	9	6	7	17	13	42	42	64	50	21	18	19	11	24	19	15	59	78	20	47	54	19	41	

FIGURE 6.2-43.

MORISITA'S INDEX FOR ALL QUARTERLY DATES COMBINED. CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION

CLUSTER DENDROGRAM FOR ALL
QUARTERLY DATES COMBINED

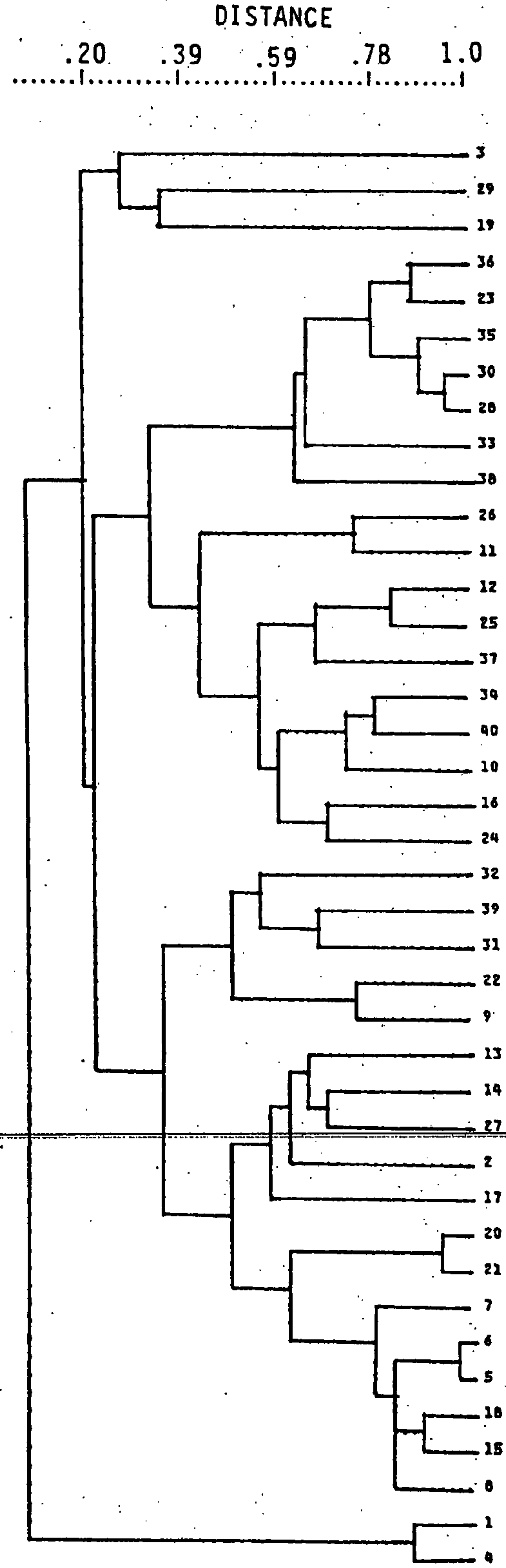

FIGURE 6.2-44.

CLUSTER DENDROGRAM FOR ALL QUARTERLY DATES COMBINED. CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION

MORISITA'S INDEX OF FAUNAL SIMILARITY (X100)

ALL QUARTERLY AND SIX WEEKS SAMPLES COMBINED

STATIONS	4	5	7	9	12	13	15	17	18	20	22	25	26	27	29	30	31	33	35	37
4		◇	◇	·	·	·	◇	·	◇	·	·	·	·	·	·	·	·	·	·	·
5	37		✱	◇	·	◇	✱	◇	✱	☼	·	·	·	◇	·	·	·	·	·	·
7	28	85		☼	·	◇	✱	◇	✱	☼	◇	·	·	☼	·	·	◇	·	·	·
9	16	42	51		◇	◇	◇	·	◇	◇	☼	◇	·	◇	·	·	◇	◇	·	◇
12	3	5	8	26		·	·	·	·	·	◇	✱	✱	·	·	◇	·	◇	·	☼
13	9	27	35	27	21		◇	◇	◇	◇	◇	·	◇	◇	◇	✱	◇	☼	✱	·
15	29	84	91	44	5	28		◇	✱	✱	◇	·	·	◇	·	·	·	·	·	·
17	11	41	47	19	4	38	29		◇	◇	◇	·	·	☼	·	·	◇	·	·	·
18	30	87	87	42	6	28	93	30		☼	◇	·	·	◇	·	·	·	·	·	·
20	18	53	73	49	11	28	76	43	69		☼	·	·	☼	·	·	◇	◇	·	·
22	8	21	44	66	33	31	37	31	30	70		◇	◇	☼	◇	·	☼	☼	·	◇
25	3	7	12	31	77	15	8	7	7	16	40		☼	·	·	·	·	◇	·	✱
26	2	4	9	22	77	36	6	6	6	12	31	62		·	◇	◇	·	◇	◇	☼
27	11	39	57	41	15	50	46	54	41	53	59	15	18		·	·	☼	◇	·	·
29	3	6	14	22	22	32	11	11	10	22	39	18	28	22		◇	·	◇	·	·
30	4	8	12	19	27	85	8	11	8	11	23	22	39	23	30		·	☼	✱	◇
31	9	24	36	45	23	33	21	36	23	38	56	25	23	69	23	18		◇	·	◇
33	6	14	20	44	46	55	10	20	11	25	53	44	45	38	29	57	49		◇	☼
35	0	1	3	10	25	78	2	5	1	3	13	20	38	21	25	92	11	46		·
37	7	15	18	43	74	24	8	10	10	19	47	76	65	22	23	26	39	63	21	

FIGURE 6.2-45.

MORISITA'S INDEX FOR ALL QUARTERLY AND SIX WEEK SAMPLES COMBINED. CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION

CLUSTER DENDROGRAM FOR ALL SIX WEEK
AND QUARTERLY SAMPLES COMBINED

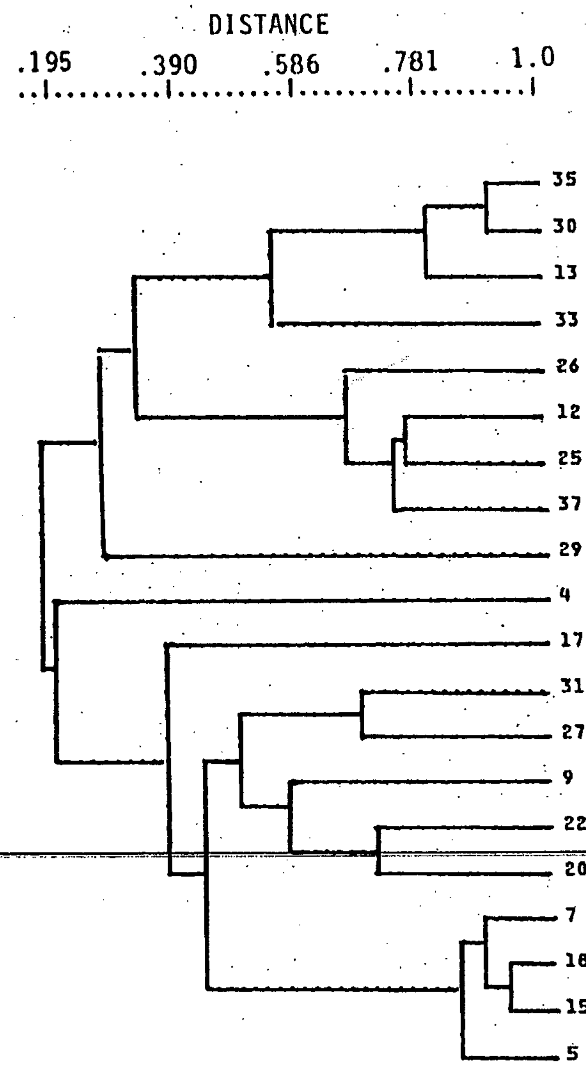

FIGURE 6.2-46.

CLUSTER DENDROGRAM FOR ALL QUARTERLY AND SIX WEEK SAMPLES COMBINED.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

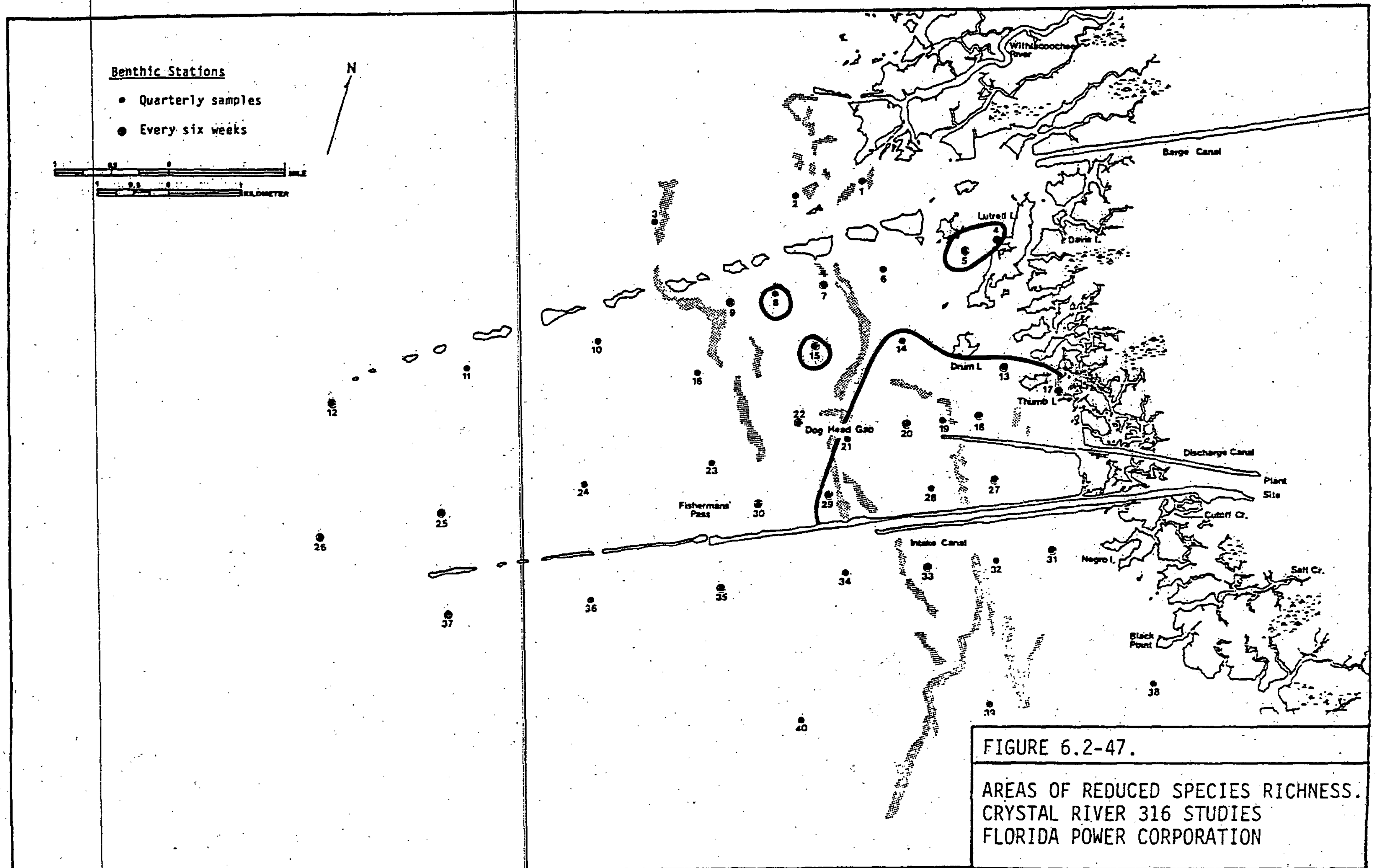

FIGURE 6.2-47.

AREAS OF REDUCED SPECIES RICHNESS.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

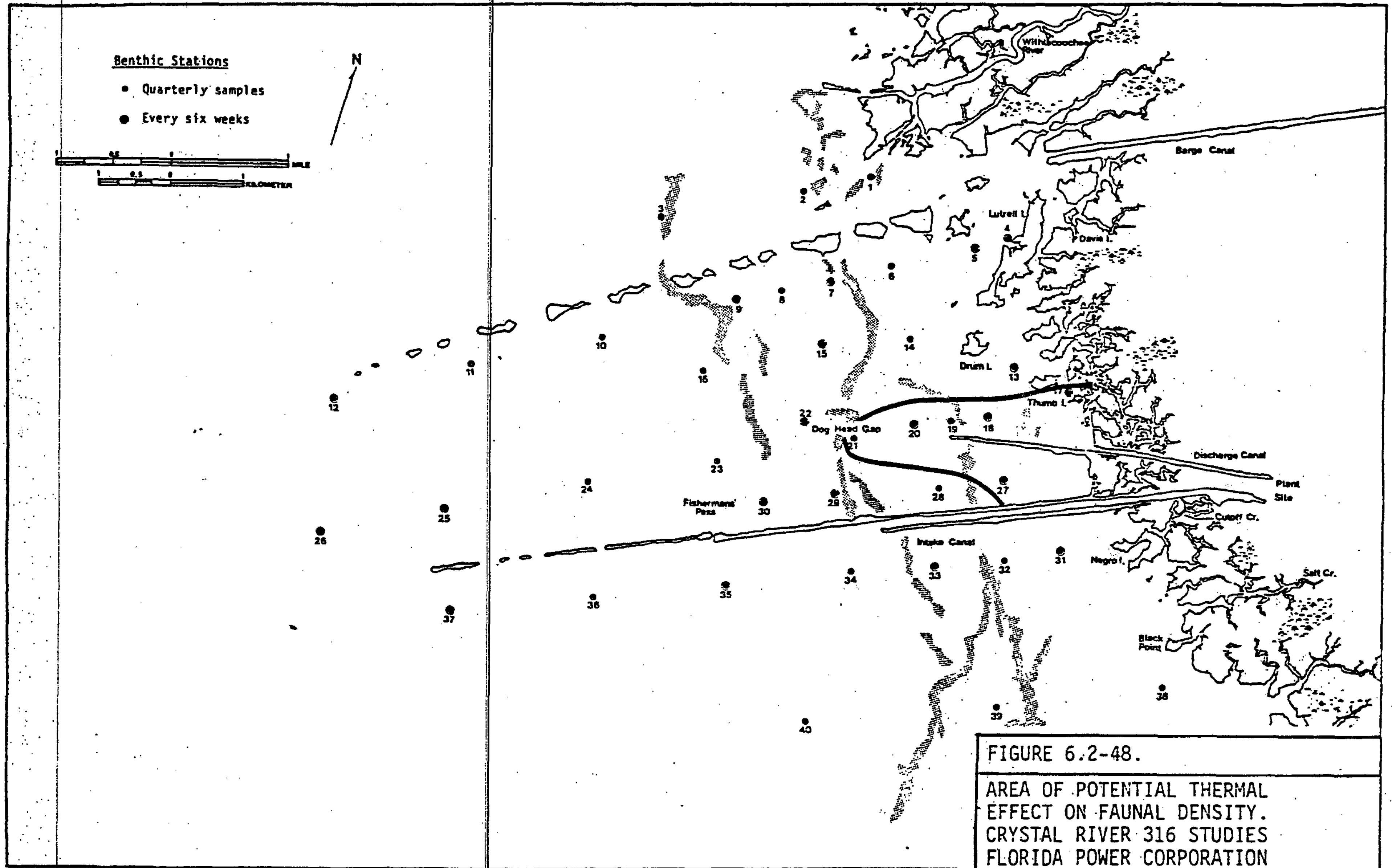

FIGURE 6.2-48.

AREA OF POTENTIAL THERMAL EFFECT ON FAUNAL DENSITY. CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION

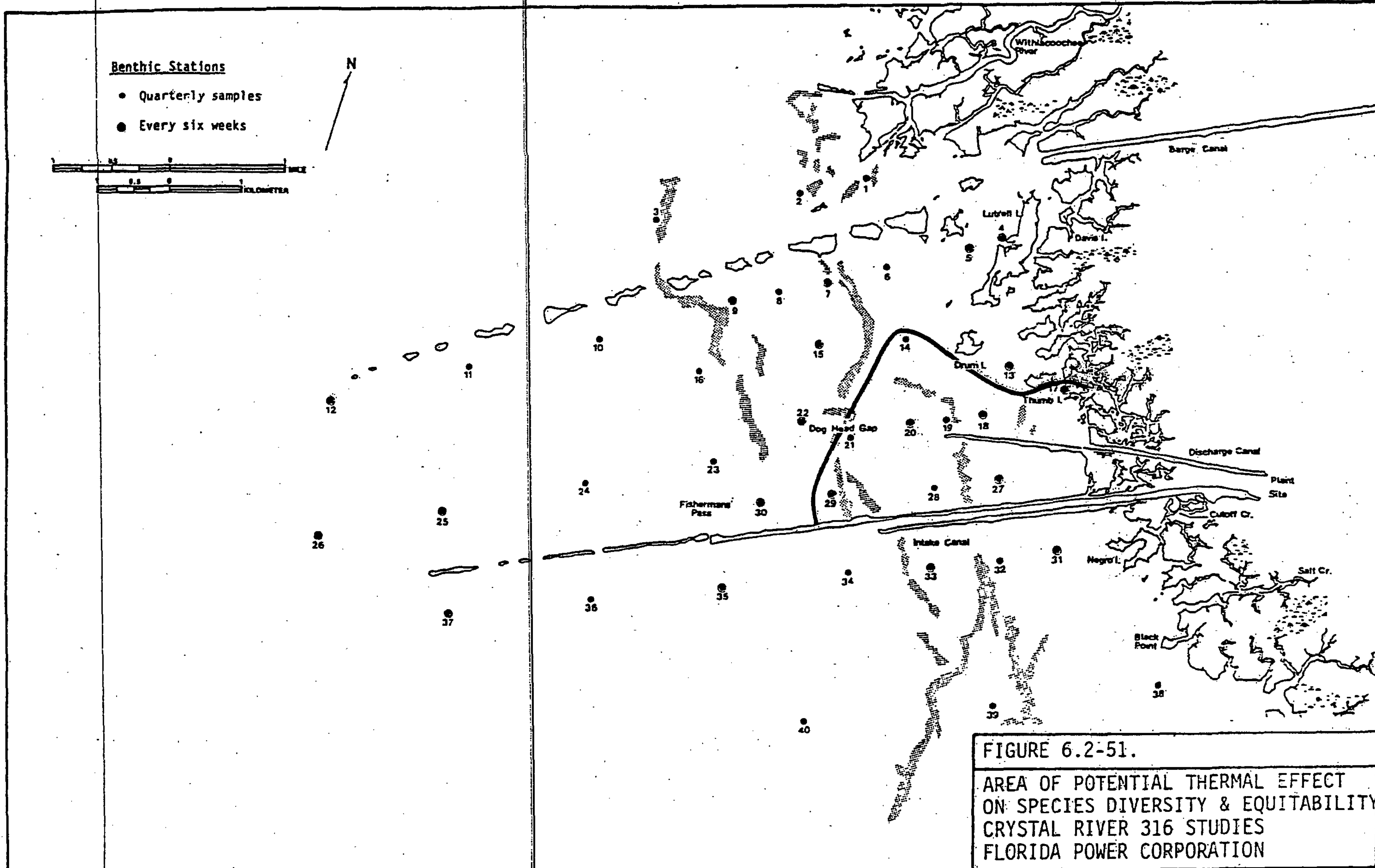

FIGURE 6.2-51.

AREA OF POTENTIAL THERMAL EFFECT ON SPECIES DIVERSITY & EQUITABILITY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

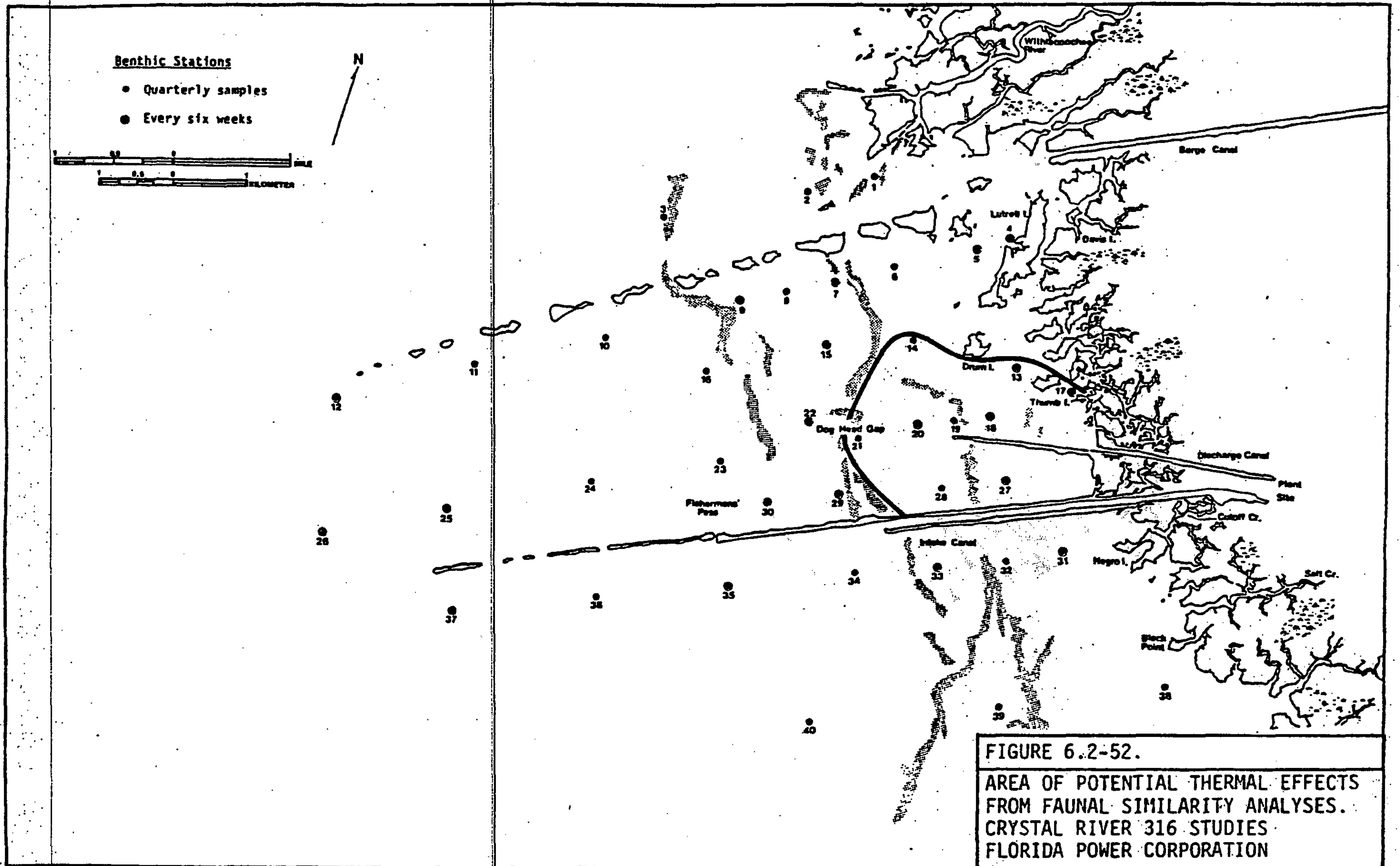

FIGURE 6.2-52.

AREA OF POTENTIAL THERMAL EFFECTS FROM FAUNAL SIMILARITY ANALYSES. CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION

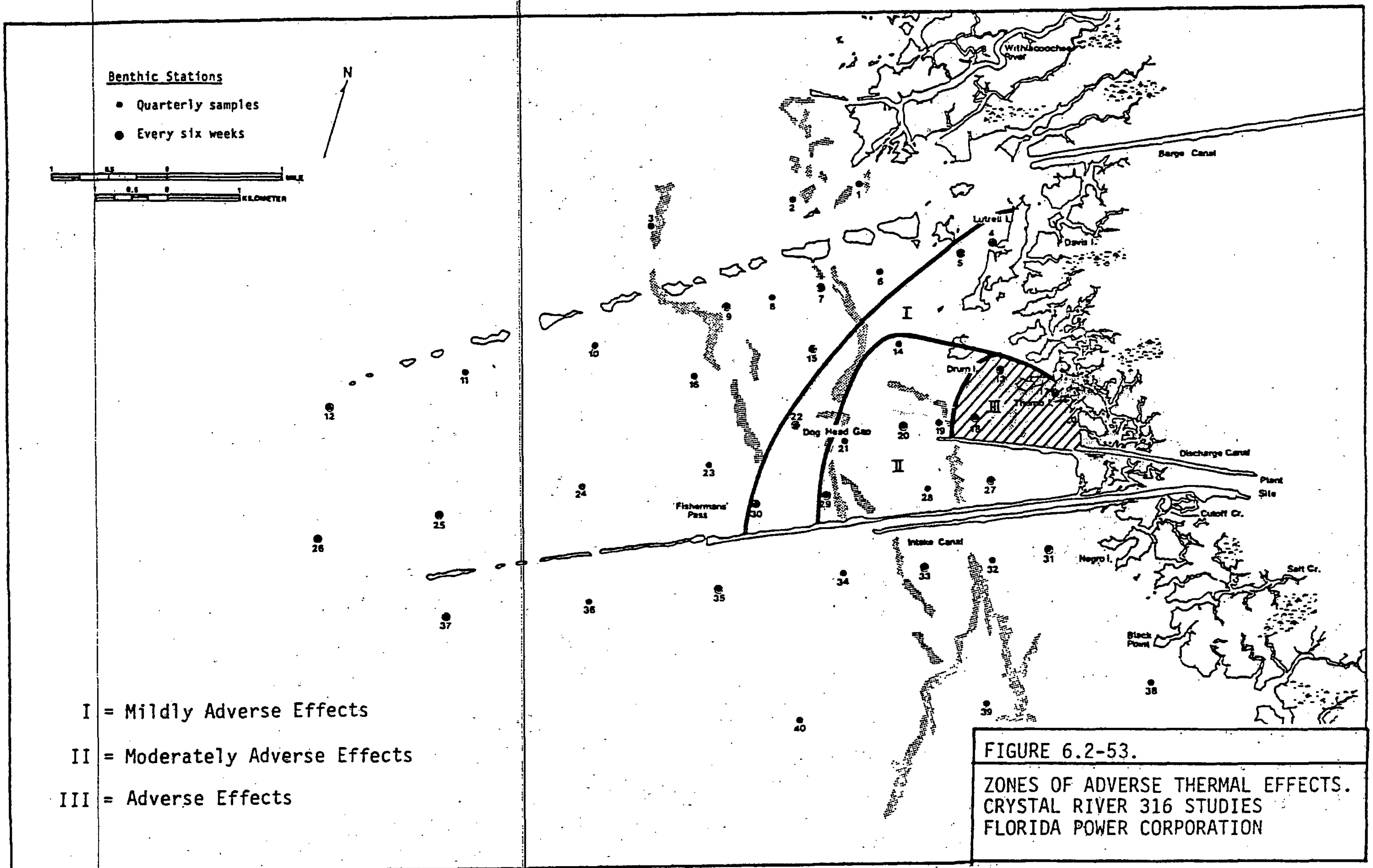

FIGURE 6.2-53.

ZONES OF ADVERSE THERMAL EFFECTS.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

6.3 MACROPHYTES

6.3.1 Sampling and Laboratory Analysis

Three areas were selected to study the submergent macrophyte communities in Crystal Bay. The area between the CFBC and the intake spoil was defined as the thermally affected area. Two control areas were also sampled - one located off the Withlacoochee River and the CFBC and one off Crystal River. Fifty stations on 10 transects were established (Figure 6.3-1) for ground truthing. Of these stations, nine were designated as intensive monitoring (IM) stations and were subjected to a more extensive sampling program.

Quarterly overflights to shoot 1:18,000 (1 in. = 1,500 ft) scale vertical color aerial photographs were planned to map the distribution of the seagrass and macroalgae in the study area over the course of 15 months. However, conditions at the site prevented successful aerial photography as scheduled. Photographs which could be used for ground truthing were obtained only three times during the study (October 1983; February and April 1984). These photographs, along with others obtained from various sources were then ground-truthed each quarter by teams of divers.

Ground truthing was performed at each of the 50 stations using 10 randomly placed 1-m^2 quadrats. Quadrats were surveyed by divers who estimated percent cover for each species of seagrass and rhizophytic alga observed. An estimate of the percent bare bottom was also made during the latter part of the study. Estimates of percent coverage were facilitated by dividing each quadrat into 25 subunits (a 5 x 5 grid) and estimating percent cover in each subunit.

Of the nine stations selected (Figure 6.3-1) for intensive monitoring, three (A, D, and G) contained Halodule wrightii as the dominant seagrass; 3 (B, E, and H) contained Syringodium filiforme as the dominant seagrass; and 3 (C, F, and I) contained Thalassia testudinum as the dominant seagrass. These stations were sampled at 6 week intervals between June 1983 and July 1984, for a total of 10 sampling episodes. In addition to percent cover estimates, biomass and productivity samples were collected during each sampling episode.

Above-ground biomass of seagrass and algae was sampled using a plexiglass clip box sampler (25 x 25 cm). The box was inserted into the sediment and all plant material was clipped at the sediment surface. The clipped material was retained in the box. Six replicates were collected in this fashion at each IM station during each sampling episode. Samples were preserved in the field in 5-10 percent formalin in seawater. Five replicates were analyzed by sorting the plant material to species; drying to constant weight at 70°C; and weighing. The sixth replicate was saved, principally in case of loss or damage to one of the first five; however, the sixth replicates were examined to identify the algal epiphytes present.

Estimates of seagrass productivity (after Zieman, 1975) were based on quadrat sampling. Quadrats measuring 10 cm x 10 cm were employed at Halodule stations (A, D, and G); 10 cm x 20 cm quadrats were used at all other IM stations. Three quadrats were placed at the time the clip box samples were taken. After placement, all seagrass blades within the quadrats were clipped off level with the top of the quadrat and discarded. Two weeks later the uadrats were revisited and all new growth was harvested and preserved in

5-10 percent formalin/seawater. Samples were returned to the laboratory, sorted, dried to constant weight, and weighed. Shoot counts were made both at the time of quadrat placement and at harvesting using seven randomly placed 10 x 10 cm quadrats at Halodule stations and four 10 x 20 cm quadrats at Syringodium and Thalassia stations.

SAS was used to provide summary tables of percent cover, growth rates, total standing biomass, and total shoot density by time and station. The SAS GLM procedure was used to provide an analysis of covariance for the above four measures of macrophyte abundance. Tukey's HSD test was used to contrast means of main effect variables of station and time period. These analyses were also conducted by species to compare differences across stations for each species.

6.3.2 Results

Five species of seagrasses were observed in the Crystal Bay area during the course of this study: *Ruppia maritima* L., *Halophila engelmannii* Aschers; and *Thalassia testudinum* Banks ex Koenig, and *Syringodium filiforme* Kuetzing and *Halodule wrightii* Aschers.

Seagrass diversity (number of species) at the nine intensive monitoring stations over the course of this study is summarized, in Table 6.3-1. The three southern stations (A, B, and C, south of the intake canal) and the two central stations (E and F) usually contained the highest number of seagrass species, although in the last two sampling periods one or more of the three northern stations (G, H, or I) contained the greatest number of species. Station D (in Basin 1) routinely contained only one species of seagrass, *Halodule wrightii*.

Parameters of the seagrass communities which were measured were biomass (above ground standing crop), shoot density, productivity and percent cover. Table 6.3-2 summarizes the results of the ANOVA analyses on the seagrass data. Time (sampling date) and station were the two parameters which consistently had a significant effect on seagrass biomass, productivity, shoot density and percent cover. In most cases, the effect was highly significant (P less than 0.01, see Table 6.3-2). The other parameters tested showed no clear pattern. Temperature, salinity, pH, dissolved oxygen (DO), and the extinction coefficient (light penetration), all measured at the bottom, had a significant effect on the different species of seagrasses, but in a sporadic fashion, affecting various species differently (e.g., biomass in some cases, productivity in others, etc.). The environmental factors used in the ANOVA analyses are, of course, linked with the time of year and station location, and the relationship between these factors is examined in Section 6.1.

For all seagrasses combined, one or more of the three southern stations (A, B, and C) consistently had significantly higher biomass, shoot density and productivity than the other intensive monitoring stations. Appendix IV contains the results of the ANOVA analyses on the total seagrass data. There were some variations in this general pattern depending on the species of seagrass, i.e., Halodule stations tended to have higher shoot densities than Syringodium or Thalassia stations, since the former species is smaller, and thus has more shoots per unit area. Halodule stations had lower biomass and productivity compared to Thalassia and Syringodium stations, since the latter two species have larger blades than the former. Stations E and F typically exhibited intermediate seagrass biomass, shoot densities, and productivities. Stations G, H, I, and D usually displayed significantly lower seagrass parameters than the other stations. Temperature, salinity, pH and DO were environmental factors which significantly influenced the measures of abundance of total seagrasses.

The following paragraphs discuss the analytical results for each species of seagrass separately.

Halodule wrightii

The ANOVA analyses performed on the *Halodule* percent cover, biomass, shoot density, and productivity data are presented in Appendix IV. Table 6.3-3 summarizes annual means for each of these items. Station A exhibited significantly higher biomass, shoot density and productivity than the other two *Halodule* intensive monitoring stations (D and G). Stations D and G did not differ significantly with respect to biomass or productivity, but Station G had a significantly greater shoot density (number per area) than Station D. All three *Halodule* stations were similar with respect to percent cover (areal coverage). This is contrary to the ANOVA results, which indicate that station differences do exist for percent cover, however the multiple comparison test used (Tukey's test) is very conservative. In addition, Zieman (personal communication) has questioned the value of percent cover data as an indicator of thermal effects of seagrasses.

Typically, productivity, biomass, shoot density and percent cover of *Halodule* were all significantly higher during the late spring -summer - early fall sampling periods. Salinity, pH, DO and light levels were environmental factors which significantly influenced one or more of the *Halodule* measures of abundance. Appendix IV contains summary tables on *Halodule* biomass, productivity and shoot density by sampling date and station.

Syringodium filiforme

The ANOVA analyses performed on *Syringodium* percent cover, biomass, shoot density, and productivity are presented in Appendix IV. Station B had significantly higher biomass, productivity, shoot density and percent cover than the other two *Syringodium* intensive monitoring stations. Station E had significantly higher biomass, shoot density and percent cover than Station H, but these two stations did not differ with respect to productivity. The summer months typically exhibited significantly higher *Syringodium* biomass, shoot density, productivity and percent cover. However, percent cover tended to be significantly higher during the winter months relative to the other three parameters examined. Temperature, light, salinity and DO were the environmental factors which significantly influenced *Syringodium* parameters. *Syringodium* biomass, productivity and shoot density by station and month are summarized in Appendix IV. Annual means by station and sampling date are shown in Table 6.3-4.

Thalassia testudinum

The ANOVA analyses performed on *Thalassia* percent cover, biomass, shoot density, and productivity data are presented in Appendix IV. Station C exhibited significantly higher *Thalassia* biomass, shoot density, and productivity than Stations F and I, which did not differ for any of these parameters. Thalassia percent cover among stations was not tested, since in two cases (Stations E and F and Stations B and C), a Thalassia and a Syringodium station were located in the same grassbed and sampling results were for a mixed seagrass bed. For the four Thalassia parameters tested, significantly higher values were observed during the summer sampling periods, but the winter values for Thalassia tended to place relatively higher in the rank order, compared to the winter values of Syringodium and Halodule. Temperature, light and pH were environmental factors which significantly influenced the Thalassia measures of abundance. Thalassia biomass, productivity and shoot density by station and month are summarized in Appendix IV. Annual means by station and sampling data are shown in Table 6.3-5.

Macroalgae

Rhizophytic Algae

Table 6.3-6 lists the species of rhizophytic (attached) algae observed during the course of this study. More stations south of the power plant discharge (Stations 32 and higher) supported rhizophytic algae, compared to the northern stations, and the southern stations usually exhibited higher rhizophytic algal percent cover than the northern stations (see quarterly data tables). Percent cover was higher during the summer/fall period. Rhizophytic algal diversity is summarized in Table 6.3-7. More species of rhizophytic algae were found at the three southern intensive monitoring stations (A, B, and C) throughout the study period, compared to the other intensive monitoring stations.

Rhizophytic algal biomass was significantly correlated to time (sampling date), station and bottom DO. Results of the ANOVA analyses are found in Appendix IV. Station E had significantly higher biomass compared to the other stations. Other than for this station, however, no clear station trend was evident. Rhizophytic algal biomass was significantly higher during the summer/fall sampling periods.

Drift Algae

A number of species of drift algae were collected during the course of this study. These are listed in Table 6.3-6. Percent cover was the only drift algal parameter measured and statistically analyzed. Time, station, temperature and salinity at the bottom had significant effects. Station B had the significantly highest drift algal percent cover, but no other clear trends were evident. Drift algal percent cover tended to be significantly higher during winter and summer months.

Typically, a species of Gracilaria (G. tikvahiae or G. verrucosa) tended to dominate the drift algae throughout the year in the northern half of the study area (the discharge area and north), with Sargassum filipendula locally dominant in areas with rocky bottom. Gracilaria debilis and/or G. sjoestedii dominated the drift algae in the southern part of the study area in the winter. Drift algae appeared to form a lesser proportion of the total macrophyte cover during the summer months in the south part of the study area. Red algae, as a group, were the dominant component of the drift algae in the study area throughout the period of study.

Total Macrophyte Percent Cover

An estimate of the percent bare substratum was made when estimating percent cover of the different species of macrophytes, in order to obtain an estimtae of total macrophyte cover. Time, station, bottom temperature and DO had significant effects on total macrophyte cover (see Appendix IV). The southern intensive monitoring Stations A and 47 (B and C) had the significantly highest total macrophyte coverage. Stations 33 (E and F) and I were intermediate, and Stations D, H, and G had significantly lower total submergent macrophyte cover. Station D exhibited the lowest total macrophyte cover. Total macrophyte cover tended to be significantly higher during the summer months. Drift algal cover and occurrence in the thermal areas was lower during the summer than it was in other parts of the study area.

Macrophyte maps of the area show much higher total macrophyte cover in the south part of Crystal Bay (south of the intake canal and dike) compared to the northern region. Figures 6.3-2 to 6.3-10 show macrophyte distribution in Crystal Bay in February 1984.

Syringodium was not widely distributed at many of the stations in the northern half of the study area, but occurred frequently at many southern stations throughout the study period. This was not the case for the other species of seagrasses observed. These species typically occurred at similar numbers of southern and northern stations. *Thalassia* and *Syringodium* occurred at the fringes of Basins 1 and 3, but were not found within these basins at the hottest areas of the discharge. *Halodule* and *Halophila engelmanni* were the only species of seagrasses which occurred in the thermal area, occurring in Basin 3 and portions of Basin 1.

Seagrass or seagrass/rhizophytic algal assemblages dominated the macrophyte cover in the southern part of the study area. *Thalassia* and *Syringodium* were dominant offshore and *Ruppia maritima* and *Halodule* were dominant inshore. Dense patches of rhizophytic algae (generally *Caulerpa* sp.) were found locally in inshore areas of the southern part of the study area. Seagrasses formed a lesser proportion of the macrophyte cover in the northern half of the study area. Algae, particularly drift algae, were dominant there. Seagrasses and algae in the northern part of the area existed as small patches, while larger, more continuous areas of cover were found in the southern area.

An historical trend analysis of submergent macrophyte communities was compiled from seven sets of vertical aerial photography, dating back to October 1950. Trend analysis focused on the Basin 1 area. When available, data from past Crystal River monitoring reports were also used in compiling this summary.

Analysis of the early(1950 and 1960) photography indicated a general absence of strong signatures of submergent macrophyte communities in the Basin 1 area. Some seagrass and algae appear to be present; however, the quality of the black and white photography does not allow conclusive interpretation. Historically, the Basin 1 area appears to have been subjected to freshwater inundation from Rocky Creek, a tidal drainage creek of the type found throughout the study area. The flow of Rocky Creek was subsequently interrupted by construction of the Crystal River discharge canal. The obstruction of the freshwater flow may have permitted seagrasses to invade the

Basin 1 region, due to higher salinities. No field data are available to support the above, and thus it must be regarded as speculative. The 1972 aerial photography (color) shows the presence of photographic signatures consistent with relatively dense submergent macrophyte communities. FPC (1974) confirmed the presence of extensive beds of <u>Halodule</u> (= <u>Diplanthera</u>) <u>wrightii</u> in Basin 1. FPC (1978; 1979) also depicted extensive (> 50 percent coverage of the bottom) <u>Halodule</u> cover in Basin 1. The 1981 photography reveals a slight decrease in submergent macrophyte coverage, supported by percent cover data from FPC (1981). Current (1983-84) photography reveals further declines in macrophyte cover in Basin 1, a trend confirmed by the field verification and sampling program conducted in the present study. Although <u>Halodule</u> may be sparsely distributd throughout Basin 1 (as suggested by the aerial photography), field inspection indicated this was not so, <u>Halodule</u> being confined to the northeast portion of the basin. Other areas of Basin 1 were unvegetated mud bottom, sometimes associated with a blue-green algal mat. These mats, along with areas of benthic diatom concentrations, could be responsible for the "green mud" signatures visible in the recent photography of Basin 1.

6.3.3 Impact Assessment

<u>Seagrasses</u>

The effects of the effluent from the power plant discharge on seagrass received much attention in past studies (Van Tine 1977; FPC 1978; 1979; 1980; 1981) at Crystal River. It is known that the effluent from the plant results in a lower number of species of seagrasses in the area affected by the discharge. This was seen in the present study. <u>Halodule wrightii</u>, the most eurythermal of the seagrass species in the area (Phillips 1960; Zieman 1982), was the only species of seagrass found at Station D, the station most exposed to the power plant discharge. More seagrass species were observed at Stations E and F further offshore. These stations appeared to be only moderately impacted by the effluent plume. The greatest number of seagrass species throughout the period of study were seen at these two stations and at the three southern stations (A, B, and C). The three northern stations (G, H, and I) generally had a lower number of seagrass species throughout the study period.

The intensive monitoring stations (D, E, and F) located in the discharge area routinely exhibited significantly lower seagrass biomass, for all three species, compared to the three southern unimpacted stations (A, B, and C). <u>Thalassia</u> and <u>Halodule</u> biomass did not differ between thermal and northern stations (F and I; D and G, respectively), but <u>Syringodium</u> biomass was significantly higher at the impacted Station F than at the northern Station H. Previous monitoring studies at the Crystal River complex have not considered biomass of each species of seagrass separately (e.g., FPC 1978; 1979), or only considered biomass of <u>Halodule</u>, since it is the only species of seagrass found in the discharge area (FPC 1981). The past Crystal River monitoring reports, however, show the same general trends seen in this study: lower seagrass biomass in the discharge area compared to the southern area (the region south of the intake canal).

All three species of seagrass chosen for intensive monitoring displayed the same type of annual biomass trend: summer maxima and winter minima. The thermal effects from the effluent plume are likely to be more pronounced during the summer when the organisms are normally exposed to natural water temperatures closer to their thermal tolerance limits.

Like biomass, seagrass productivity was significantly lower in the discharge area than in the southern area. All three species of seagrass showed highest productivity at the three southern stations. None of the thermal stations differed from any of the respective northern stations, suggesting that thermal effects alone are not entirely responsible for the depressed productivity. None of the previous monitoring studies conducted at Crystal River specifically examined seagrass productivity. Zieman and Wood (1975) showed that Thalassia productivity (gm/m 2 /day) decreased linearly with increasing temperatures above 32°C. Thalassia has a temperature optimum for productivity of 28-30°C (Zieman and Wetzel 1980). Seagrass productivities in the present study exhibited summer maxima and winter minima for all three species of seagrass. Productivities during the winter were more similar in the thermal area and in the northern and southern control areas suggesting that thermal effects of the plant discharge are more pronounced during the summer.

Shoot densities of all three seagrass species were significantly higher at the three southern intensive monitoring stations (A, B, and C). The northern Halodule Station G had a significantly higher shoot density than the thermal Station D. Shoot density of Syringodium at the thermal Station E was significantly higher than at the northern Station H, while Thalassia shoot densities at thermal and northern stations (F and I) did not differ. Shoot densities did not show as pronounced an annual trend as biomass and productivity.

Percent cover of Halodule did not differ among the three intensive monitoring stations (A, D and G), while cover of Syringodium was significantly higher at Station B than at Station E, which in turn was significantly higher than cover at H. Thalassia percent cover was not tested among stations. Previous monitoring reports at Crystal River have principally used percent cover estimates to monitor the seagrass and macroalgal communities in the area. These reports (FPC, 1978; 1979; 1980; 1981) indicate that Halodule cover is reduced in the area immediately adjacent to the mouth of the discharge canal, but that in general Halodule cover does not differ between impacted and control areas. Syringodium and Thalassia, however, were generally not found in the inner discharge area (van Tine 1977, "Basin 1") and typically exhibited higher cover south of the intake canal. Similar trends were seen in the present study.

The seagrass coverage depicted in the macrophyte maps generally support the quantitative data, seagrass cover being greater in the southern part of the Crystal Bay area. The area impacted by the thermal plume was devoid of macrophytes, along with the area around the mouth of the Cross Florida Barge Canal.

Seasonally, percent cover tended to be significantly higher during the summer months for the three species of seagrass. FPC (1980) reported winter cover maxima (December) in the southern control and discharge areas of the Crystal River Plant, while FPC (1981) reported fall (September) cover maxima in the southern area, with no appreciable seasonal cover changes of seagrasses in the discharge area.

Macroalgae

Algae may be better indicators of thermal stress than seagrasses, since the buried rhizomes of seagrasses may be protected from thermal efects by the sediment (Zieman and Wood 1975). In particular, Zieman (pers. comm.) has noted that the rhizophytic green algae (members of the orders Siphonales and Dasycladales) are especially susceptible to thermal stress.

In the present study, rhizophytic algal diversity (number of species) was lower at all the thermal stations (D, E, and F) compared to the southern stations (A, B, and C). However, the northern stations also supported few species of these algae, once again suggesting that other factors, in addition to thermal stress, are regulating submergent macrophyte communities in the area.

Rhizophytic algal biomass (g dry wt/m^2) at the nine intensive monitoring stations was tested statistically. Station E had significantly higher algal biomass than any other station. No other clear station trend was evident. Rhizophytic algal biomass was significantly higher during the summer/fall period. Van Tine (1977) noted that very few species of siphonaceous green algae (*Caulerpa* spp., *Udotea* spp.) were found in the discharge area of the Crystal River Plant. Other monitoring studies at this site did not consider rhizophytic algae (FPC 1978; 1979; 1980), but FPC (1981) reported that siphonaceous algae did not occur in the discharge area of the plant. Zieman and Wood (1975) noted at Turkey Point that, in areas most severely impacted by thermal addition, the seagrass/macroalgal community was replaced by a blue-green algal mat. This phenomenon was also seen at Crystal River in the Basin 1 section of the discharge canal.

Drift algal diversity and biomass were not measured in the present study. A general impression was that a greater number of species of drift algae were found south of the intake canal. Drift algal percent cover was highest in the southern part of the Crystal Bay study area (Station B), but no other clear percent cover trends were evident from the percent cover analyses. Steidinger and Van Breedveld (1971) showed that the discharge area of the Crystal River Plant supported fewer species of algae than the rest of the Crystal Bay area. Van Tine (1977) also showed that the thermally impacted area of Crystal Bay supported a lower number of species of all three divisions of algae: Rhodophyta (red algae); Chlorophyta (green algae) and Phaeophyta (brown algae). He also showed that algal biomass was lower in the impacted area. FPC (1981) showed that drift red and brown algae were excluded from the Crystal River Plant discharge area.

In summary, the data and observations collected in the present study suggest that the thermal effluent from Crystal River exerts a negative effect on the seagrass and macroalgal communities in the inner part of the discharge area (Basin 1). The thermal effects appear to be more moderate in the outer parts of the discharge area (Basin 3). However, other factors are influencing the submergent macrophyte communities in the study area and the data gathered in the present study cannot distinguish between these different factors. Thus, the observed trends in macrophyte biomass, percent cover, etc, cannot be attributed solely to the effects of thermal addition. Increased turbidity and sedimentation, some of which may be due to the outflow current from the discharge canal, may be exerting a negative effect on the macrophyte communities in the discharge area. The selection of the three northern intensive monitoring stations (G, H, and I) in the region of the Cross Florida Barge Canal (CFBC) represented an attempt to distinguish between potential turbidity and sediment loading effects and any thermal effect, but the statistical analyses of the data failed to differentiate between stations located in the thermal and northern areas. Decreased light levels (associated with increased water turbidity) and increased sedimentation are suspected of causing declines in seagrass coverage (Zieman 1982). Other factors influencing the seagrass and macroalgal communities in the study area are nutrient concentrations in the water column, sediment type and depth and salinity changes associated with freshwater influx.

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TABLE 6.3-1

SEAGRASS DIVERSITY (NUMBER OF SPECIES) AT THE INTENSIVE MONITORING STATIONS

STATION	AUG. 1983	SEPT. 1983	OCT. 1983	DEC. 1983	JAN. 1984	MAR. 1984	APR. 1984	MAY 1984	JULY 1984	AUG. 1984
A (40)	3	3	4	4	2	2	1	1	1	2
B & C (47)	3	1	4	3	2	3	2	2	1	1
D (27)	1	1	1	1	1	1	1	1	1	1
E & F (33)	4	4	4	4	4	4	4	4	3	3
G (3)	3	1	2	1	3	2	2	2	4	1
H (9)	1	2	2	2	2	4	3	2	4	3
I (4)	2	0	2	2	2	3	2	2	2	3

A-I Intensive Monitoring Station

(40) Corresponding Ground-truthing Station

TABLE 6.3-2

SUMMARY OF THE ANOVA ANALYSES OF THE SEAGRASS DATA

	Time (Sampling Date)	Station	Bottom Temperature	Bottom Extinction Coefficient	Bottom Salinity	Bottom pH	Bottom Dissolved Oxygen
Halodule							
BM	**	**	NS	NS	*	**	NS
SD	**	**	NS	NS	NS	NS	NS
PR	**	**	NS	NS	NS	*	NS
PC	**	*	NS	*	NS	NS	**
Thalassia							
BM	**	**	NS	*	NS	NS	NS
SD	**	**	*	NS	NS	**	NS
PR	**	**	NS	NS	NS	NS	NS
PC	**	-	-	-	-	-	-
Syringodium							
BM	**	**	NS	NS	NS	NS	NS
SD	**	**	*	NS	NS	NS	NS
PR	**	**	NS	**	NS	NS	NS
PC	**	**	**	NS	**	NS	*
All Seagrasses							
BM	**	**	NS	NS	*	*	NS
SD	**	**	**	NS	NS	NS	**
PR	**	**	NS	NS	NS	NS	NS
PC	-	-	-	-	-	-	-

BM = biomass (g dry weight/m^2)
SD = shoot density (#/m^2)
PR = productivity (g dry weight/m^2/day)
PC = percent cover
* = significant at P 0.05
** = significant at P 0.01
NS = not significant
- = parameter not tested

TABLE 6.3-3

ANNUAL MEANS, BY STATION AND SAMPLING DATE, FOR THE HALODULE DATA

BIOMASS ($g\ dry\ wt/m^2$)

MEANS

SD	N	STANDBIO
2	10	12.4800000
3	15	12.0960000
4	10	9.2480000
5	15	0.6986667
6	15	0.7893333
7	5	0.5120000
8	15	2.7840000
9	15	4.0213333
10	15	12.5013333

STATION	N	STANDBIO
A	40	12.8400000
D	45	2.8373333
G	30	2.3973333

PRODUCTIVITY ($g\ dry\ wt/m^2/day$)

MEANS

SD	N	AVEGROW
2	9	0.30952381
3	9	0.08974359
4	5	0.04285714
5	9	0.08241758
6	9	0.02941176
7	8	0.05416667
8	9	0.08547009
9	9	0.10101010
10	8	0.38025210

STATION	N	AVEGROW
A	26	0.19884049
D	26	0.08899460
G	23	0.10800504

PERCENT COVER

MEANS

SD	N	PC
2	30	47.3666667
3	21	35.9523810
4	15	51.0000000
5	21	28.0000000
6	17	17.8823529
7	13	10.7692308
8	17	7.6470588
9	8	5.2500000
10	16	53.8750000
11	12	14.6666667

STATION	N	PC
A	27	33.9259259
D	92	31.7934783
G	51	26.3137255

SHOOT DENSITY ($No./m^2$)

MEANS

SD	N	BDEN
2	21	790.47619
3	21	633.33333
4	14	1371.42857
5	21	647.61905
6	21	709.52381
7	21	509.52381
8	21	1119.04762
9	21	1490.47619
10	21	2371.42857

STATION	N	BDEN
A	63	1425.39683
D	63	750.79365
G	56	996.42857

TABLE 6.3-4

ANNUAL MEANS, BY STATION AND SAMPLING DATE, FOR THE SYRINGODIUM DATA

BIOMASS ($g\ dry\ wt/m^2$)

MEANS

SD	N	STANDBIO
2	15	10.2613333
3	15	14.8266667
4	10	13.3760000
5	14	11.7314286
6	14	7.3028571
7	15	7.2320000
8	15	3.5466667
9	15	19.9786667
10	15	24.7786667

STATION	N	STANDBIO
B	45	24.7680000
E	45	9.2195556
H	38	2.1094737

PRODUCTIVITY ($g\ dry\ wt/m^2/day$)

MEANS

SD	N	AVEGROW
2	6	0.41666667
3	7	0.16483516
4	6	0.25595238
5	9	0.16559829
6	9	0.03819444
7	7	0.09047619
8	9	0.23041311
9	9	0.46969697
10	9	0.73046398

STATION	N	AVEGROW
B	27	0.47418589
E	20	0.27076476
H	24	0.09641170

PERCENT COVER

MEANS

SD	N	PC
2	20	16.6000000
3	11	12.8227273
4	13	39.2307692
5	20	30.8500000
6	23	43.7826087
7	23	30.3260870
8	17	23.5294118
9	26	22.5384615
10	23	45.8695652
11	17	15.1764706

STATION	N	PC
B	85	38.9647059
E	84	23.9053571
H	24	11.8125000

SHOOT DENSITY ($No./m^2$)

MEANS

SD	N	BDEN
2	12	512.50000
3	12	787.50000
4	8	837.50000
5	12	775.00000
6	12	683.33333
7	12	712.50000
8	12	820.83333
9	12	1070.83333
10	12	1254.16667

STATION	N	BDEN
B	36	1188.88889
E	36	740.27778
H	32	520.31250

TABLE 6.3-5

ANNUAL MEANS, BY STATION AND SAMPLING DATE, FOR THE THALASSIA DATA

BIOMASS
(g dry wt/m^2)

MEANS

SD	N	STANDBIO
2	15	21.4613333
3	15	19.8826667
4	10	16.6720000
5	15	10.3306667
6	12	6.0266667
7	15	3.6693333
8	15	2.9333333
9	15	11.8720000
10	15	34.1120000

STATION	N	STANDBIO
C	45	30.0088889
F	44	6.7181818
I	38	4.1305263

PRODUCTIVITY
(g dry wt/m^2/day)

MEANS

SD	N	AVEGROW
2	9	0.41269841
3	9	0.16666667
4	6	0.26190476
5	9	0.13431013
6	9	0.04963235
7	9	0.06481481
8	9	0.19764957
9	7	0.51948052
10	9	0.64752568

STATION	N	AVEGROW
C	25	0.38454299
F	27	0.24320132
I	24	0.17031086

PERCENT COVER

MEANS

SD	N	PC
~~2~~	~~10~~	~~62.8000000~~
5	9	41.6666667
6	8	44.1250000
7	9	6.6666667
8	9	23.1111111
9	10	22.7000000
10	10	25.7000000
11	2	1.0000000

SHOOT DENSITY
(No./m^2)

MEANS

SD	N	BDEN
~~2~~	~~12~~	~~412.500000~~
3	12	500.000000
4	8	443.750000
5	12	620.833333
6	12	562.500000
7	12	537.500000
8	12	487.500000
9	12	566.666667
10	12	666.666667

STATION	N	BDEN
C	36	715.277778
F	36	443.055556
I	32	440.625000

TABLE 6.3-6

SPECIES OF MACROALGAE COLLECTED
R = RHIZOPHYTIC ALGAE, ALL OTHERS ARE CONSIDERED DRIFT ALGAE

Division Chlorophyta
  Order Ulvales
    Family Ulvaceae

Enteromorpha intestinalis
Enteromorpha compressa
Ulva lactuca

  Order Siphonales
    Family Caulerpaceae

Caulerpa ashmeadii R
Caulerpa prolifera R
Caulerpa paspaloides R
Caulerpa mexicana R

    Family Codiaceae

Codium taylori
Halimeda incrassata R
Penicillus capitatus R
Udotea conglutinata R
Udotea flabellum R

  Order Dasycladales
    Family Dasycladaceae

Acetabularia crenulata R
Bataphora oerstedi R

Division Phaeophyta
  Order Ectocarpales
    Family Ectocarpaceae

Ectocarpus siliculosus
Ectocarpus intermedius
Giffordia mitchelliae

  Order Dictyotales
    Family Dictyotaceae

Padina vickersiae R

  Order Fucales
    Family Sargassaceae

Sargassum filipendula

TABLE 6.3-6 (Cont)

Division Rhodophyta
Order Gelidiales
Family Gelidiaceae

Pterocladia americana

Order Gigartinales
Family Gracilariaceae

Gracilaria debilis
Gracilaria foliifera var. _angustissima_ (= _G. tikvahiae_)
Gracilaria verrucosa
Gracilaria sjoestedtii

Family Solieriaceae

Agardhiella tenera

Family Hypneaceae

Hypnea musciformis
Hypnea cervicornis

Order Rhodymeniales
Family Champiaceae

Champia parvula
Lomentaria baileyana

Order Ceramiales
Family Ceramiaceae

Centroceras clavulatum
Centroceras unidentified species
Ceramium fastigiatum
Spyridia filamentosa

Family Rhodomelaceae

Acanthophora spicifera
Chondria cnicophylla
Chondria sedifolia
Chondria tenuissima
Digenia simplex
Laurencia intricata
Laurencia obtusa
Laurencia poitei
Polysiphonia subtilissima
Polysiphonia ramentacea

TABLE 6.3-6 (Cont)

Family Dasyaceae

Dasya pedicellata
Dasya ramosissima

TABLE 6.3-7

RHIZOPHYTIC ALGAL DIVERSITY (NUMBER OF SPECIES)
AT THE INTENSIVE MONITORING STATIONS

STATION	AUG. 1983	SEPT. 1983	OCT. 1983	DEC. 1983	JAN. 1984	MAR. 1984	APR. 1984	MAY 1984	JULY 1984	AUG. 1984
A (40)	1	3	2	1	0	0	0	0	1	1
B & C (47)	5	3	4	4	2	5	3	3	4	3
D (27)	0	0	0	0	0	0	0	0	0	0
E & F (33)	1	1	1	1	1	1	2	1	1	0
G (3)	0	0	0	0	0	0	0	1	0	0
H (9)	0	1	1	1	0	0	1	1	1	0
I (4)	0	0	1	0	0	1	1	1	0	2

A-I Intensive Monitoring Station

(40) Corresponding Ground-truthing Station

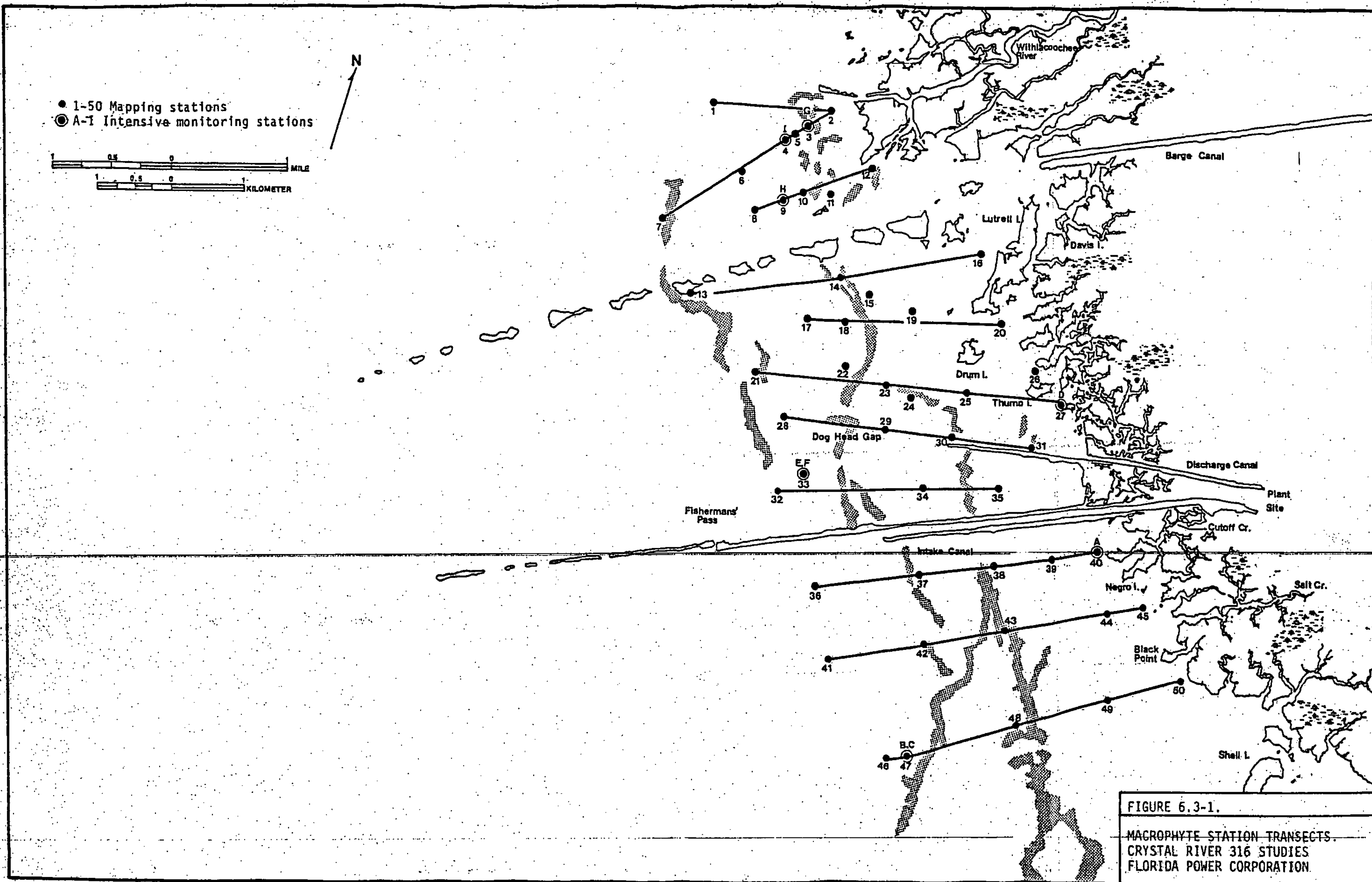


FIGURE 6.3-1.

MACROPHYTE STATION TRANSECTS.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

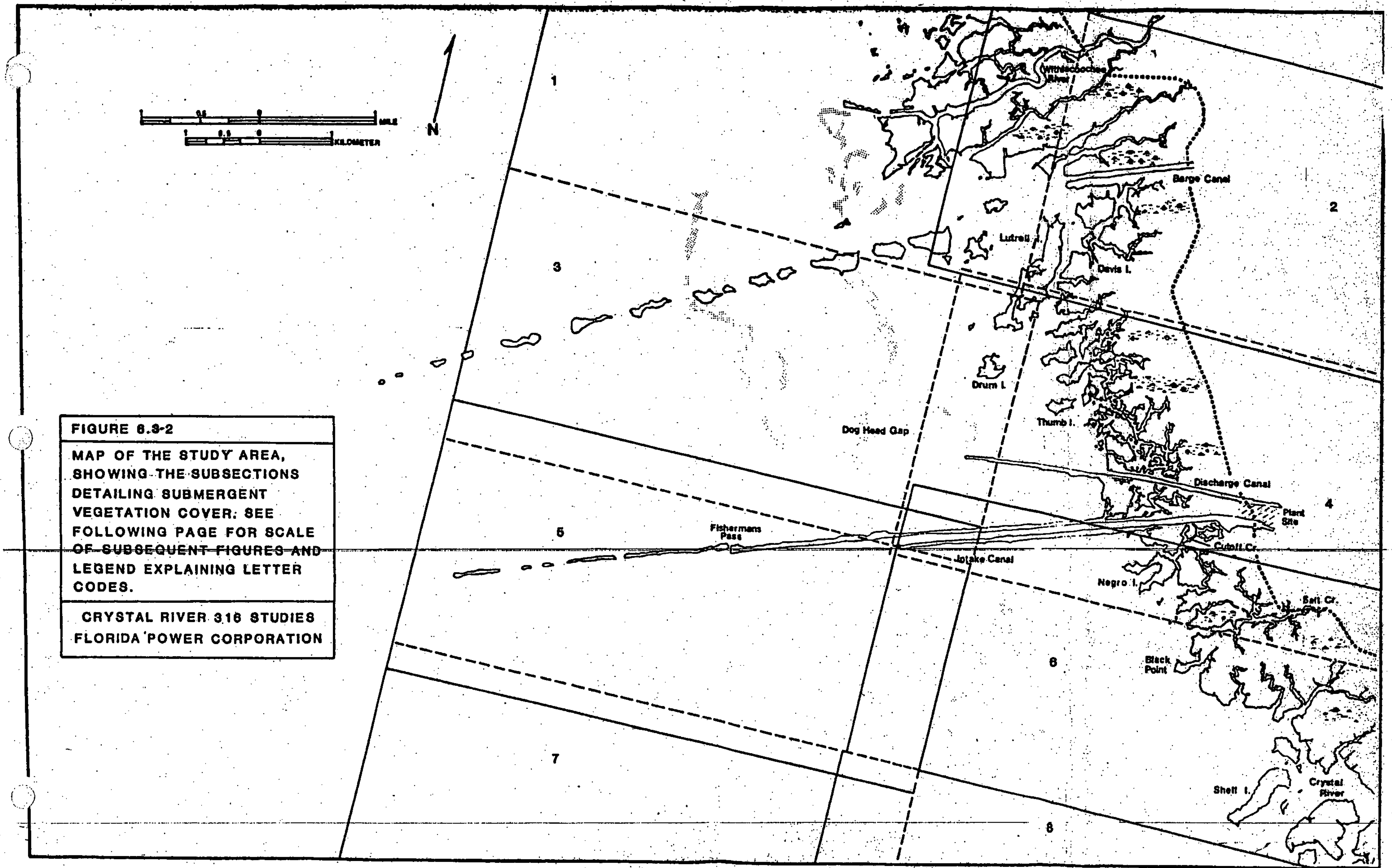


FIGURE 6.3-2

MAP OF THE STUDY AREA, SHOWING THE SUBSECTIONS DETAILING SUBMERGENT VEGETATION COVER: SEE FOLLOWING PAGE FOR SCALE OF SUBSEQUENT FIGURES AND LEGEND EXPLAINING LETTER CODES.

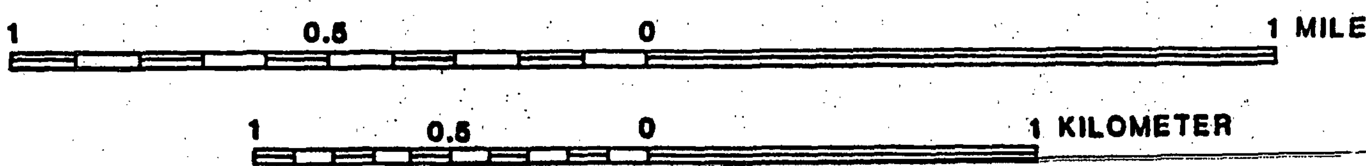
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

CRYSTAL RIVER 316 STUDIES

MACROPHYTE MAPPING

SUBMERGENT VEGETATION

ALL SUBSEQUENT FIGURES TO SCALE INDICATED BELOW:



SCALE 1:18 000

SOURCE: COLOR INFRARED VERTICAL AERIAL PHOTOGRAPHY 26 OCT 83
22 NOV 83

COMMUNITY DESIGNATION

S · SEAGRASS
A · ALGAE
O · UNVEGETATED
SA · SEAGRASS AND ALGAE (SEAGRASS DOMINANT)
AS · ALGAE AND SEAGRASS (ALGAE DOMINANT)

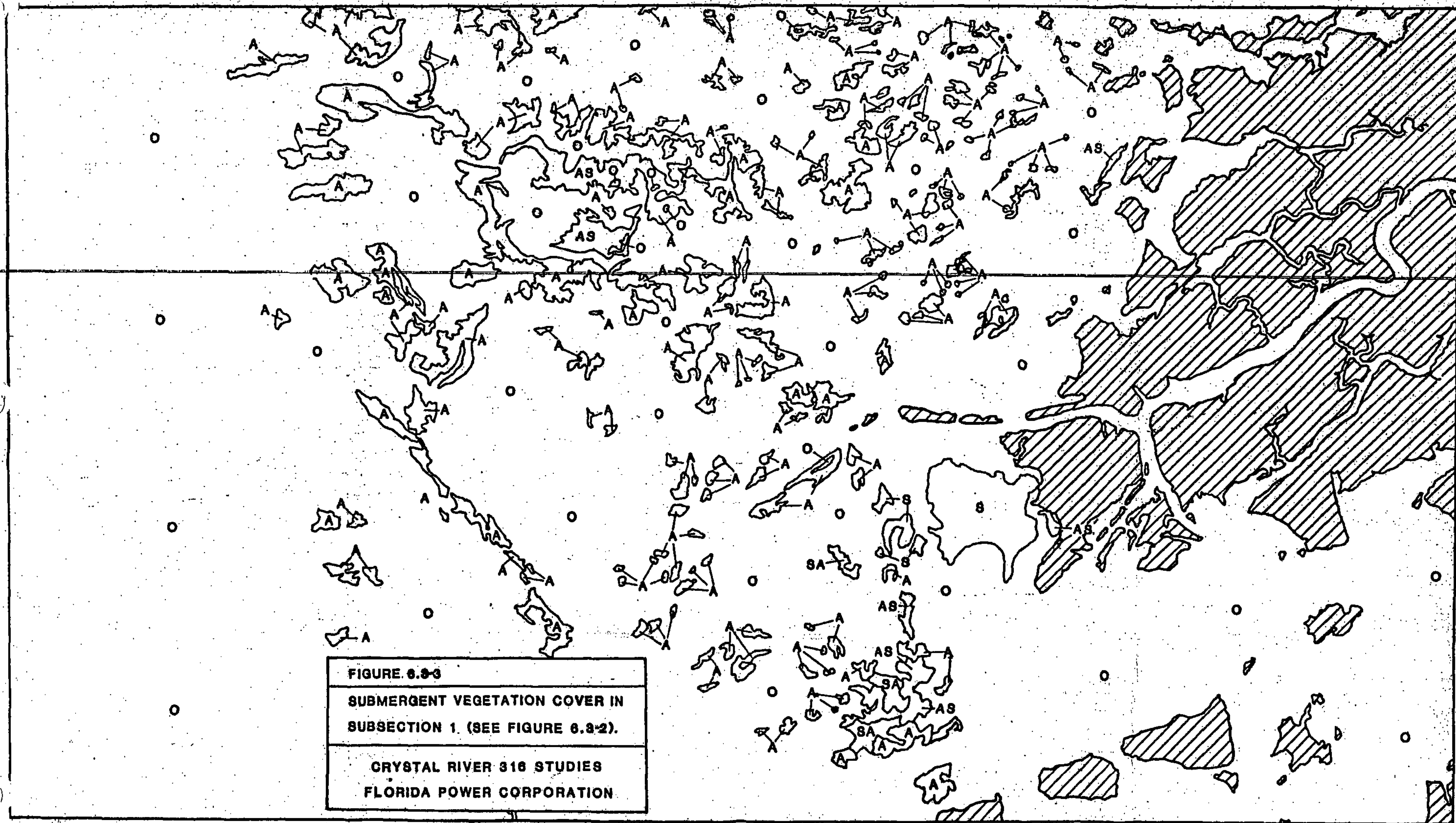


FIGURE 6.3-3

SUBMERGENT VEGETATION COVER IN SUBSECTION 1. (SEE FIGURE 6.3-2).

CRYSTAL RIVER 316 STUDIES

FLORIDA POWER CORPORATION

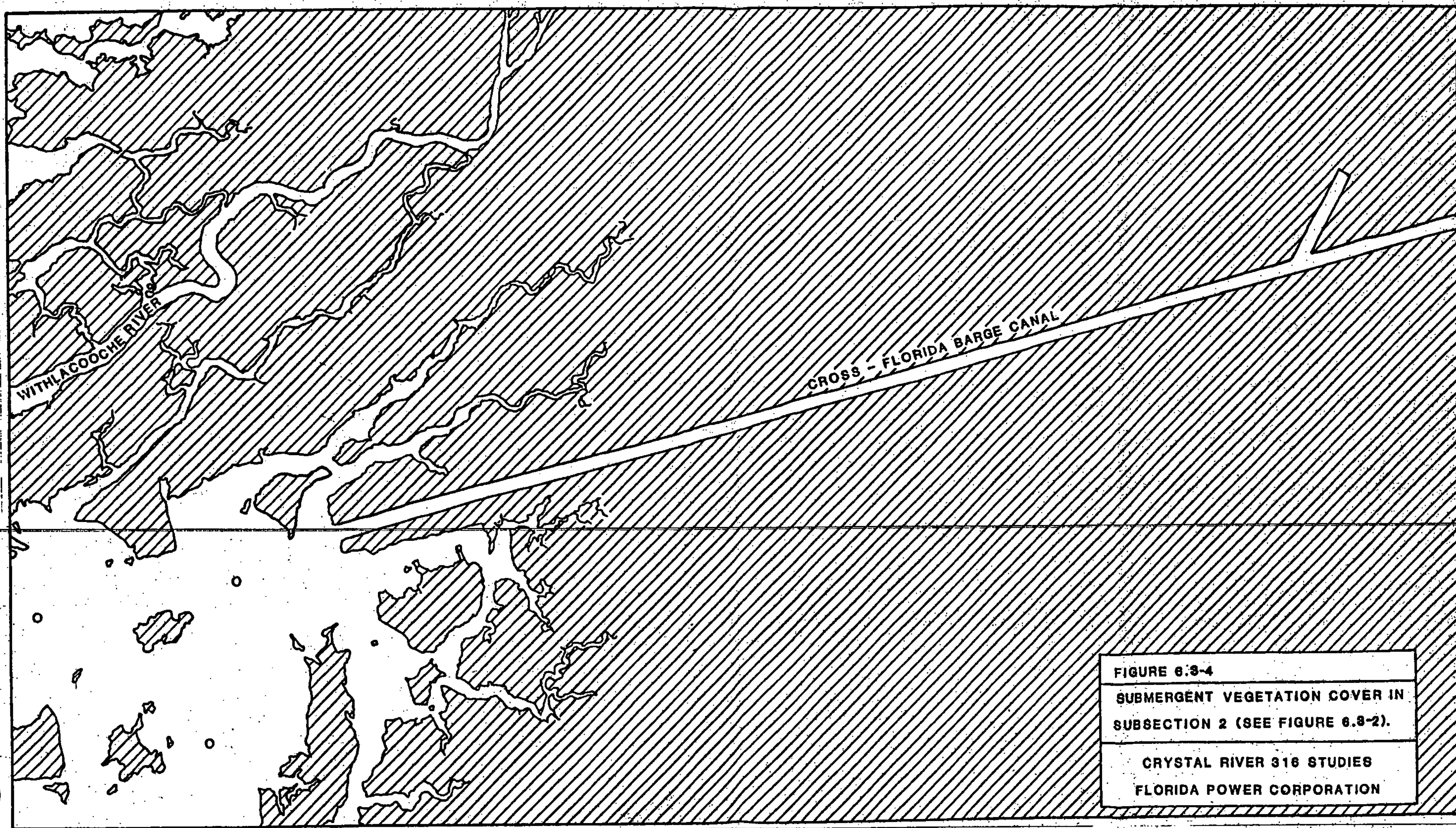


FIGURE 6.3-4
SUBMERGENT VEGETATION COVER IN SUBSECTION 2 (SEE FIGURE 6.3-2).

CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

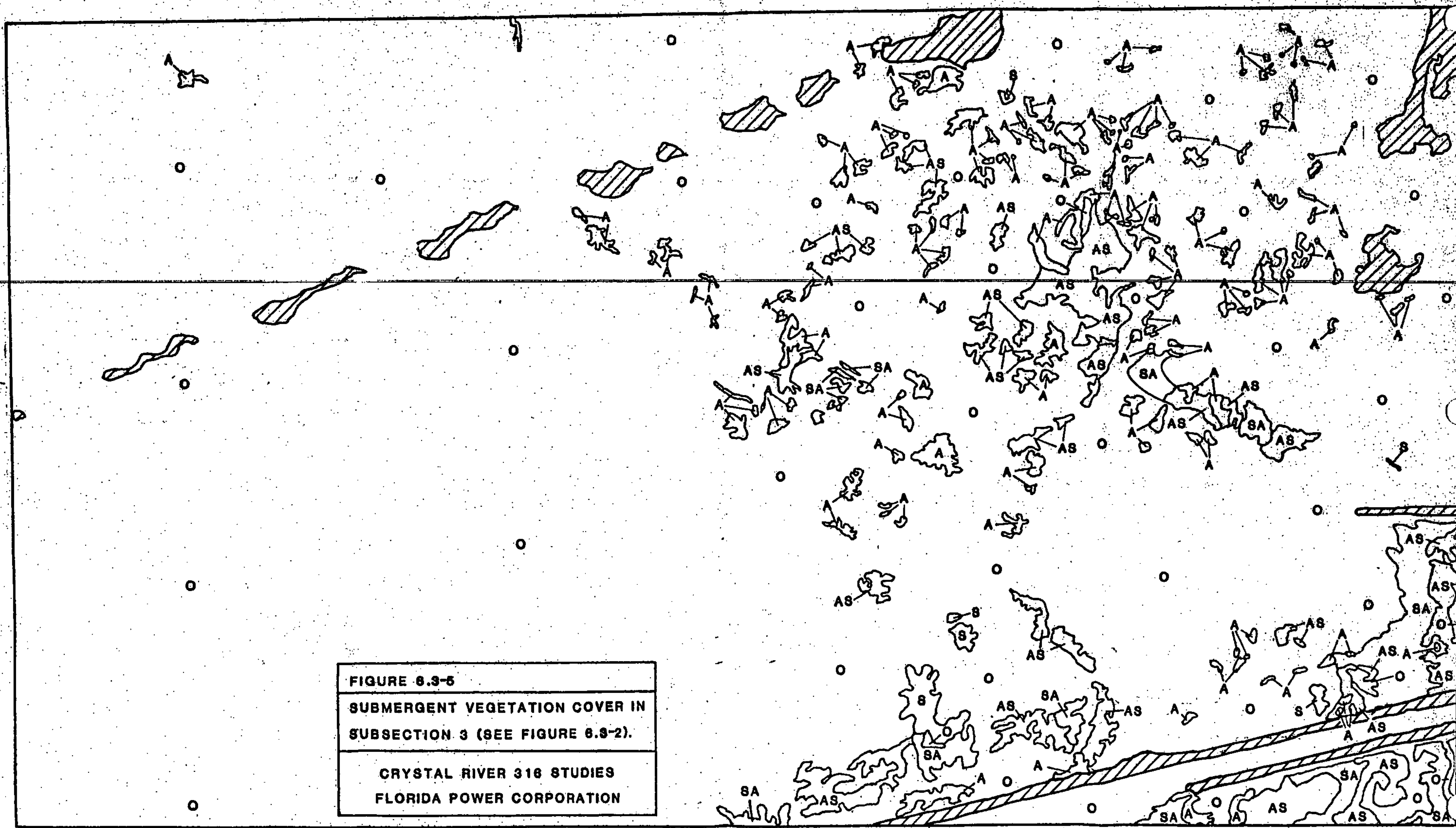


FIGURE 6.3-5

SUBMERGENT VEGETATION COVER IN SUBSECTION 3 (SEE FIGURE 6.3-2).

CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

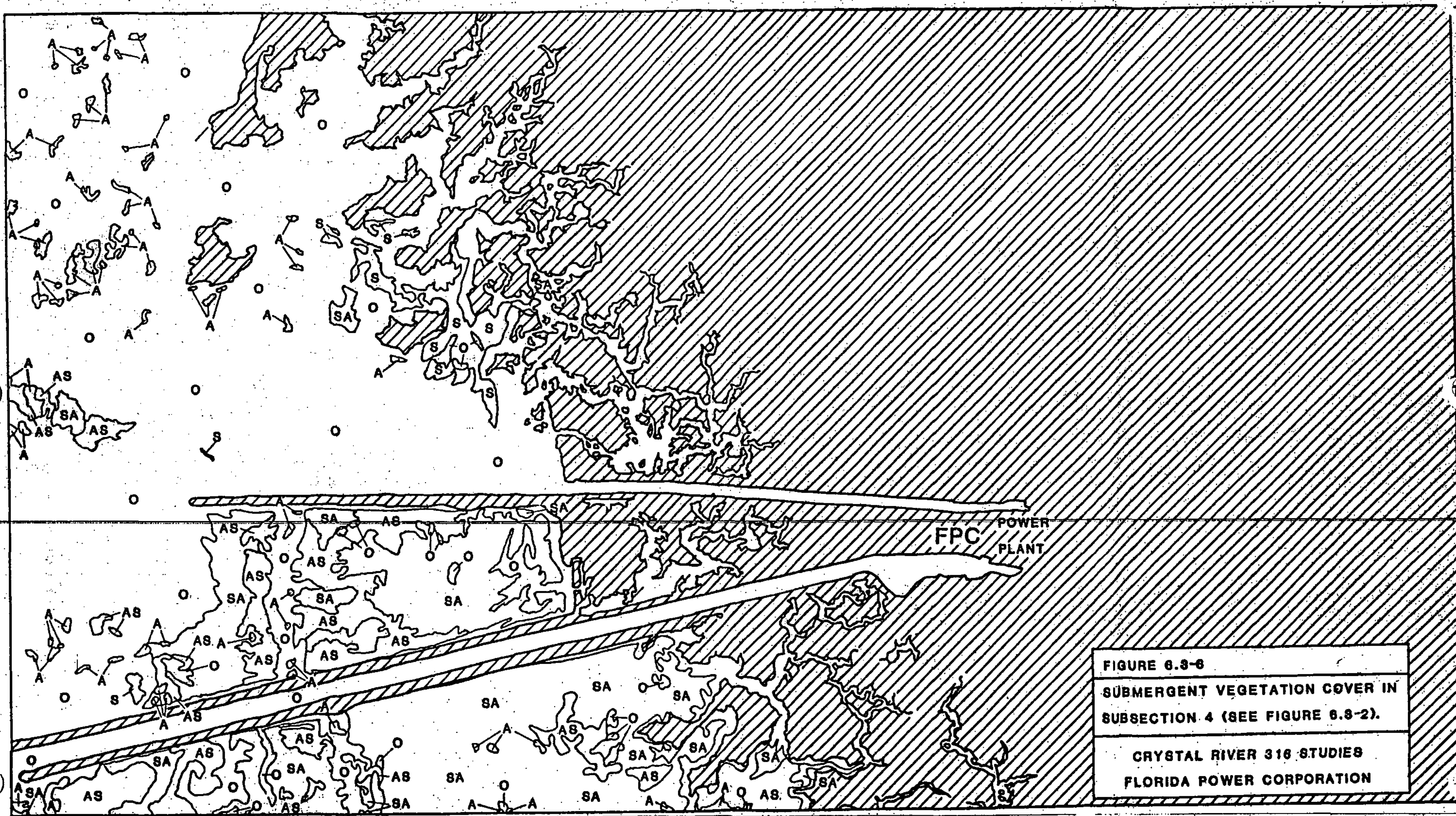


FIGURE 6.3-6

SUBMERGENT VEGETATION COVER IN SUBSECTION 4 (SEE FIGURE 6.3-2).

CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

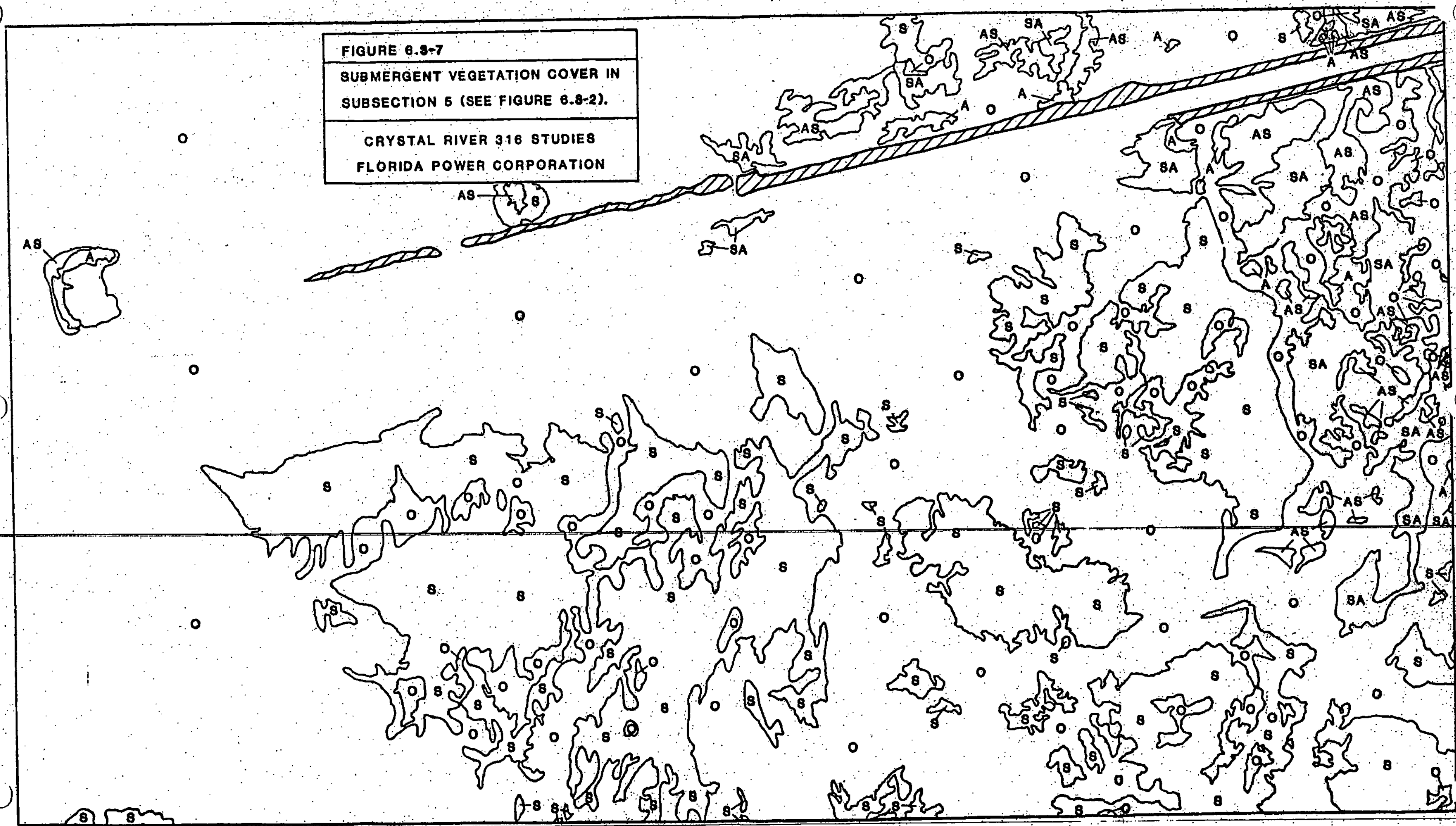


FIGURE 6.8-7
SUBMERGENT VEGETATION COVER IN SUBSECTION 5 (SEE FIGURE 6.8-2).

CRYSTAL RIVER 316 STUDIES
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FIGURE 6.3-8

SUBMERGENT VEGETATION COVER IN SUBSECTION 6 (SEE FIGURE 6.3-2).

CRYSTAL RIVER 316 STUDIES

FLORIDA POWER CORPORATION

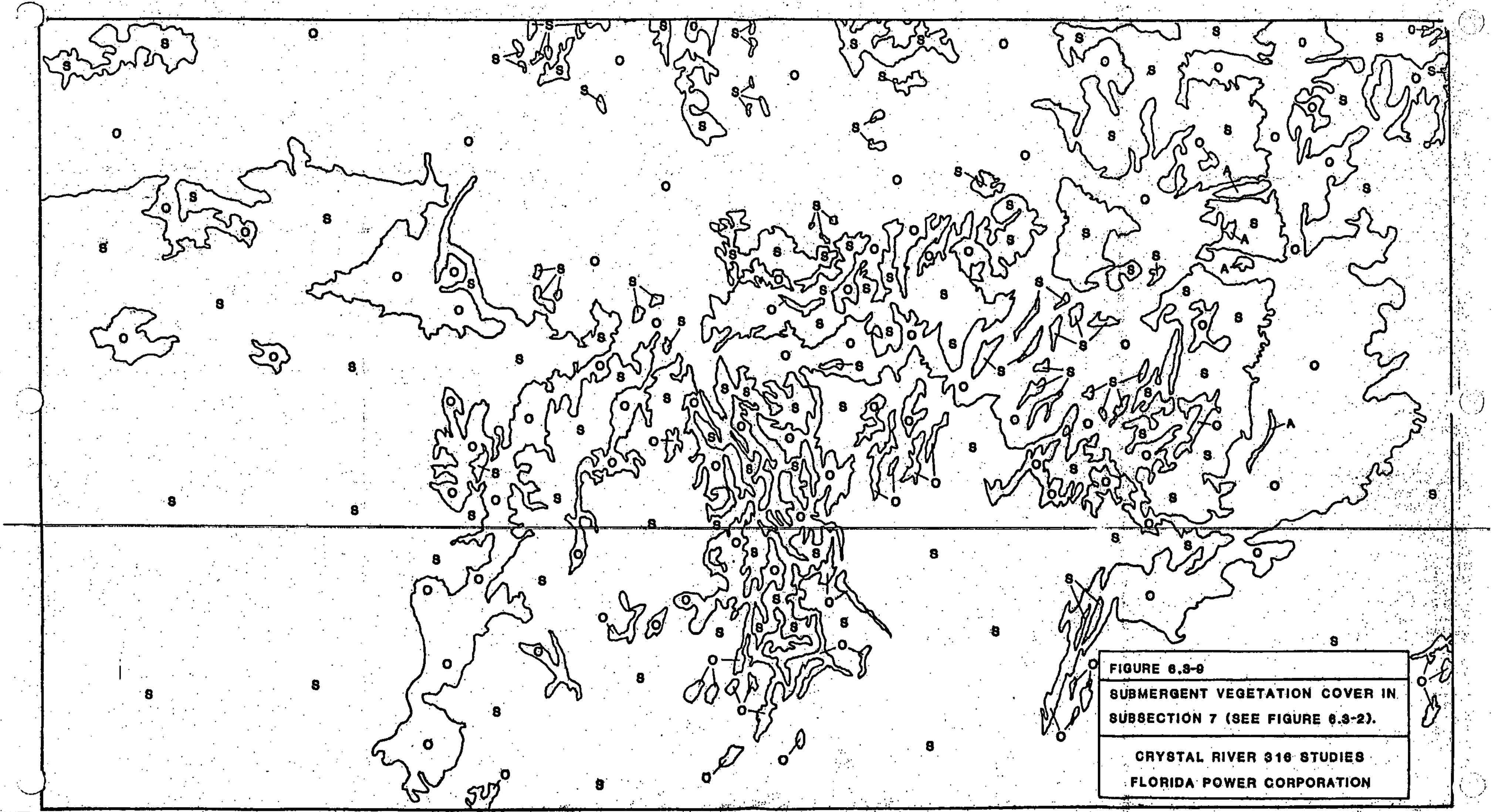

FIGURE 6.3-9

SUBMERGENT VEGETATION COVER IN SUBSECTION 7 (SEE FIGURE 6.3-2).

CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

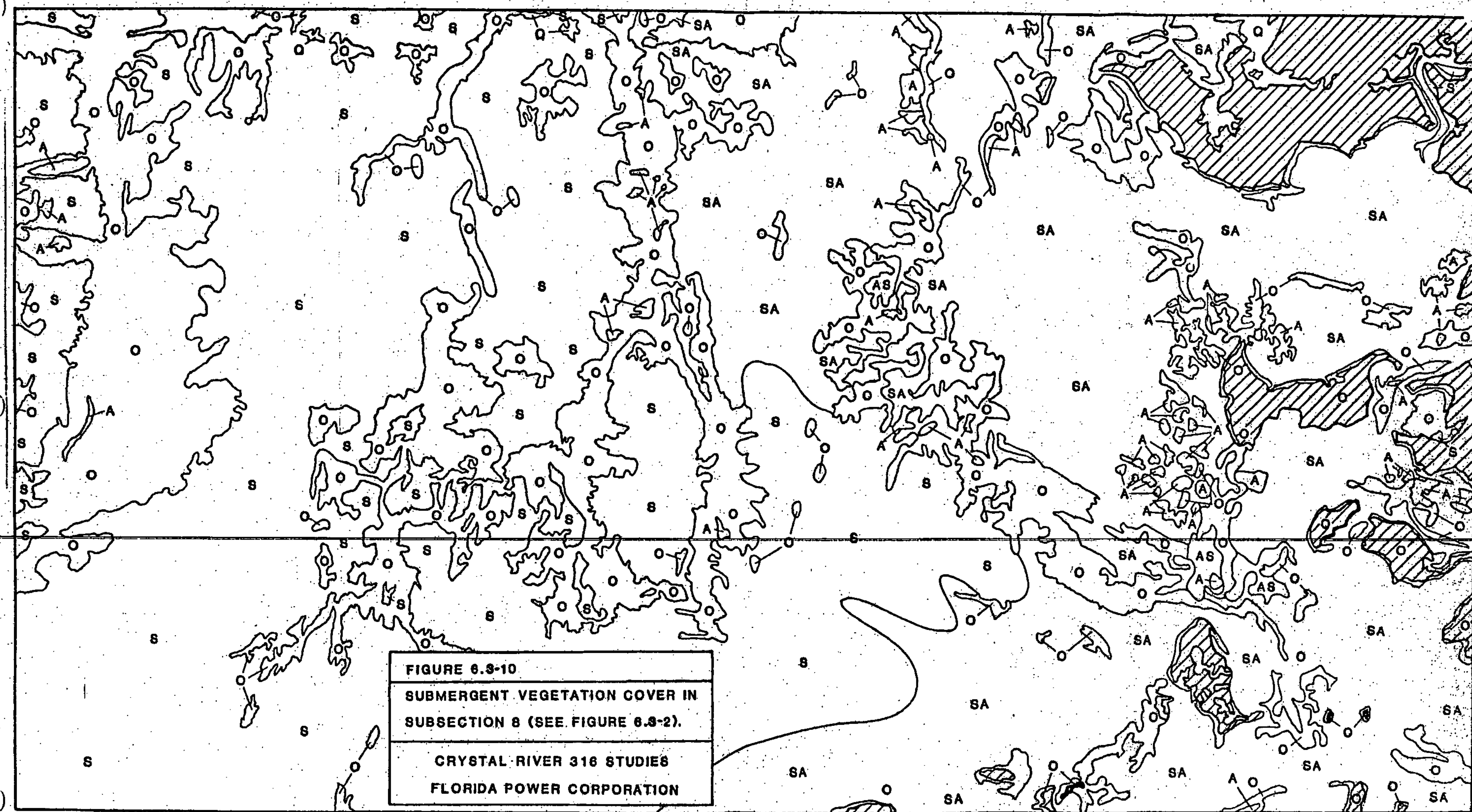

FIGURE 6.3-10

SUBMERGENT VEGETATION COVER IN SUBSECTION 8 (SEE FIGURE 6.3-2).

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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 microenviromental 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 microenviroments 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.

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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 $\pm$ 3.5	34.3 $\pm$ 1.9	28
Nights	22.8 $\pm$ 1.4	32.9 $\pm$ 1.7	28
All times	25.0 $\pm$ 4.9	23.6 $\pm$ 1.9	56

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

A. Spartina

Quarter	Littorina Density, No./m^2 at Station							
	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

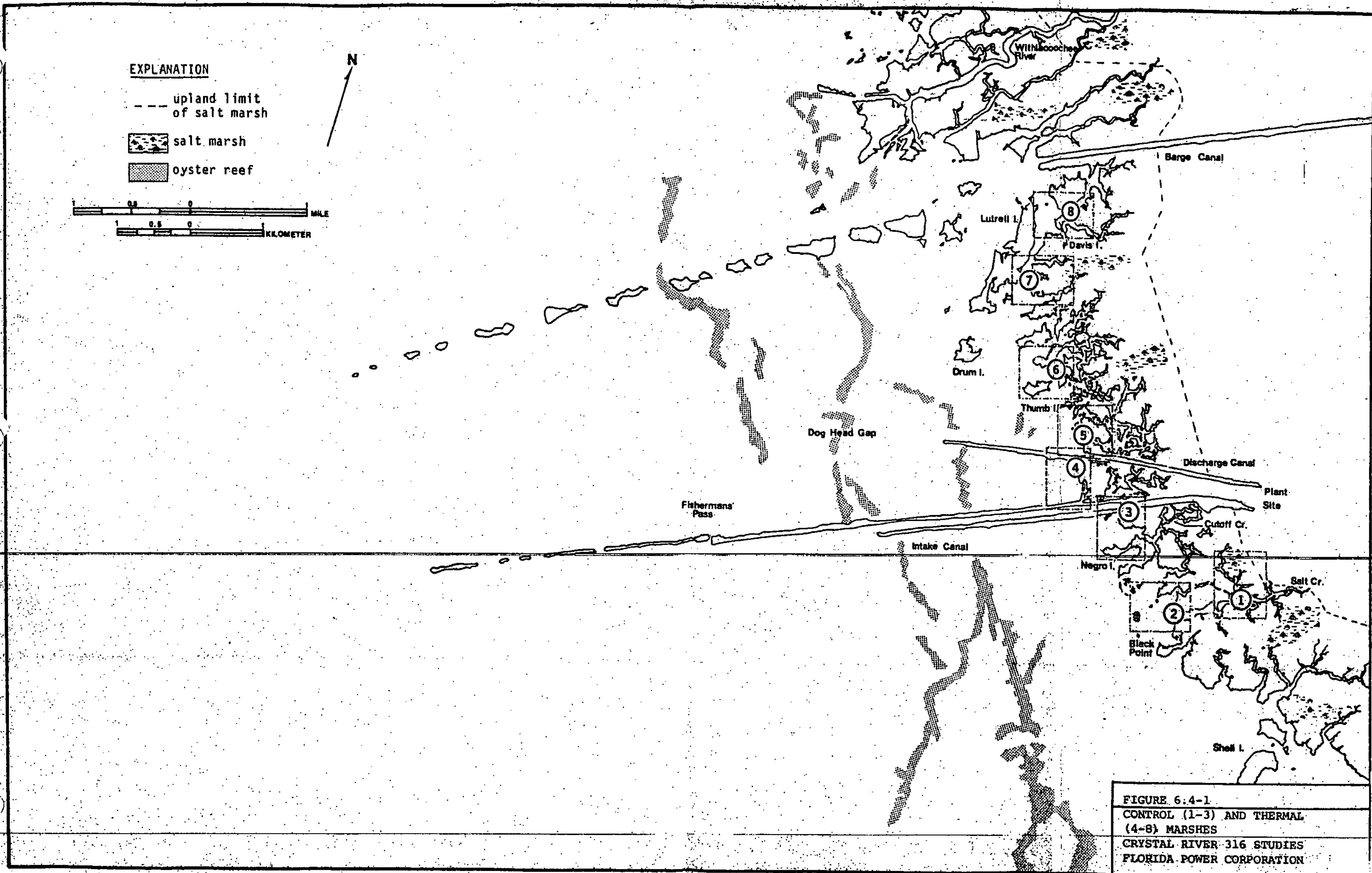


FIGURE 6.4-1
CONTROL (1-3) AND THERMAL (4-8) MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

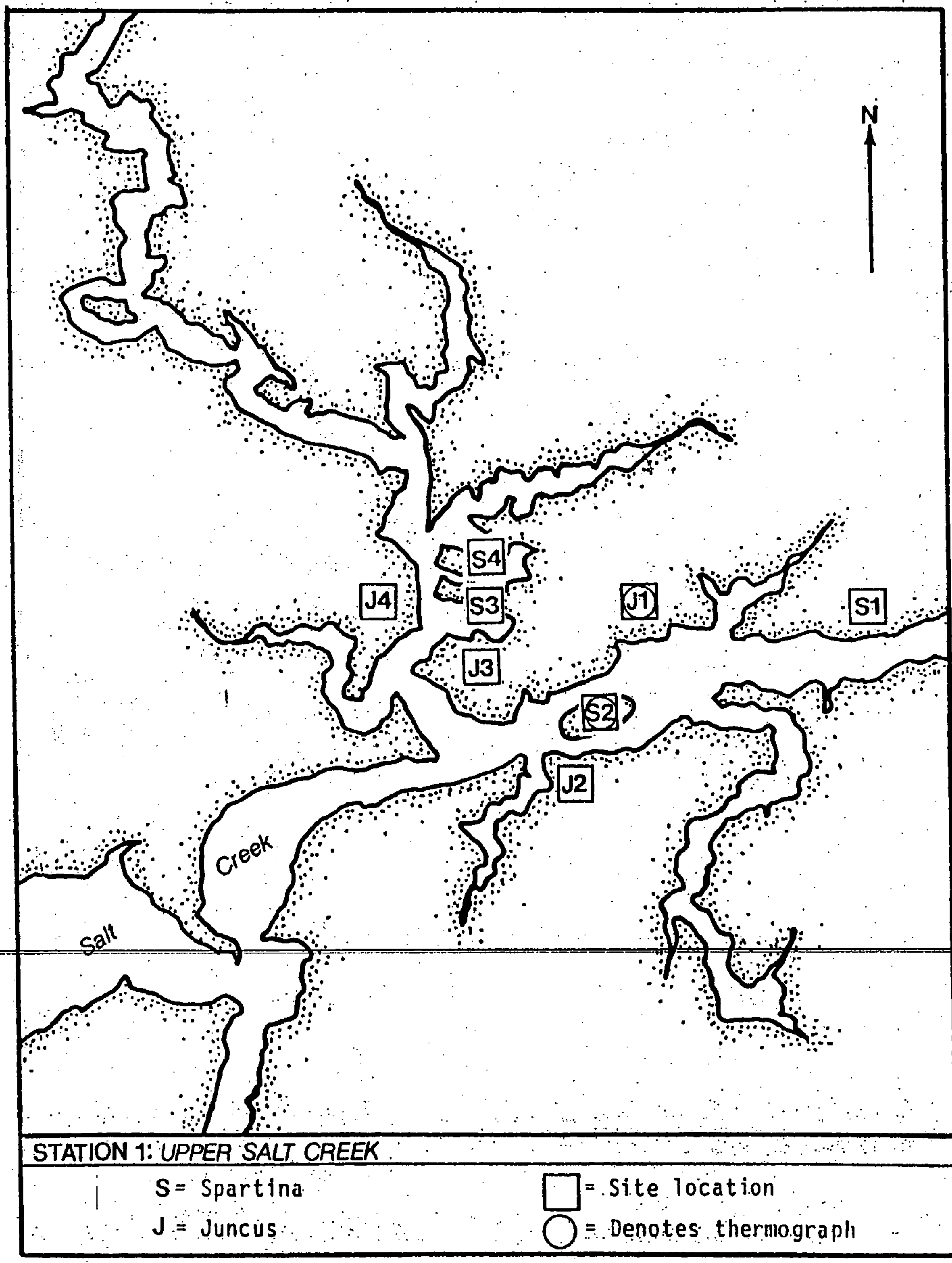


FIGURE 6.4-2
STATION 1
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

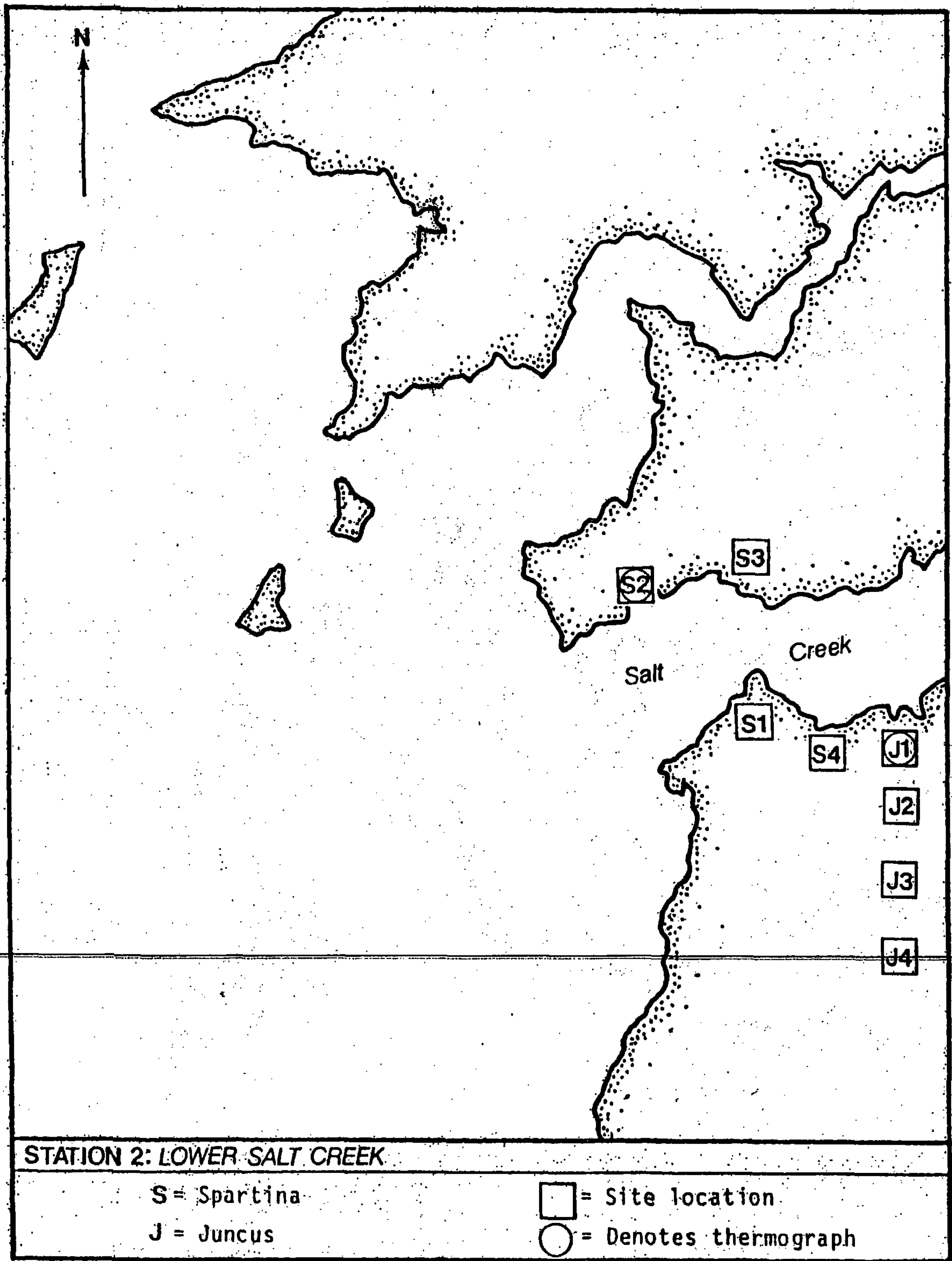


FIGURE 6.4-3
STATION 2
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

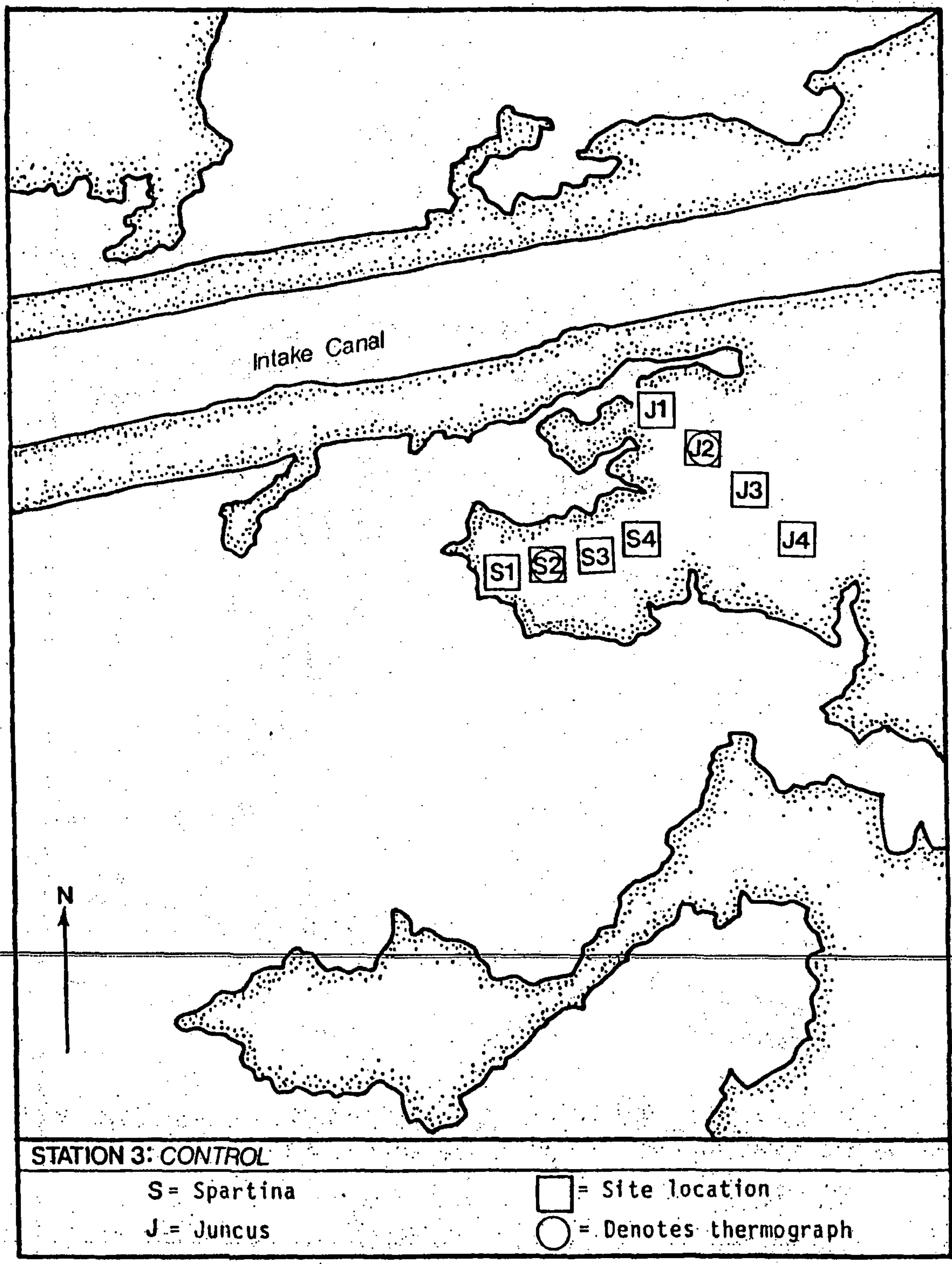


FIGURE 6.4-4
STATION 3
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

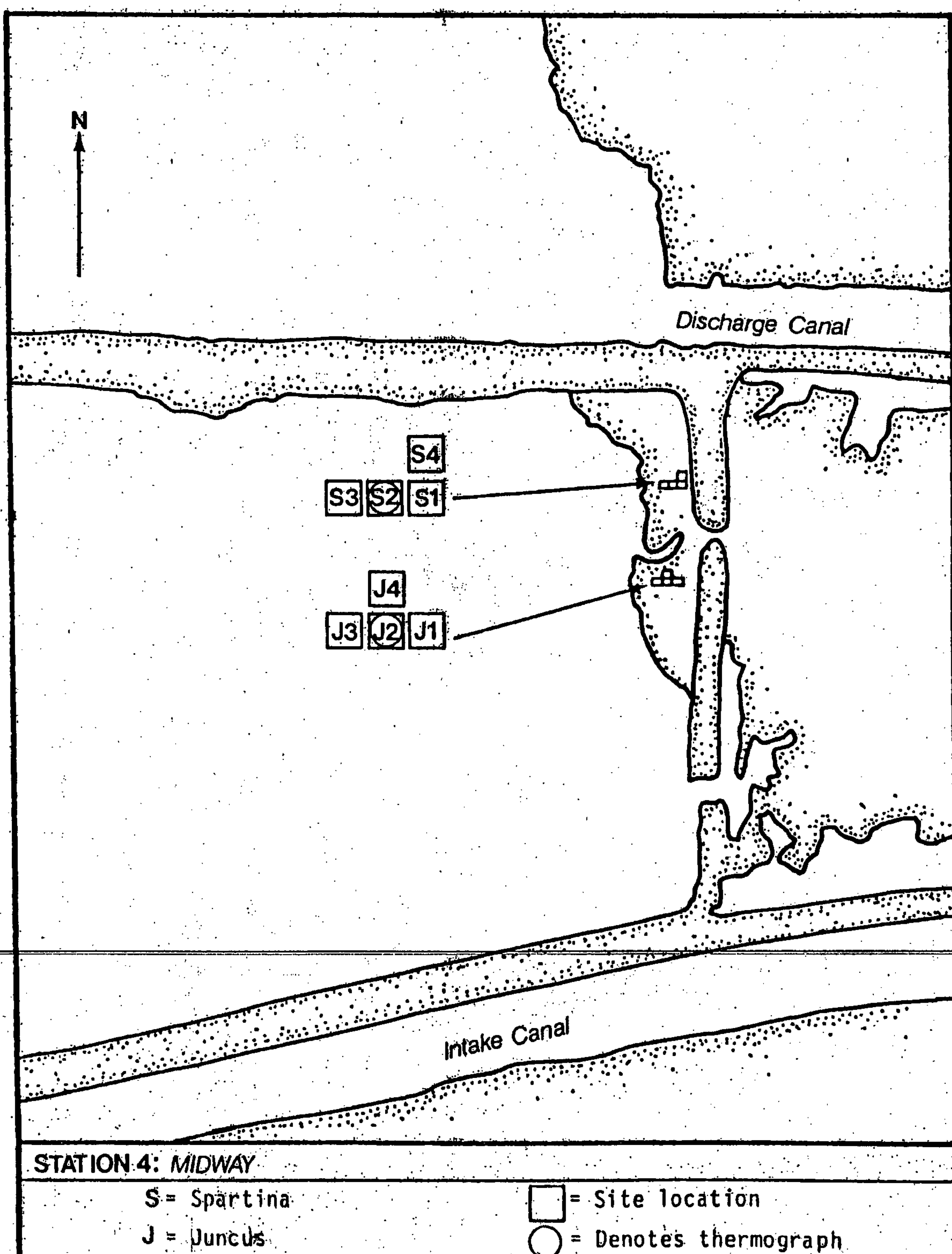
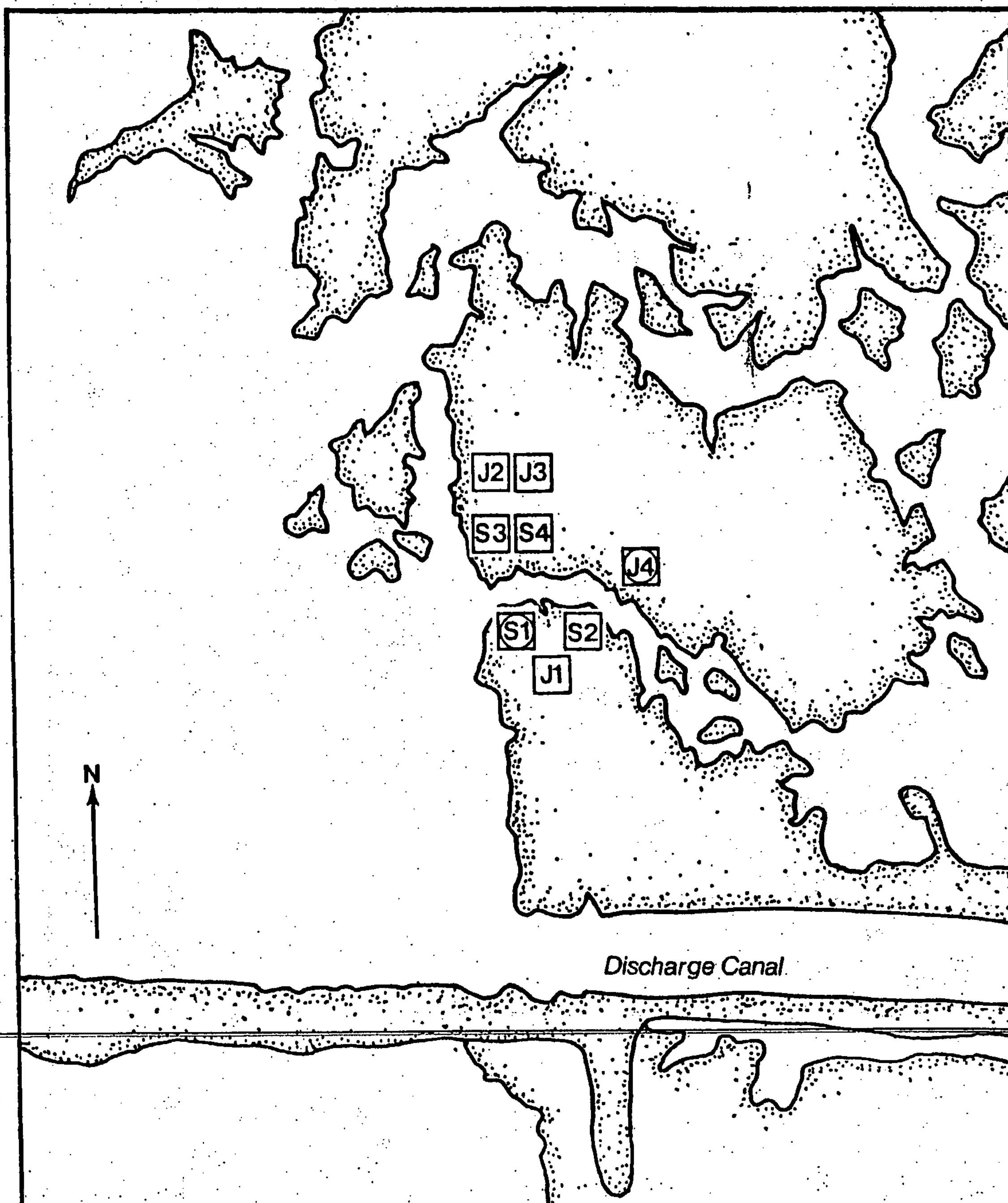


FIGURE 6.4-5

STATION 4
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION 5: *THERMAL*

S = Spartina

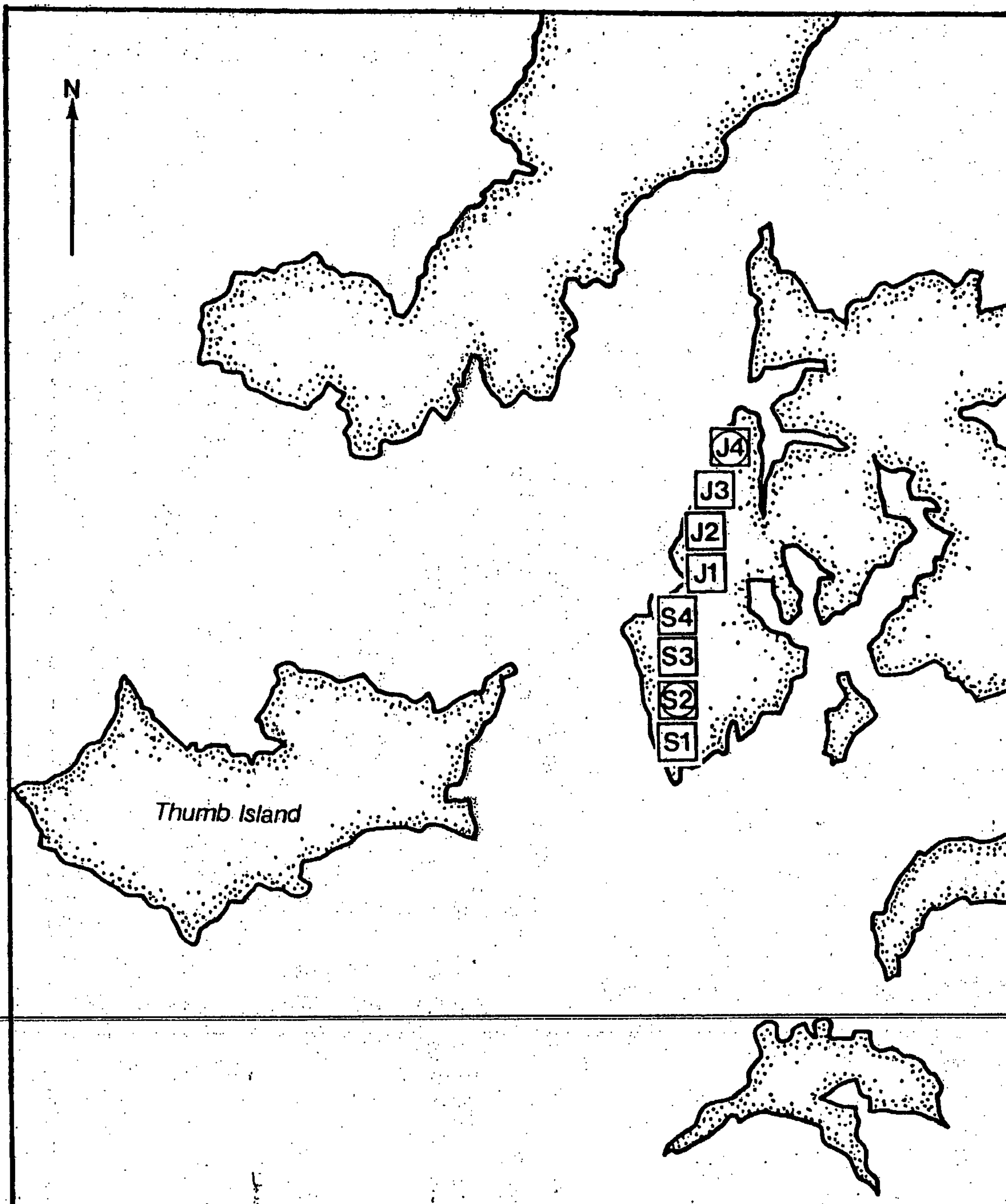
J = Juncus

□ = Site location

○ = Denotes thermograph

FIGURE 6.4-6

STATION 5
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION 6: *THUMB ISLAND*

S = Spartina

J = Juncus

☐ = Site location

◯ = Denotes thermograph

FIGURE 6.4-7

STATION 6
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

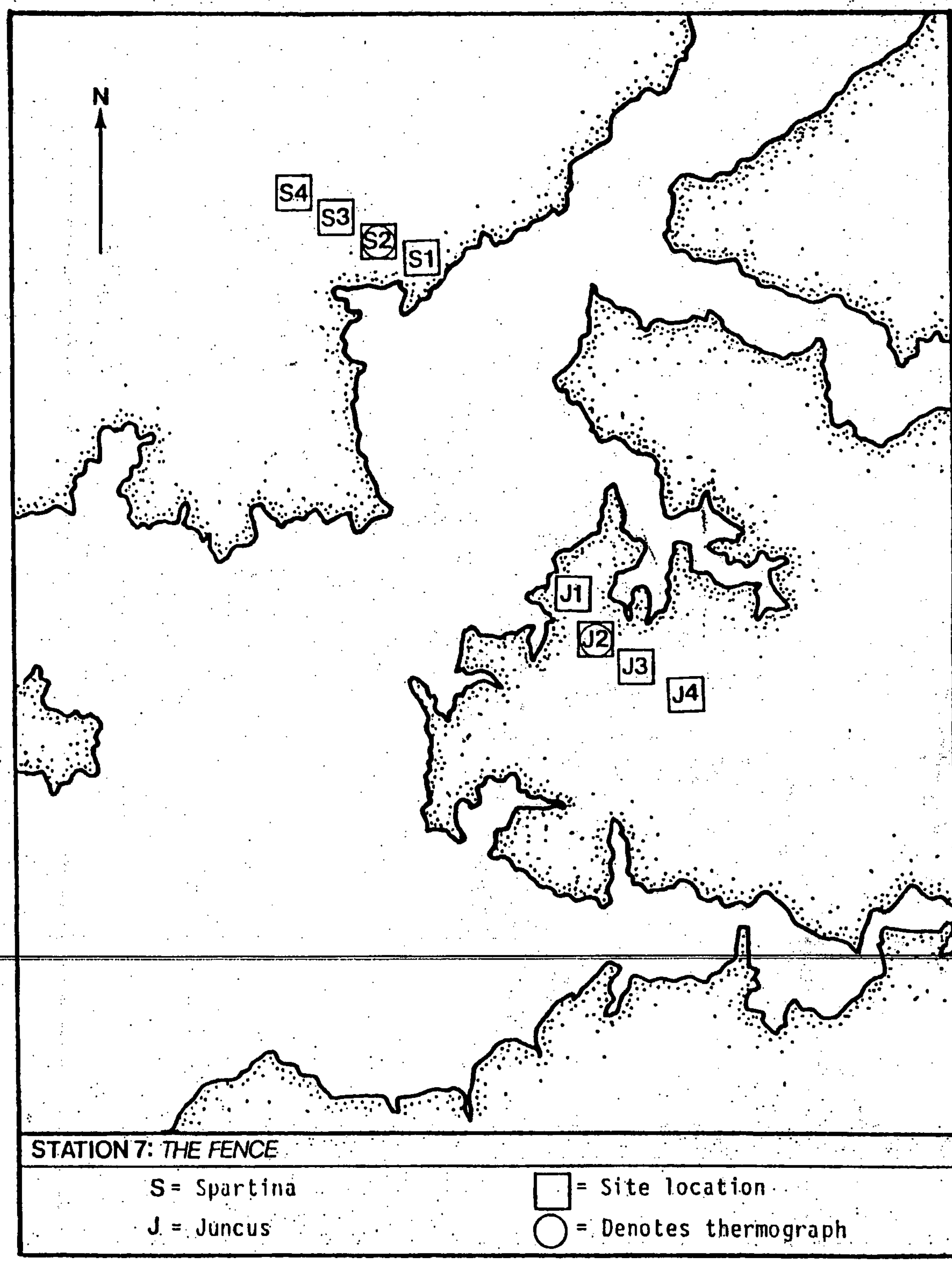


FIGURE 6.4-8

STATION 7
MARSH SITES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

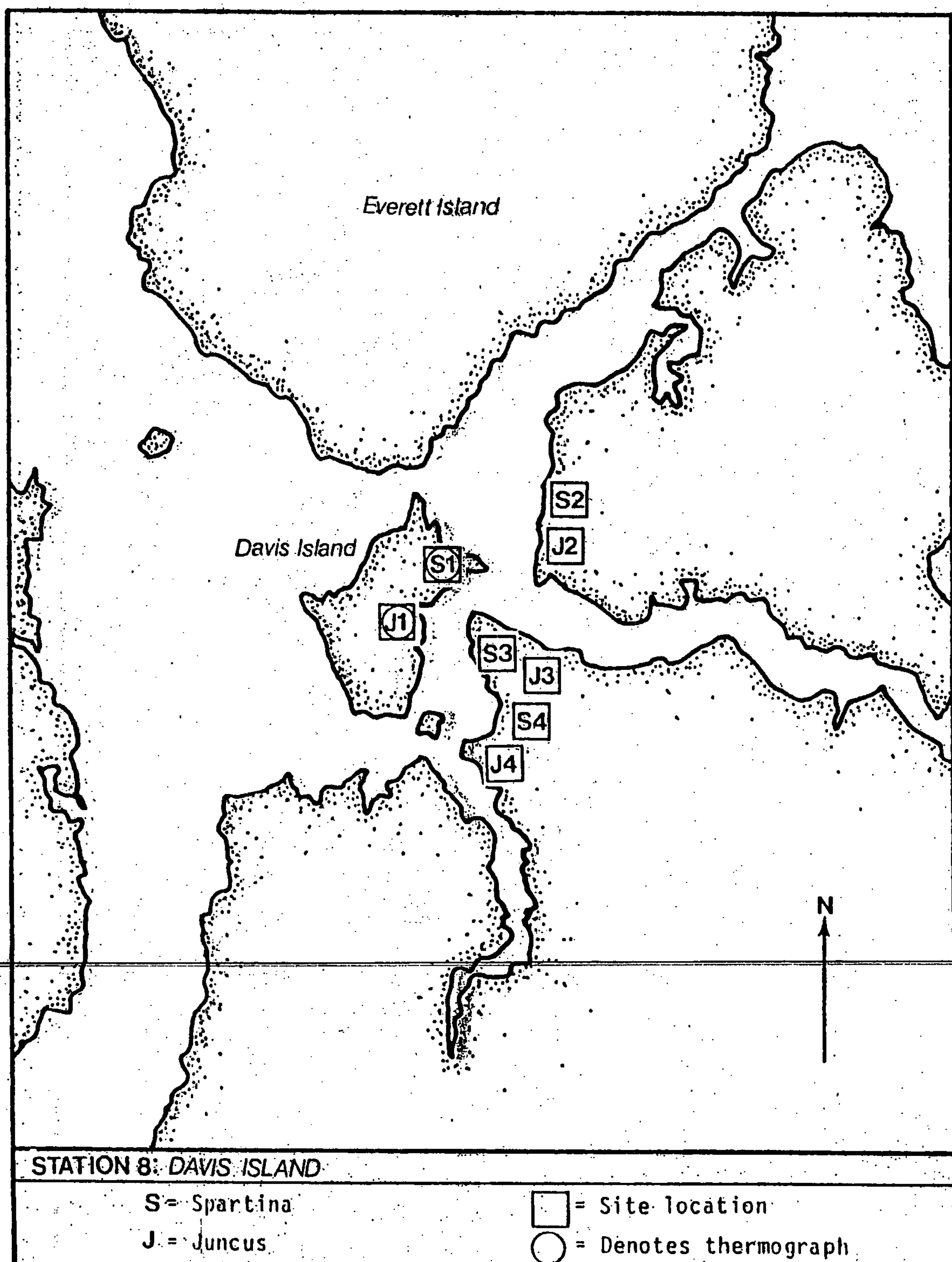


FIGURE 6.4-9

STATION 8
MARSH SITES

CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

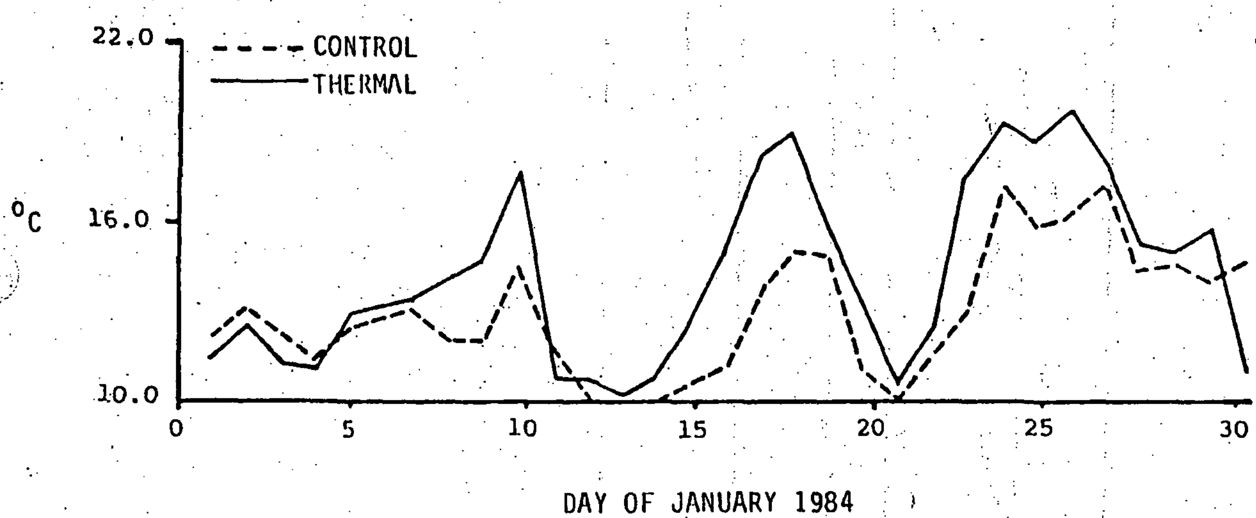
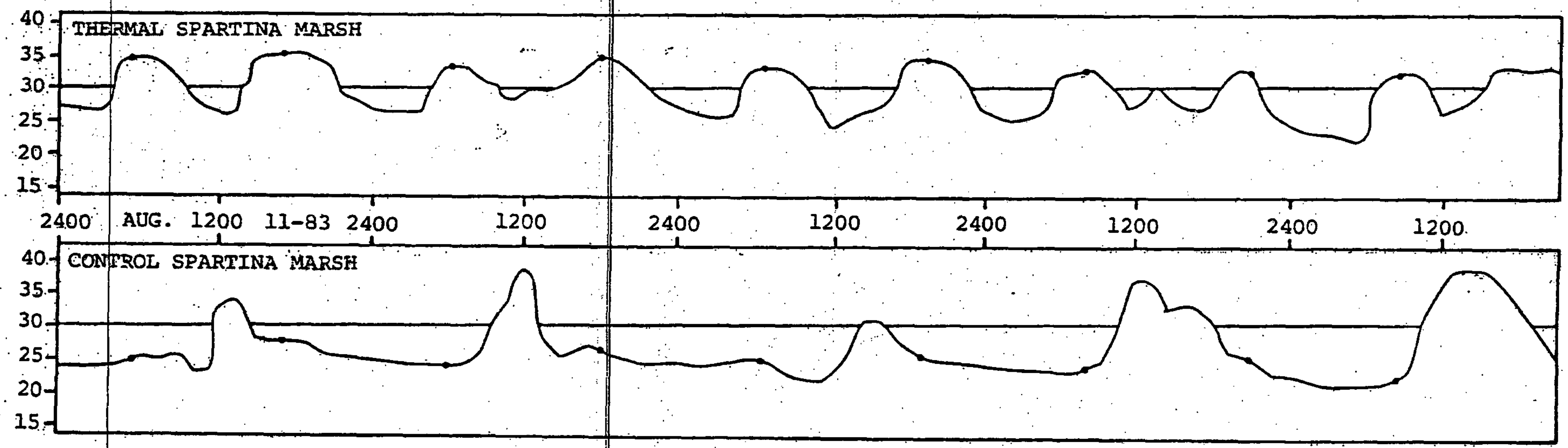


FIGURE 6.4-10

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

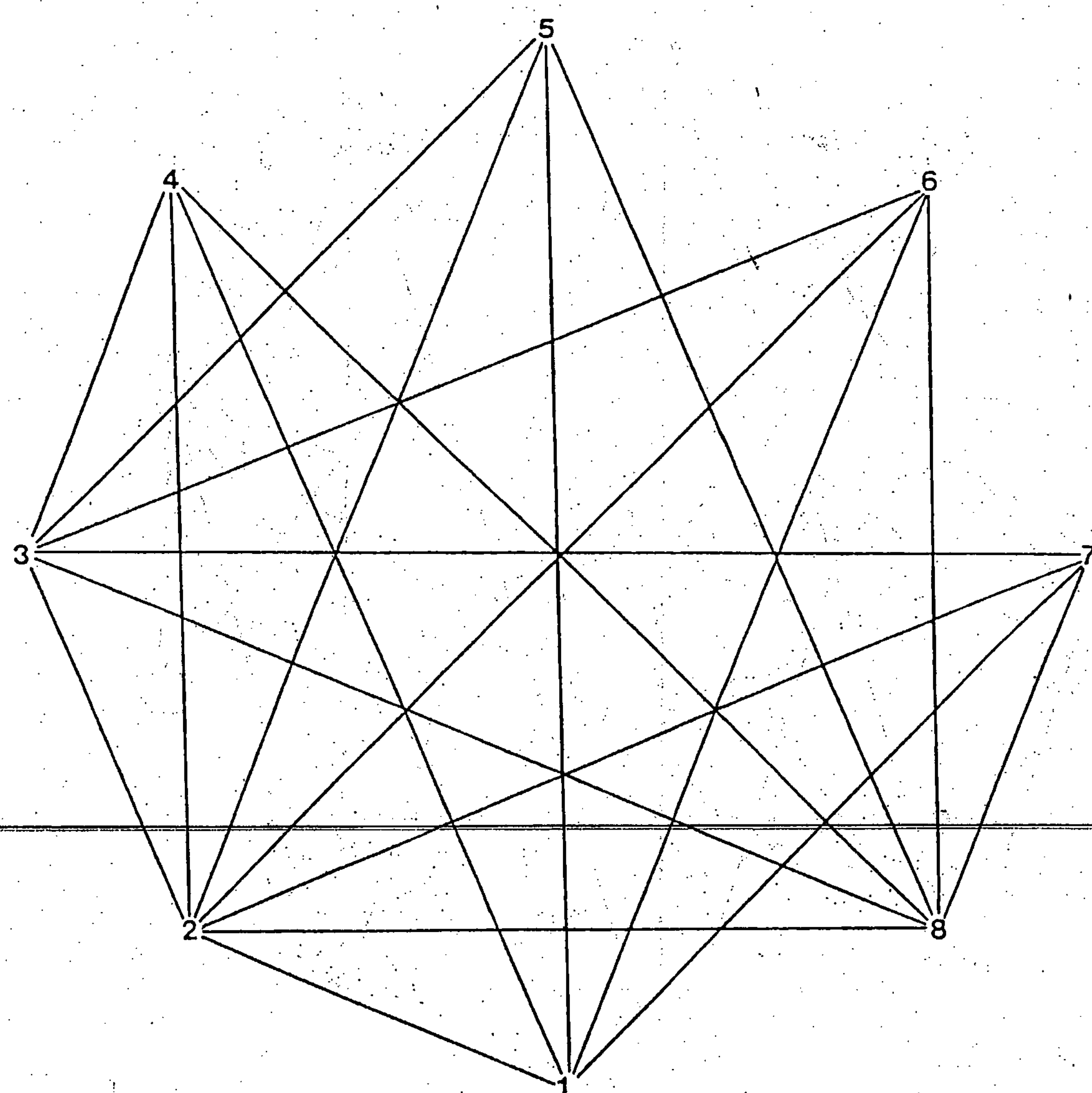


NOTE:

Closed circuits indicate times of slack high tide.

FIGURE 6.4-11

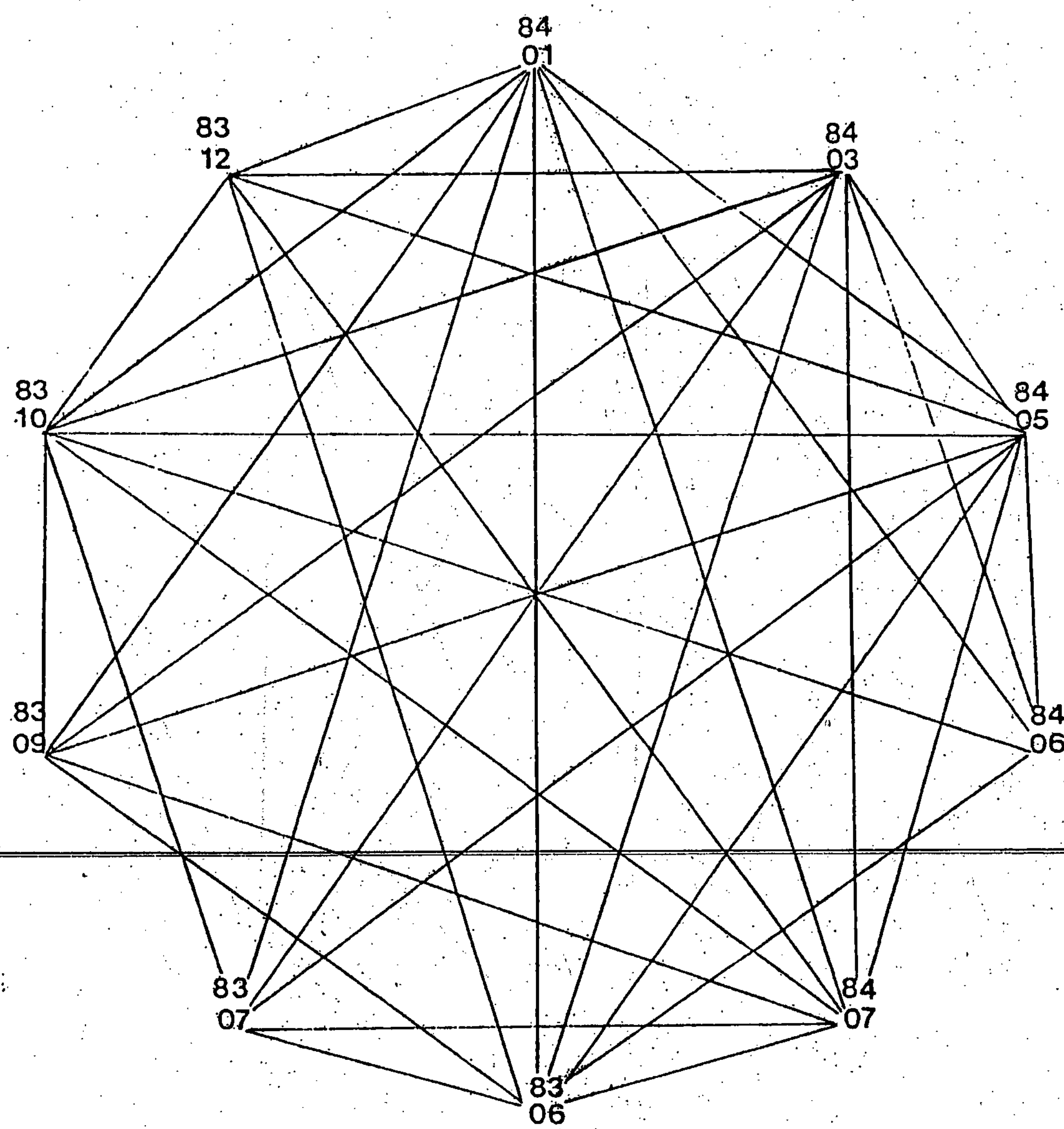
CONTROL AND THERMAL MARSH TEMPERATURES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



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

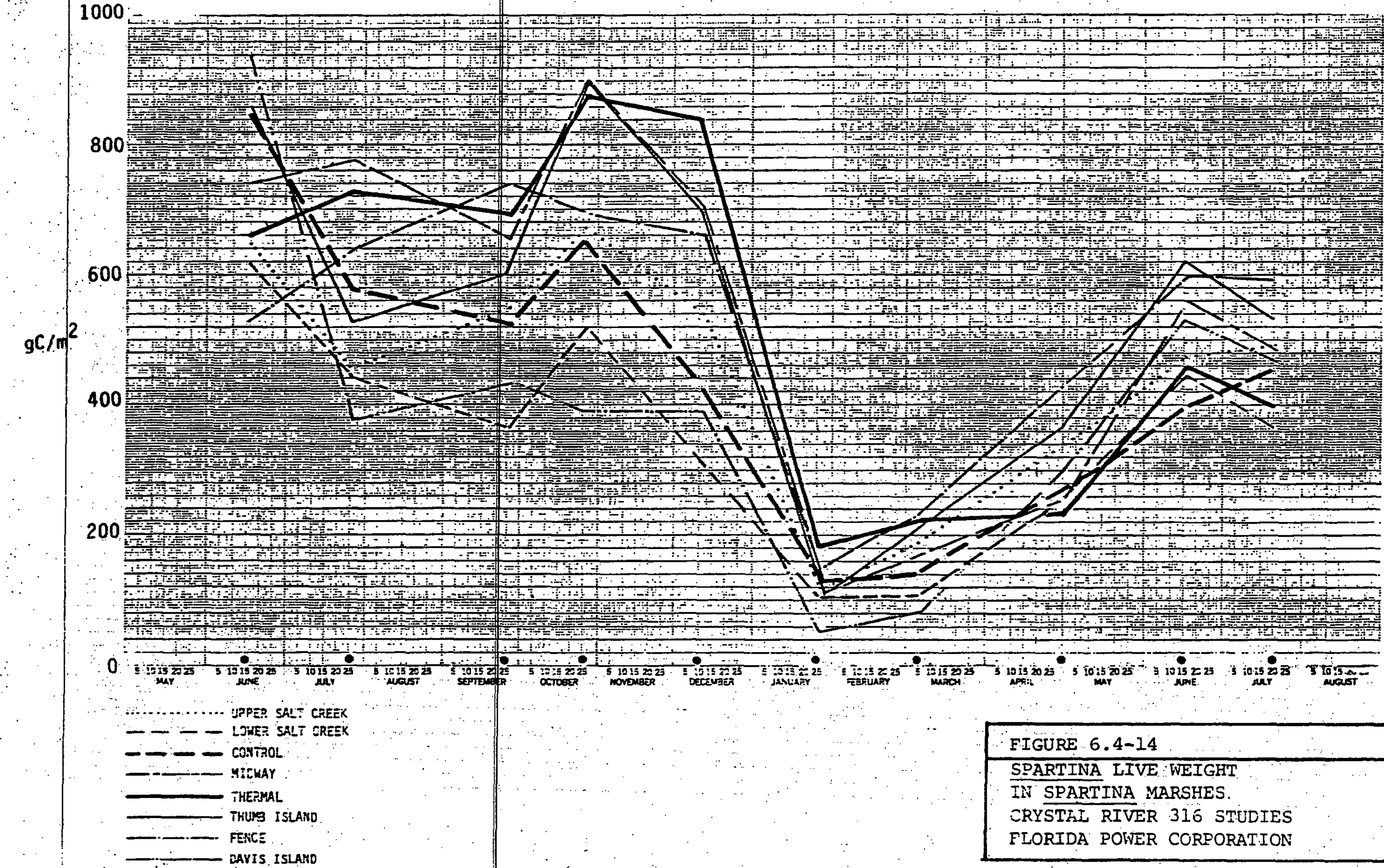


FIGURE 6.4-14

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

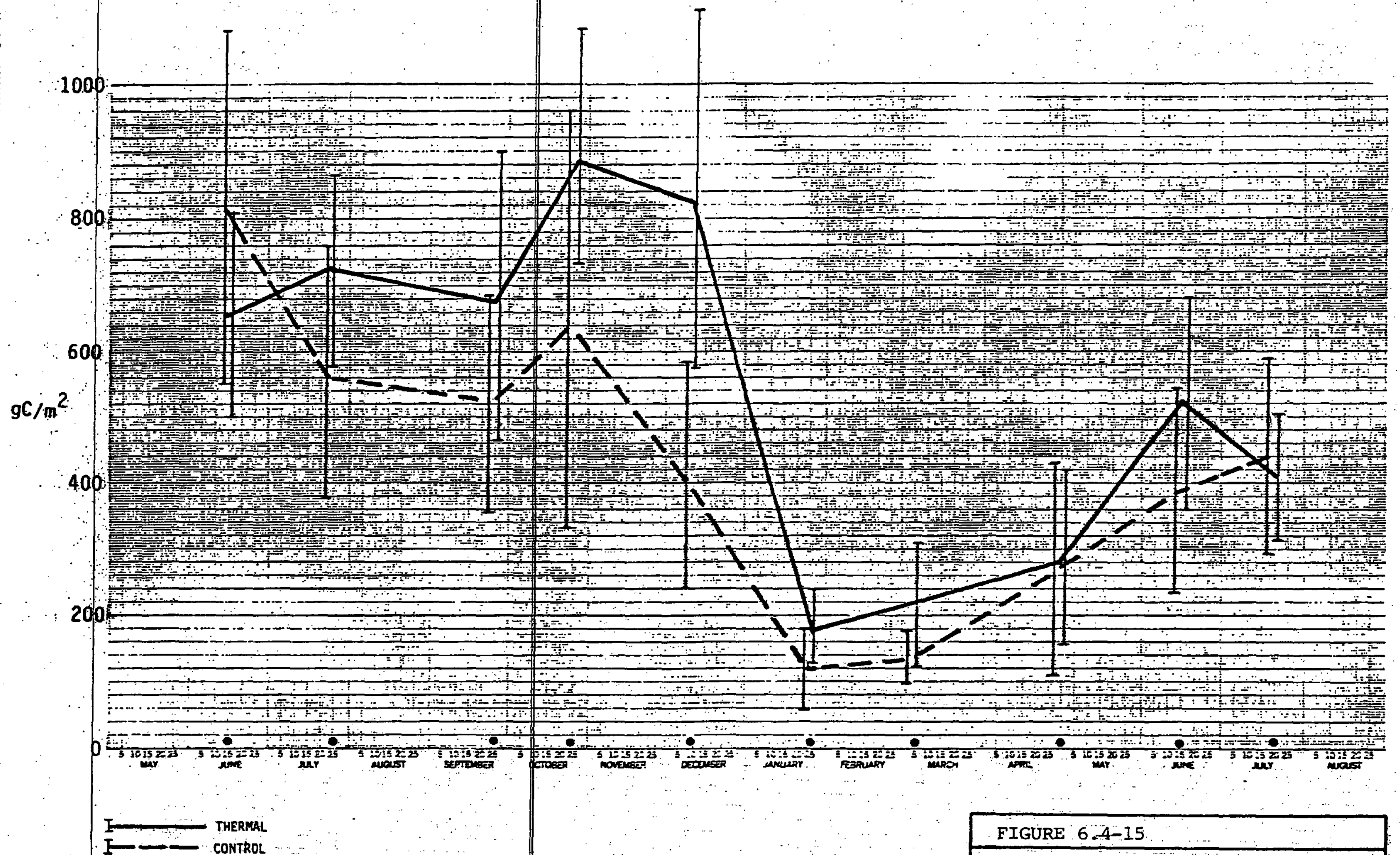
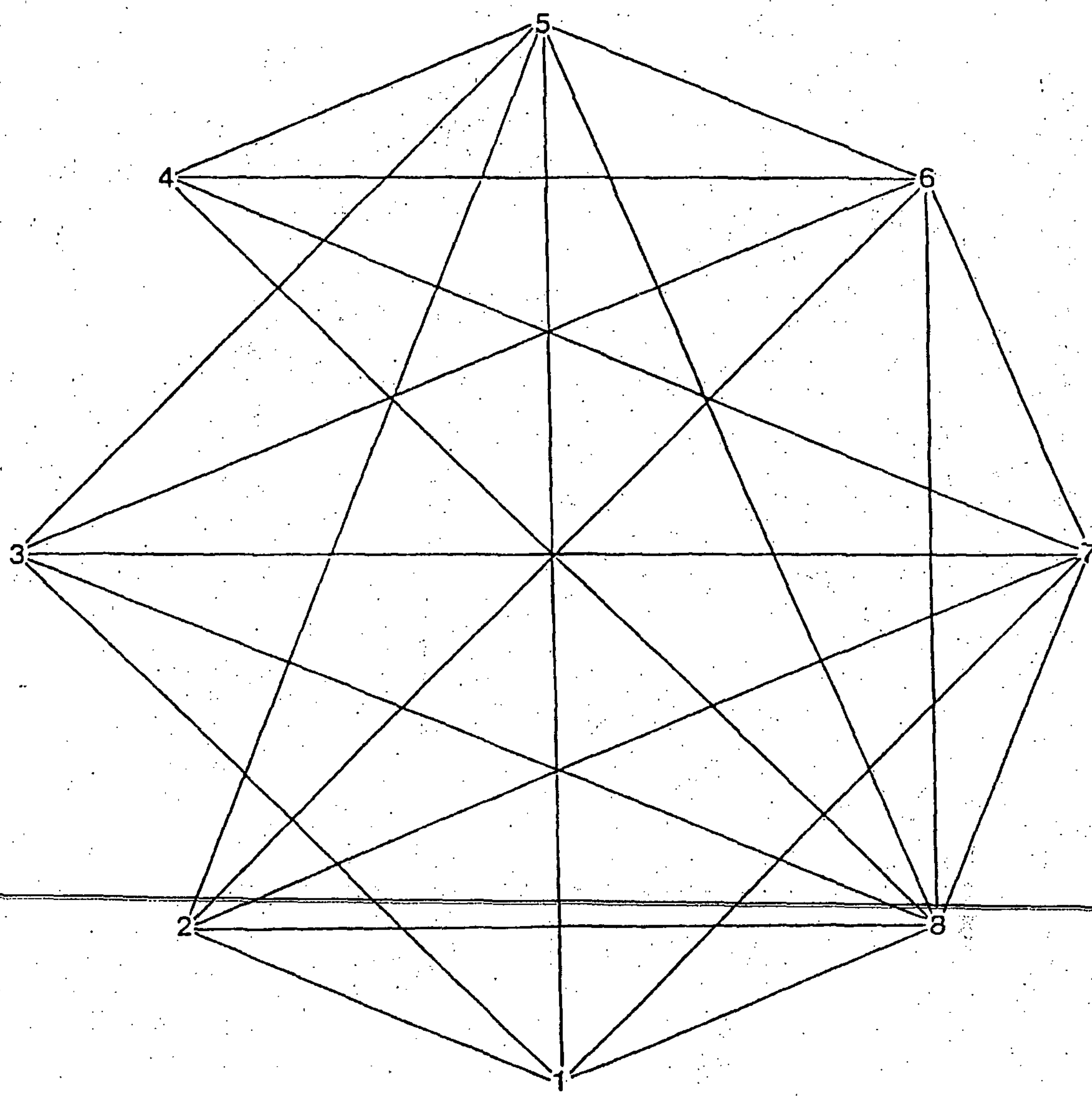


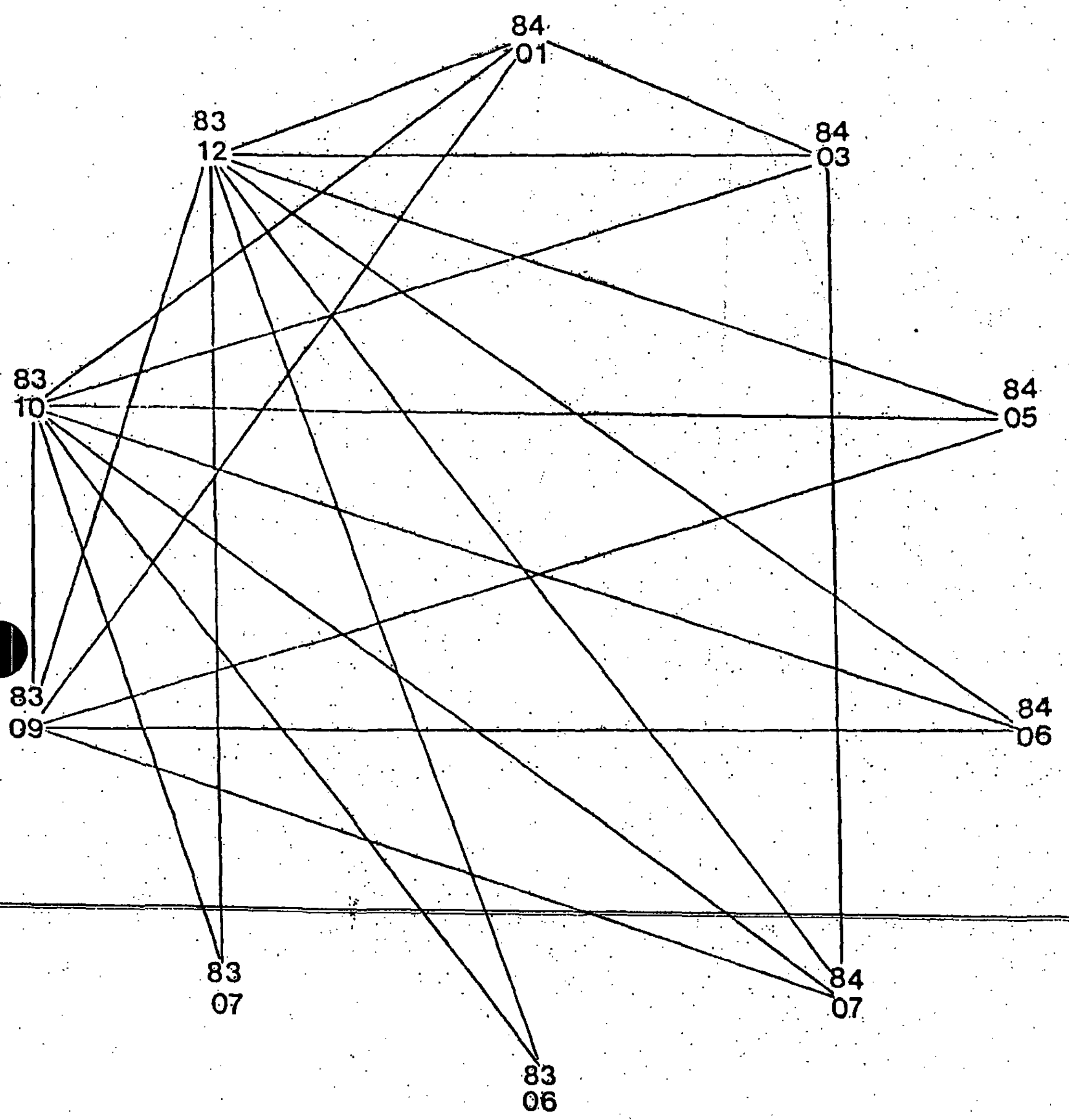
FIGURE 6.4-15

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~~

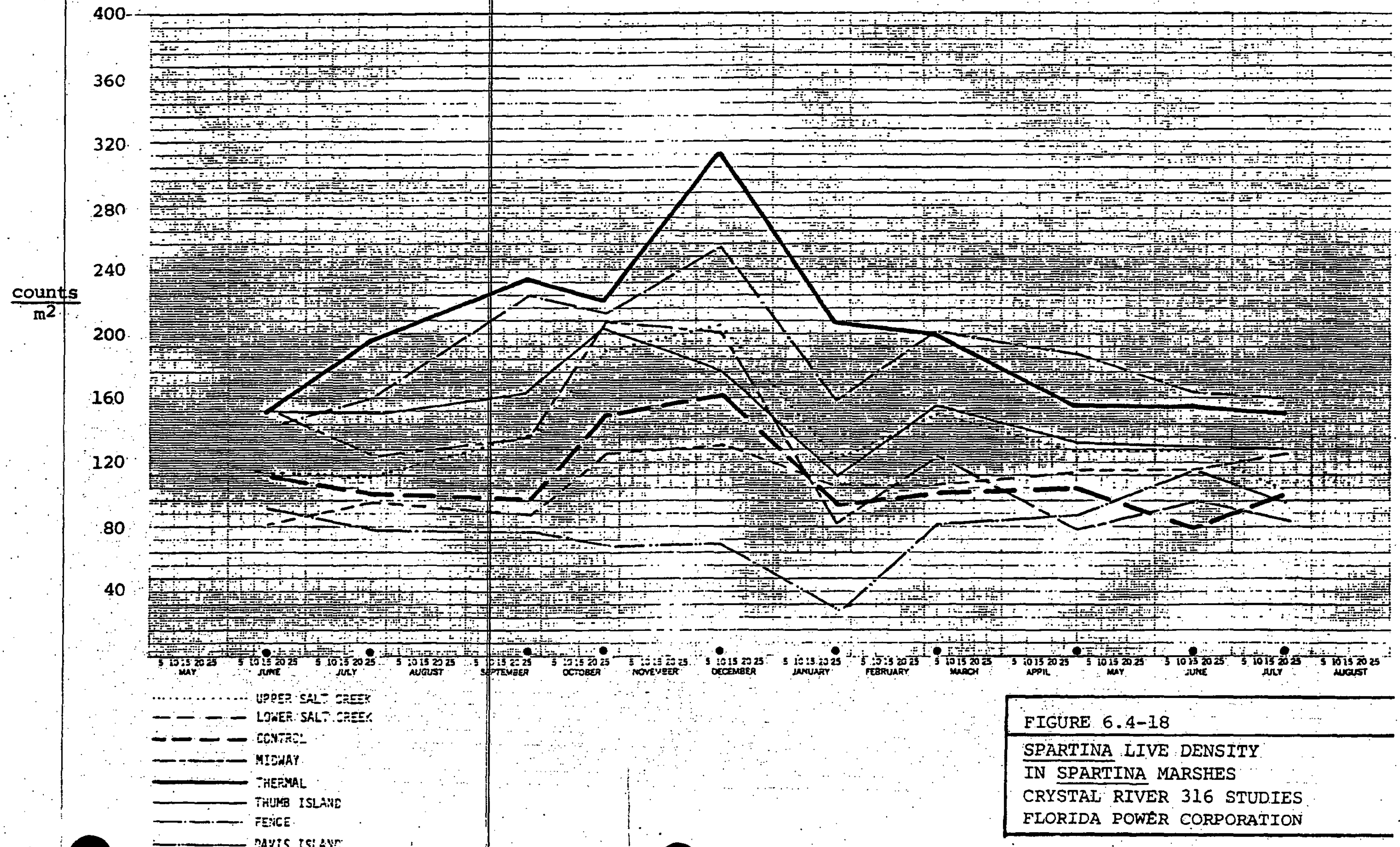


FIGURE 6.4-18

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

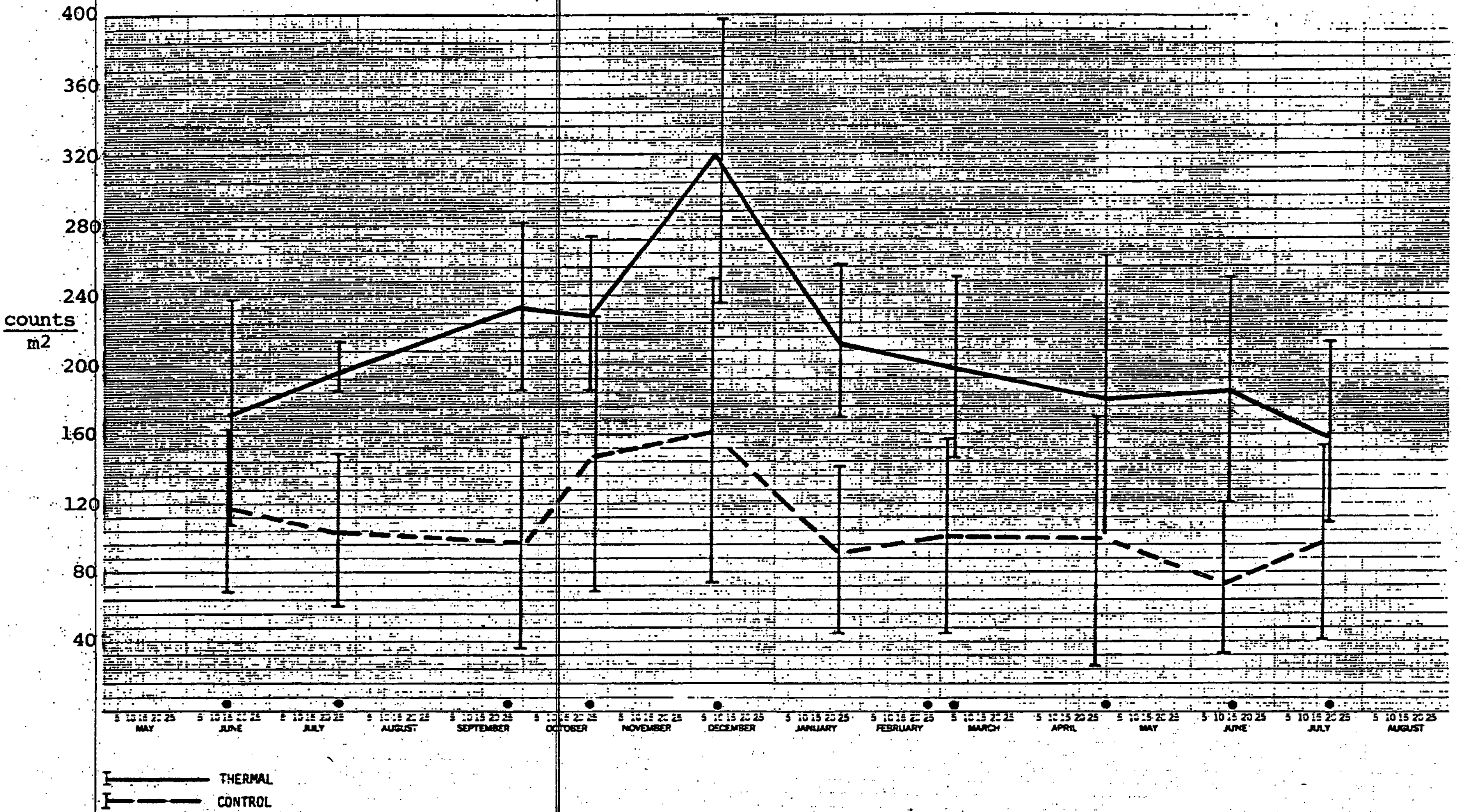


FIGURE 6.4-19

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

	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	••	••	••	••	••	••	

2 Sided P

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

df≈238

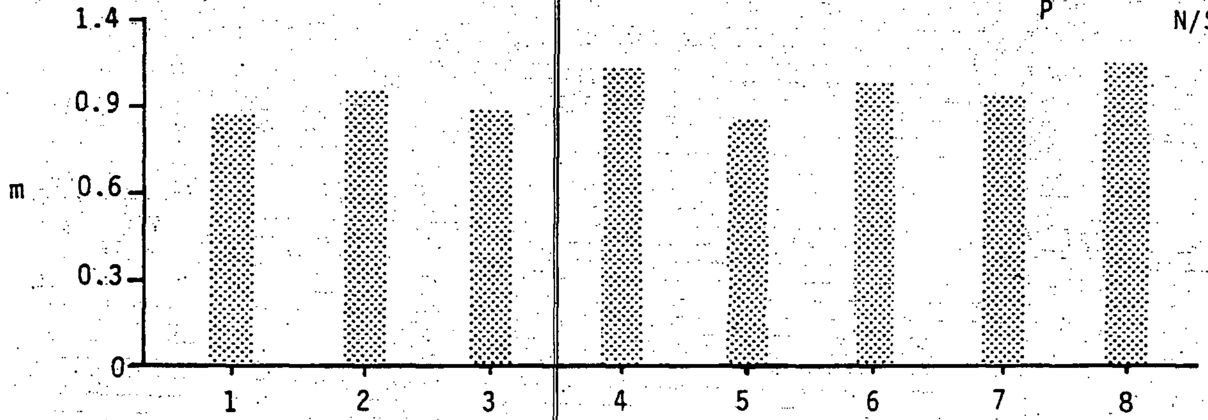


FIGURE 6.4-20

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

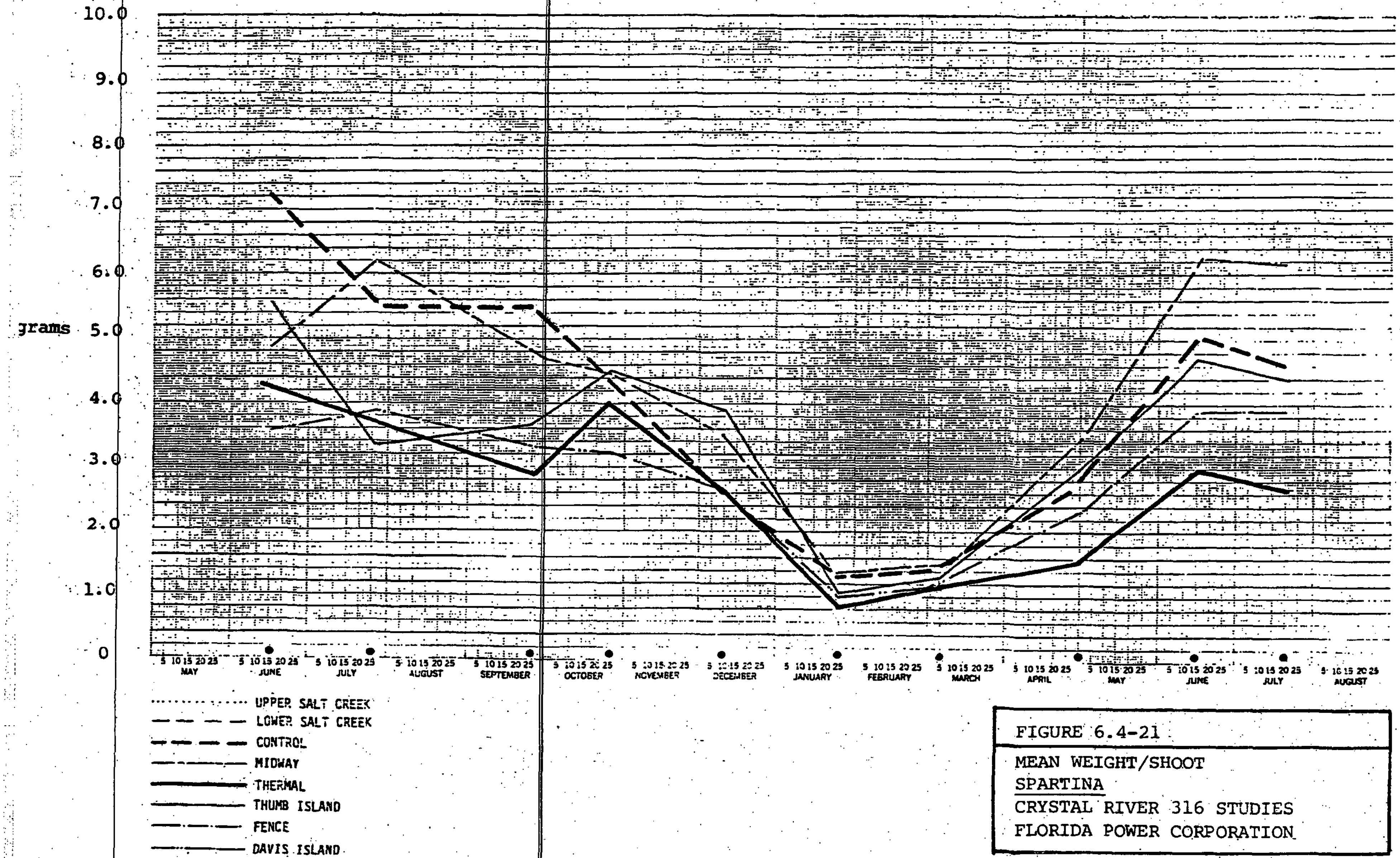


FIGURE 6.4-21

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

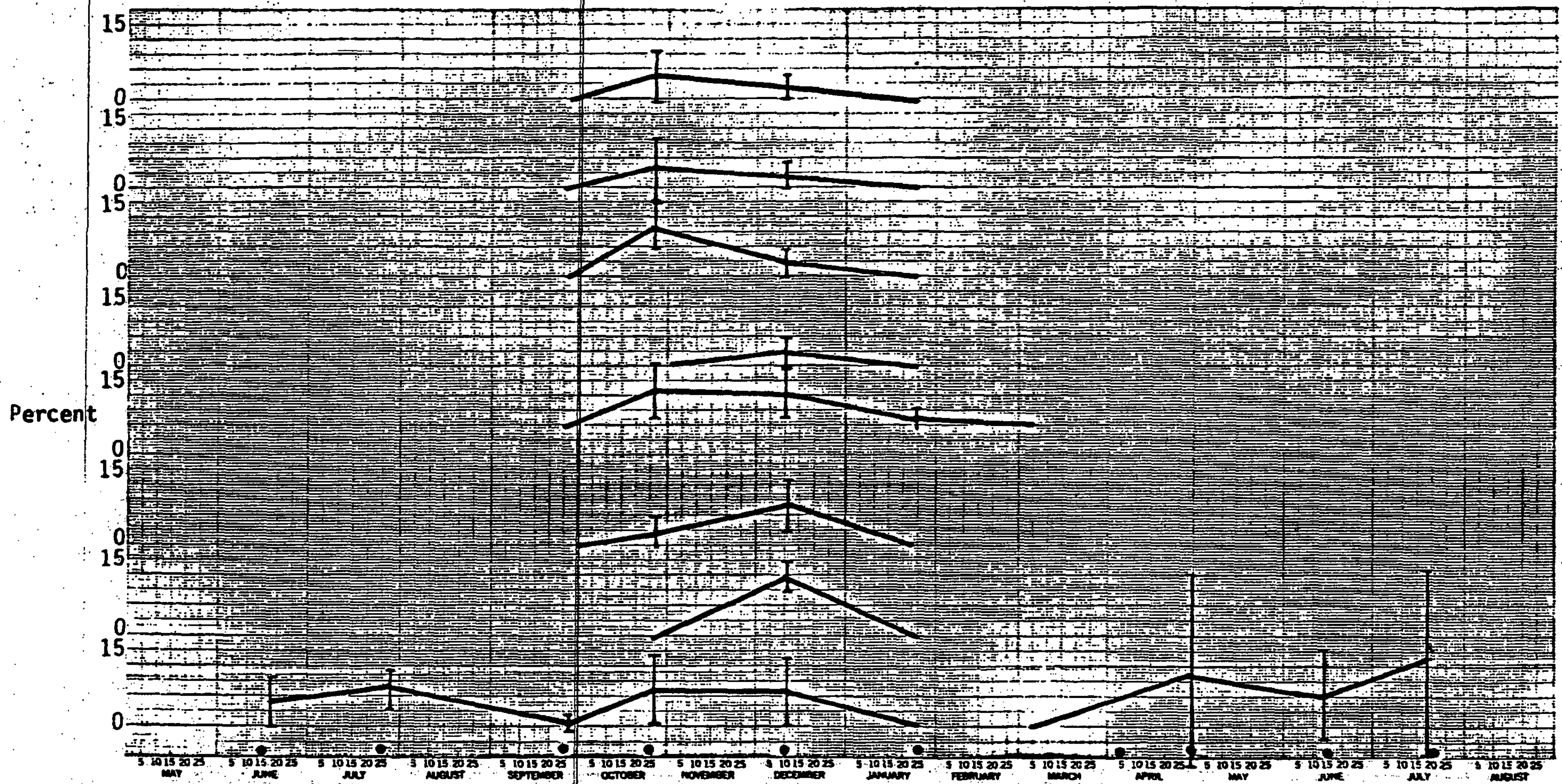


FIGURE 6.4-22
REPRODUCTIVE SPARTINA SHOOTS,
PERCENT TOTAL
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

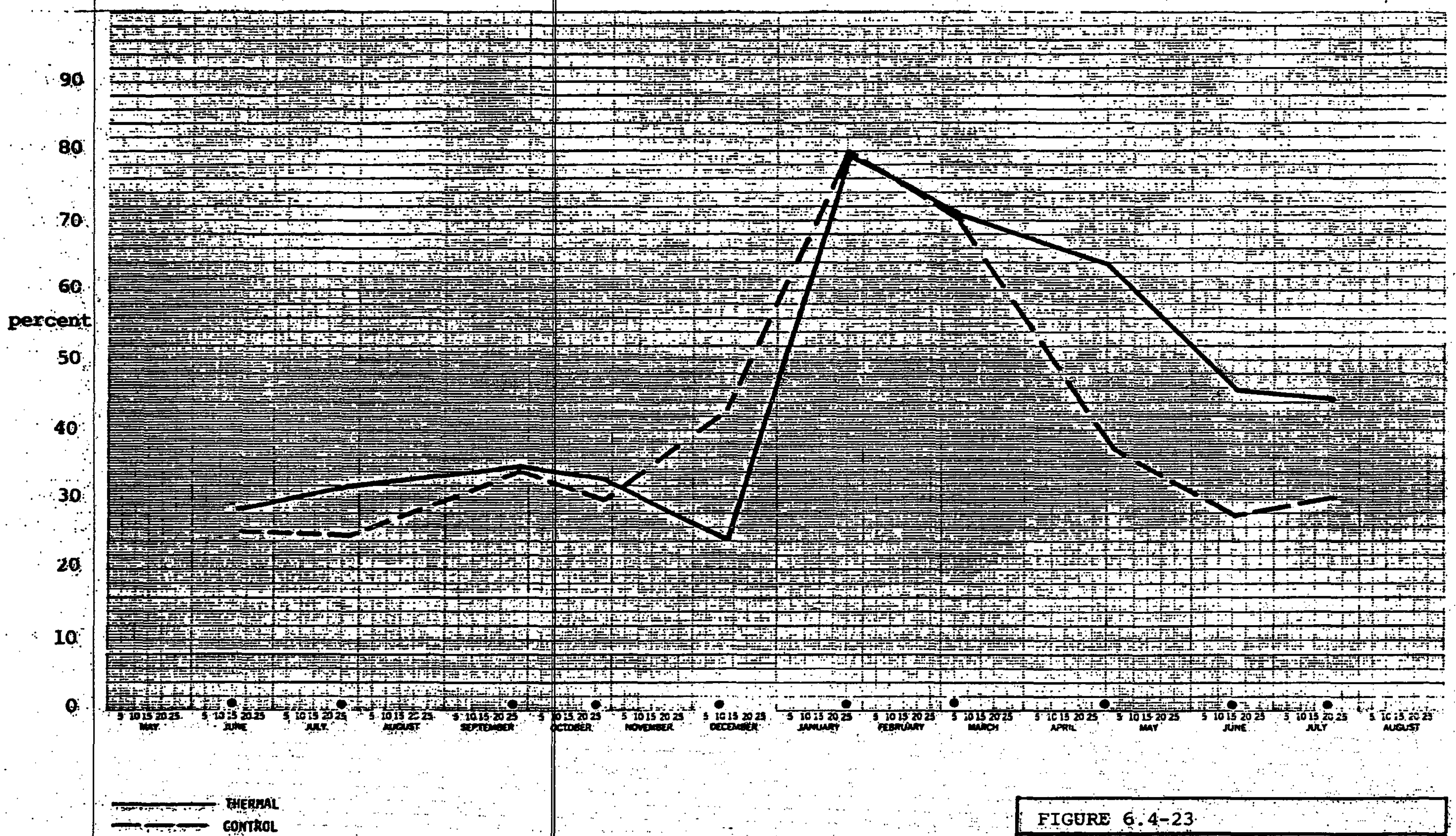
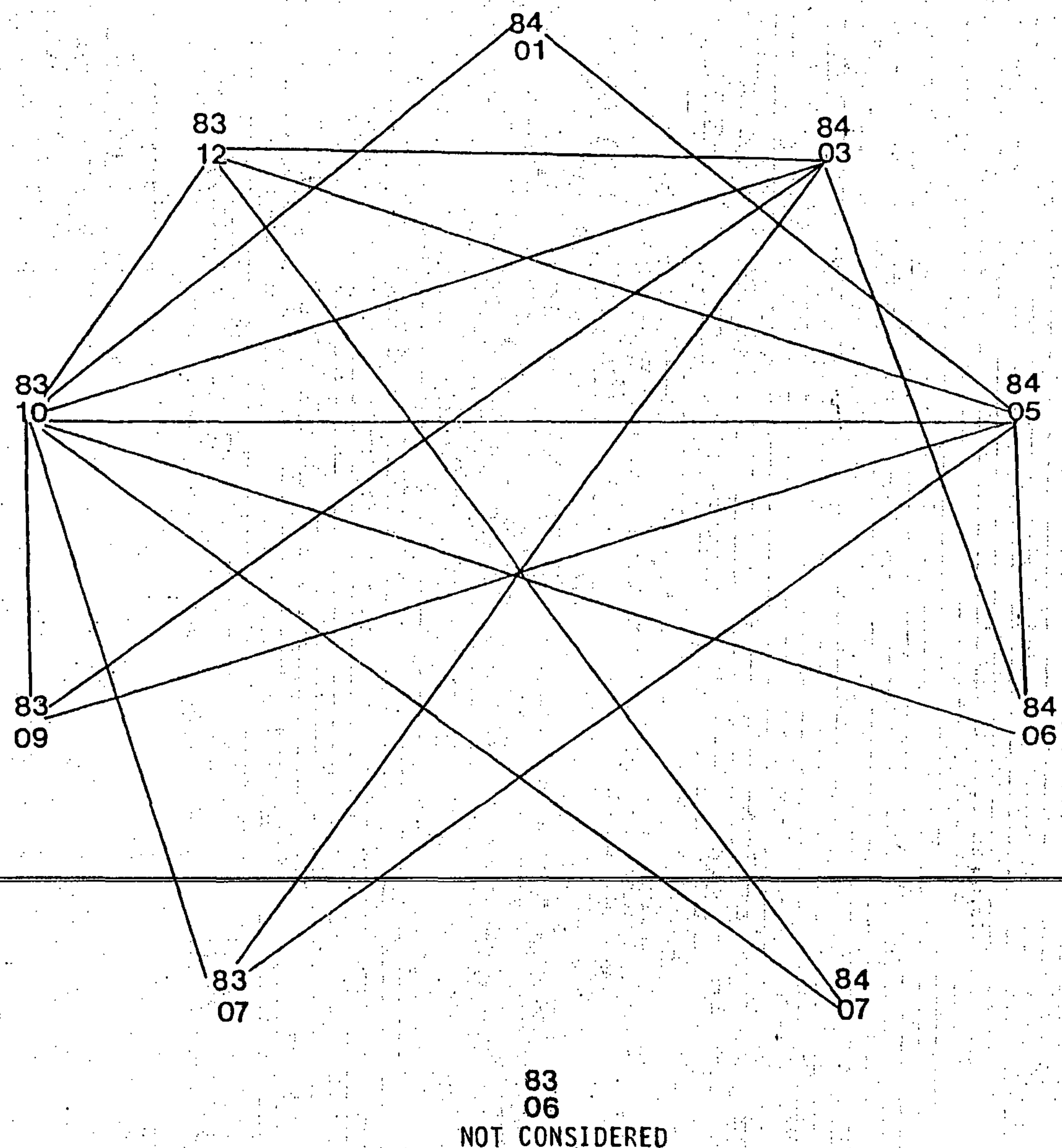


FIGURE 6.4-23

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



TIME DIFFERENCES

FIGURE 6.4-24

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

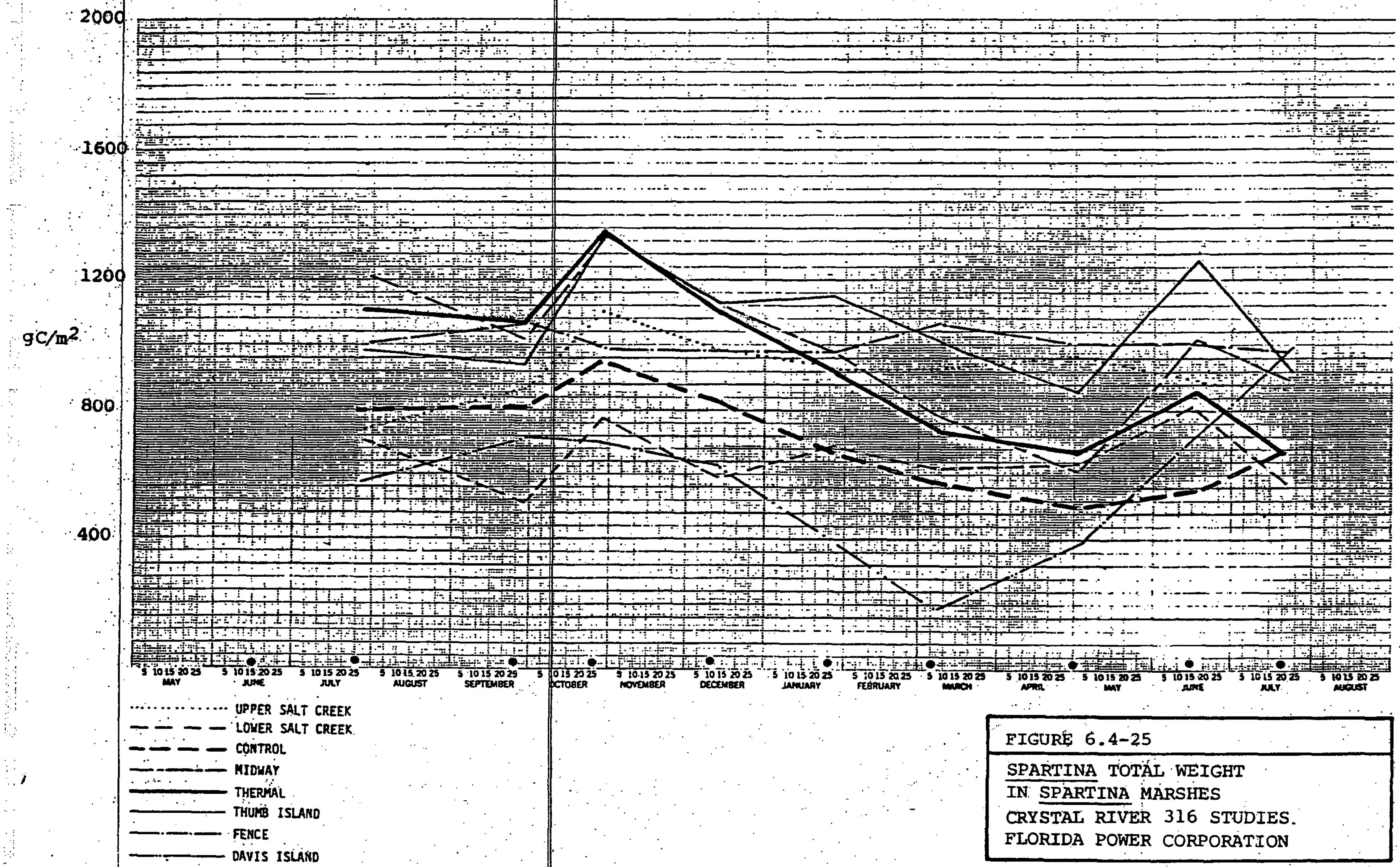


FIGURE 6.4-25

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

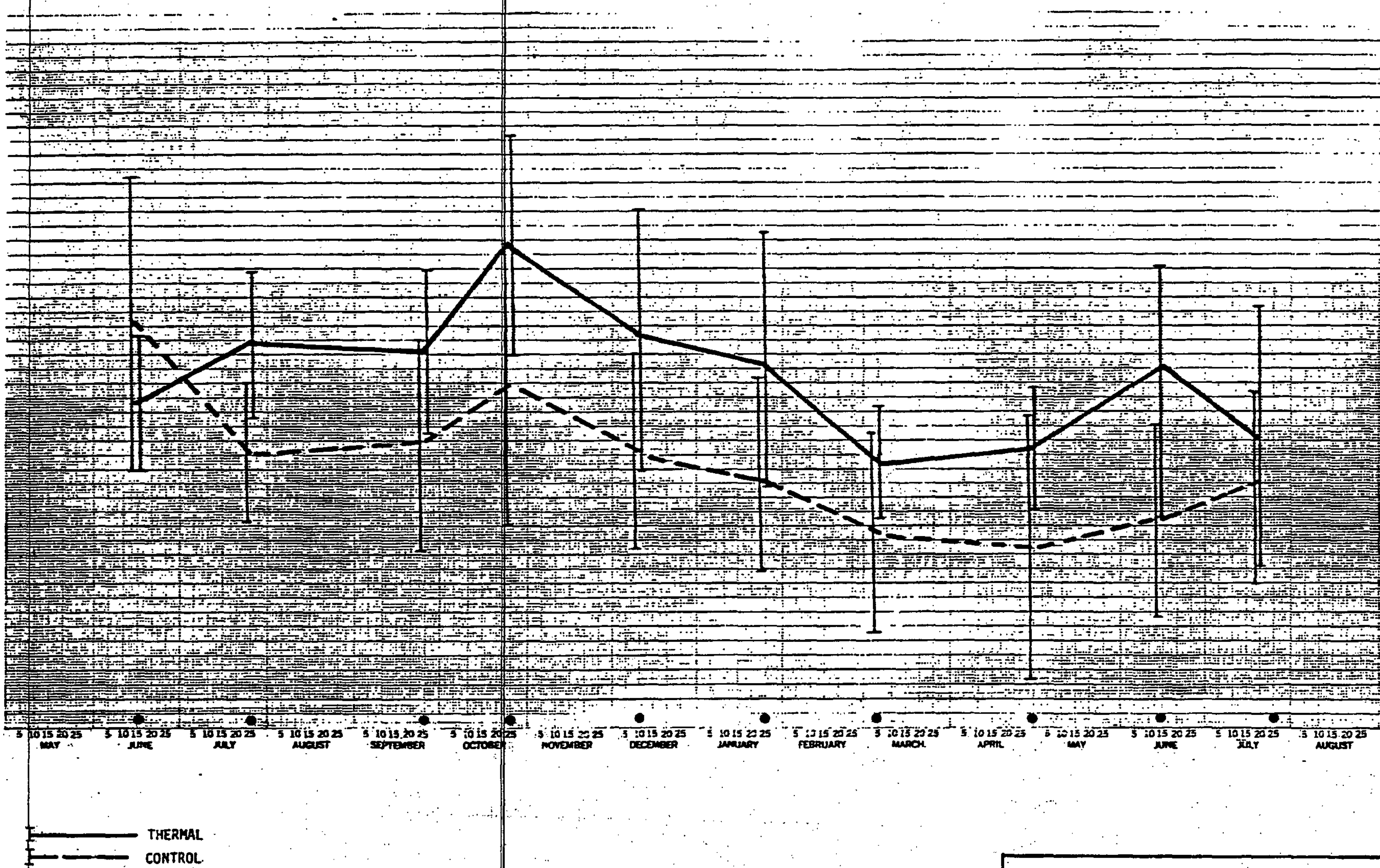
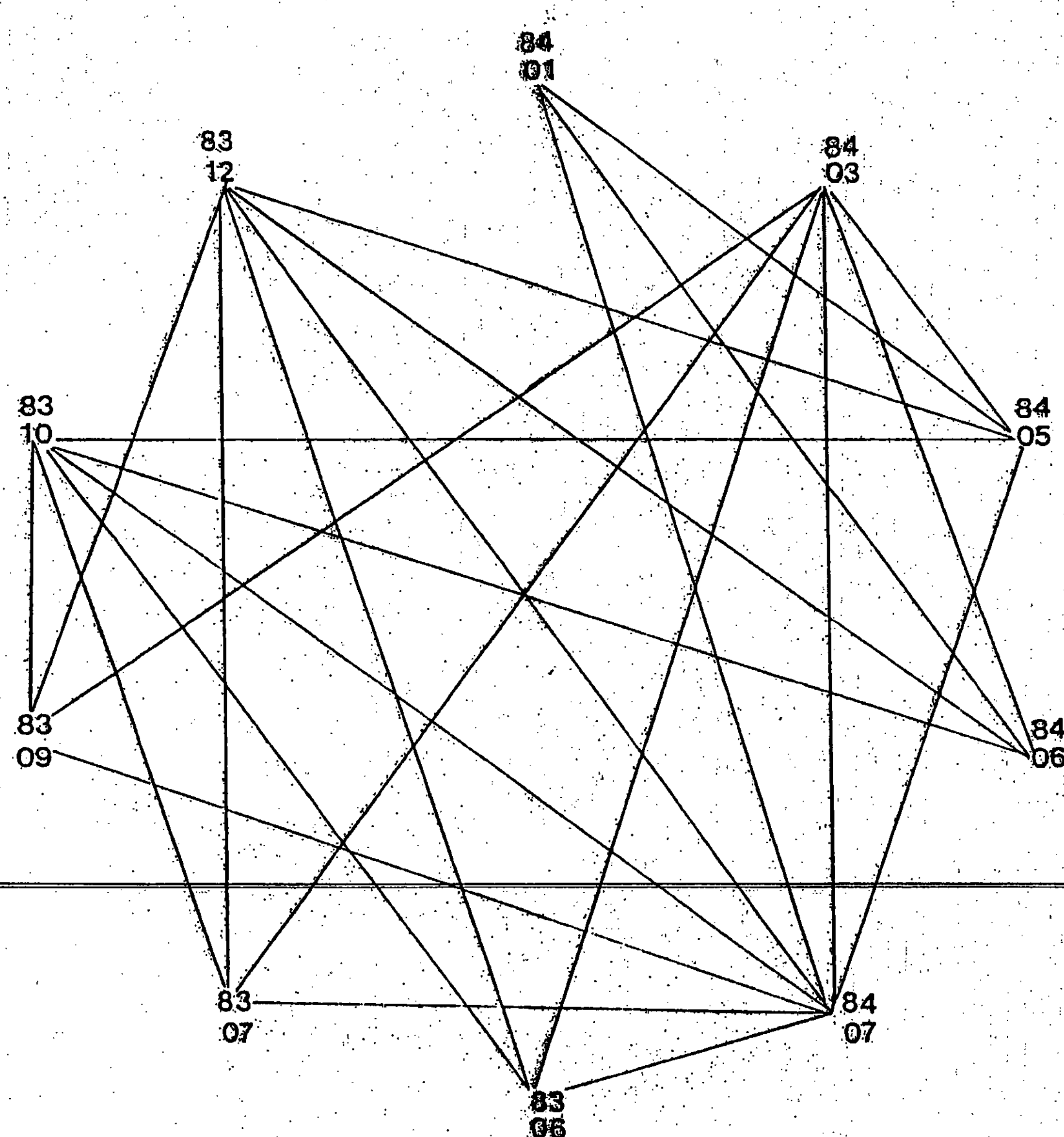


FIGURE 6.4-26

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

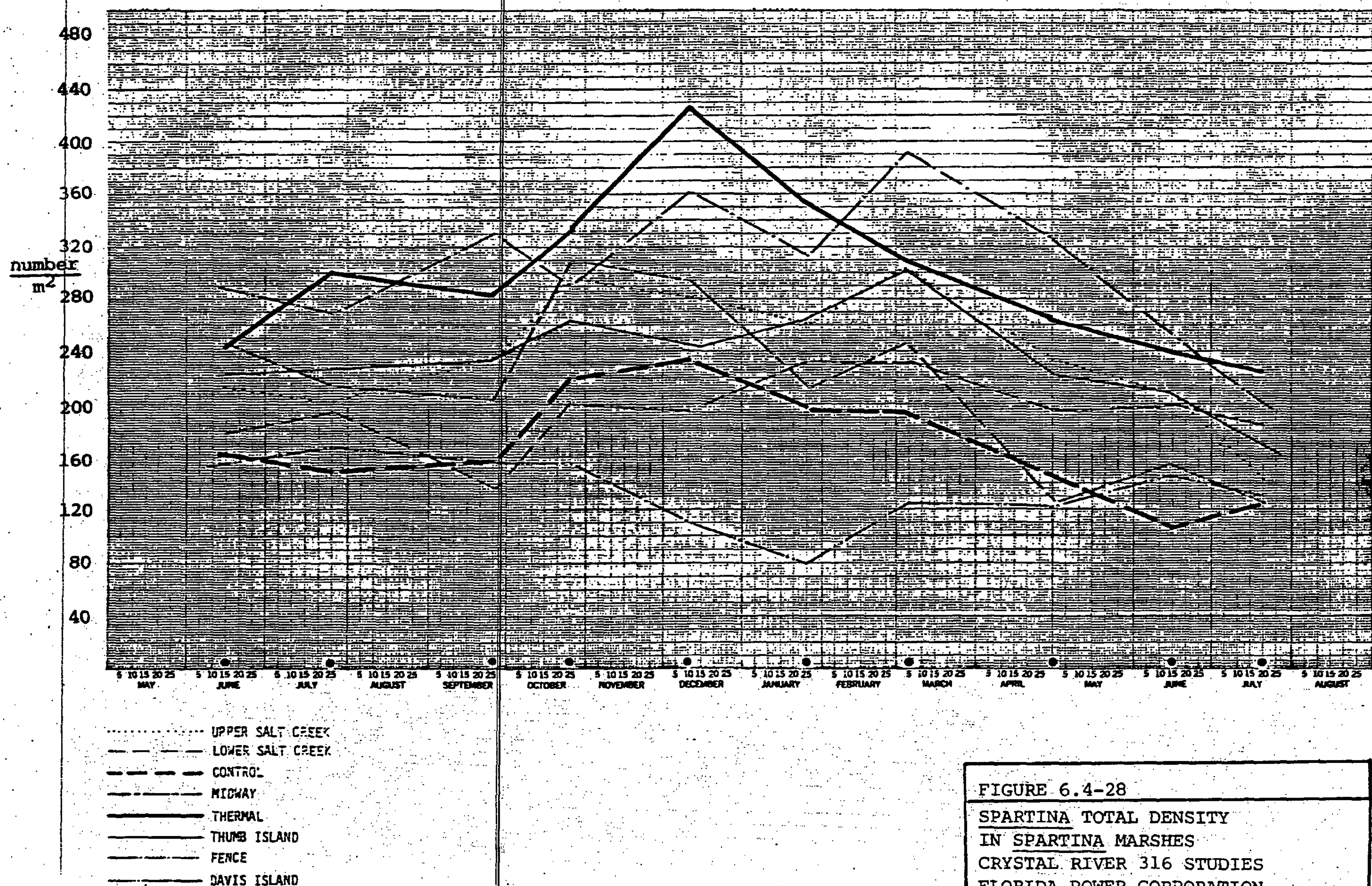


FIGURE 6.4-28

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

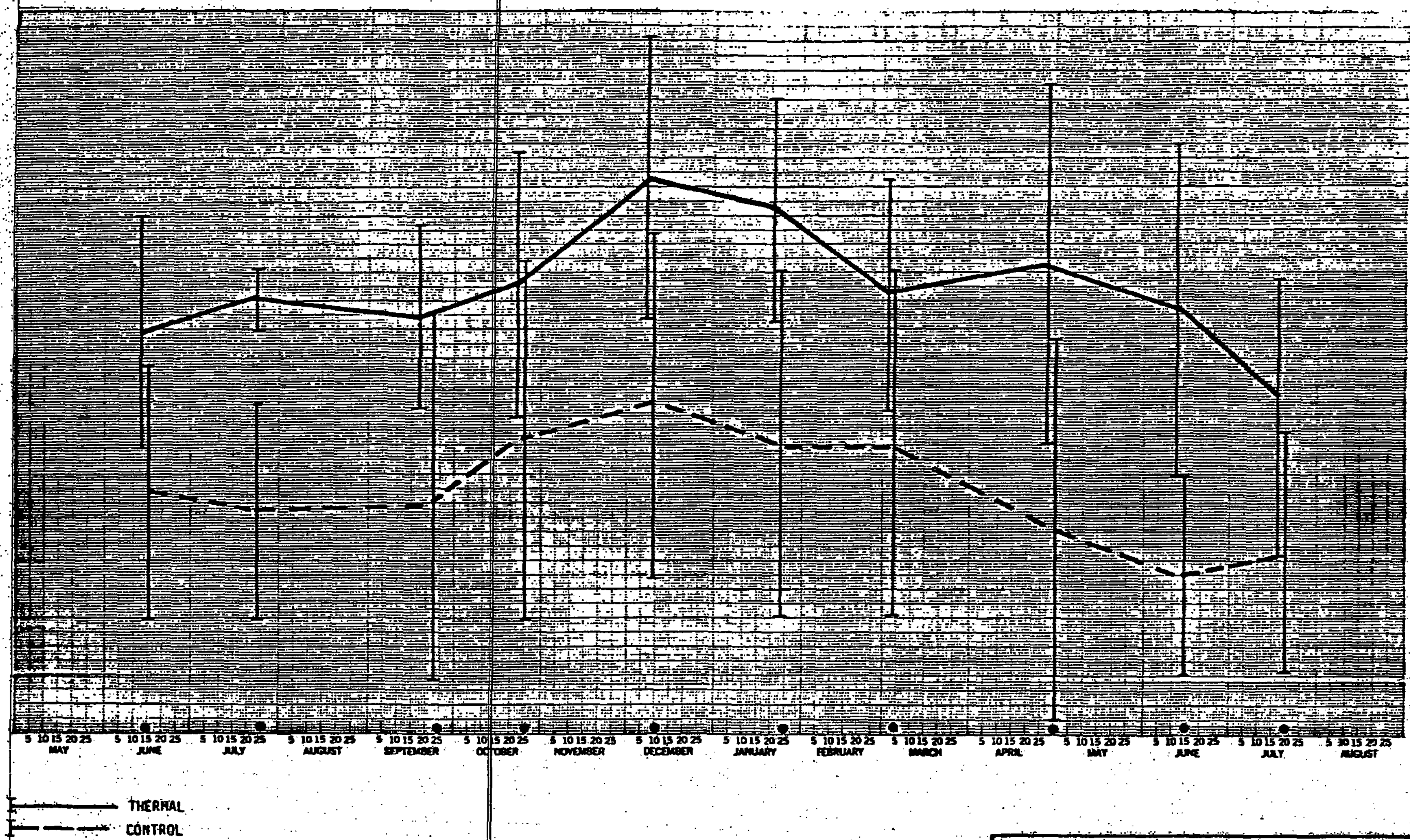
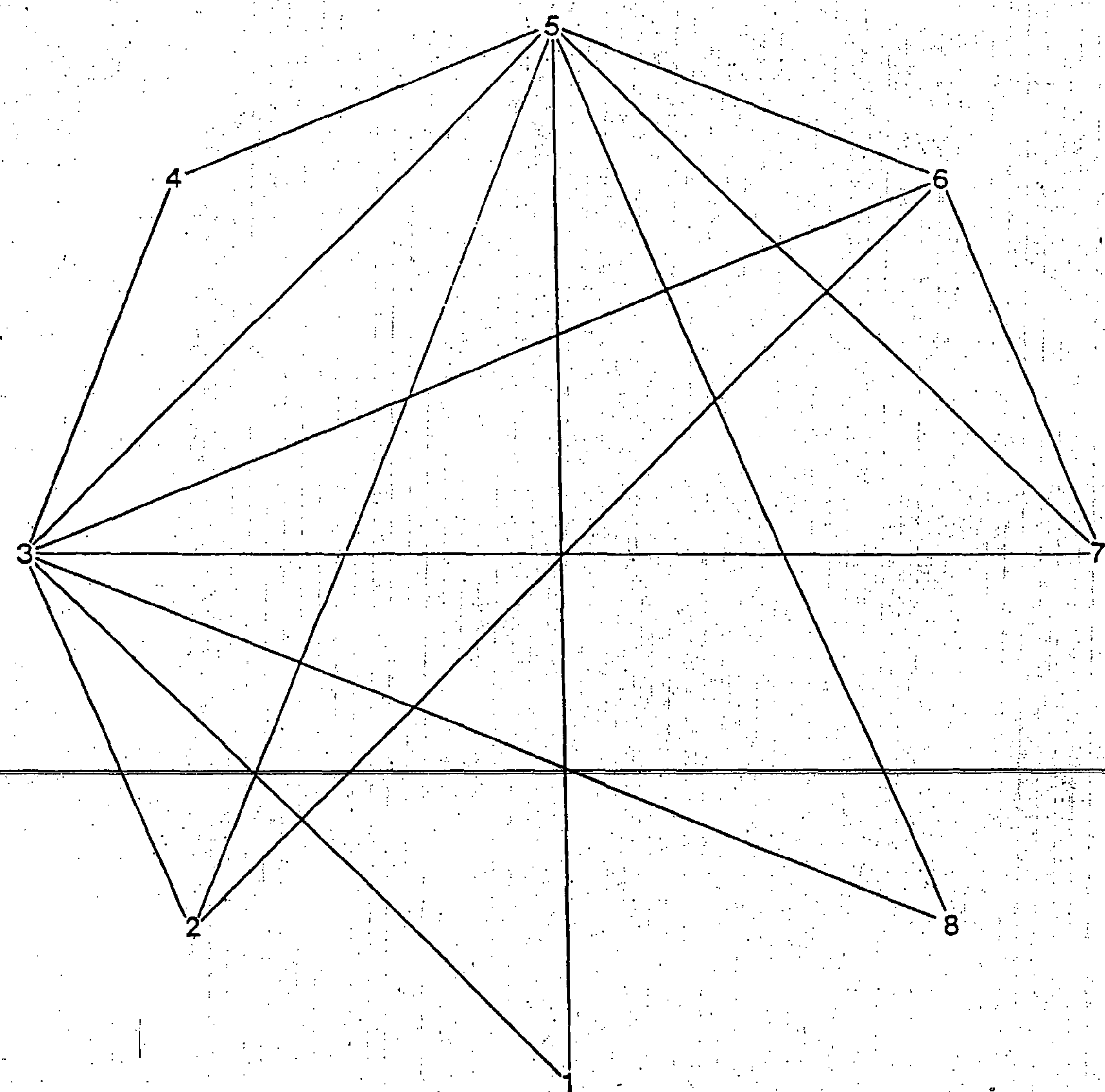


FIGURE 6.4-29

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

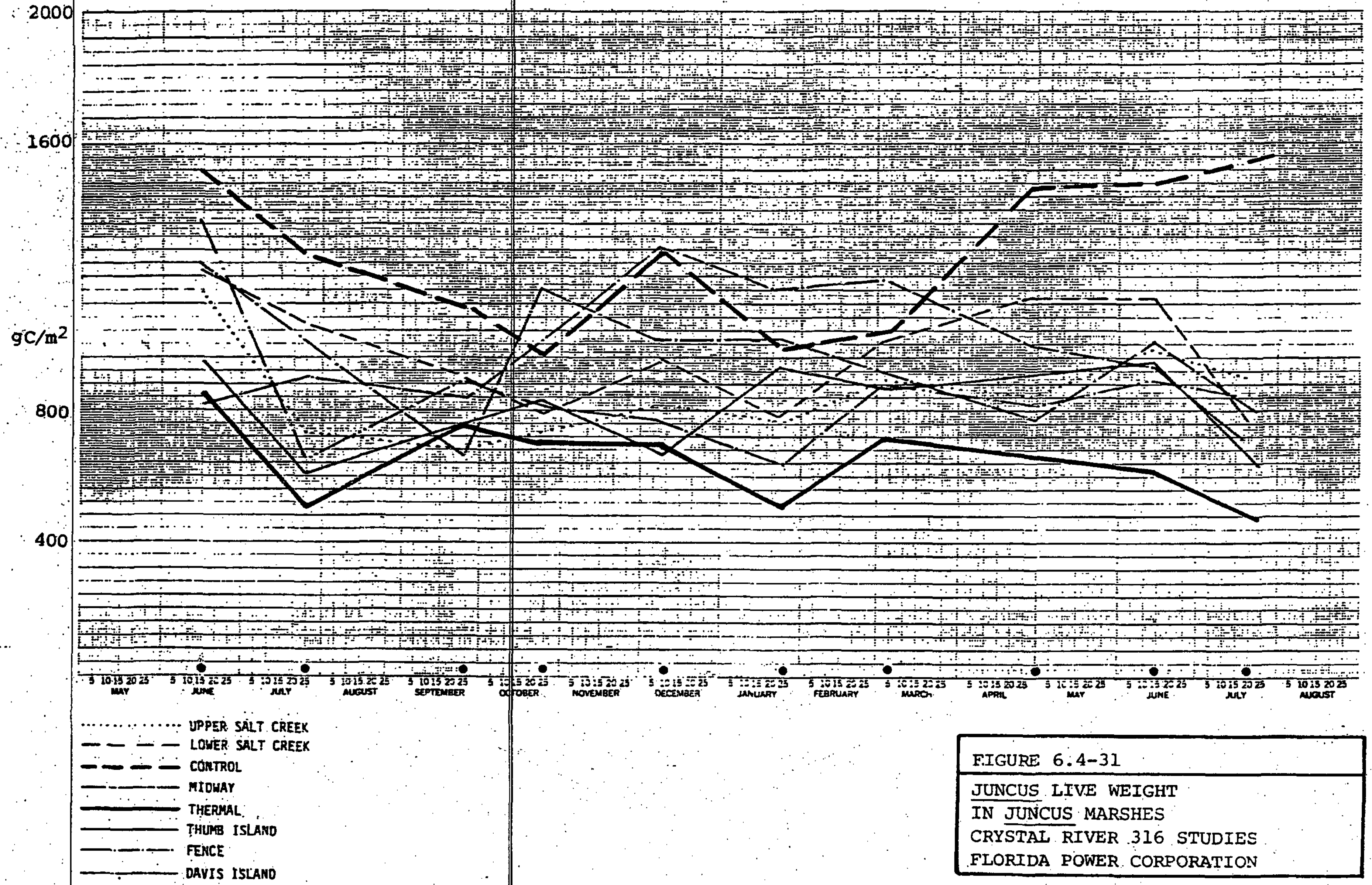
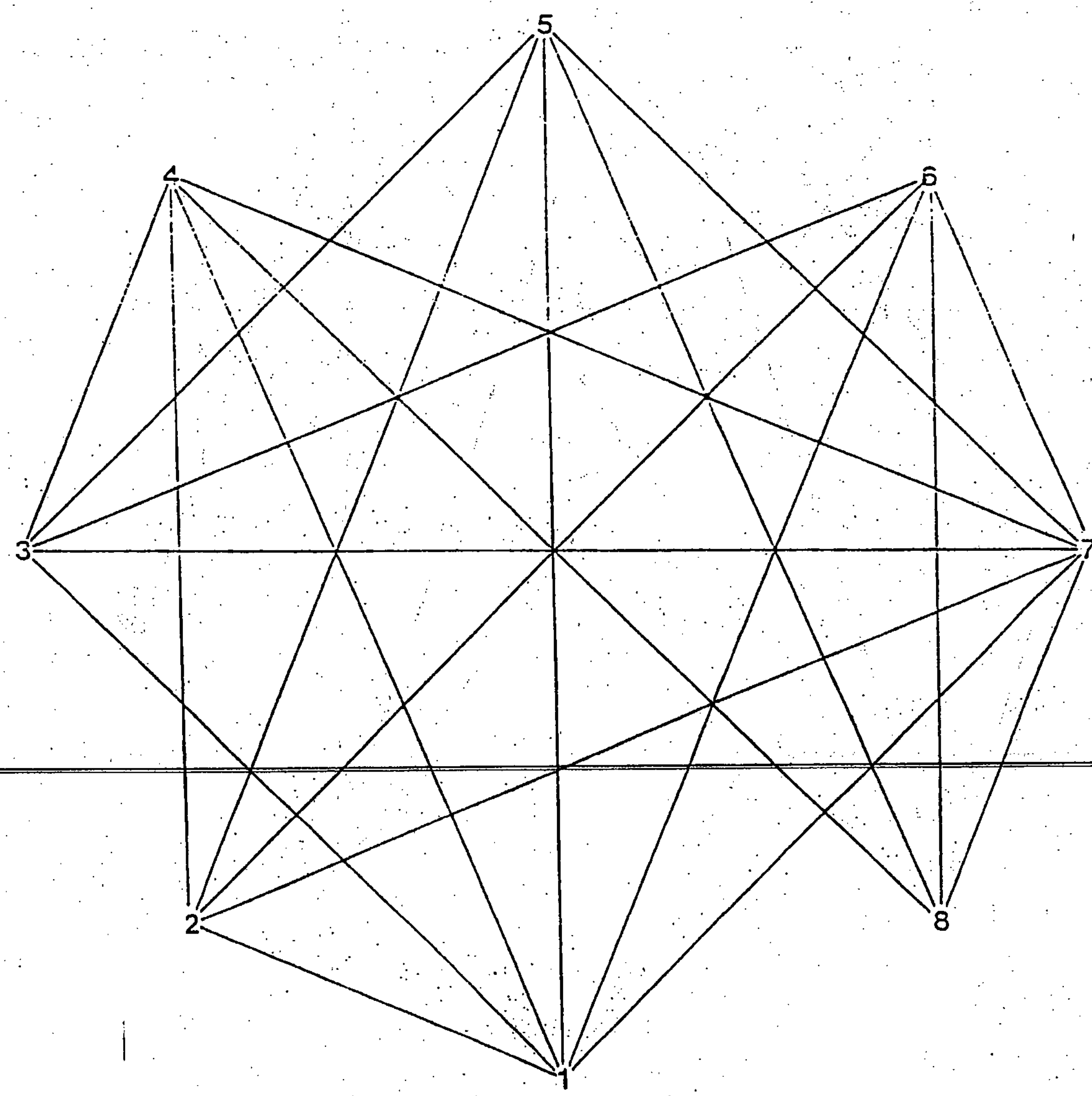


FIGURE 6.4-31

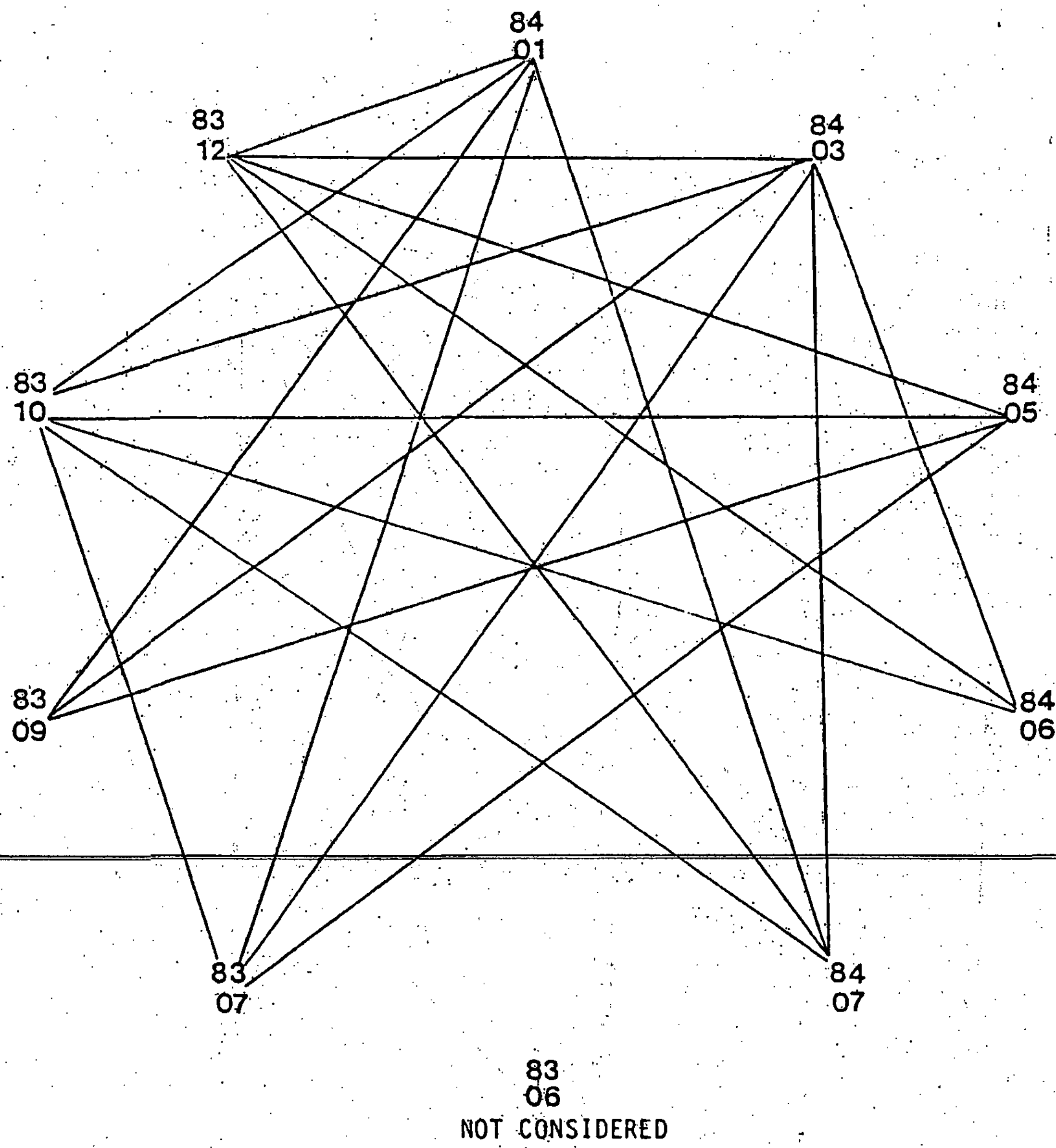
JUNCUS LIVE WEIGHT
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



STATION DIFFERENCES

FIGURE 6.4-32

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



TIME DIFFERENCES

FIGURE 6.4-33

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

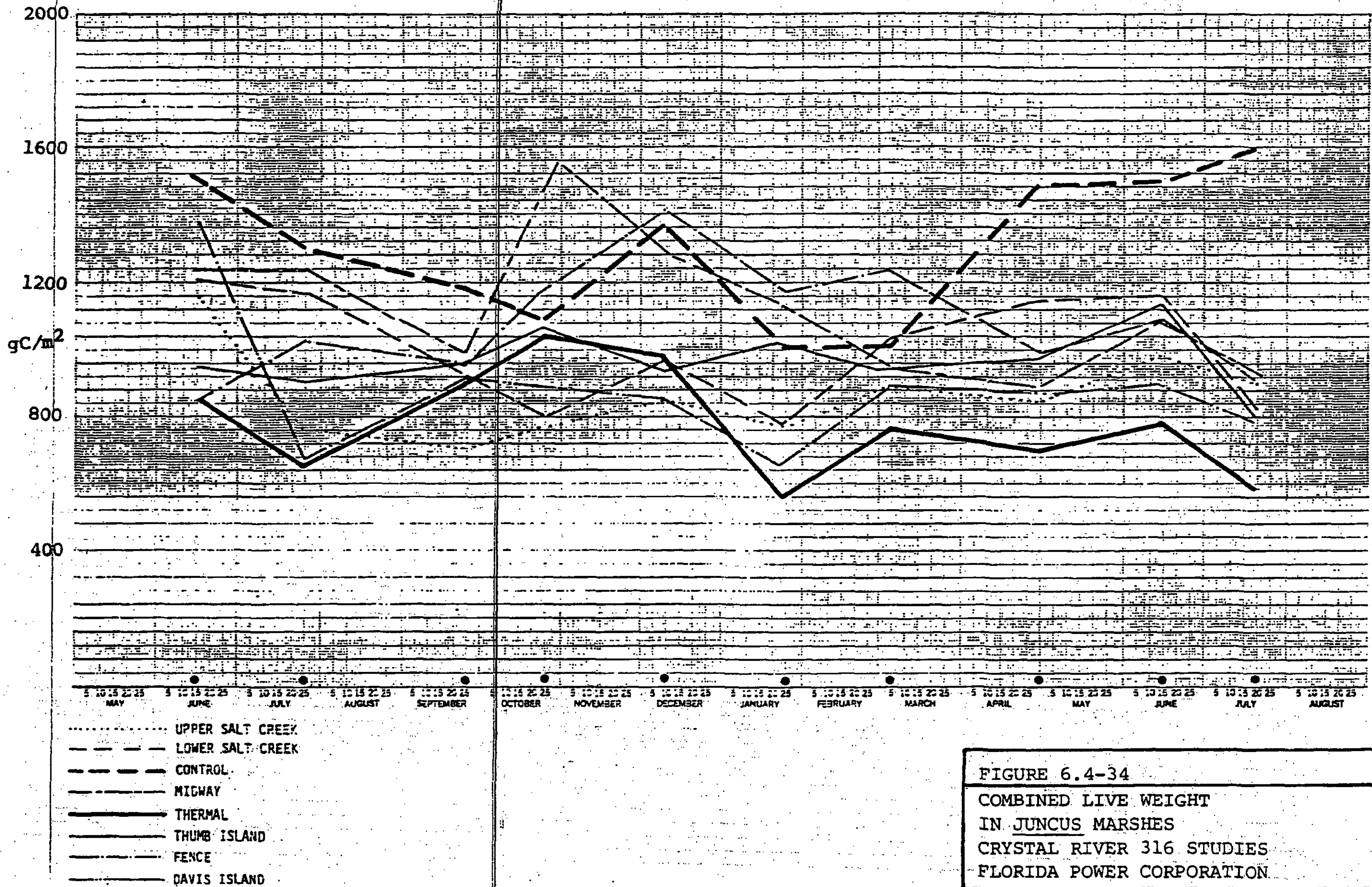


FIGURE 6.4-34

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

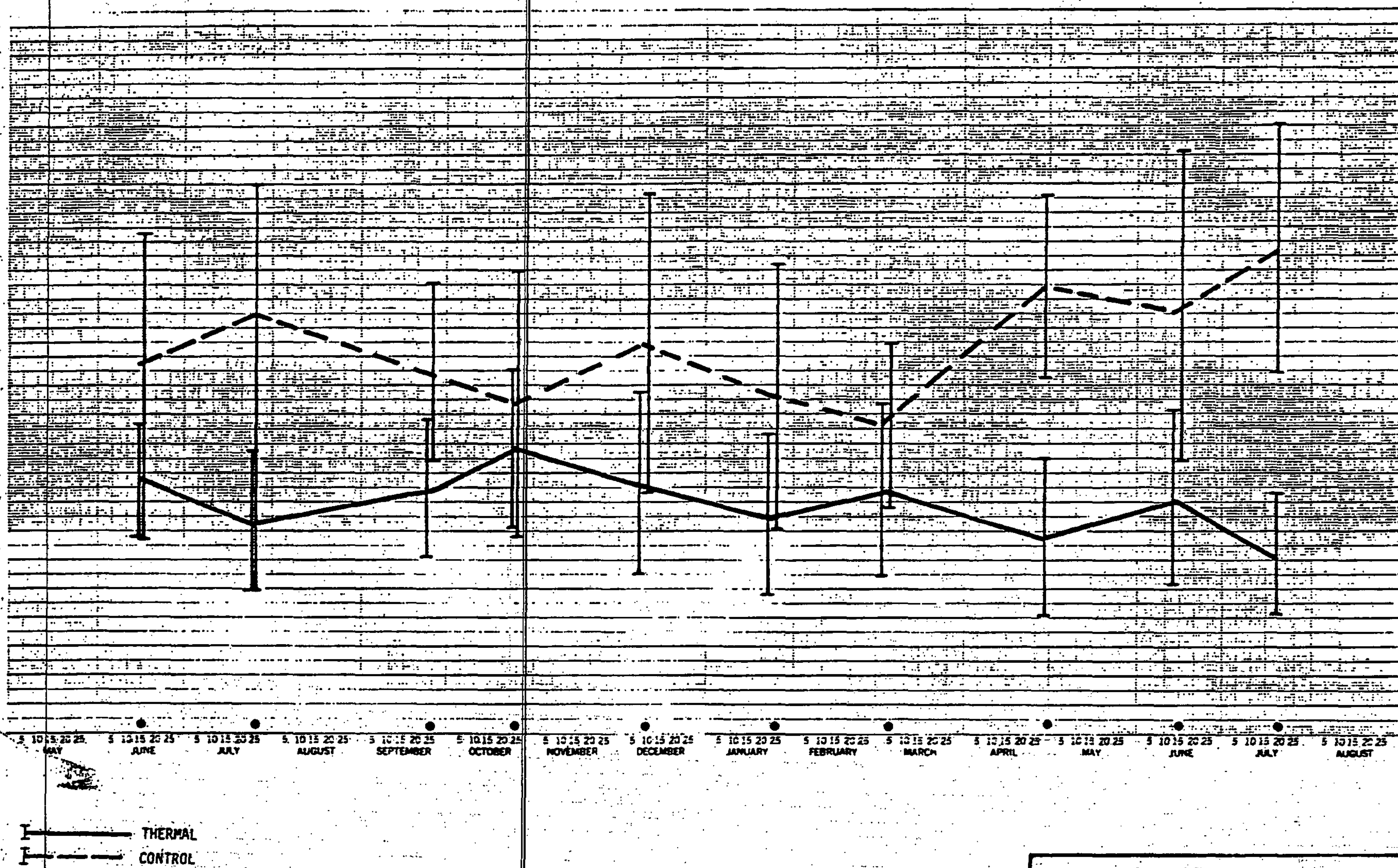
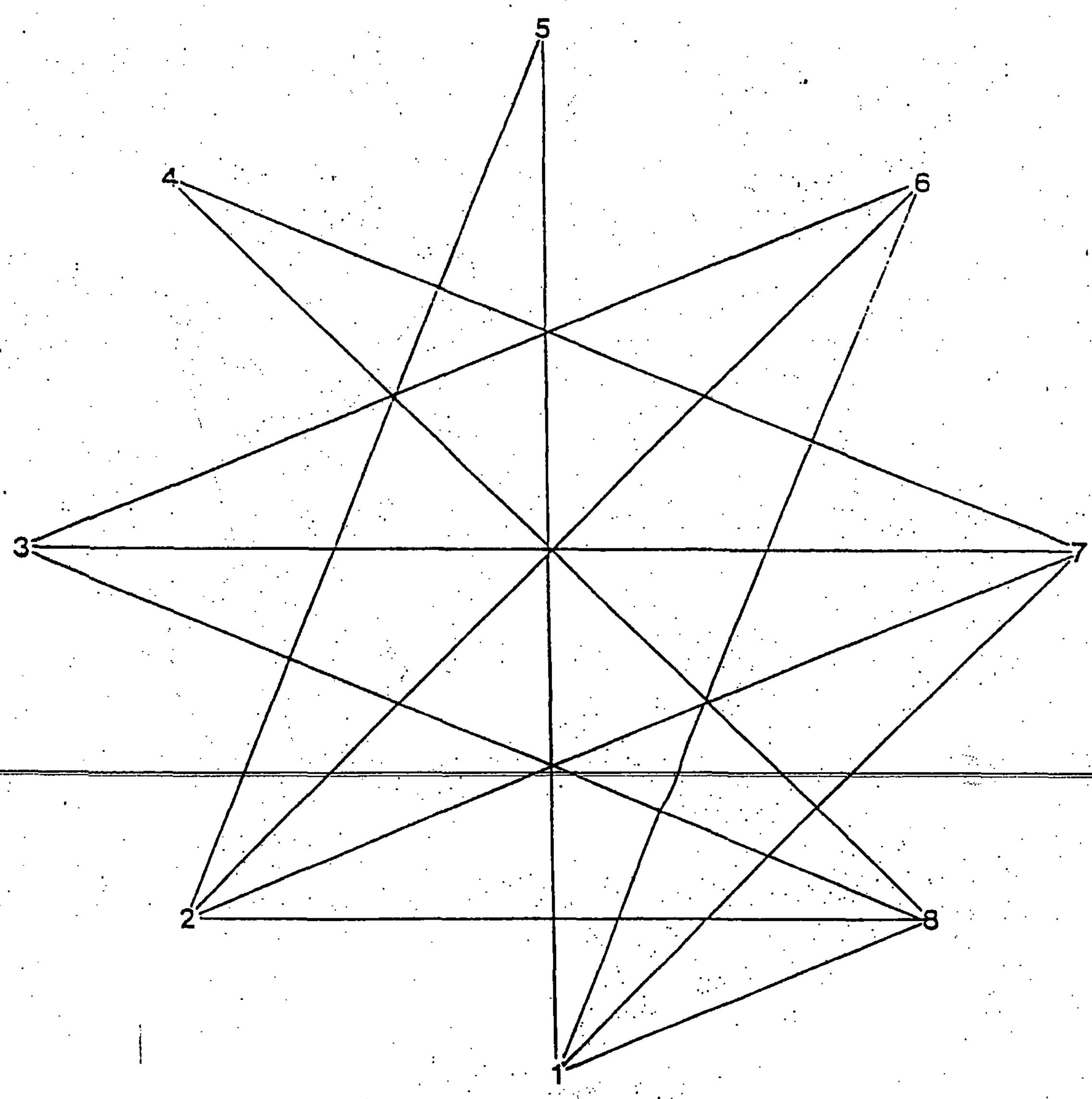


FIGURE 6.4-35

COMBINED LIVE WEIGHT
IN <u>JUNCUS</u> 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

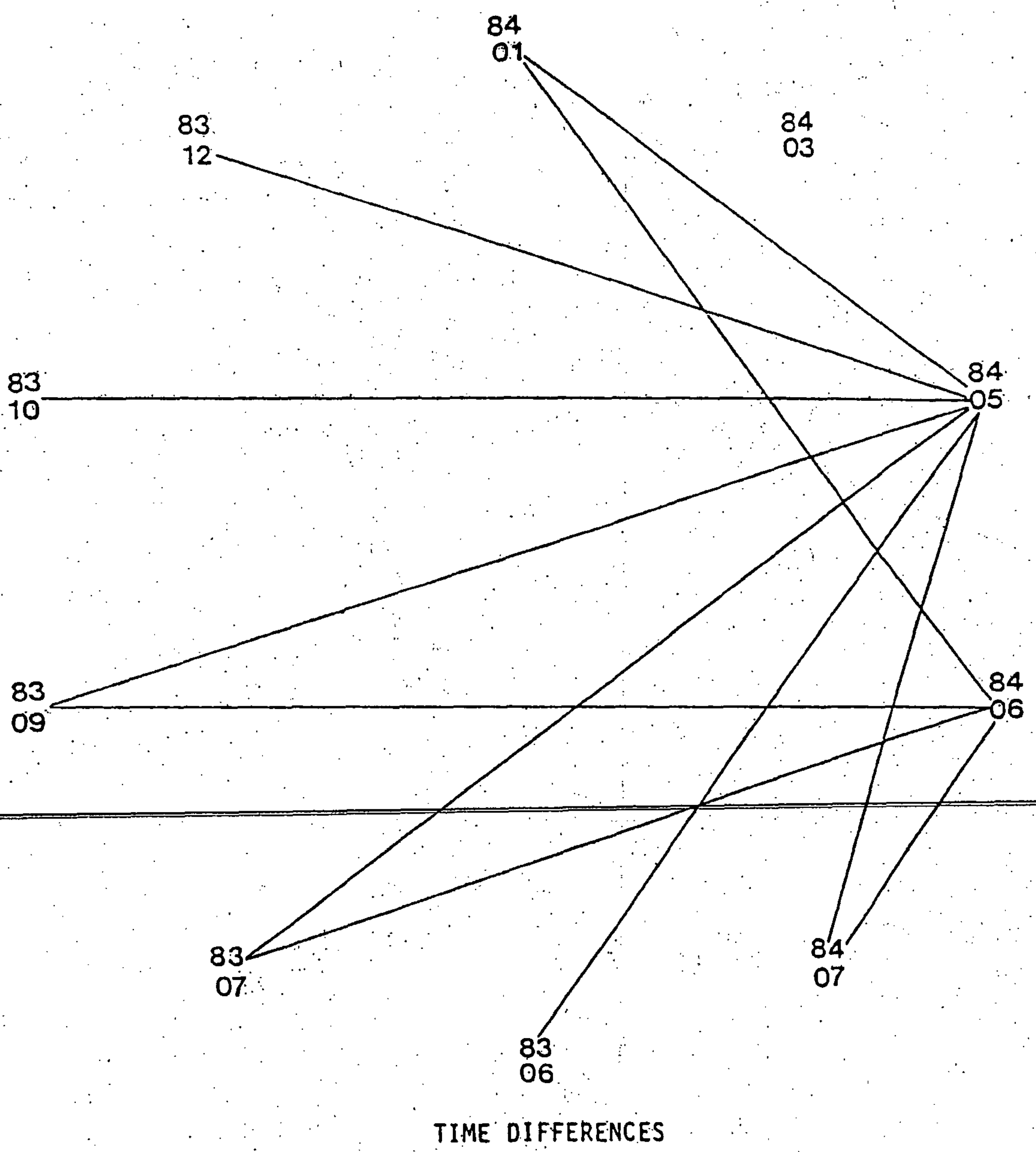


FIGURE 6.4-37

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

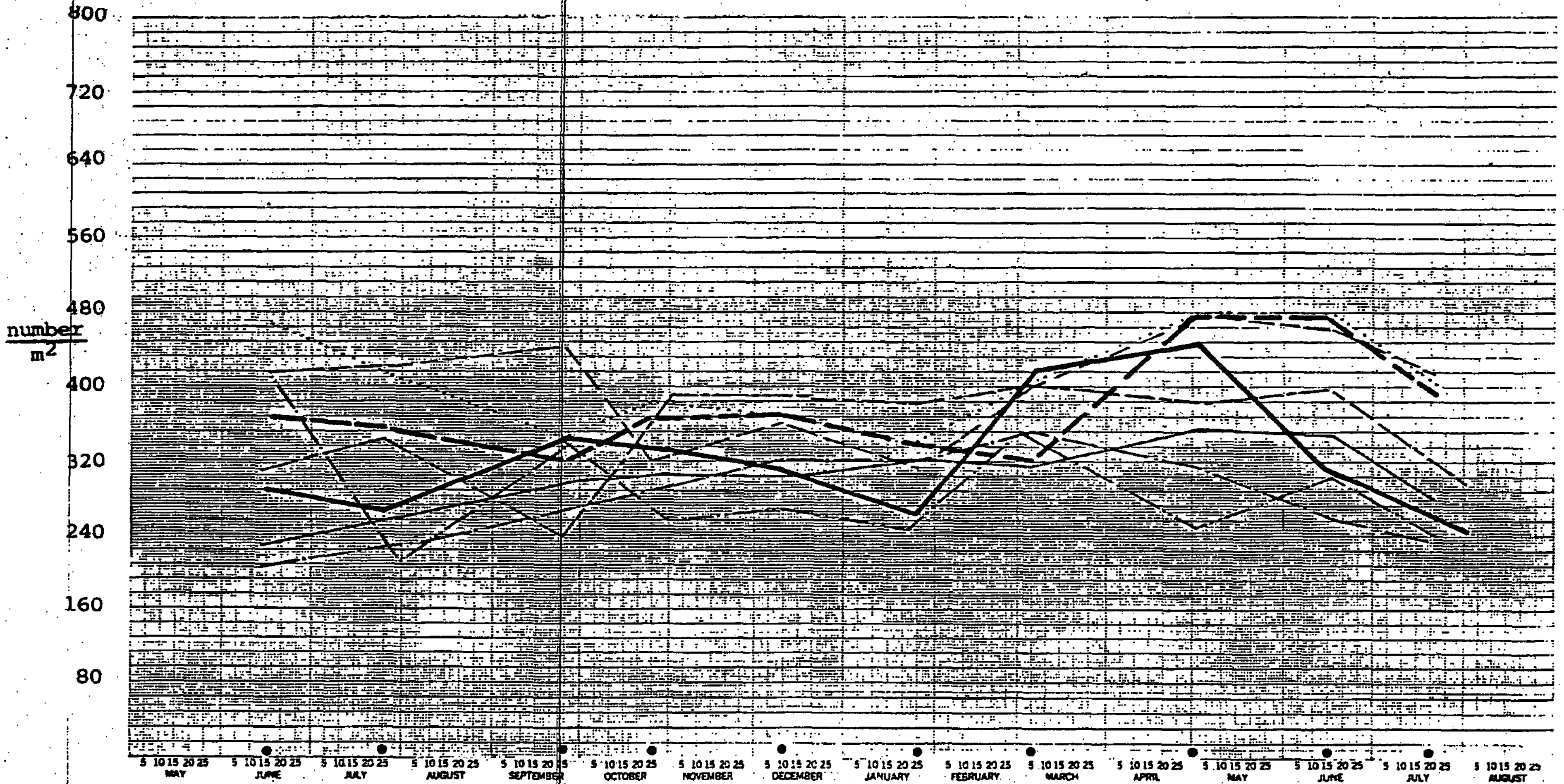
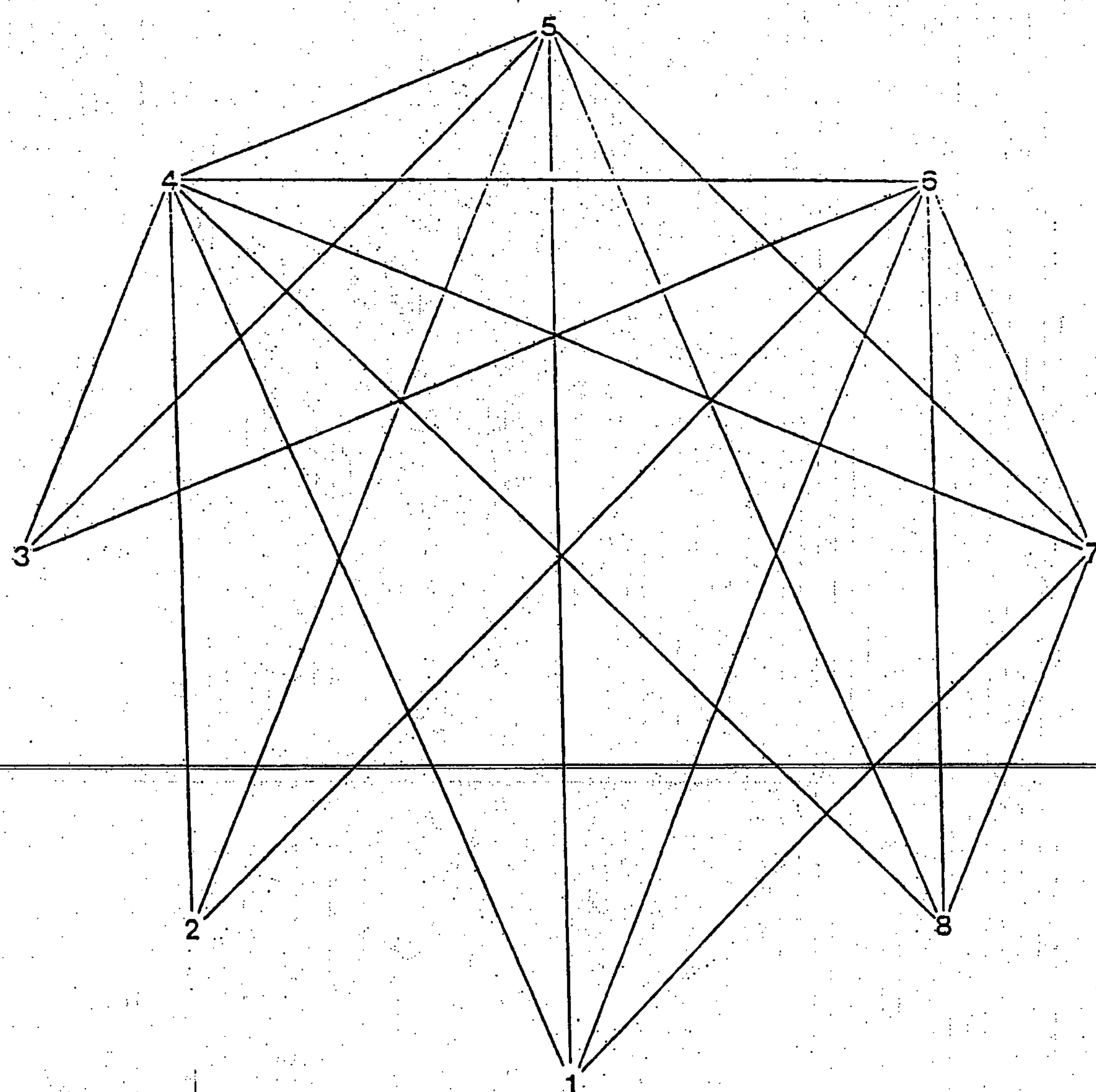


FIGURE 6.4-38

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

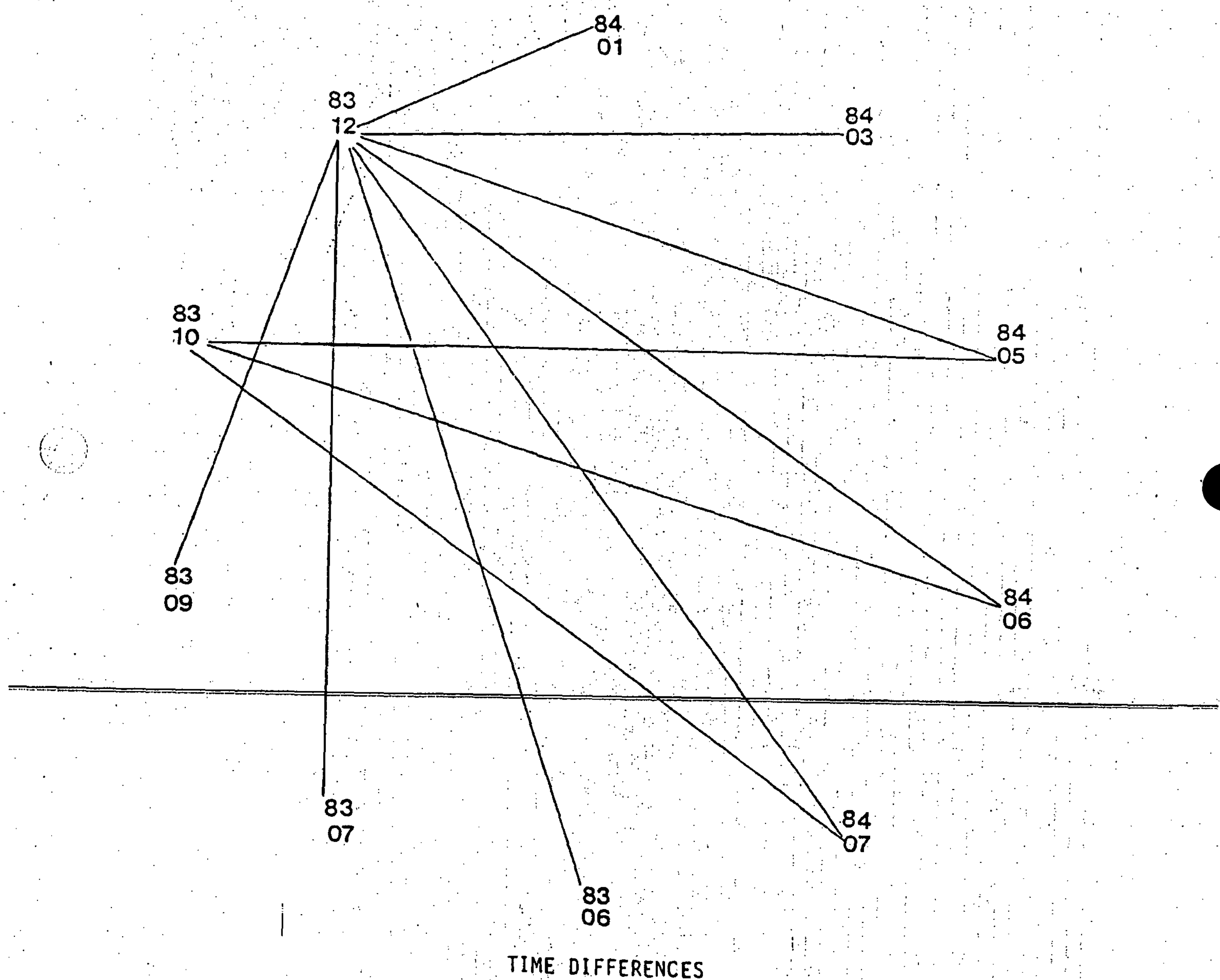


FIGURE 6.4-40

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

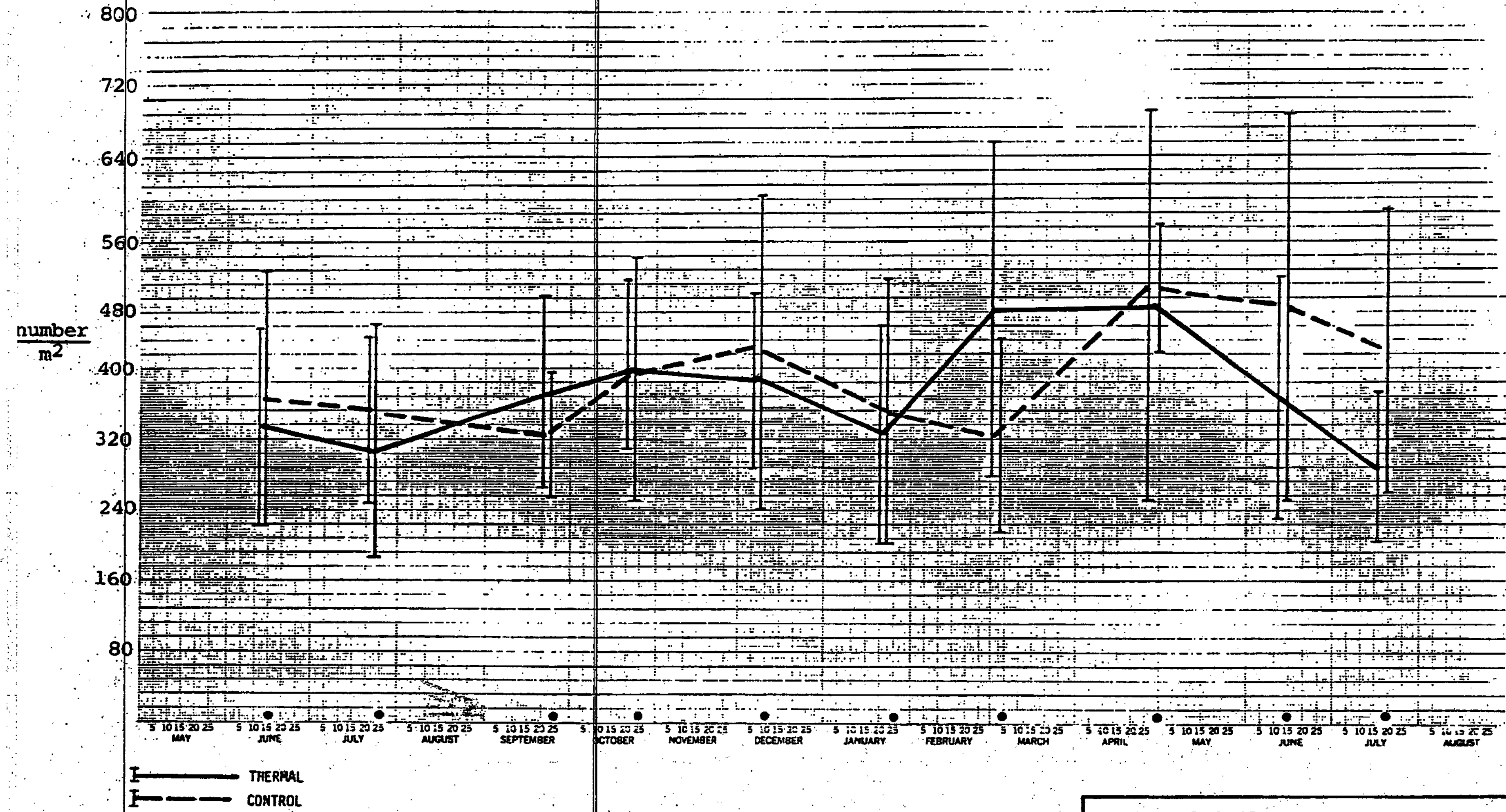
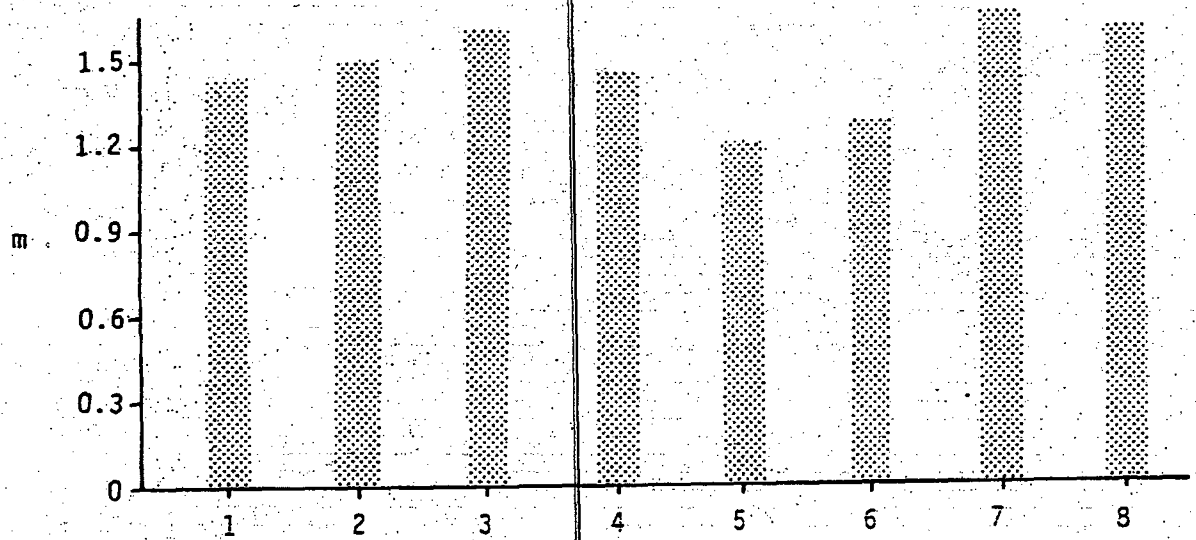


FIGURE 6.4-41

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

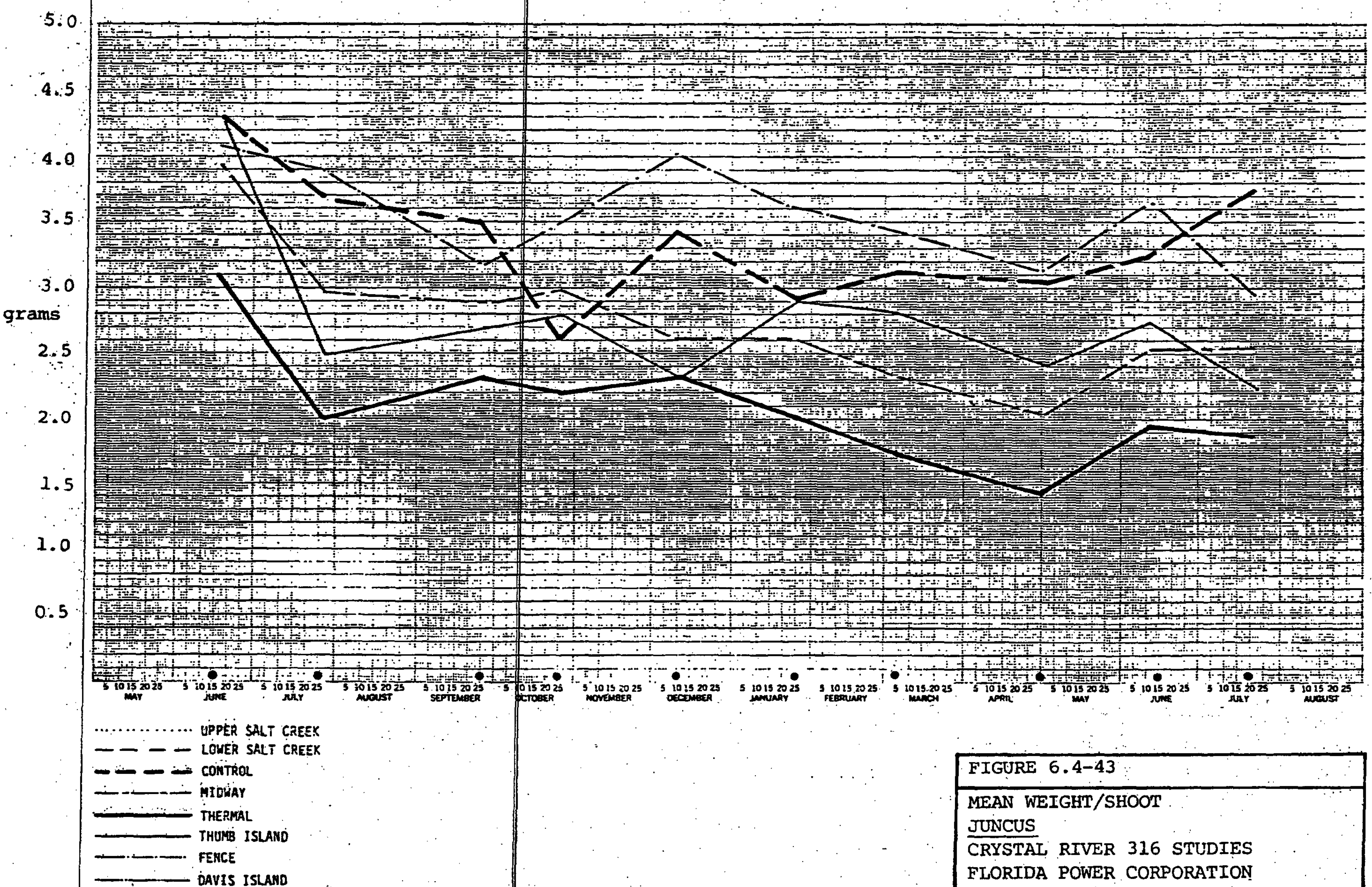


FIGURE 6.4-43

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

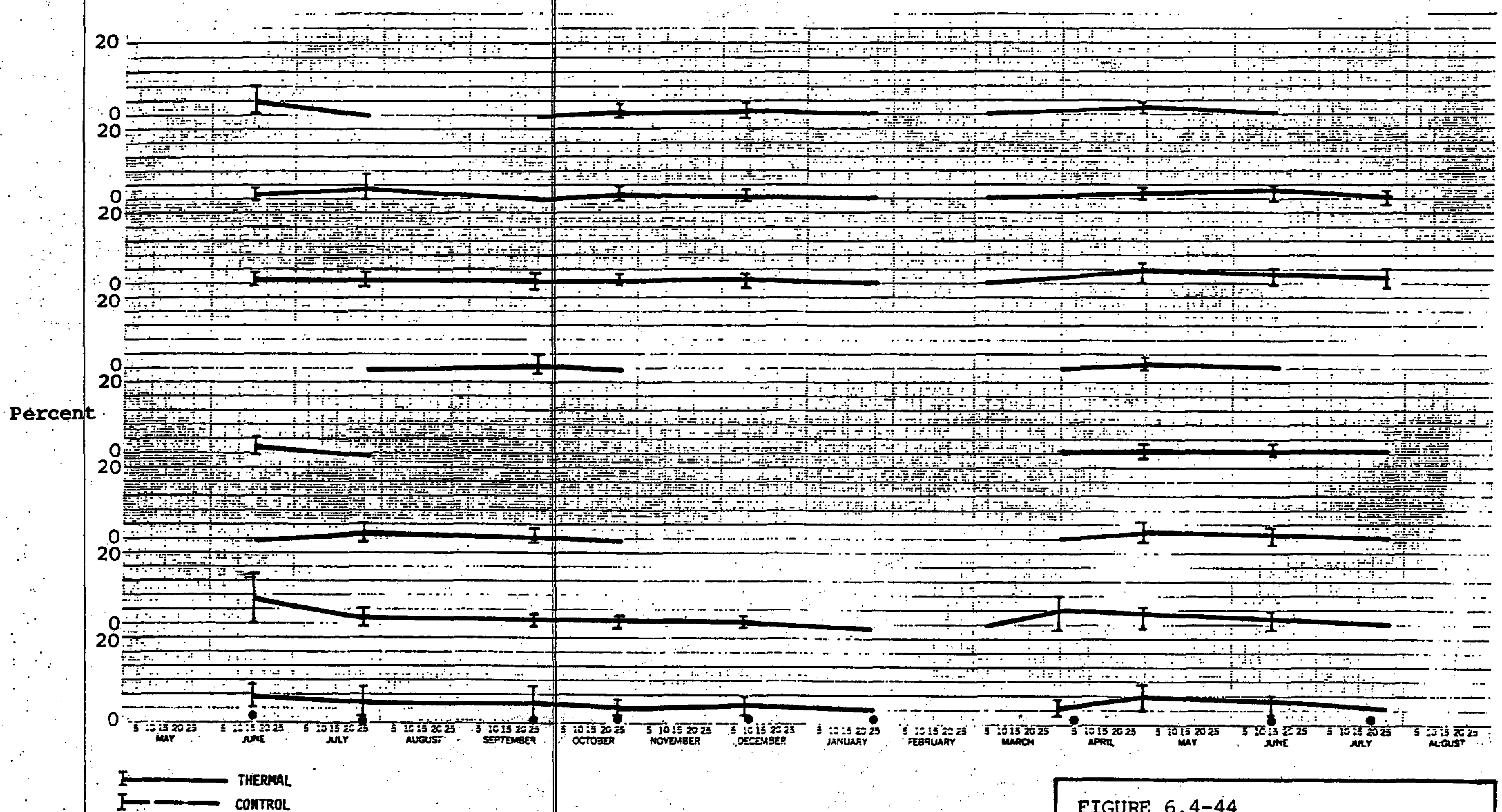
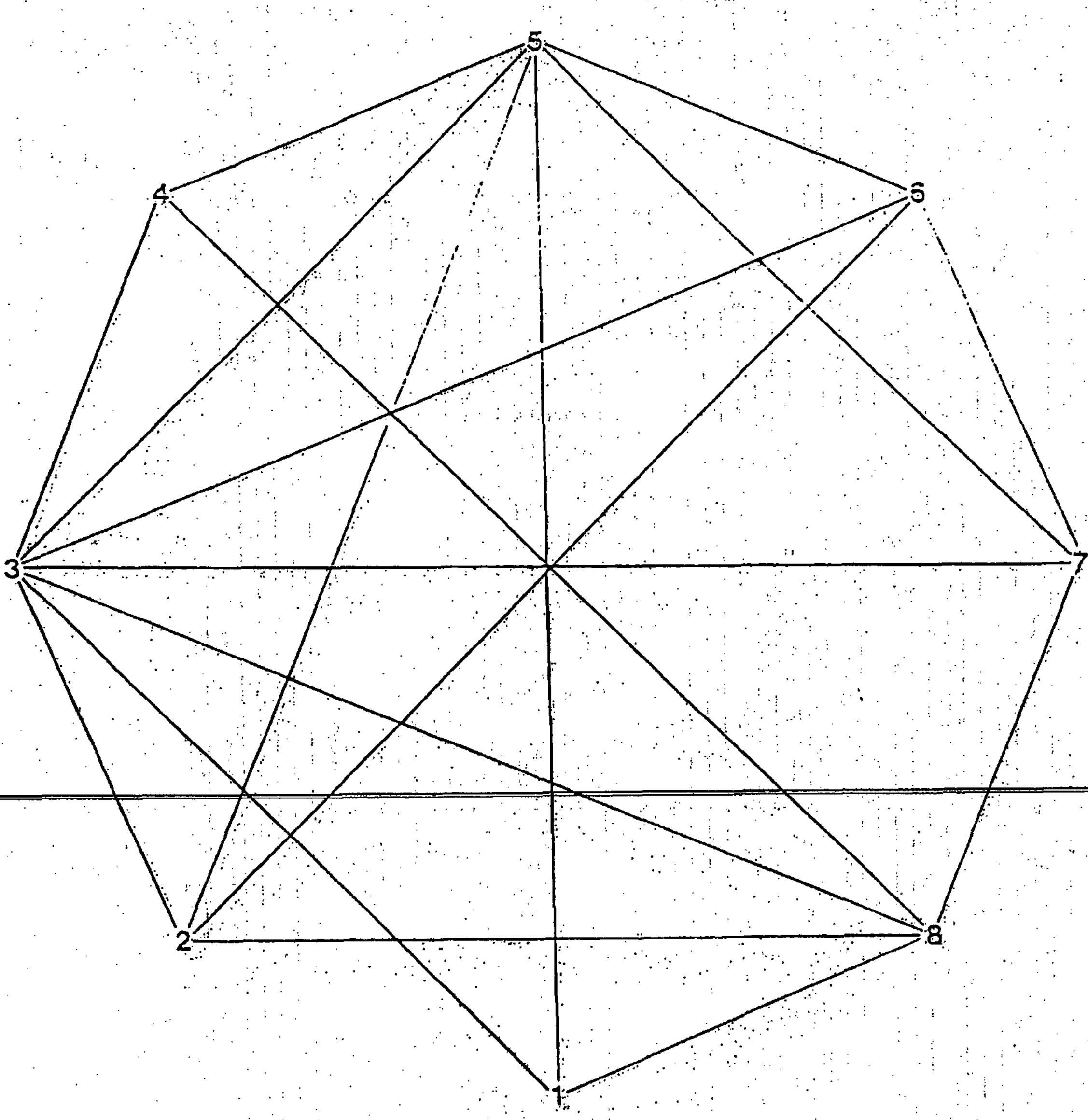


FIGURE 6.4-44

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

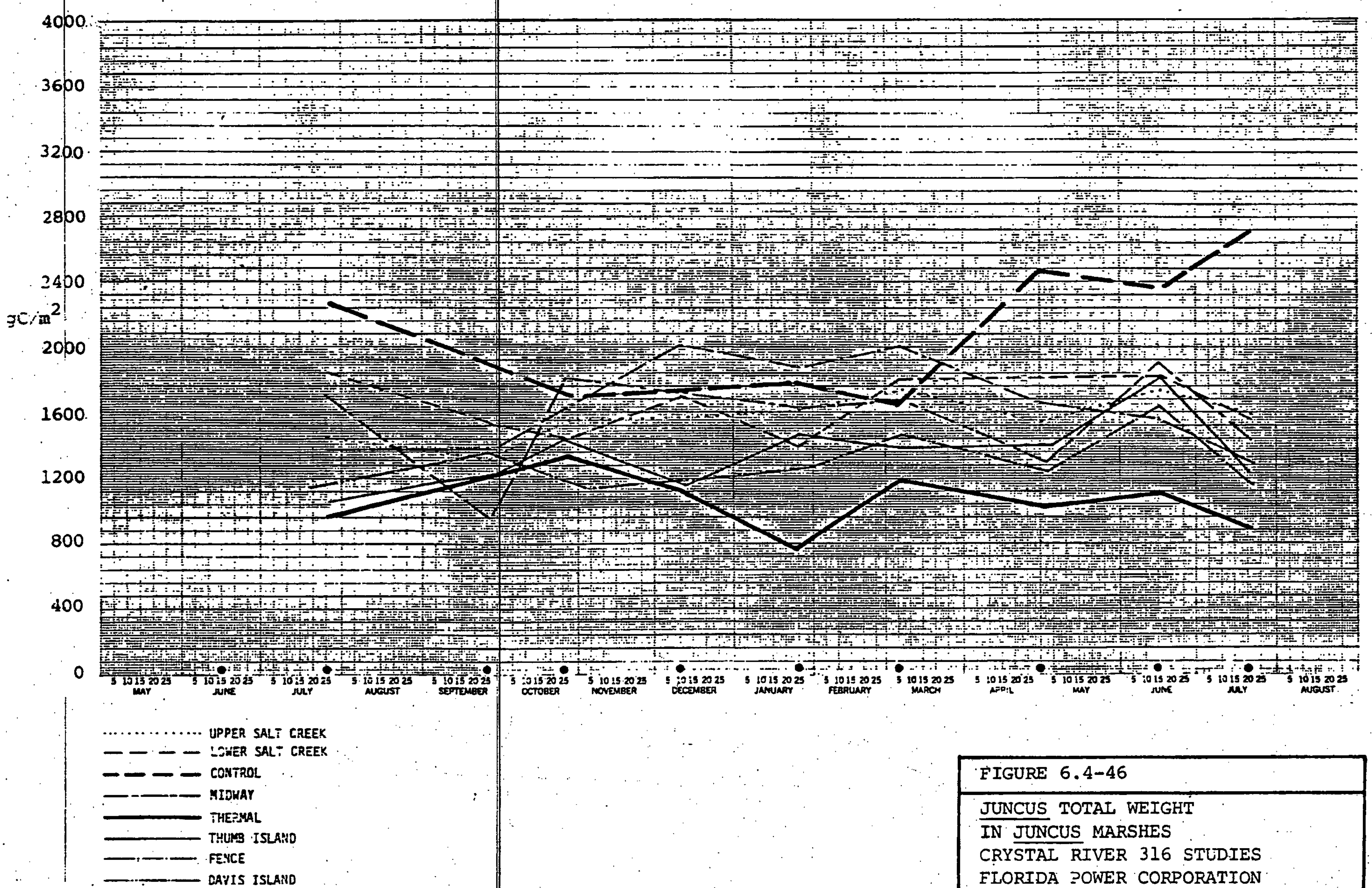
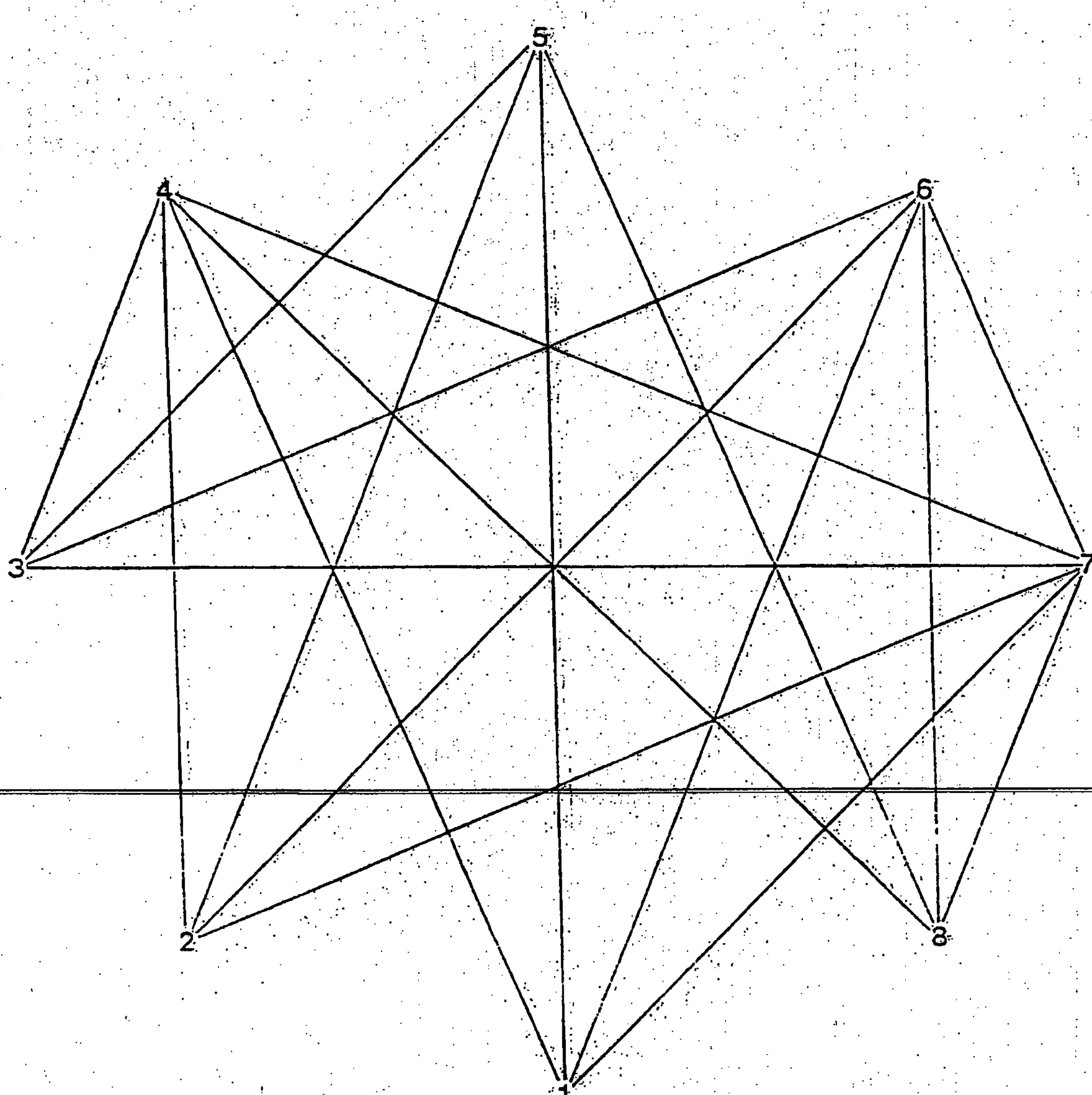


FIGURE 6.4-46

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

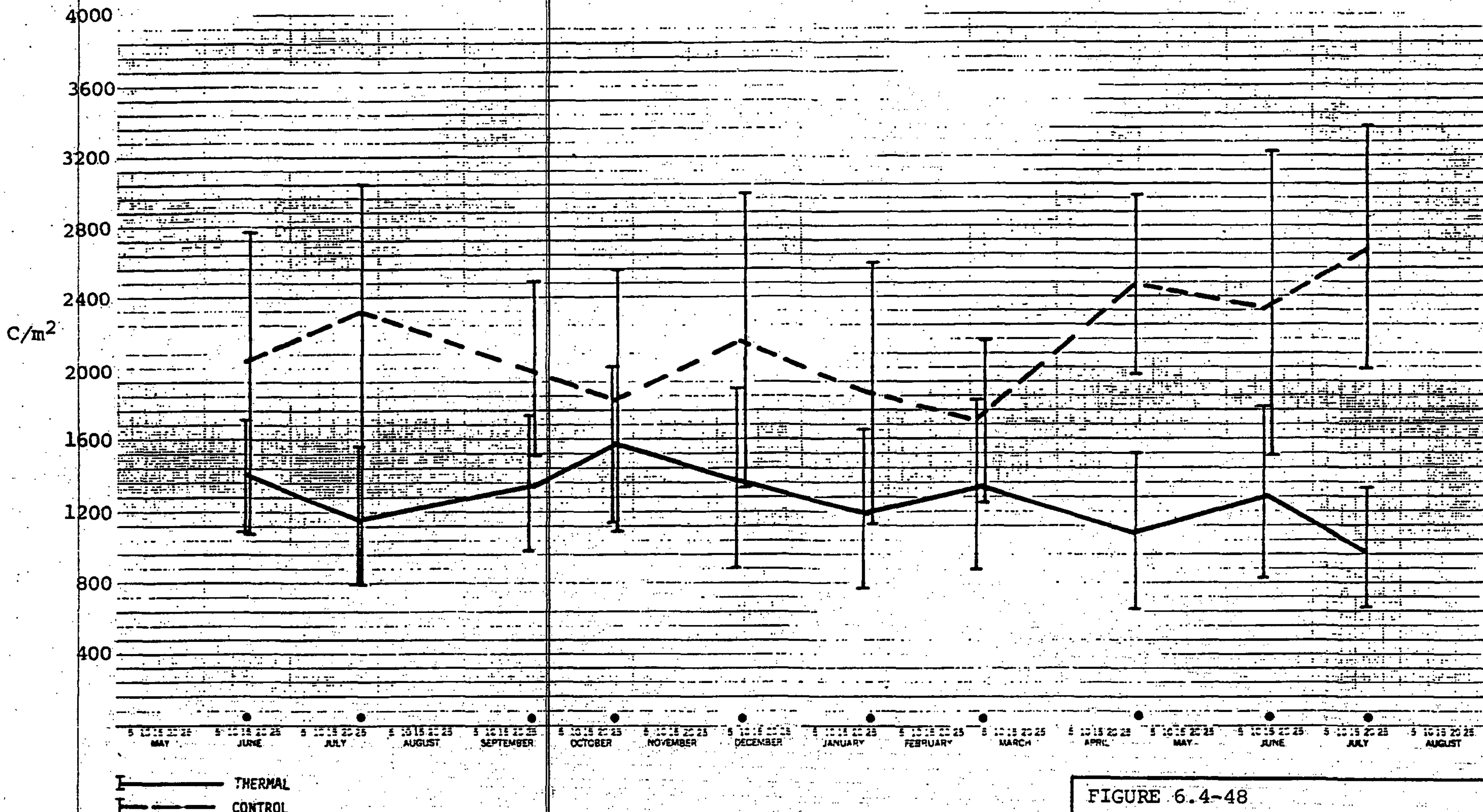


FIGURE 6.4-48

COMBINED TOTAL WEIGHT
IN <u>JUNCUS</u> MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

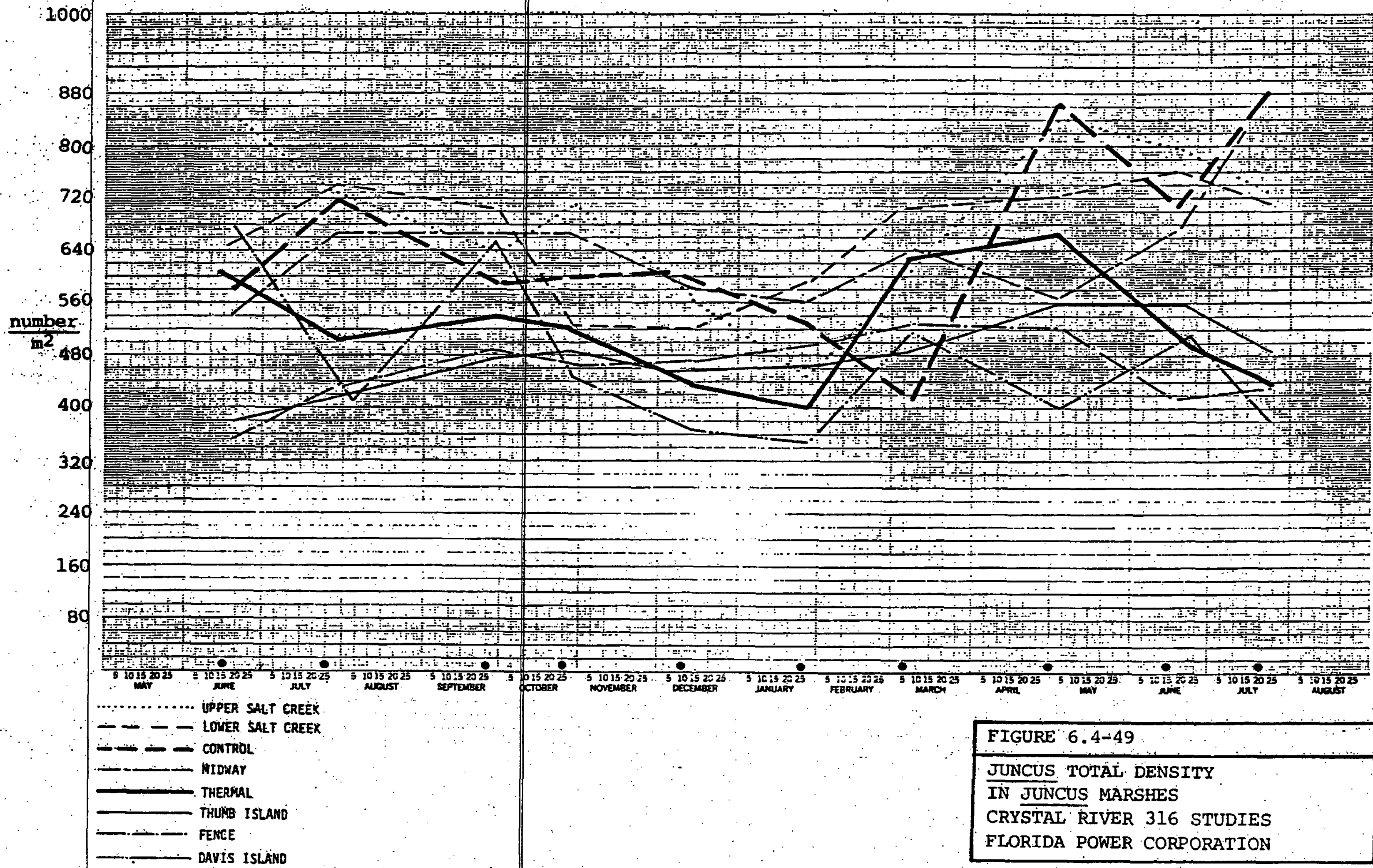
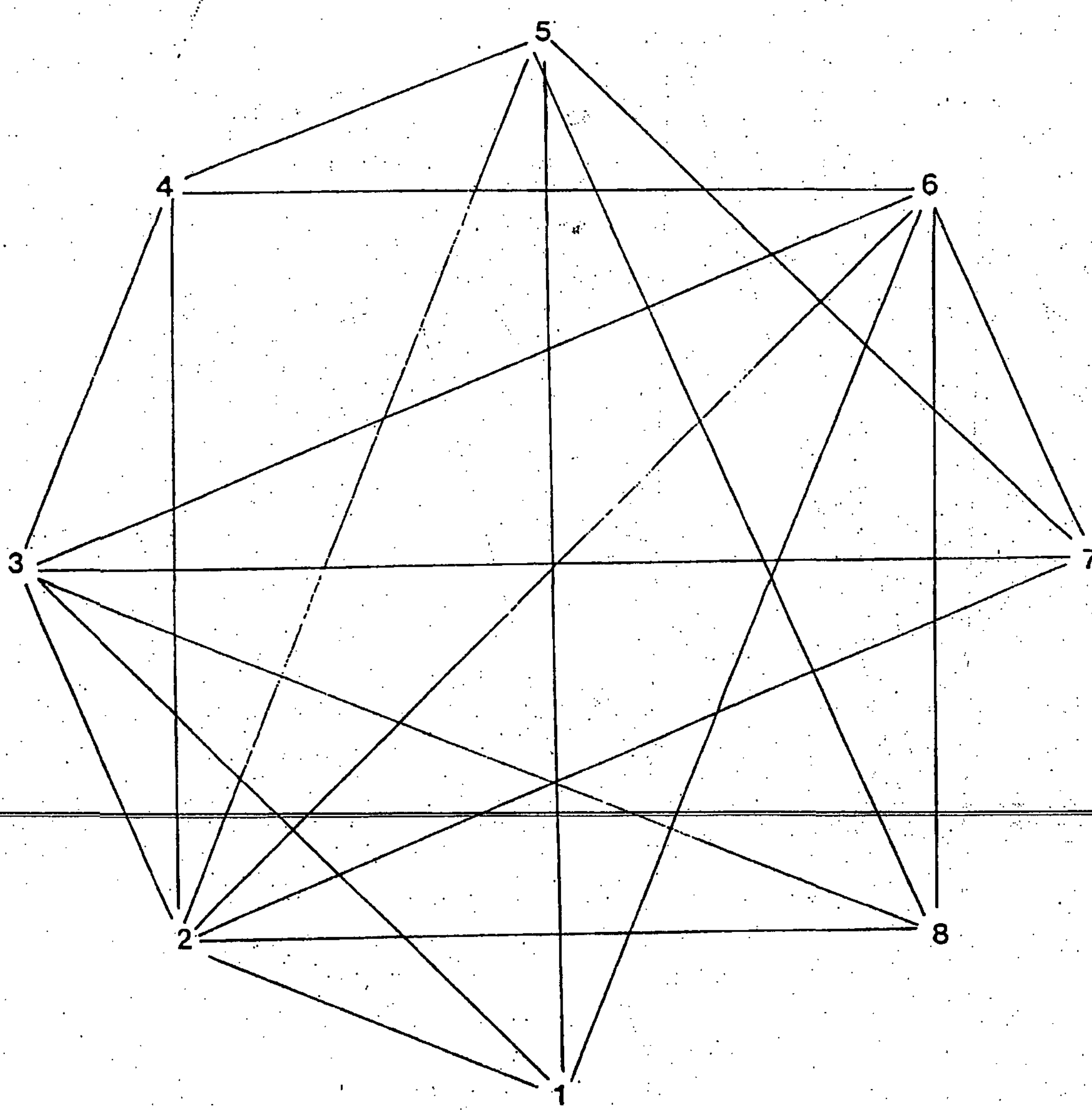


FIGURE 6.4-49

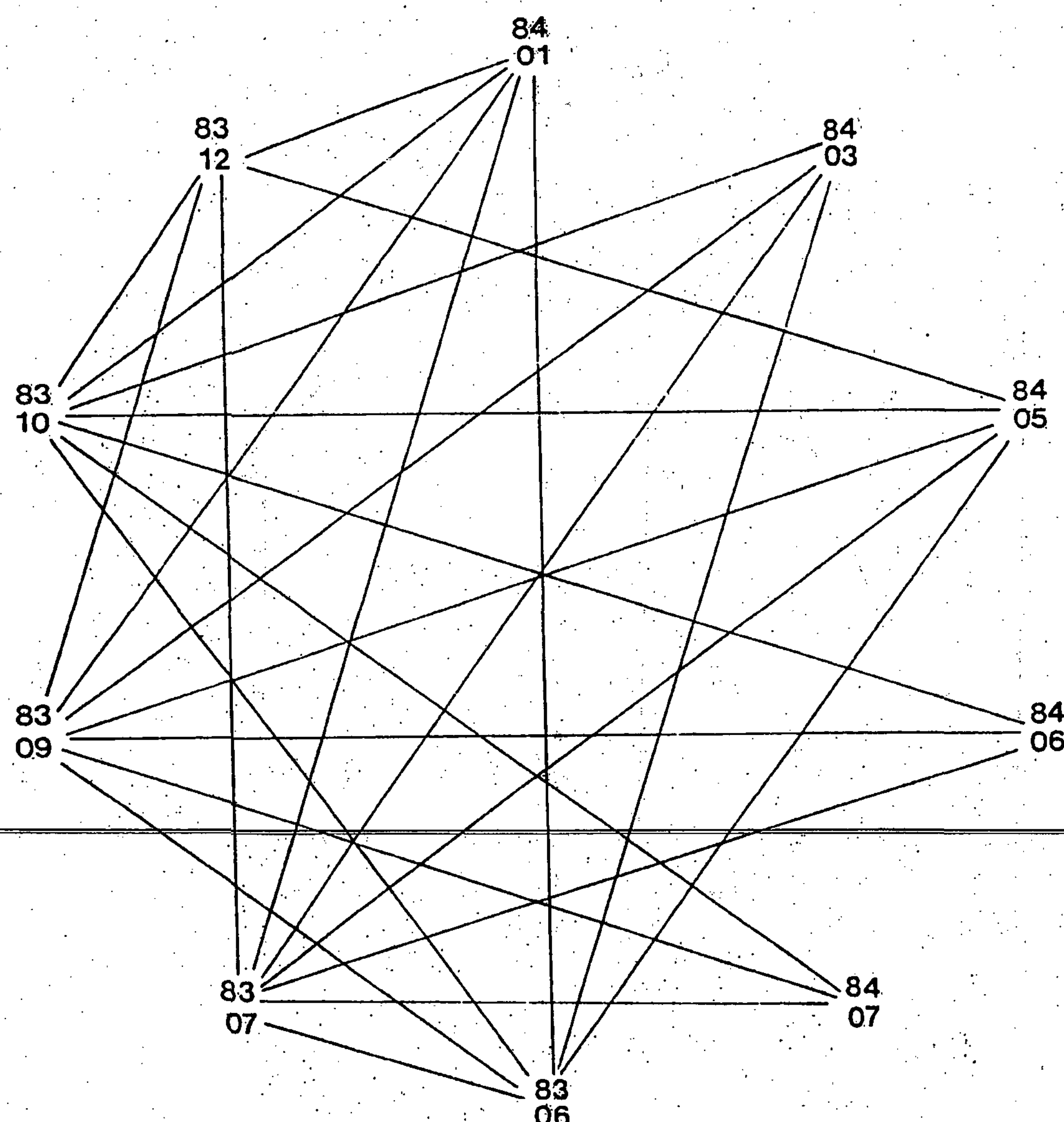
JUNCUS TOTAL DENSITY
IN JUNCUS MARSHES
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



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

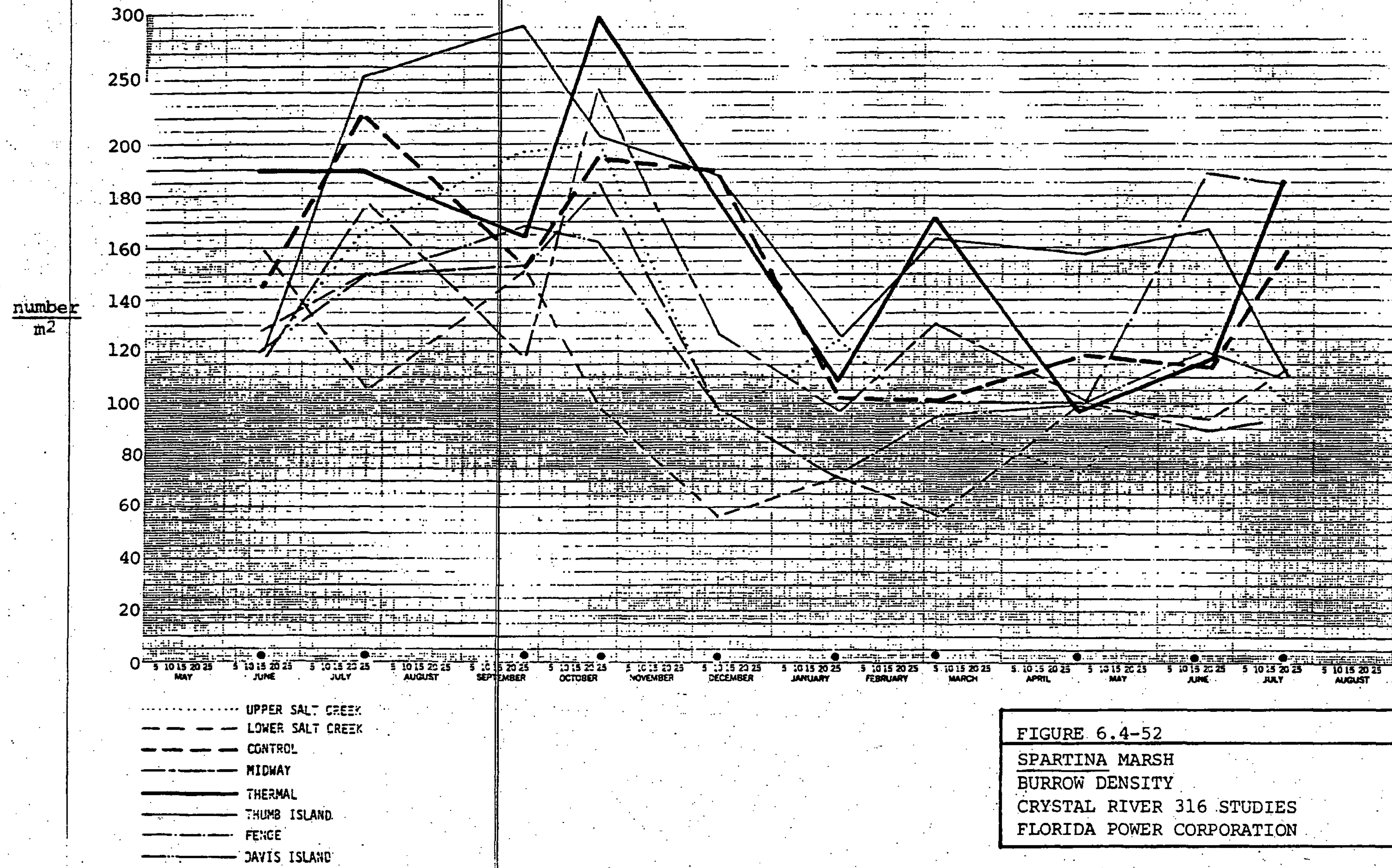
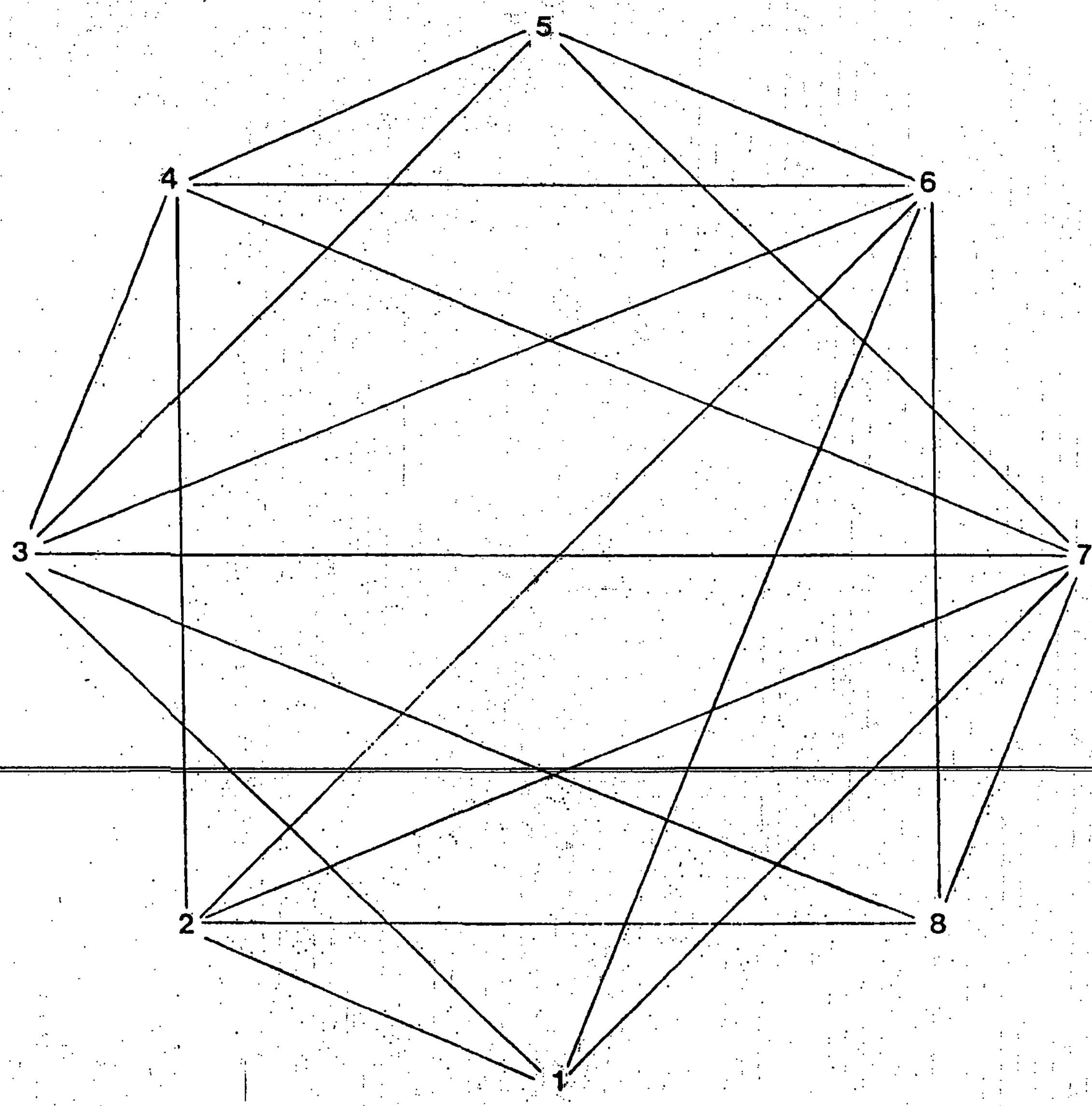


FIGURE 6.4-52

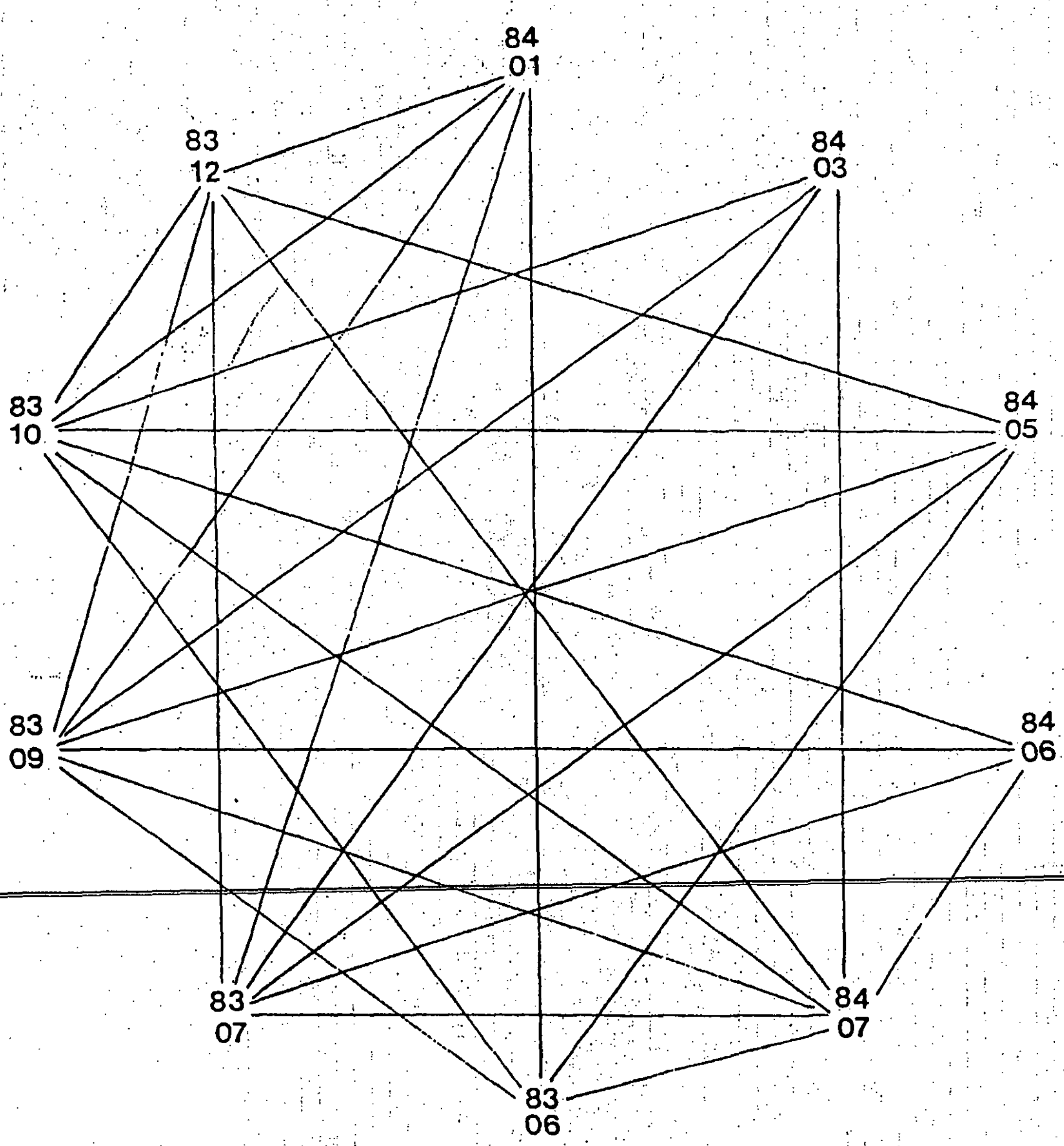
SPARTINA MARSH
BURROW DENSITY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



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

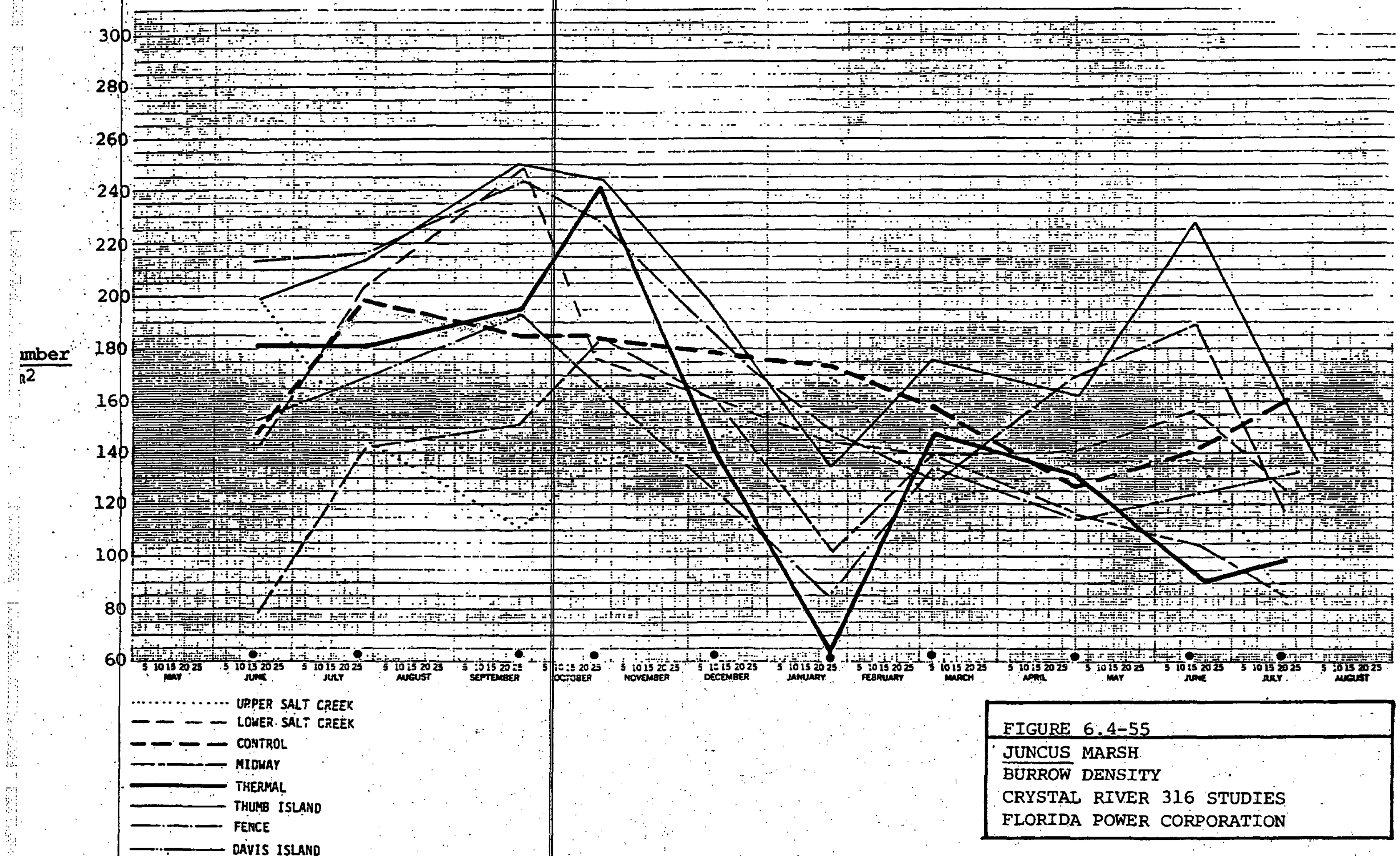


FIGURE 6.4-55

JUNCUS MARSH

BURROW DENSITY

CRYSTAL RIVER 316 STUDIES

FLORIDA POWER CORPORATION

6.5 OYSTER REEFS AND ASSOCIATED FAUNA

6.5.1 Sampling and Laboratory Analysis

Nine stations were selected in the study area (Figure 6. station, cages of oysters were deployed under comparable con to an oyster reef. In all cases, the cages were placed about low water. Cages were constructed of 1/4 in. mesh, galvanize to contain the oysters for short and long term growth and mo Each cage consisted of 10 compartments each containing an oy

Prior to deployment oysters were collected near the barge c culled, cleaned with brushes, and then placed in the int processed. During processing the height, length, volumetric weight of each oyster was recorded. Height is measured as t the dorsal to the ventral shell margin. Oyster length is t from the anterior to posterior shell margin. When nine cages had been filled, they were bundled together to form a station.

Each month one bundle of 90 premeasured oysters was anchored with cement blocks at each of the nine stations; the bundle placed the previous month was collected. Dead oysters were noted, and the live oysters were remeasured and weighed. Each live oyster was shucked, and the wet meat was weighed. The meat and shell were then baked in foil pans at 100°C for 24 hours, and then weighed.

Before they were shucked, ten retrieved oysters were chosen randomly from each station for each sampling and inspected under a dissecting microscope for oyster spat. If ten live oysters were not present at any station, the shells of dead retrieved oysters were substituted. The spat were counted, removed, and the combined meat weighed wet, then again after drying at 100°C for 24 hours.

In addition to the monthly sampling, six bundles of 90 premeasured oysters were placed at each of the nine stations in July 1983. One bundle was collected every other month for 1 year. The same analyses were performed on the long term oysters as on the short term oysters, including oyster spat analysis.

Each month three clumps of oysters were collected from the reefs at each station. The clumps were placed in cloth bags and then transported to the on-site facility. The bagged clumps were submerged in a 15 percent $MgSO_4$ solution for narcotization of the associated fauna. Each clump was later broken up and the number of live oysters greater than 2 cm in height was noted. The sample was then concentrated by pouring through a 0.5 mm sieve. Most shell was rinsed and discarded. The samples were later sorted and organisms identified and enumerated.

The SAS GLM Procedure was used to compare changes in length, weight, height, volume, and condition index of monthly oyster collections. The effect of covariates in such a model were also explored. The live/dead data was analyzed with a contingency table analysis since this data was bivariate (live-dead). This type of analysis compares the relative numbers in a two-way table (for instance, live/dead vs station number) and determines if some stations have a statistically significant difference in relative proportion of live/dead by station (or period). Long-term oyster collections were similarly analyzed using the GLM procedures to compare treatment duration, station and duration-station interactions. Associated faunal data was evaluated by calculating Morisita's index of faunal similarity for all station pairs.

6.5.2 Results

Abiotic Parameters

The temperature and salinity measurements made weekly at photometry stations were used to characterize the environments of the oyster stations. Monthly averages were determined for each parameter at the photometry station nearest each oyster station. The mean monthly values were then determined for the nine selected stations and the differences from the mean were plotted (Figures 6.5-2 and 6.5-3). The temperature and salinity values obtained at photometry stations are referred to with the designation of the nearest oyster station (OR1, OR2, etc.). Maximum and minimum temperature and salinity values from weekly measurements at each station are presented in Table 6.5-1.

Stations OR1, OR2 and OR9 were well below the mean temperature (of all oyster stations) each month (Figure 6.5-2). Station OR3 also was slightly below the mean each month. Temperatures at OR7 and OR8 were similar, with temperatures near the mean. The effect of the thermal effluent is evident at Stations OR4, OR5, and OR6. A greater temperature difference between the stations south of the intake canal (OR1, OR2) and the thermal stations occcurred in winter than in summer. The temperature difference between OR1 and OR4 was nearly 12°C in December and only 4°C in July.

The deviations from the mean monthly salinity measurements are shown in Figure 6.5-3. Salinity was highest near the discharge and decreased with distance from the plant. Station OR9, however, had much lower salinities (about 10 ppt) than any other station. Lowest salinities occurred in April at each station. Highest salinities were generally observed in October and November.

Mortality

Oyster mortality was significantly correlated with both season and station. Significantly higher mortality occurred in September, October and November 1983 and February 1984, and at Stations OR4, OR5, and OR6. Figure 6.5-4 shows the percent mortality at each of the nine stations over the 12 monthly short-term oyster samplings. The seasonal trend of high late summer-early fall mortality and low winter mortality is roughly discernable at each station. The oysters collected during the February sampling period may have been stressed by subfreezing temperatures and very low tides. This may explain the increase in mortality rate which occurred at every station that month. Many gaping oysters with the meat still intact were observed on oyster reefs during the February field work. Increased mortality of Gulf oysters growing at mean low water levels during periods of sudden winter freezes has been documented (Butler 1954).

The high mortalities in September, October and November coincide with high water temperatures and the highest salinities of the study year at most stations. Higher oyster mortality in late summer is not uncommon (Copeland and Hoese 1966). Dawson (1955) observed an increasing rate of mortality of Crystal River oysters from April to July, when his study terminated.

Among stations, oysters at OR4, OR5, and OR6 had the highest mortalities. Incidences of mortality significantly higher than the mean at a station for each sampling date are indicated on Figure 6.5-4. Twelve of the fifteen significant points occurred at Stations OR4, OR5, and OR6. Higher salinities and temperatures were found at these stations. The detrimental effect of combined exposure to high temperatures and salinities combined has been demonstrated (Quick 1971). However, the salinities at OR4, OR5, and OR6 were only a few parts per thousand higher than those at any other stations with the exception of OR9. Salinities at OR9 were approximately 10 ppt lower than at all other stations. Mortalities at OR9 were similar to other stations.

The percent mortality of the long-term oysters is presented in Figure 6.5-5. Over 75 percent of the oysters from OR4 and OR5 were dead after only 2 months. Only at Station OR1 did many oysters survive the entire study period. At every other station more than 75 percent of the recovered oysters were dead at the last collection. Heavy siltation was observed on the oysters at Stations OR5 and OR6 and certainly contributed to the mortalities there. In January 1984, approximately 30 percent of the oysters at OR4 were observed to be buried. To counteract high sedimentation rates, the oyster cages were raised above the sediment. In February, however, about 15 percent of the oysters at OR4 and OR5 were silted over, and in April all OR4 and OR5 oysters were buried. None of the oysters deployed and collected monthly were silted over.

Short-Term Oyster Growth

The height, length, volume, and weight of each oyster were measured before and after deployment in the field. The mean monthly increases in growth are presented in Figures 6.5-6 and 6.5-7. The monthly oyster growth at each station is illustrated only for the parameter of weight (Figure 6.5-8). Results were fairly consistent, however, with all four growth parameters.

The rate of oyster growth was affected by the seasons (Figure 6.5-6). Overall growth rates increased during the fall, fell sharply in January and February, increased again during spring and appeared to be dropping again (with 3 of 4 parameters) in summer. An isolated peak of growth is apparent in March in the plot of each growth parameter. This peak follows two months of little or no growth. The drop in growth rates in June is probably related to spawning. Heavy spatfall occurred on the oysters collected in June (Figure 6.5-11). Dawson (1955) observed minimum growth of Crystal River oysters in March and April and maximum growth in December, January and June. Although the exact months do not coincide, observations by Dawson and the present study are in agreement on the existence of a minimum growth period in winter-spring and of two rapid growth periods - one immediately preceding the slow growth period and the other in May or June. The maximum growth in height of 0.8 mm weekly observed by Dawson is comparable to the maximum height increases observed in the present study.

Growth rates were low for the oysters at Station OR1 (Figure 6.5-7). Station OR2 oysters showed more growth than those at OR1 in each of the parameters measured. Both stations are control stations south of the intake canal. Water currents may have enhanced growth at OR2, which was located in a gap subject to strong currents.

Growth rates of oysters at Station OR8 were not high. Station OR7 oysters grew significantly greater than those at OR8 in 3 of 4 parameters measured, although temperatures and salinities were very similar at the two stations. Again, the growth difference may be related to water currents; OR7 was located in a high current location. Growth rates at Station OR3 were similar to those at OR7.

Oyster growth was not impeded at the thermal stations. Oysters at OR6 showed the greatest growth in 3 of 4 parameters. Station OR5 oysters, however, grew less than those at OR6, and in turn OR4 oysters grew less than those at OR5. Stations OR6, OR5, and OR4, respectively, fall along a gradient of increasing thermal exposure. In general, growth at the thermal stations, particularly OR5 and OR6 was greater than at control stations.

Salinities at Station OR9 were much less than at any other station, which complicates assessing thermal effects on growth rate through comparisons of OR9 to the other stations. Growth at OR9 was always greater than growth at the control Station OR1, however, and never significantly different than growth at OR2, another control station.

Long-Term Oyster Growth

The growth of the long-term oysters at all stations is illustrated in Figure 6.5-9. Each of the four growth parameters measured indicate slow growth of oysters collected during the first 10 months. Weight and height increases between the 4 and 6 month duration periods (collected in November and January) were not significantly different, nor were the increases between the 8 and 10 month duration periods (collected in March and May). Growth analysis of the short-term oysters revealed a rapidly declining growth rate in oysters collected in December and January (Figure 6.5-6), which coincides with the insignificant growth observed between the 4 and 6 month duration periods. The insignificant growth difference between the 8 and 10 month periods coincides with the drop in growth rate observed in the short-term oysters collected in April. The sharp increase in growth rate evident in the July collection of oysters does not coincide with a particularly rapid growth period in the last two months of the short-term oyster growth study, except in the parameter of weight.

Analysis of long-term oyster growth by station revealed poor growth at Station OR1 (Figure 6.5-10), consistent with that found in the short-term growth study. Again, growth at OR2 was significantly greater than at OR1 in each parameter. Greatest growth was observed at Stations OR6 and OR7. Unlike results of the short-term growth study, mean growth at OR4 and OR5 was much less than OR6 and OR7. Growth at OR4 and OR5 was not significantly different than at the control Stations OR1, OR2, and OR9, however.

Oysters at Station OR3 grew more in volume and weight (but not height and length) than oysters from OR1, OR2, OR4, OR8, and OR9. In the short-term growth study, oyster growth at OR8 was not high. In the long-term study, OR8 oysters grew significantly less in all four growth parameters than those only at Station OR7. Oysters at Stations OR6 and OR3 had higher growth rates than oysters at Station OR8 in some parameters.

In summary, the long term oyster growth analysis revealed greatest growth at two thermally affected stations (OR6 and OR7) and no significant differences in growth between the oysters subject to the highest discharge temperatures (OR4 and OR5) and those at the control stations.

Spat and Condition Index

Ten oysters retrieved monthly (short-term oysters) from each station were examined for the presence of oyster spat. Spat abundance is graphically illustrated in Figure 6.5-11. The seasonal pattern of heavy spatfall in fall and for a short period in spring is evident at most stations. Spatfall at Stations OR6, OR7, OR8, and OR9 was very similar, with greatest numbers of spat in June. Stations OR2 and OR3 had moderate spatfall with the fall and spring peaks nearly equal. Fewest spat were found at OR1, OR4, and OR5. Siltation on the oysters may have contributed to the smaller numbers of spat at Stations OR4 and OR5.

Oyster condition index (CI) of the short-term oysters is also presented on the graph of spat abundance (Figure 6.5-11.). CI is the dry oyster meat biomass times 100 divided by the shell cavity volume. The shell cavity volume is determined by subtracting the shell weight from the oyster weight. This method is valid because the effective density of cavity contents is close to 1 g per cm^3 Evaluation of CI may allow use of oysters as environmental monitors (Lawrence and Scott 1983). The peak of CI during the period of minimum spatfall is evident in Figure 6.5-11. An increase of CI after spawning has been previously demonstrated (Galtsoff 1964).

The CI of short- and long-term oysters were analyzed to identify differences between the oysters from different stations. Seasonal CI, mean CI at each station and results of a between station significance test for short-and long-term oysters are presented in Figure 6.5-12. The seasonal pattern of highest CI in spring is less conspicuous in the long-term oysters. Very few oysters survived to be analyzed for CI in the later sampling periods of the long-term study, however.

The similarity of the pattern of CI values at the nine stations in both the short- and long-term oyster studies reduces the concern that short-term CI values were biased by the condition of the oysters at the time of their deployment. Oysters at the thermally affected stations did not have reduced CI values. Station OR4 values were lower, however, than OR5 values, which, in turn, were lower than those at OR6 (short-term oysters). The CI was significantly greater at OR6 and OR7 than at the control Stations OR1 and OR9 in both the short- and long-term oyster studies. CI values at OR4 were not significantly different than values of OR1 and OR9 in either study. Oysters from OR3 had greater CI values than those at OR2, and OR2 oysters had greater values than those at OR1.

A similar pattern frequently occurred in the oyster growth and CI studies. The pattern was comprised of: increasing values from OR1 to OR2 to OR3;

decreasing values from OR3 to OR4; increasing values from OR4 to OR5 to OR6; decreasing values from OR6 to OR7 to OR8; and low to moderate values at OR9. This pattern occurred in the short-term oyster height and weight analysis (Figure 6.5-7) and the short-term CI analysis (Figure 6.5-12). Growth and CI showed a positive correlation.

Associated Fauna

Species Composition

A total of 59,840 organisms comprising 175 taxa were collected and identified during the study (Table 6.5-2). The most abundant individual taxon was the polychaete *Polydora websteri*, which comprised 11.5 percent of the total fauna. This species was particularly abundant in the thermal area (Stations OR4, OR5, and OR6) where it comprised 27 percent of the total fauna. The second most abundant taxon was the crab *Eurypanopeus depressus*, which comprised 9.5 percent of total faunal abundance. Third in overall abundance was the mollusc taxon Mytilidae spp. (9.0 percent of total fauna). The most abundant individual group of organisms was Mollusca, which comprised 30 percent of total abundance. Second in abundance was the group Polychaeta (28 percent of total abundance). Although these two groups were relatively close in total numbers, their distributions were quite different, with polychaetes dominant at thermal stations and molluscs dominant at south control stations.

Certain large and/or mobile organisms which are well known to be associated with oyster reefs (the American oystercatcher, *Heamatopus palliatus*; the lightning whelk, *Busycon contrarium*; the crown conch, *Melongena corona*; and the blue crab, *Callinectes sapidus*) were observed but not collected. The numbers of oysters reported in the associated fauna include only oysters greater than 2 cm in height. The group Nematoda and barnacles of the genus *Balanus*, although collected, were recorded only as present or absent.

Seasonal Comparisons

Oyster faunal abundance by species and sampling period are given in Appendix V. Total numbers of individuals collected through the twelve sampling periods are given in Figure 6.5-13. Seasonally, faunal densities were greatest in early fall, followed by marked decreases during winter and only a slight recovery during the following spring and summer. This limited recovery may be due in part to the extremely cold winter experienced in the Crystal River area during 1983-84. Unusually low tides, combined with air temperatures well below freezing, may have caused high mortality among the exposed associated faunal populations. Figures 6.5-14 through 6.5-19 show seasonal patterns for six of the most abundant organisms collected, including *Crassostrea virginica*. The effects of the harsh winter in Crystal River are best illustrated in abundances of Mytilidae sp. (Figure 6.5-15), *Odostomia impressa* (Figure 6.5-16), and *Melita* spp. (Figure 6.5-17). At stations within the immediate thermal area (OR4, OR5, OR6), values remained generally low or appeared to be unaffected by the cold temperatures. With the exception of a general decrease during the winter months, seasonal patterns of individual taxa are difficult to discern, particularly in certain opportunistic species, which reproduce throughout the year. This is best illustrated in the seasonal data for *Polydora websteri* (Figure 6.5-18) and

Platyhelminthes spp. A + B (Figure 6.5-19), which have numerous peaks in abundance throughout the year. In addition, it is extremely likely that since an oyster reef environment forms a non-uniform substrate, distribution of the associated fauna may be highly patchy, with numbers of individuals collected being dependent upon the number of crevices or gaping oysters available to provide a suitable habitat.

Spatial Comparisons

Total numbers of individuals collected at each station over the year are shown in Figure 6.5-13. Greatest numbers were found at control Stations OR1 and OR2. Lowest numbers were observed at Station OR4, followed by a progressive increase at Stations OR5, OR6, and OR7, respectively. Noticeably low numbers also occurred at Station OR9, which had values nearly as low as those found at the station closest to the point of discharge (OR4). This is believed to be due to the marked decrease in salinity and increase in suspended solids caused by the combined freshwater input from both the Withlacoochee River and the Cross Florida Barge Canal. Both species diversity (Shannon-Weaver H') and evenness (Pielou, J') exhibited a similar, nearly linear increase with distance from the point of discharge (Figure 6.5-20). Highest mean diversity observed was at Station OR1 (H' = 2.48). Lowest mean diversity was at Station OR4 (H' = 1.72). Neither species diversity or evenness exhibited any particular seasonal pattern, although there was a greater amount of variability in both H' and J' at Stations OR4, OR5, and OR6.

Figure 6.5-21 displays the percentage breakdown of major groups of associated fauna by station. The group Mollusca was the dominant component of the associated fauna at both stations OR1 and OR2. Polychaetes were the most abundant group at Stations OR3, OR5, OR6, and OR7. Amphipods were slightly greater in abundance at Station OR4, however. This is primarily due to a large number of the amphipod *Corophium ascherusicum* collected during the month of April. Abundances of molluscs decreased drastically at stations within the thermal area. Lowest numbers of molluscs occurred at Station OR4, where they comprised only 2.3 percent of the total faunal abundance. In contrast, molluscs comprised 38.5 percent at Station OR1 and 56.0 percent at Station OR2. Mollusc abundances gradually increased with increasing distance from the point of discharge, and once again became the most abundant group at Stations OR8 and OR9. Polychaete abundances remained relatively high at Stations OR8 and OR9 where they were second in overall abundance, as they were at Stations OR1 and OR2. In contrast to the high spatial variability exhibited by the molluscs and polychaetes, the Decapoda remained relatively constant in abundance among the 9 stations. The Amphipoda, although exhibiting a great deal of variability, showed no particular spatial patterns.

Although there was a great deal of variability in the spatial distribution of individual taxa, the general trend was for noticeably low abundances at Stations OR4, OR5, and OR9. Equally important is the trend toward increasing abundances from Station OR4 to OR7, which can be translated into increasing numbers of organisms with increasing distance from the point of discharge. This trend is particularly evident in the abundances of the common associated fauna presented in Figure 6.5-22. Abundances of the polychaete *Polydora websteri* remained relatively high at discharge Stations OR4, OR5, and OR6. It should be noted, however, that similar increasing values with distance from the discharge still occurred for this species.

Faunal Similarity

A list of similarity values (Morisita's Index) between all station combinations during each sampling period are given as trellis diagrams in Appendix V. Highest similarities were observed between Stations OR4 and OR5, which had a mean Morisita value of 0.75. High similarity was also observed between Stations OR1 and OR2 (0.73) and between Stations OR8 and OR9 (0.70). Lowest similarities observed during the study were between Stations OR2 and OR4 (0.18) and between Stations OR2 and OR5 (0.23).

Overall, Morisita's index values were consistently low when comparing south control Stations OR1 and OR2 to thermal Stations OR4, OR5, and OR6. In only 8 instances out of 72 possible comparisons were Morisita values greater than 0.50 between these two groups of stations. At no time throughout the year was there a Morisita value greater than 0.70 observed between these 2 groups. This suggests that southern stations, far removed from the influence of the Crystal River Power Station, are not only distinctly different from thermal stations in terms of abundance of associated fauna, but also in faunal composition.

6.5.3 Impact Assessment

Thermal effluent did not impede overall oyster growth. Growth was greatest at stations receiving moderate thermal effects. In the area of maximum temperatures, however, growth rates were somewhat lower. This may be the result of reduced ciliary action which occurs at temperatures over 32°C (Galtsoff 1964). Growth at the stations with maximum thermal impact was not, however, less than growth at the control stations. The CI of the oysters also was not reduced in the thermal area. CI values correlated closely with growth rates.

Number of oyster spat was low in the discharge basin (OR4 and OR5) but was also low at one control station. Heavy siltation was observed near the discharge canal and may have limited suitable substrate for spat settlement. Recent studies have indicated fewer spat in the discharge area (Applied Biology 1983).

The key factor in the assessment of the plant effects on the oysters may be the high mortalities in the discharge area. Few oysters survived the first two months in the discharge area in the long term study, and fewer oysters survived in the discharge area than in control areas in the short-term study. Quick (1971) reports that "35°C can cause rapid death in oysters when accompanied by high salinities, at least among oysters from cool waters with great reserves of glycogen or other storage products". Oysters used in this study were from relatively cool waters north of the power plant, and glycogen reserves of the oysters (as reflected by the CI) were moderate in summer. Salinities were somewhat higher in the discharge area but were still below open ocean values. Temperatures were near or greater than 35°C at the stations with highest mortalities.

Other factors not analyzed may have influenced oyster mortality. Heavy sedimentation, which may be highly destructive to an oyster community (Galtsoff 1964), was observed in the thermal area.

The most striking trend in the associated faunal data is the marked decrease in abundance of the majority of organisms in the immediate thermal area. This appears to be the result of thermal stress, although the additional role of sedimentation in the thermal area is uncertain. Consistently low abundances of organisms at Station OR9 can be attributed primarily to the combined effects of the outflow from both the Withlacoochee River and the Cross Florida Barge Canal, resulting in low salinities and high amounts of suspended material. As stated by Wells (1961) and Galtsoff (1964), lower salinities and increased suspended material will result in fewer associated fauna, as was observed at Station OR9.

Certain groups such as polychaetes appear to be relatively unaffected in the immediate thermal area. This may be due to the fact that as a group, these organisms may be opportunistic by nature, and may have an affinity for certain disturbed systems. Molluscs (including Crassostrea virginica), however, were greatly reduced in the thermal area, suggesting a low level of tolerance to thermal stress.

The nine oyster reef stations comprise a wide variety of environmental conditions. The Crystal River Power Station appears to have a significant effect on localized oyster reef populations. Effects seen include enhanced oyster growth and increased oyster mortality. Direct effects appear to be limited to the immediate vicinity of the discharge canal. The power plant also appears to have reduced abundance of oyster reef associated fauna at stations in close proximity to the discharge canal, although certain species appear to do well there.

TABLE 6.5-1

MINIMUM AND MAXIMUM (BOTTOM) TEMPERATURES AND SALINITIES MEASURED AT PHOTOMETRY STATIONS NEAREST OYSTER STATIONS.

Station	Temperature (°C)		Salinity (ppt)	
	Minimum	Maximum	Minimum	Maximum
OR1	11.5 (Jan)	30.4 (Aug)	14.9 (Apr)	24.5 (Jul)
OR2	11.5 (Jan)	30.7 (Aug)	14.1 (Apr)	24.5 (Oct)
OR3	13.5 (Jan)	31.4 (Aug)	16.1 (Apr)	24.1 (Oct)
OR4	16.8 (Dec)	38.3 (Aug)	17.7 (Apr)	29.1 (Oct)
OR5	19.5 (Jan)	34.3 (Aug)	17.1 (Apr)	25.0 (Nov)
OR6	16.2 (Jan)	33.9 (Aug)	16.3 (Apr)	26.8 (Oct)
OR7	14.9 (Dec)	32.8 (Aug)	16.0 (Apr)	25.7 (Oct)
OR8	15.5 (Jan)	32.6 (Aug)	13.0 (Apr)	23.4 (Oct)
OR9	12.8 (Dec)	30.3 (Jul)	6.7 (Apr)	15.6 (Oct)

TABLE 6.5-2. OYSTER REEF ASSOCIATED FAUNA TAXA LIST.

STREBLOSPIO BENEDICTI
ORDER CIRRATULIDA
FAMILY CIRRATULIDAE
THARYX ANNULOSUS
THARYX CF. DORSOBRANCHIALIS
ORDER CAPITELLIDA
FAMILY CAPITELLIDAE
CAPITELLA CAPITATA
MEDIOMASTUS CALIFORNIENSIS
FAMILY MALDANIDAE
CLYMENELLA TORQUATA
ORDER OWENIIDA
FAMILY OWENIIDAE
MYRIOCHELE OCULATA
ORDER TEREBELLIDA
FAMILY TEREBELLIDAE
AMAEANA TRILOBATA
POLYCIRRUS SP.
STREBLOSOMA HARTMANAE
ORDER SABELLIDA
FAMILY SABELLIDAE
CHONE AMERICANA
FABRICIA SP.A
HYPISCOMUS PHAETAENIA
POTAMILLA RENIFORMIS
FAMILY SERPULIDAE
FILOGRANA IMPLEXA
HYDROIDES DIANTHUS
CLASS OLIGOCHAETA
PHYLUM MOLLUSCA
CLASS GASTROPODA
ORDER MESOGASTROPODA
FAMILY RISSOINIDAE
RISSOINA CATESBYANA
FAMILY CAECIDAE
CAECUM PULCHELLUM
CAECUM STRIGOSUM
FAMILY DIASTOMIDAE
DIASTOMA VARIUM
FAMILY CERITHIIDAE
CERITHIOPSIS GREENI
CERITHIUM ERURNEUM
SEILA ADAMSI
FAMILY CALYPTRAEIDAE
CREPIDULA MACULOSA
CREPIDULA PLANA
ORDER NEOGASTROPODA
FAMILY PYRENIDAE
ANACHIS OBESA.OSTREICOLA
MITRELLA LUNATA
FAMILY OLIVIDAE
OLIVELLA SPP.
ORDER PYRAMIDELLACEA
FAMILY PYRAMIDELLIDAE
ODOSTOMIA IMPRESSA
TURBONILLA SPP.
ORDER CEPHALASPIDEA
FAMILY ACTEOCINIDAE
ACTEOCINA CANALICULATA
ORDER BASOMMATOPHORA
FAMILY ELLOBIIDAE
MELAMPUS BIDENTATUS
ORDER APLYSIACEA
NUDIBRANCHIA SPP.
FAMILY STILIGERIDAE
STILIGER(ERCOLANIA) SP.

TABLE 6.5-2. OYSTER REEF ASSOCIATED FAUNA TAXA LIST.

FAMILY AMPHILOCHIDAE
  GITANOPSIS SPP.
FAMILY AMPITHOIDAE
  CYMADUSA COMPTA
FAMILY AORIDAE
  LEMBOS SMITHI
  MICRODEUTOPUS MYERSI
FAMILY BATEIDAE
  BATEA CF.CATHARINENSIS
FAMILY COLOMASTIGIDAE
  COLOMASTIX HALICHONDRIAE
FAMILY COROPHIIDAE
  COROPHIUM SPP.
  COROPHIUM ACHERUSICUM
  COROPHIUM LACUSTRE
  COROPHIUM SIMILE
  COROPHIUM TUBERCULATUM
  COROPHIUM ACUTUM
  COROPHIUM LOUISIANUM
  ERICTHONIUS SPP.
  ERICTHONIUS BRASILIENSIS
  GRANDIDIERELLA BONNIEROIDES
FAMILY GAMMARIDAE
  ELASMOPUS LEVIS
  GAMMARUS MUCRONATUS
  GAMMARIDAE SP. A
  GAMMARIDAE SP. B
  MAERA CF.WILLIAMSI
  MELITA "COMPLEX"
  MELITA APPENDICULATA
FAMILY HYALIDAE
  HYALE SP.B=CF.PLUMOSA
FAMILY LEUCOTHOIDAE
  LEUCOTHOE CF.SPINICARPA
FAMILY LYSIANASSIDAE
  LYSIANOPSIS CF.ALBA
FAMILY PODOCERIDAE
  PODOCERUS SPP.
FAMILY STENOTHOIDAE
  STENOTHOE SPP.
  STENOTHOE CF.GALLENSIS
  STENOTHOE CF.MINUTA
FAMILY TALITRIDAE
  ORCHESTIA UHLERI
SUBORDER CAPRELLIDEA
FAMILY CAPRELLIDAE
  CAPRELLA SPP.
  CAPRELLA EQUILIBRA
  CAPRELLA PENANTIS
  PARACAPRELLA TENUIS
  PARACAPRELLA PUSILLA
  HEMIAEGINA MINUTA
ORDER DECAPODA
SUBORDER PLEOCYEMATA
  CARIDEA SPP.
  BRACHYURA SPP.
FAMILY PALAEMONIDAE
  PERICLIMENES LONGICAUDATUS
  PALAEMON FLORIDANUS
FAMILY ALPHEIDAE
  ALPHEUS ARMILLATUS
SUBORDER REPTANTIA
FAMILY CALLIANASSIDAE
  UPOGEBIA AFFINIS
FAMILY PAGURIDAE
  PAGURUS MACLAUGHLINAE

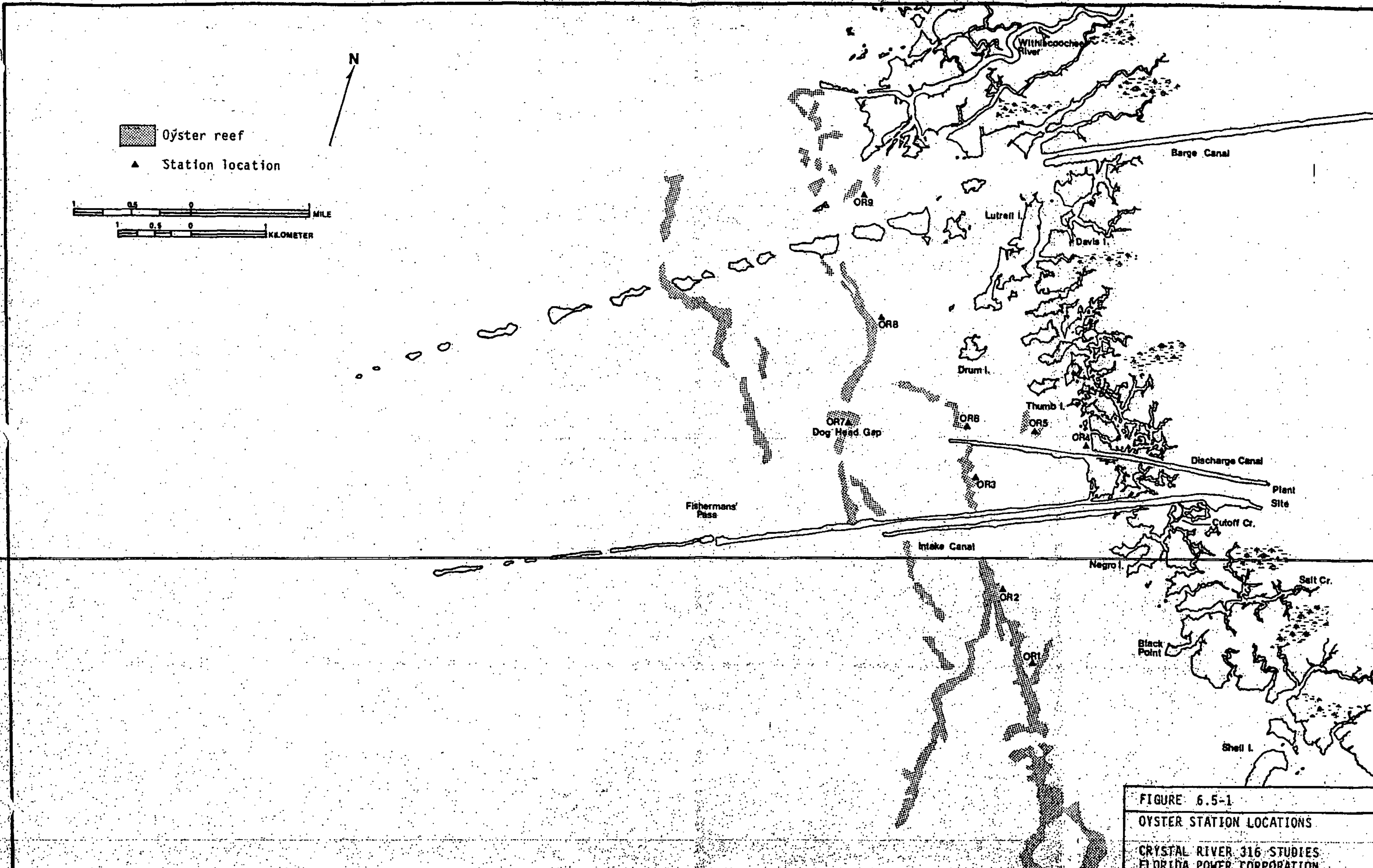
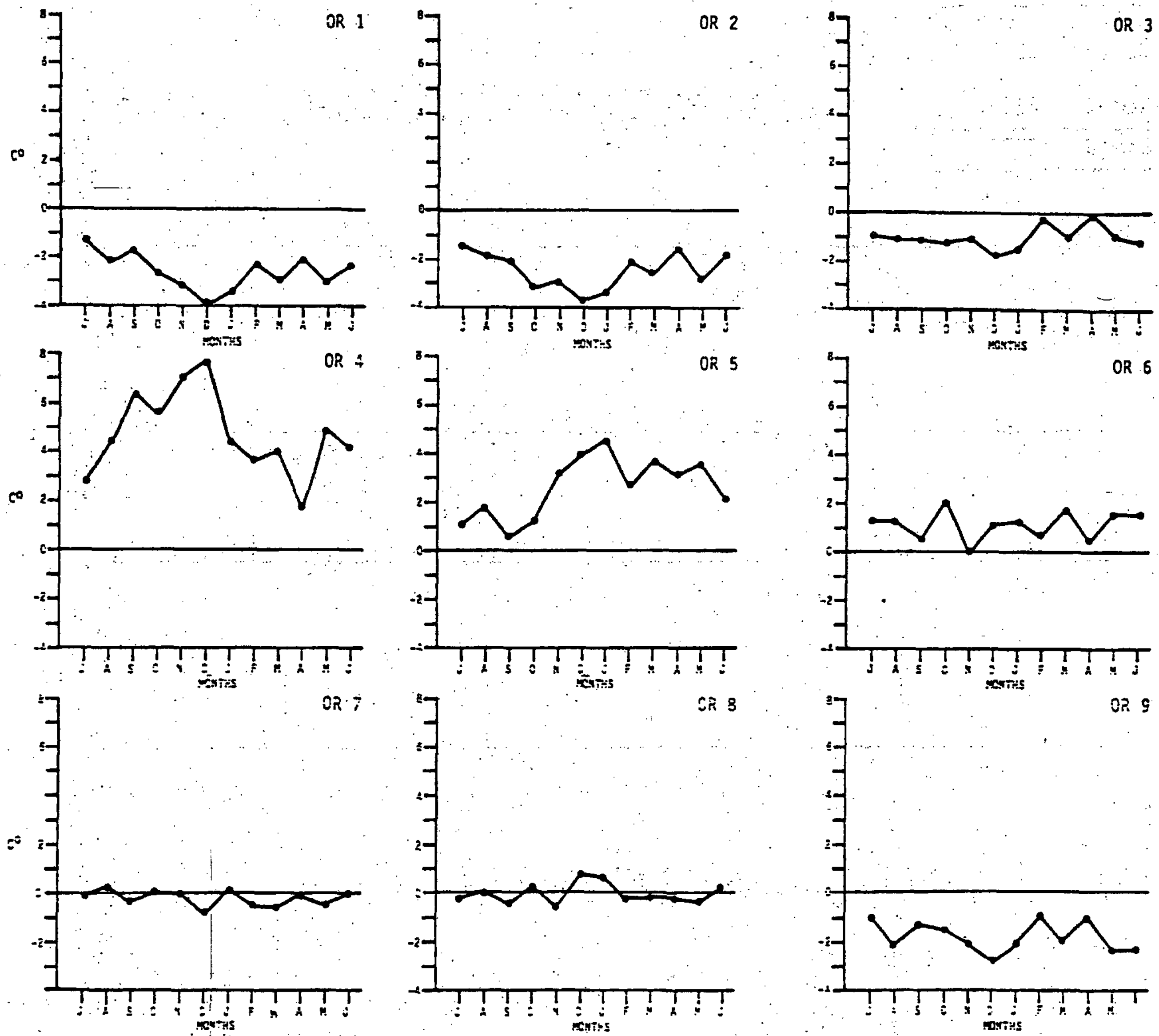


FIGURE 6.5-1

OYSTER STATION LOCATIONS

CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

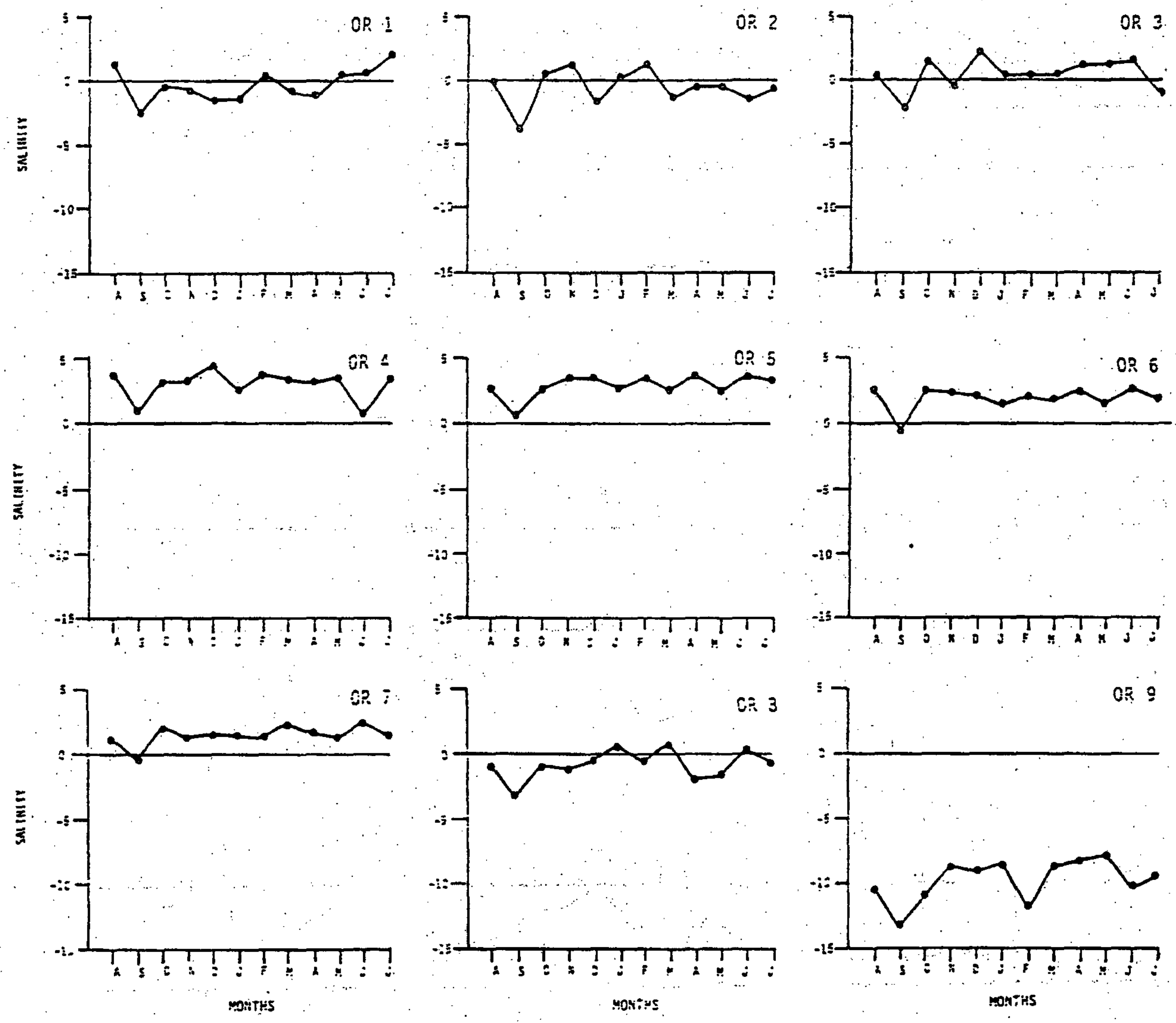


Variations from the mean temperature at each oyster station. The mean (0-line) is the mean of all stations each month.

FIGURE 6.5-2

OYSTER STATIONS, TEMPERATURES

CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

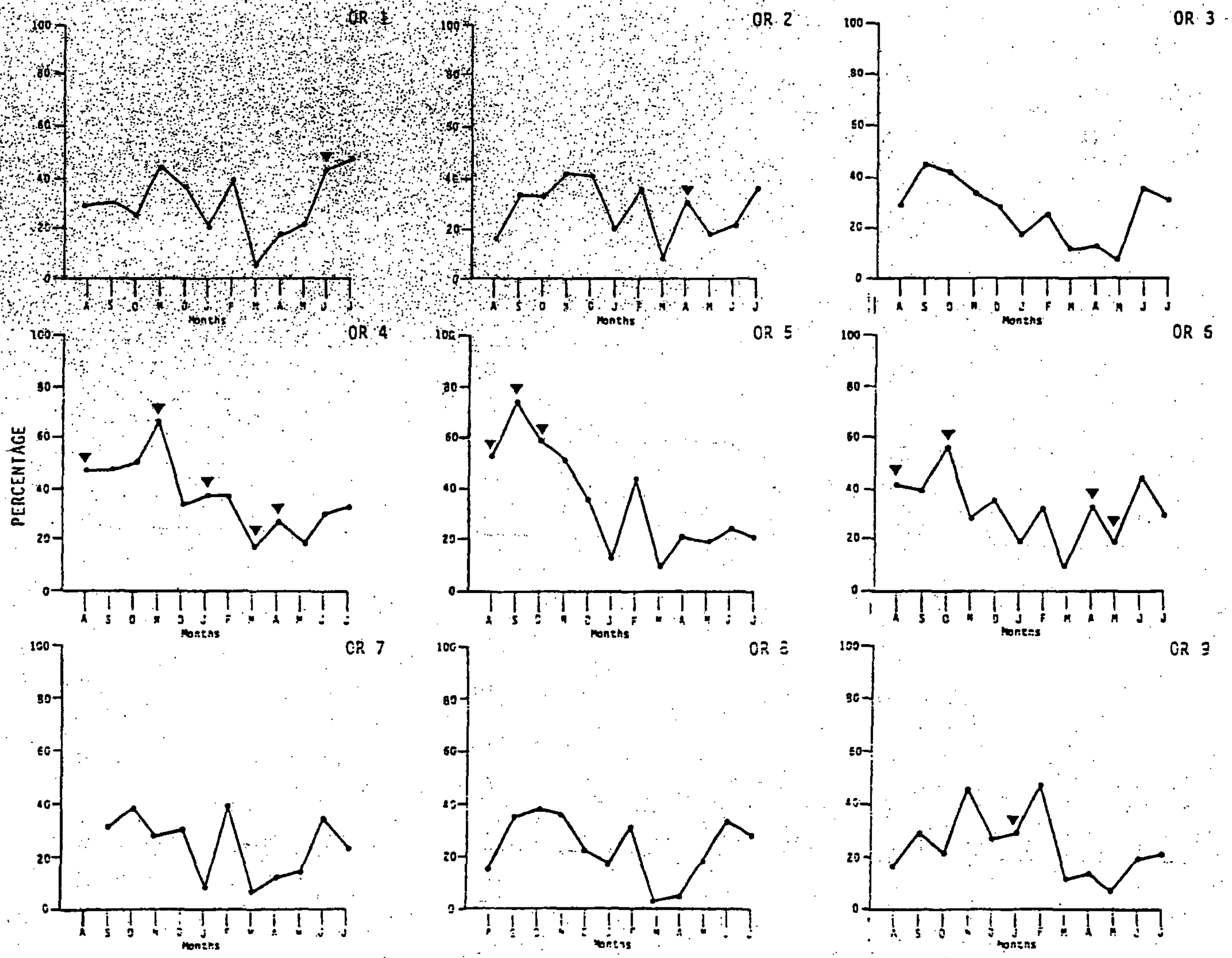


Variations from the mean salinity at each oyster station. The mean (0-line) is the mean of all stations each month.

FIGURE 6.5-3

OYSTER STATIONS, SALINITIES

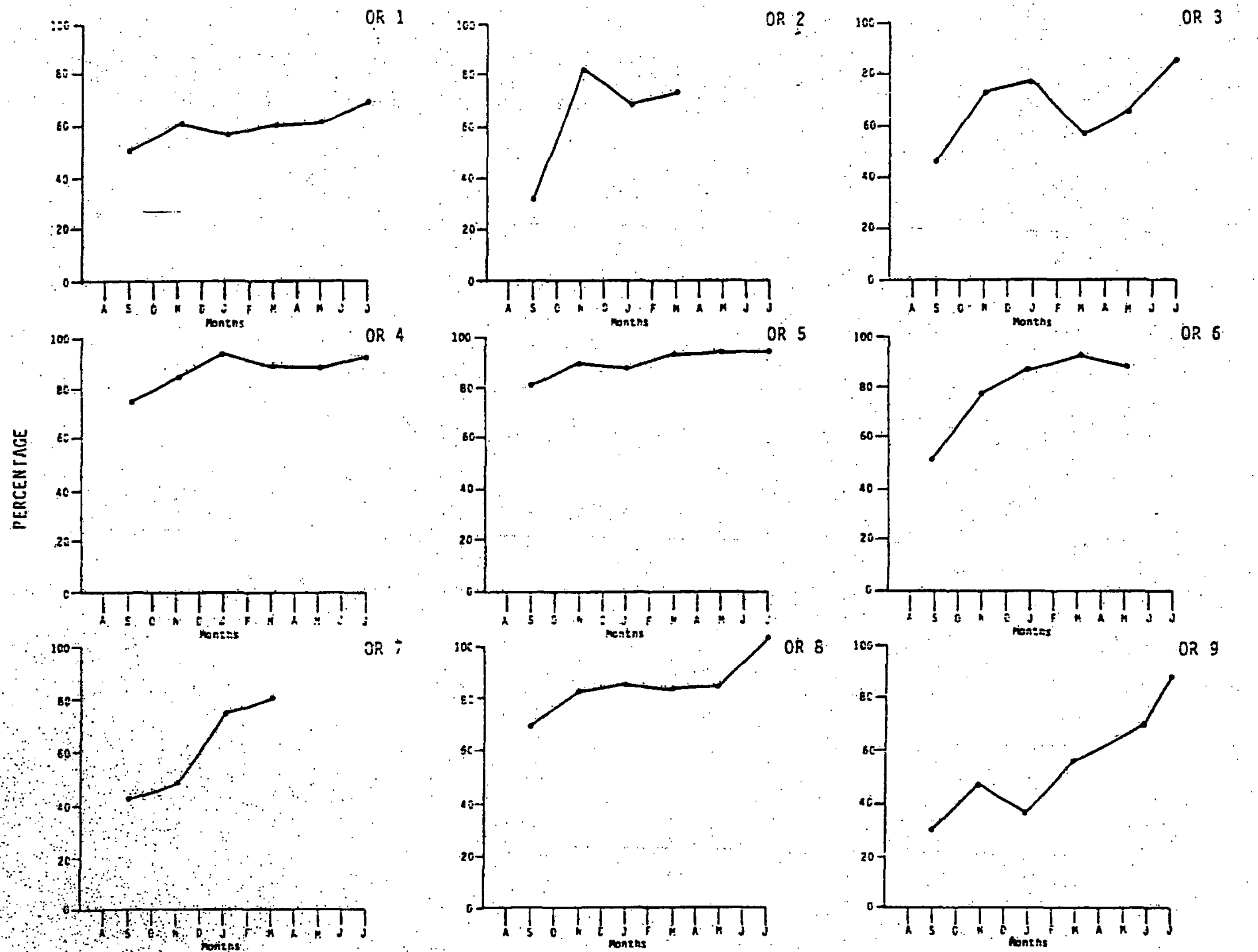
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



Percent mortality of oysters at each station and collection date (Short Term Oyster Study). Symbols (▼) indicate mortality significantly higher than the mean for that collection date.

FIGURE 6.5-4

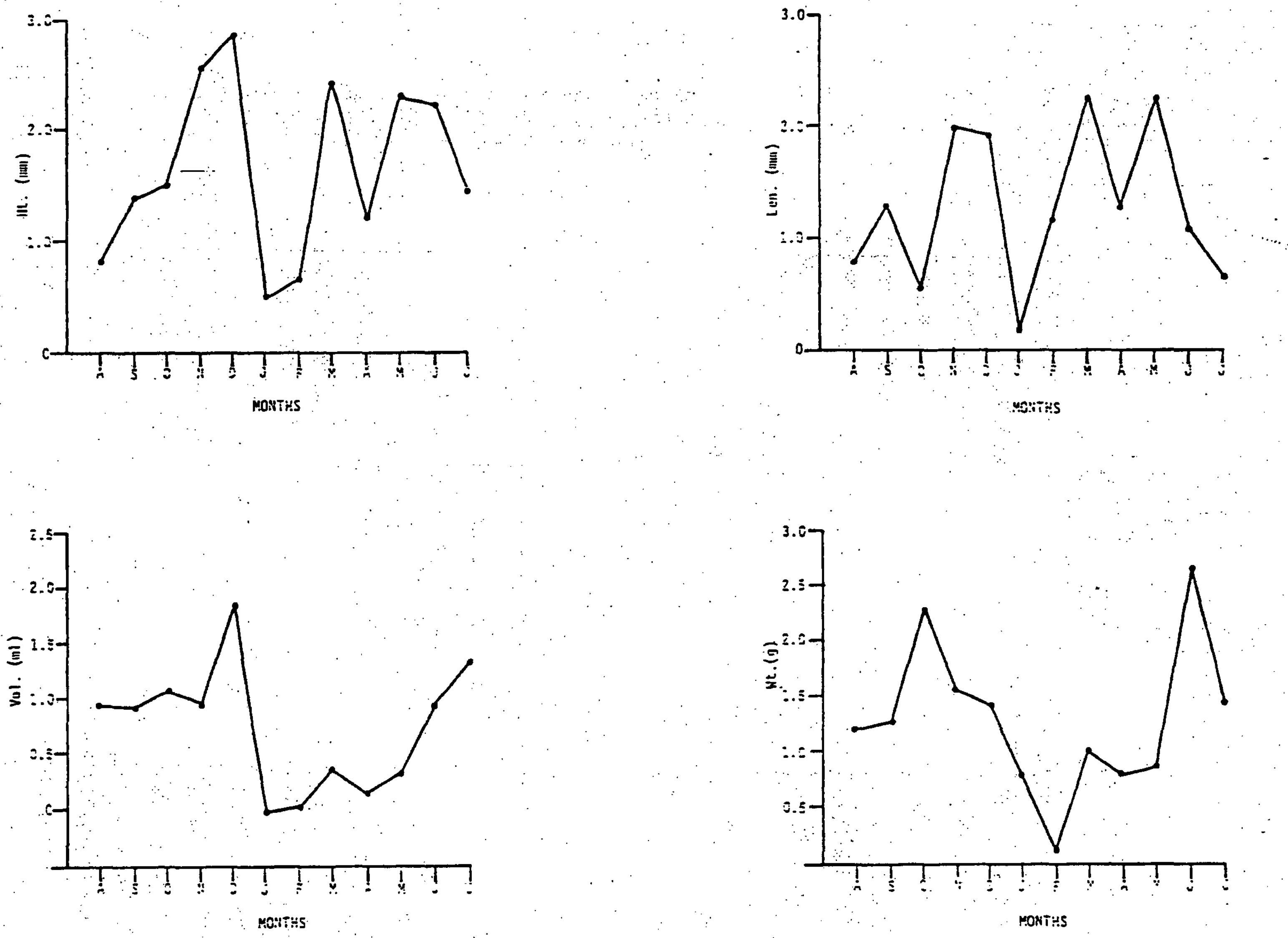
OYSTER MORTALITY, SHORT TERM STUDY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



Percent mortality of oysters at each station and collection date (Long Term Oyster Study).

FIGURE 6.5-5

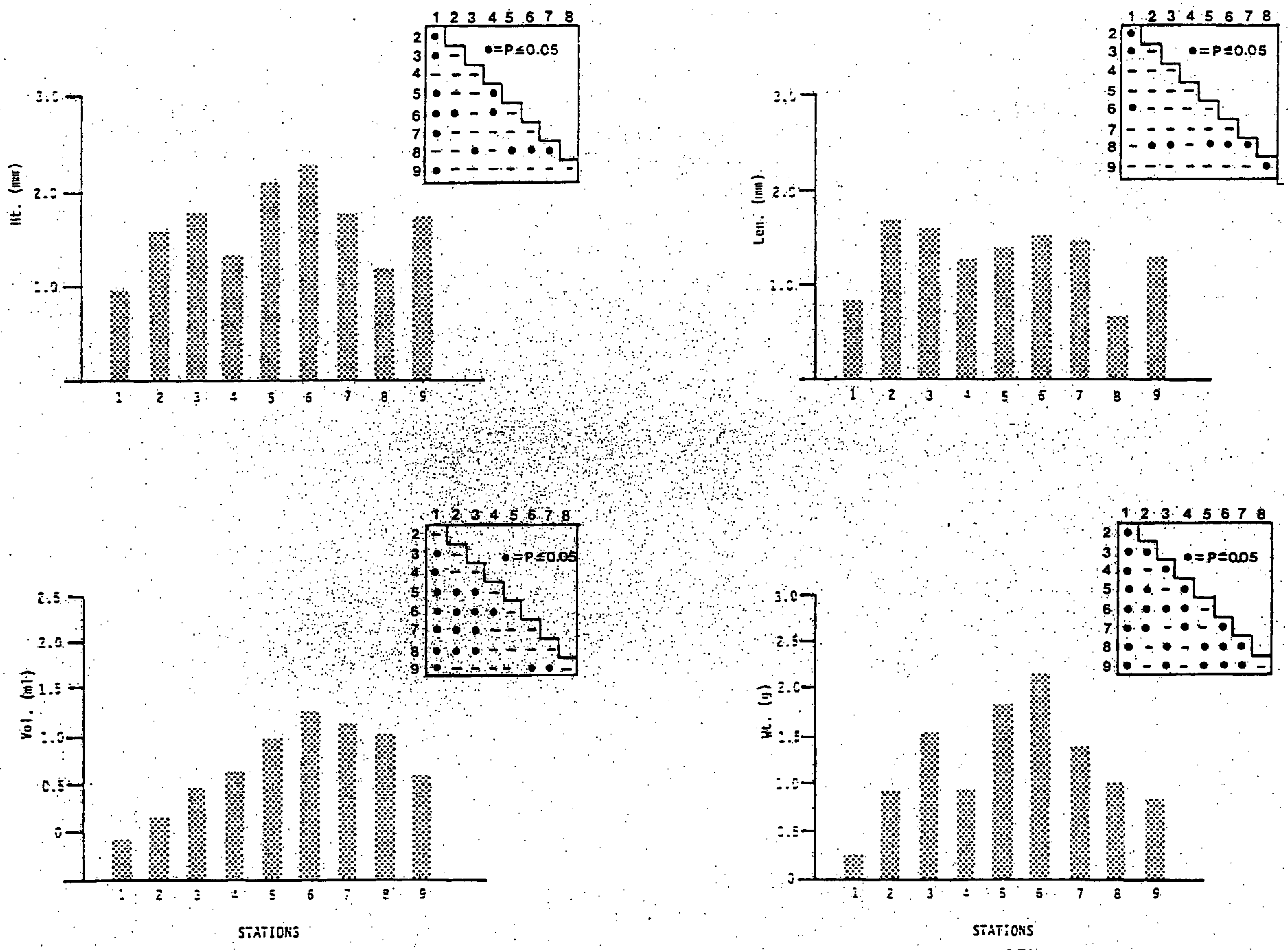
OYSTER MORTALITY, LONG TERM STUDY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



Mean monthly growth (height, length, volume and weight) of oysters at each collection date (Short Term Oyster Study). All stations are combined.

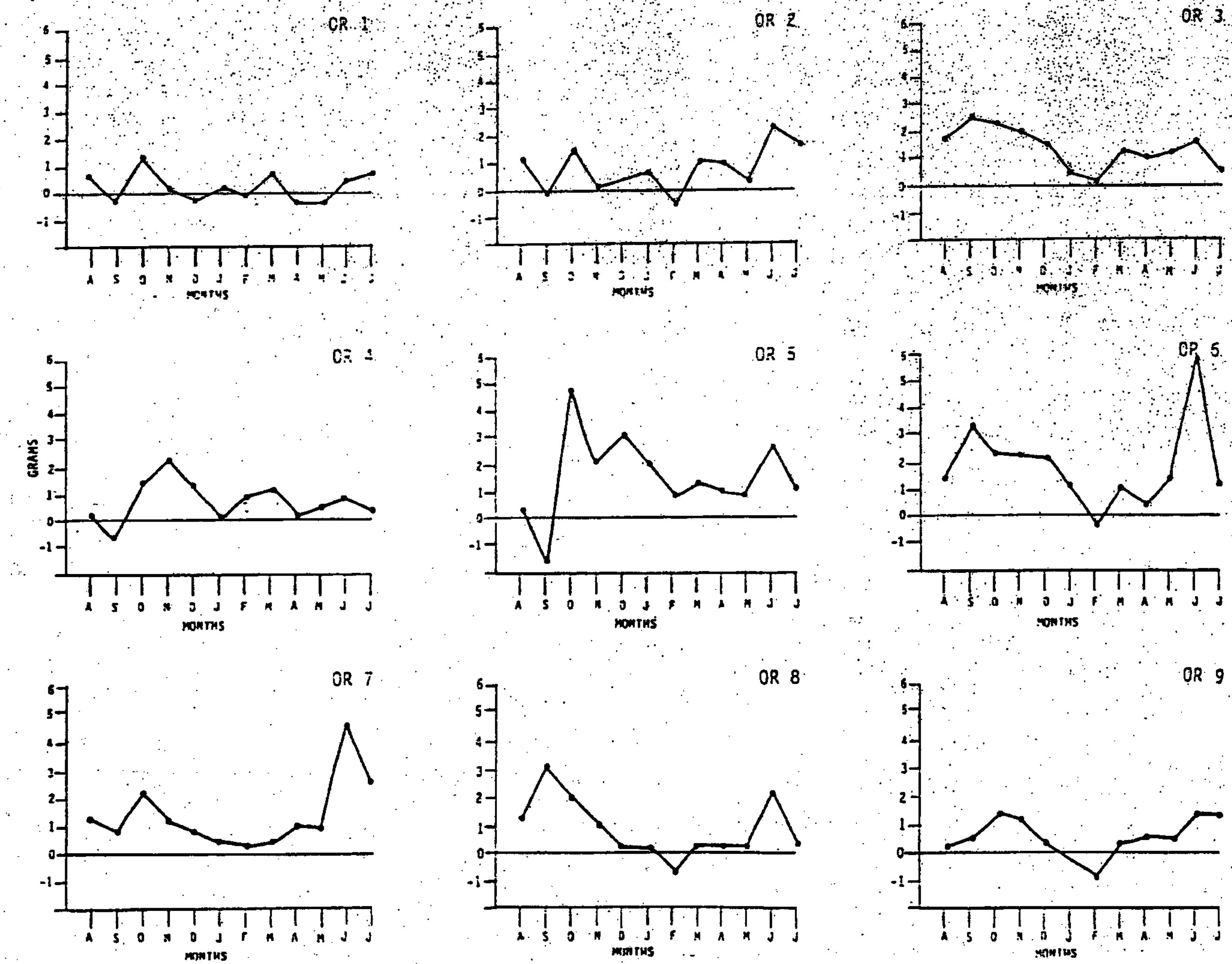
FIGURE 6.5-6

OYSTER GROWTH BY DATE, SHORT TERM STUDY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



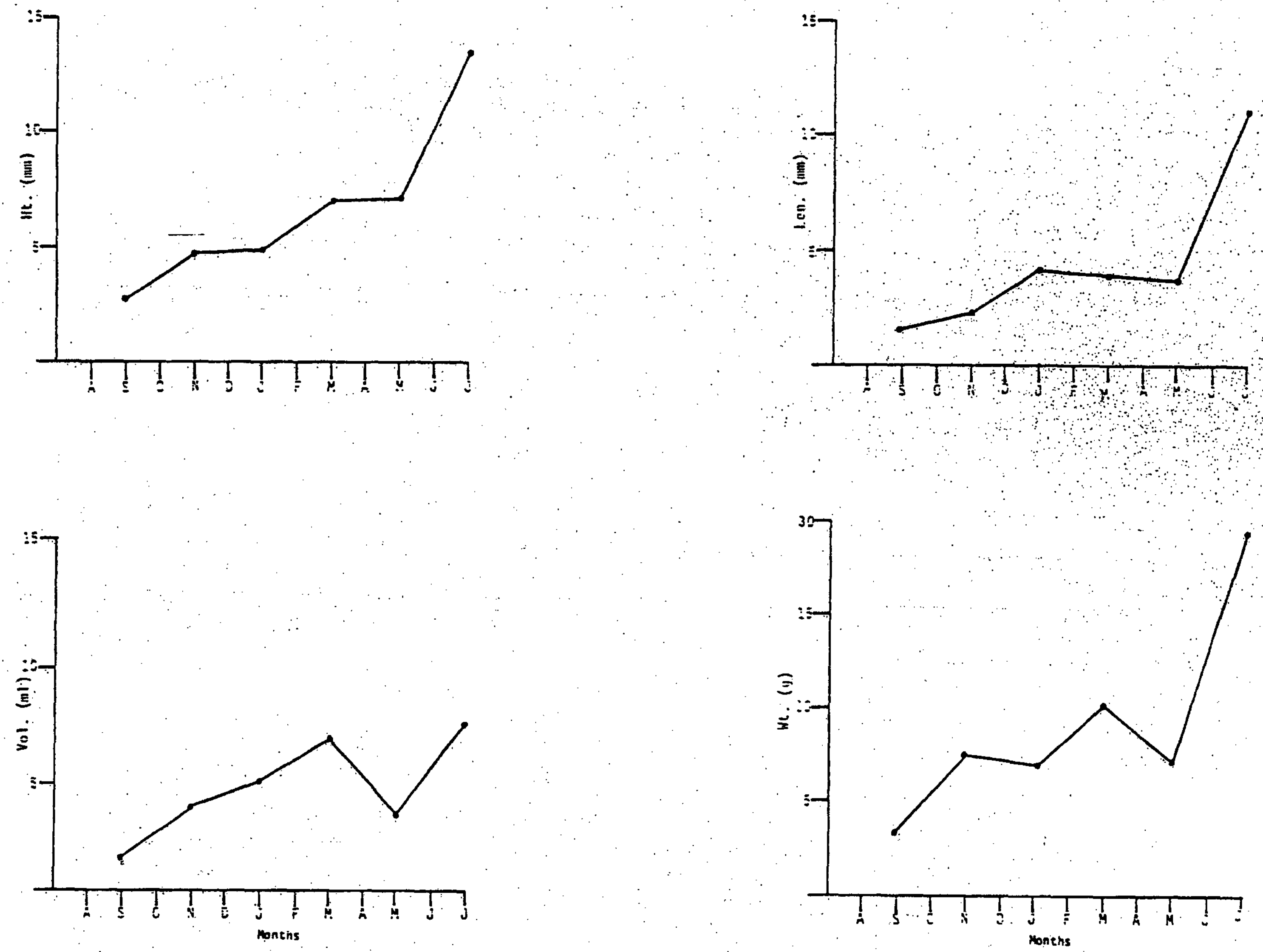
Mean monthly growth (height, length, volume and weight) of oysters at each station (Short Term Oyster Study). Significant differences are indicated on insets (Tukey's Studentized Range (HSD) Test).

FIGURE 6.5-7
OYSTER GROWTH BY STATION, SHORT TERM STUDY CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION



Mean weight change of oysters deployed and collected monthly in oyster growth study (Short Term Oyster Study).

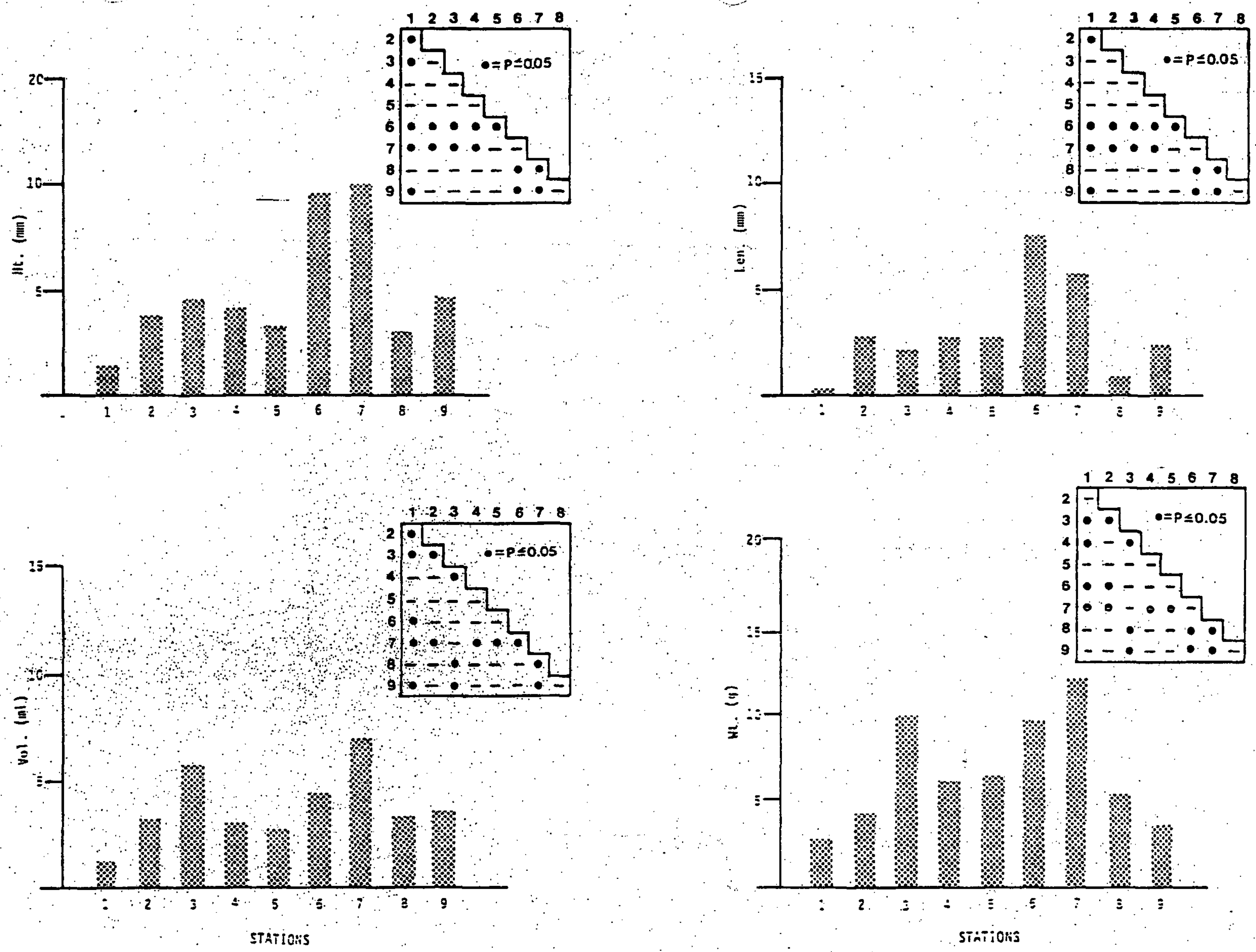
FIGURE 6.5-8
OYSTER WEIGHT CHANGES, SHORT TERM STUDY CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION



Mean growth (height, length, volume, weight) of oysters at each collection date. All stations are combined. (Long Term Study).

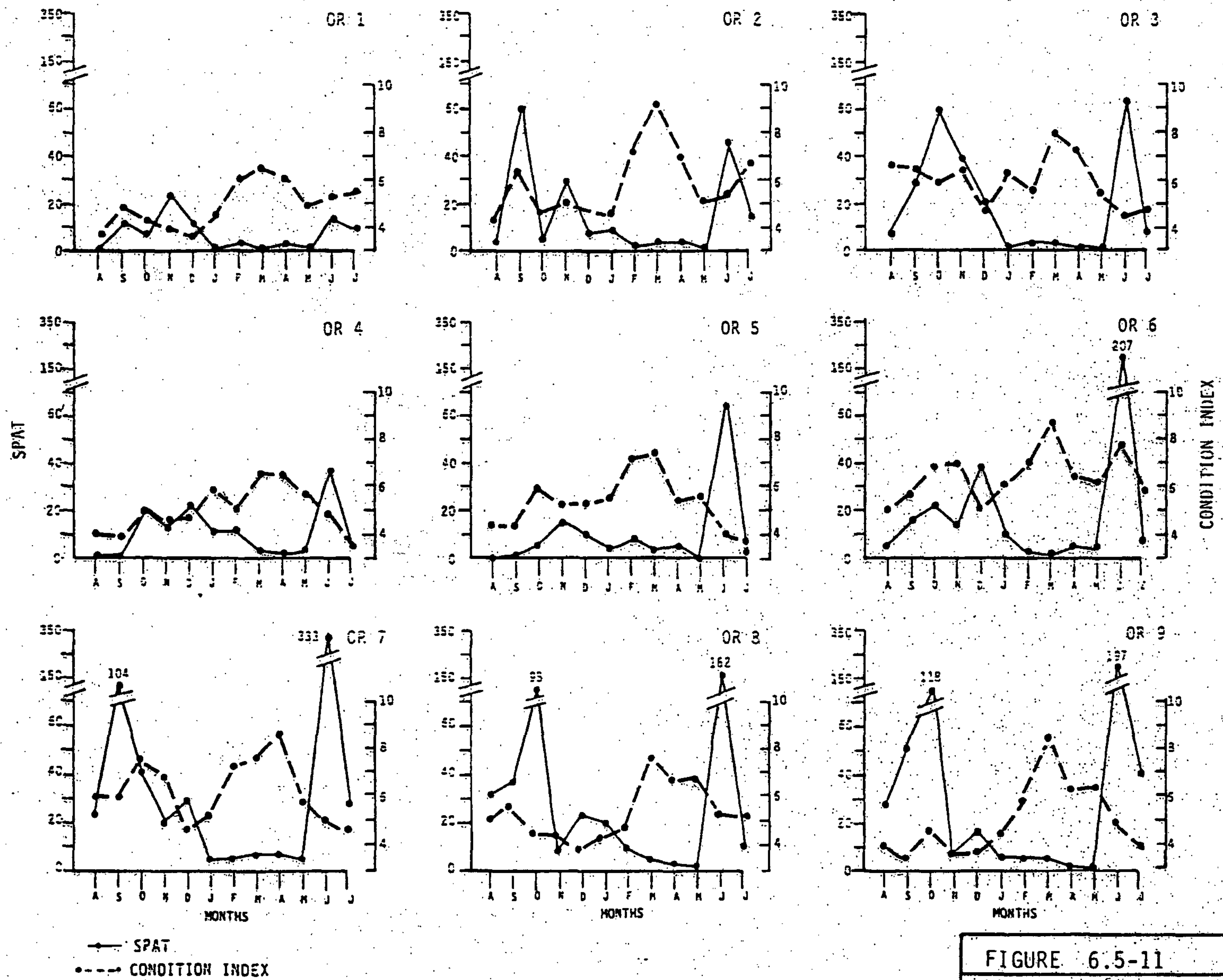
FIGURE 6.5-9

OYSTER GROWTH BY DATE, LONG TERM STUDY
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



Mean monthly growth (height, length, volume and weight) of oysters at each station (Long Term Oyster Study). Significant differences are indicated on insets (Tukey's Studentized Range (HSD) Test).

FIGURE 6.5-10
OYSTER GROWTH BY STATION, LONG TERM STUDY CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION



Number of spat on ten randomly selected oysters from each station each collection date in short term study. Superimposed is the mean Condition Index of oysters (short term study), each station each sampling.

FIGURE 6.5-11

OYSTER SPAT AND CONDITION INDEX

CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

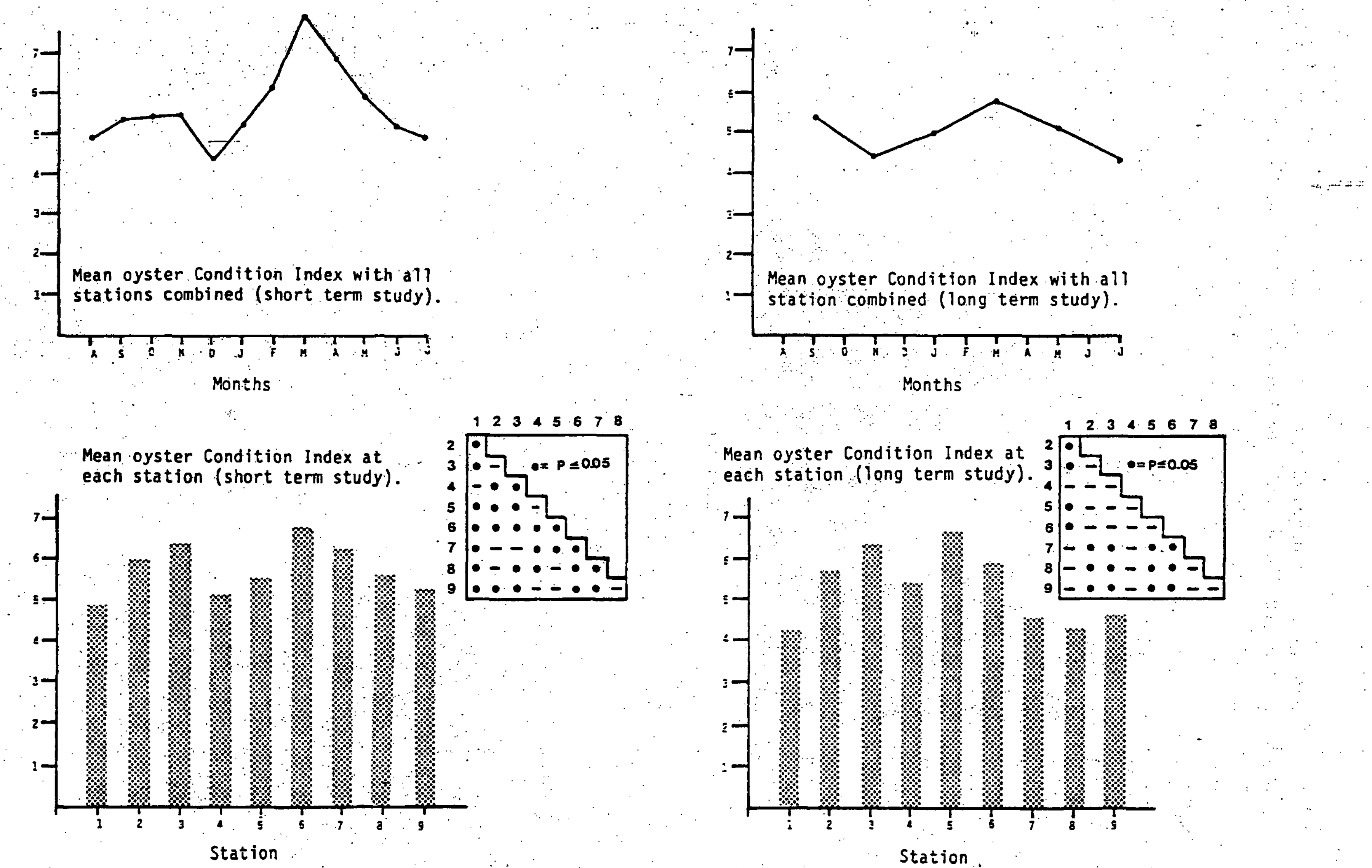
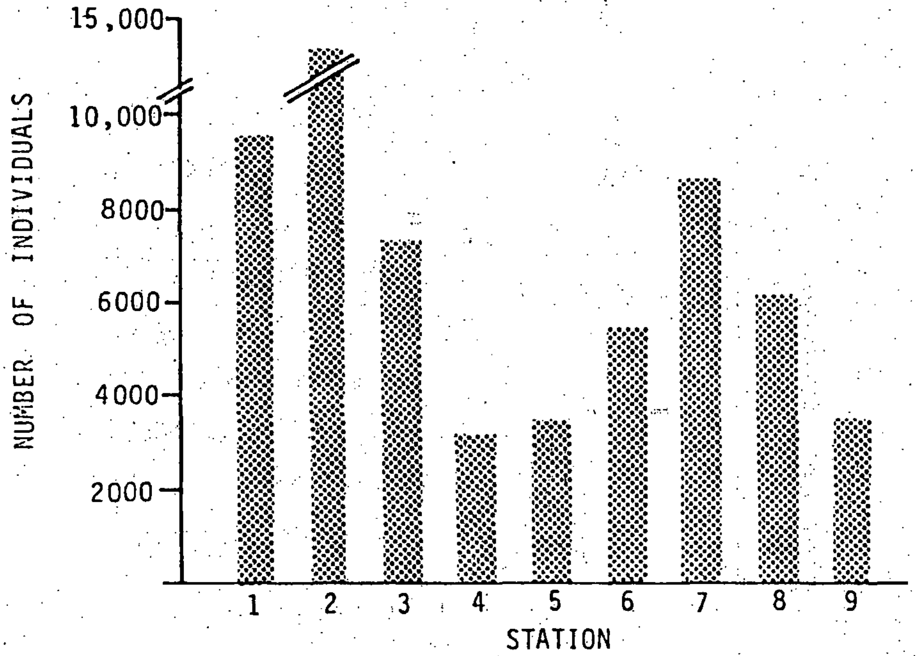


FIGURE 6.5-12

OYSTER CONDITION INDEX, BY DATE AND STATION
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

Total numbers of associated fauna collected at each station (top) and each sampling date (bottom).



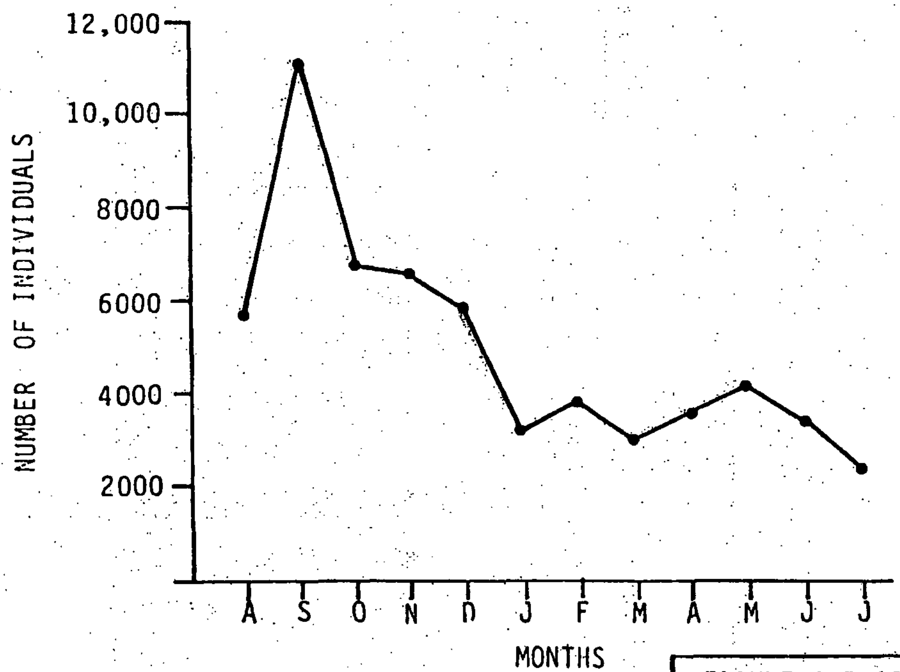
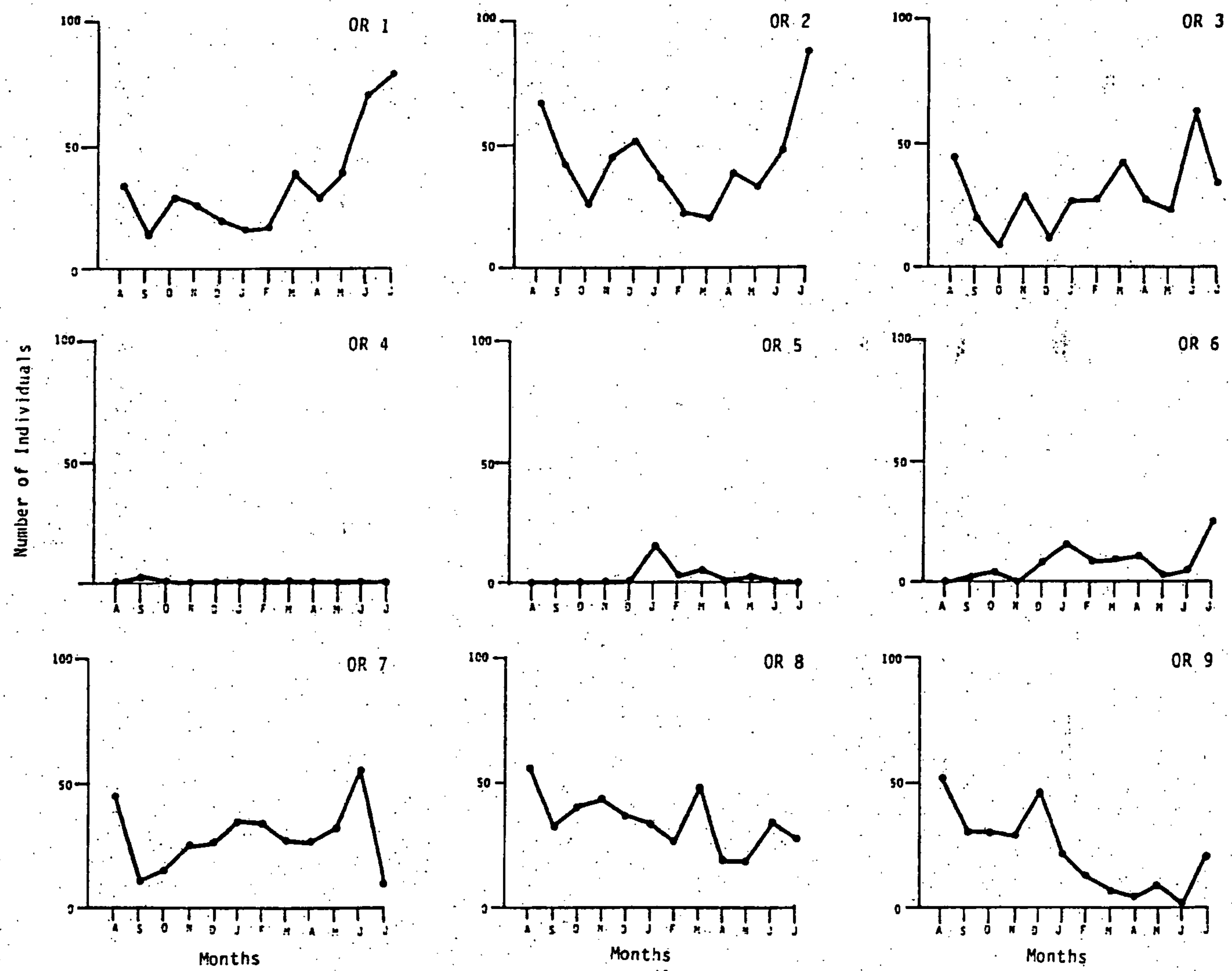


FIGURE 6.5-13

ABUNDANCE OF OYSTER REEF ASSOCIATED FAUNA
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



Monthly abundances of <u>Crassostrea</u> <u>virginica</u> collected in three oyster clumps

FIGURE 6.5-14

OYSTER REEF FAUNA-
<u>Crassostrea virginica</u>
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

7.0 IMPINGEMENT

Collections were made on a weekly basis of organisms impinged on the travelling water screens. The results are intended to describe overall impingement throughout the study period and to allow evaluation of effects of impingement on selected taxa.

7.1 SAMPLING AND LABORATORY ANALYSIS

7.1.1 Sampling Procedures

Impingement sampling was conducted at the Crystal River site for one, randomly chosen, 24 hr period once a week for 12 months at Units 1, 2 and 3. During each 24 hr sampling period, samples were taken at each unit at 6 hr intervals for a total of four samples per unit. The travelling screens for Units 1 and 2 were cleaned at 0900 hr (the beginning of the first sampling interval) and then cleaned every 6 hr, so that collections were made at 1500 hr, 2100 hr, 0300 hr, and 0900 hr. The Unit 3 travelling screens were cleaned at 1000 hr and sampled at 1600 hr 2200 hr, 0400 hr, and 1000 hr. Each sample collected contained the organisms impinged during the 6 hr interval immediately preceding the collection.

Samples were collected in wire baskets designed to fit into the screen wash collection sumps of each unit. The screens were rotated and cleaned for 30 minutes to ensure that all organisms were washed from the travelling screens. At the end of the screen wash, fish and macroinvertebrates were separated from seagrass, algae, and other debris and then preserved.

At certain times during the year, samples collected contained excessive numbers of organisms. When this situation occurred, a random sample splitter was used to obtain the appropriate subsample. The percentage of sample to be analyzed (subsample) was determined by estimating the amount of sample which could be analyzed in approximately 2 hr. Both the percentage of sample analyzed (subsample) and the remaining percentage of unanalyzed sample were recorded. Total number and batch weights of each species contained in the complete sample were extrapolated. The unanalyzed portion of any split sample was sorted to avoid missing any new or rare species.

Sampling with a 3 mm mesh basket placed below the larger mesh basket was conducted once per month at each unit during one of the 6 hr intervals (a total of three collections per month). Sampling dates and sampling times were randomly chosen. The 3 mm samples were then sorted and processed separately and the results qualitatively compared to collections in the larger mesh.

Water temperature, dissolved oxygen, turbidity, and conductivity were taken 1 ft below the surface, at mid depth, and 1 ft above the bottom at each unit upon initial cleaning of the intake screens and at the end of each 24 hr period. Data on barge traffic, tidal stage, wind, weather conditions, and relative amount of seagrass in the sample were also recorded. Plant operational data (e.g., number of circulating water pumps and screens operating) were also noted.

7.1.2 Laboratory Analysis

Samples were processed as follows: all fish and macroinvertebrates were sorted, identified to species (when possible), counted and bulk weighed (by species). Size measurements (length and weight) were taken on the largest and smallest individuals of each species. Crabs of the family Xanthidae (with the exception of Menippe mercenaria) were grouped together for purposes of enumeration and measurements of biomass.

Samples collected at one 6 hr interval (randomly chosen) during each 24 hr period were subjected to detailed size-weight analysis. One such sampling was made for each of the three units for a total of three during each 24 hr sampling period. These samples were processed as follows: up to 30 individuals of fish and macroinvertebrate taxa designated as Selected Important Organisms (SIO) (Table 7.1-1) because of their economic or ecological importance were individually weighed and measured (in addition to the routine processing described above). When a large number of an SIO species was collected, the 30 individuals were selected at random.

Size measurements were recorded to the nearest mm and measured as follows: standard length for fish, maximum carapace width for crabs, maximum pen (gladii) length for squid, and maximum carapace length for shrimp. Individual and batch weights were recorded to the nearest 0.1 grams.

During the crab tagging study (see Section 9.1), impinged crabs were held in water tables for 24 hr. After 24 hr, mortality was recorded and healthy crabs were weighed, measured, tagged, and released.

Taxonomic references used for fish identifications include Hoese and Moore (1977), Parker (1972), and Walls (1975). Nomenclature followed Robins et al (1980). Taxonomic references used for macroinvertebrate identifications include Williams (1965), Felder (1973), Mutter (1976), Gosner (1971), Heard 1982), and Abbott (1968).

7.1.3 Statistical Analysis

Raw impingement numbers collected weekly from the traveling screens were converted to numbers collected per volume of water passed through the screens. This rate per unit volume impingement was analyzed using the SAS GLM procedure. Quarter of the year, barge traffic, unit, interactions of these main effects and numerous continuous and discrete covariates were explored in the analysis. The SAS graphics package was used to provide plots of impingement over time.

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TABLE 7.1-1

LIST OF SELECTED IMPORTANT ORGANISMS (SIO)

Species Name	Common Name
Anchoa mitchilli	Bay anchovy
Ogcocephalus radiatus	Polka-dot batfish
Orthopristis chrysoptera	Pigfish
Lagodon rhomboides	Pinfish
Bairdiella chrysura	Silver perch
Cynoscion nebulosus	Spotted seatrout
Leiostomus xanthurus	Spot
Sciaenops ocellatus	Red drum
Mugil cephalus	Striped mullet
Lolliguncula brevis	Brief squid
Penaeus duorarum	Pink shrimp
Menippe mercenaria	Stone crab
Callinectes sapidus	Blue crab

TABLE 7.2-1

FISH (F) AND INVERTEBRATE (I) IMPINGEMENT
AVERAGE NUMBER PER 6 HOUR COLLECTION

Month	Unit 1 F	Unit 1 I	Unit 2 F	Unit 2 I	Unit 3 F	Unit 3 I
June	7.50	24.50	31.25	107.50	-	-
July	16.50	20.50	56.72	72.72	12.63	39.63
August	8.63	26.88	73.94	112.81	40.57	276.86
September	16.35	28.15	61.75	66.83	49.65	210.80
October	7.00	25.38	41.56	56.00	41.50	115.06
November	20.14	21.00	29.36	38.91	43.00	65.25
December	33.80	65.85	51.15	127.90	52.75	127.95
January	36.95	296.00	91.15	311.10	147.05	515.25
February	132.38	238.13	417.00	276.88	639.25	1038.00
March	179.56	434.88	-	-	1053.88	1944.55
April	63.50	314.25	221.80	597.40	376.00	1424.42
May	18.06	152.82	131.62	560.56	59.40	1172.08

TABLE 7.2-2

TOTAL IMPINGEMENT BY UNIT

UNIT	NUMBER	WEIGHT IN KG
1	278854	2256.3
2	747830	10191.9
3	1601800	21505.6

TABLE 7.2-3

ANNUAL IMPINGEMENT BY UNIT

FOR SELECTED IMPORTANT ORGANISMS

	UNIT 1		UNIT 2		UNIT 3	
	NUMBER	WEIGHT IN KG	NUMBER	WEIGHT IN KG	NUMBER	WEIGHT IN KG
BAY ANCHOVY	7224	14.0	16236	29.8	64518	114.6
POLKA DOT BATFISH	11988	712.6	21772	1284.2	40728	1978.0
PIGFISH	487	1.2	2254	5.2	956	9.3
PINFISH	1990	6.5	7056	39.0	6189	33.5
SILVER PERCH	960	4.6	4826	24.1	6214	35.6
SPOTTED SEATROUT	257	1.2	940	3.3	1607	8.2
SPOT	1550	2.2	13800	31.0	12744	29.5
RED DRUM	0	0.0	0	0.0	8	0.0
STRIPED MULLET	68	4.3	690	24.2	362	5.1
PINK SHRIMP	100043	449.9	149387	676.2	391457	1952.6
BLUE CRAB	45488	350.3	82554	3570.4	255518	9186.0
STONE CRAB	400	16.4	527	11.2	608	34.5
BRIEF SQUID	4323	23.5	26916	90.1	55715	309.0

TABLE 7.2-4

TOTAL NUMBERS OF FISH COLLECTED IN 3MM IMPINGEMENT SAMPLING

CLUPEIDAE	96
UROPHYCIS FLORIDANA	4
ANCHOA MITCHILLI	3
LEIOSTOMUS XANTHURUS	3
MUGIL CEPHALUS	2
ANCHOA HEPSETUS	1
OPSANUS BETA	1
STRONGYLURA MARINA	1
SYNGNATHUS SP.	1
EUCINOSTOMUS ARGENTEUS	1

TABLE 7.2-5

TOTAL NUMBERS OF INVERTEBRATES COLLECTED IN 3MM IMPINGEMENT SAMPLING

XANTHIDAE	70
PORTUNUS GIBBESI	8
PALAEMON FLORIDANUS	7
ALPHEUS NORMANNI	4
ANEMONE	3
PENAEUS DUORARUM	3
CALLINECTES SAPIDUS	3
SQUILLA EMPUSIA	2
PETROLISTHES ARMATUS	2
MENIPPE MERCENARIA	2
ANNELIDA	1
TOZEUMA CAROLINENSE	1
PELIA MUTICA	1
ANACHIS SP.	1
LOLLIGUNCULA BREVIS	1

IMPINGEMENT RATE OF FISH NUMBERS (NUMB[illegible] 360,000,000 GALLONS)

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: NF

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	63	717710.17229569	11392.22495707	4.91	0.0001	0.484545	164.7871
ERROR	329	763493.01879600	2320.64747354		ROOT MSE		NF MEAN
CORRECTED TOTAL	392	1481203.19109169			48.17309907		29.23353676

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
SEASON	3	194980.44685684	28.01	0.0001	3	158212.75563166	22.73	0.0001
BARGE(SEASON)	4	84172.01180794	9.07	0.0001	4	95914.60356373	10.33	0.0001
UNIT	2	27062.73095498	5.83	0.0032	2	22694.65364473	4.89	0.0081
DN	1	1207.91047878	0.52	0.4711	1	3892.03736825	1.68	0.1962
SEASON*UNIT	6	21048.98498277	1.51	0.1735	6	34912.37402159	2.51	0.0219
SEASON*DN	3	1768.95708274	0.25	0.8587	3	2382.80951711	0.34	0.7972
UNIT*DN	2	17767.06759960	3.83	0.0227	2	8077.99757501	1.74	0.1771
SEASON*UNIT*DN	6	40907.41289173	2.94	0.0083	6	41190.26344914	2.96	0.0079
WINDVEL*WINDDIR	29	147658.31541913	2.19	0.0006	29	105444.38436260	1.57	0.0345
TIDESTAG	3	29900.33599546	4.29	0.0056	3	24022.75249663	3.45	0.0168
TEMP	1	145742.18383031	62.80	0.0001	1	82756.41026613	35.66	0.0001
TURB	1	19.96599714	0.01	0.9262	1	54.20873296	0.02	0.8786
SAL	1	5340.88716828	2.30	0.1302	1	5331.70390160	2.30	0.1305
DO	1	132.96123000	0.06	0.8110	1	132.96123000	0.06	0.8110

TABLE 7.2

TOTAL NUMBERS OF FISH COLLECTED IN IMPINGEMENT SAMPLING

ANCHOA MITCHILLI	11220
OGCOCEPHALUS RADIATUS	8934
PRIONOTUS TRIBULUS	7964
UROPHYCIS FLORIDANA	3161
LEIOSTOMUS XANTHURUS	2904
ANCHOA HEPSETUS	1748
LAGODON RHOMBOIDES	1741
BAIRDIELLA CHRYSOURA	1485
SPHOEROIDES NEPHELUS	1361
PEPRILUS BURTI	1209
LACTOPHRYS QUADRICORNIS	1182
EUCINOSTOMUS ARGENTEUS	1146
ATHERINIDAE	1072
CHILOMYCTERUS SCHOEPFI	875
ARIUS FELIS	792
ACHIRUS LINEATUS	732
SYMPHURUS PLAGIUSA	722
EUCINOSTOMUS GULA	643
ANCYLOPSETTA QUADROCELLATA	627
HIPPOCAMPUS ERECTUS	590
CHLOROSCOMBRUS CHRYSURUS	561
OPSANUS BETA	544
OPHISTHONEMA OGLINUM	518
STRONGYLURA MARINA	482
BREVOORTIA PATRONUS	461
MONACANTHUS CILIATUS	457
MENIDIA SP.	440
TRINECTES MACULATUS	437
SELENE VOMER	400
HARENGULA JAGUANA	383
ORTHOPRISTIS CHRYSOPTERA	383
HAEMULON AUROLINEATUM	367
SYNGNATHUS FLORIDAE	354
ALUTERUS SCHOEPFI	343
PRIONOTUS SCITULUS	341
ETROPUS CROSSOTUS	327
CYNOSCION NEBULOSUS	324
HYPSOBLENNIUS HENTZI	269
SYNGNATHUS LOUISIANAE	228
MONACANTHUS HISPIDUS	218
MENIDIA BERYLLINA	217
SYNGNATHUS SCOVELLI	195
GYMNURA MICRURA	189
HYPORHAMPUS UNIFASCIATUS	175
OLIGOPLITES SAURUS	154
OPHICHTHUS GOMESI	149
MEMBRAS MARTINICA	145
CLUPEIDAE	143
CHAETODIPTERRUS FABER	128
CHASMODES SUBURRAE	124
SERRANIDAE	114
SYNODUS FOETENS	91
MUGIL CEPHALUS	90
CYNOSCION ARENARIUS	87
ALOSA ALABAMAE	84
ASTROSCOPUS Y-GRAECUM	83

PORICHTHYS PLECTRODON	81
DASYATIS SABINA	69
CLUPEID	62
ANCHOA SP.	60
DIPLECTRUM BIVITTATUM	59
GOBIESOX STRUMOSUS	55
STRONGYLURA NOTATA	54
OPISTOGNATHIDAE	44
PARALICHTHYS ALBIGUTTA	41
CENTROPRISTIS PHILADELPHIC	40
MENTICIRRHUS AMERICANUS	39
MYROPHIS PUNCTATUS	37
EUCINOSTOMUS SP.	37
MUGIL SP.	35
SPHOEROIDES SPENGLERI	30
UNIDENTIFIED-DAMAGED	30
CENTROPRISTIS STRIATA	26
OPHIDION GRAYI	22
POLYDACTYLUS OCTONEMUS	20
BREVOORTIA SMITHI	18
CARANX HIPPOS	13
HIPPOCAMPUS ZOSTERAE	12
ELOPS SAURUS	11
GYMNOTHORAX NIGROMARGINATU	11
APOGON AUROLINEATUS	11
BAGRE MARINUS	10
SERRANUS ATROBRANCHUS	10
TRACHINOTUS FALCATUS	10
TRICHIURUS LEPTURUS	10
SARDINELLA AURITA	9
LUTJANUS GRISEUS	9
SYNGNATHUS SP.	7
RACHYCENTRON CANADUM	7
ARCHOSARGUS PROBATOCEPHALU	7
DIPLODUS HOLBROOKI	7
BASCANICHTHYS SCUTICARIS	6
DIPLECTRUM FORMOSUM	6
LAGOCEPHALUS LAEVIGATUS	5
BELONIDAE	4
CYPRINODON VARIEGATUS	4
ECHENEIS NAUCRATES	4
UNIDENTIFIED CARANGID	4
SYNODUS SYNODUS	3
RYPTICUS SAPONACEUS	3
PEPRILUS ALEPIDOTUS	3
BREVOORTIA GUNTERI	2
ALOSA CHRYSOCHLORIS	2
SERRANUS SUBLIGARIUS	2
MUGIL CUREMA	2
MICROGOBIUS THALASSINUS	2
SCOMBEROMORUS MACULATUS	2
SCORPAENA BRASILIENSIS	2
CITHARICHTHYS MACROPS	2
SPHYRNA TIBURO	1
TRACHINOCEPHALUS MYOPS	1
OGCOCEPHALUS PARVUS	1
HIRUNDICTHYS RONDELETI	1
FUNDULUS GRANDIS	1
FUNDULUS SIMILIS	1

HIPPOCAMPUS SP.	1
MYCTEROPERCA MICROLEPIS	1
HEMICARANX AMBLYRHYNCHUS	1
GERRIDAE	1
UNIDENTIFIED SPARID	1
POGONIAS CROMIS	1
SCIAENOPS OCELLATUS	1
OPISTOGNATHUS AURIFRONS	1
OPISTOGNATHUS MAXILLOSUS	1
BATHYGOBIUS SOPORATOR	1
GOBIONELLUS HASTATUS	1
UNIDENTIFIED BOTHID	1
CYNOGLOSSIDAE	1
SPHOEROIDES SP.	1
UNIDENTIFIED	1

TABLE T[illegible]

TOTAL NUMBERS OF INVERTEBRATES COLLECTED IN IMPINGEMENT SAMPLING

PENAEUS DUORARUM	76917
CALLINECTES SAPIDUS	41682
METOPORHAPHIS CALCARATA	16583
LOLLIGUNCULA BREVIS	10358
SQUILLA EMPUSIA	7546
PORTUNUS GIBBESI	6898
PALAEMON FLORIDANUS	4422
ALPHEUS HETEROCHAELIS	2956
XANTHIDAE	1619
TRACHYPENAEUS SIMILIS	1117
OVALIPES GUADULPENSIS	490
ALPHEUS NORMANNI	350
MENIPPE MERCENARIA	179
PETROLISTHES ARMATUS	143
TOZEUMA CAROLINENSE	77
UPOGEBIA AFFINIS	68
CALLINECTES ORNATUS	64
PALAEMONETES INTERMEDIUS	62
LYSMATA WURDEMANNI	62
HIPPOLYSMATA WURDMANNI	53
LIBINIA DUBIA	52
PORTUNUS SPINIMANUS	39
PALAEMONETES VULGARIS	26
LOLLIGO PEALI	21
APLYSIA WILCOXI	15
ANEMONE	14
SESARMA CINEREUM	14
PETROLISTHES GALATHINUS	10
APLYSIA SP.	10
SESARMA RETICULATUM	8
PELIA MUTICA	7
NEMERTINEA	6
PALAEMONETES PUGIO	5
DAMAGED CRAB	4
PODOCHELA SIDNEYI	4
PALAEMONIDAE	3
ANNELIDA	2
PENAEIDAE	2
PALAEMONETES SP.	2
UCA SP.	2
MACROCOELOMA TRISPINOSUM	2
POLINICES DUPLICATUS	2
PENAEUS SETIFERUS	1
PENAEUS SP.	1
PORTUNUS DEPRESSIFRONS	1
EURYPANOPEUS DEPRESSUS	1
NEOPANOPE TEXANA	1
PANOPEUS HERBSTII	1
UCA PUGILATOR	1
UCA SPECTOSA	1
LIBINIA EMARGINATA	1
PITHO LHERMINIERI	1
ANACHIS SP.	1

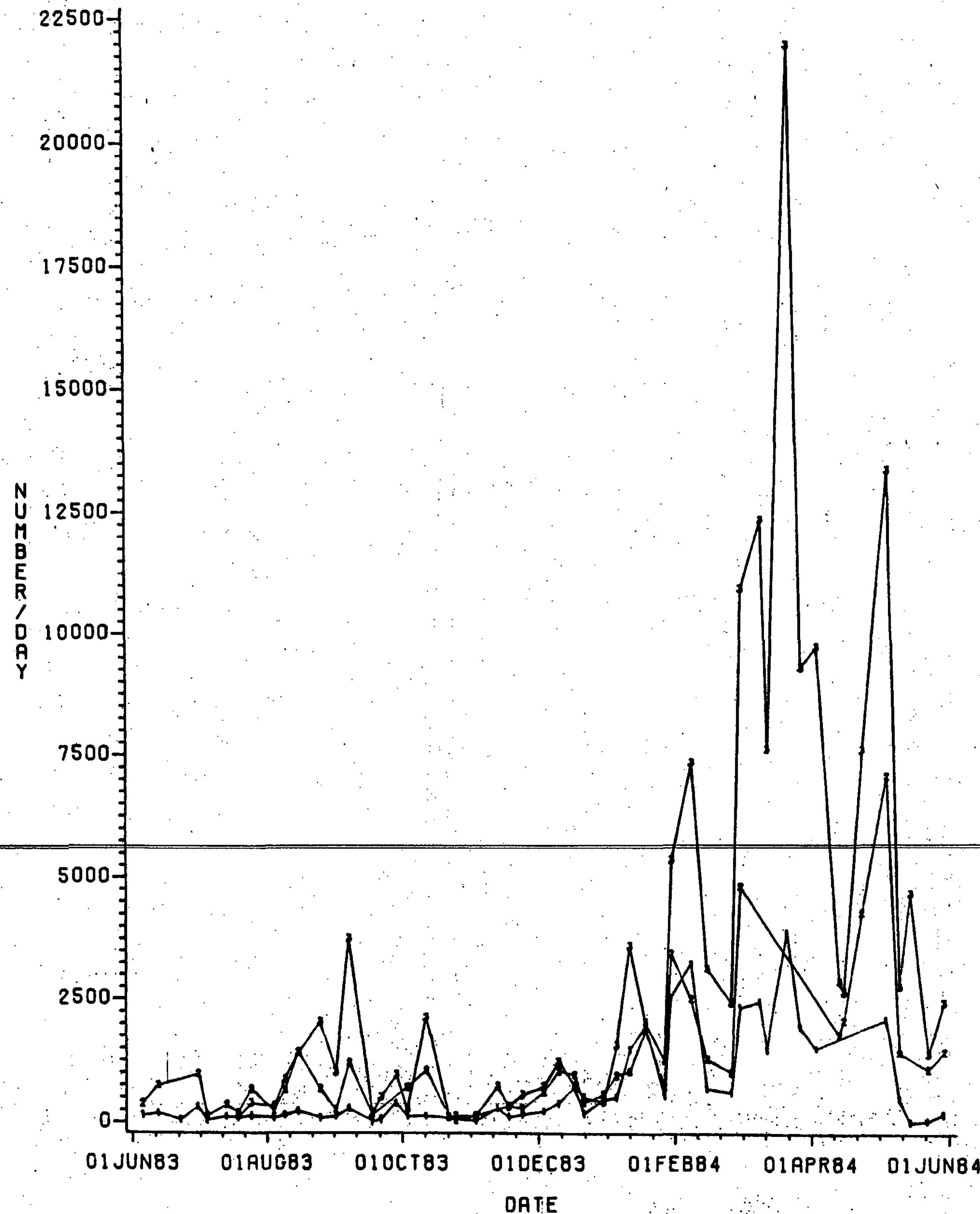

FIGURE 7.2-1
IMPINGEMENT BY DATE FOR
ALL SPECIES COMBINED
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

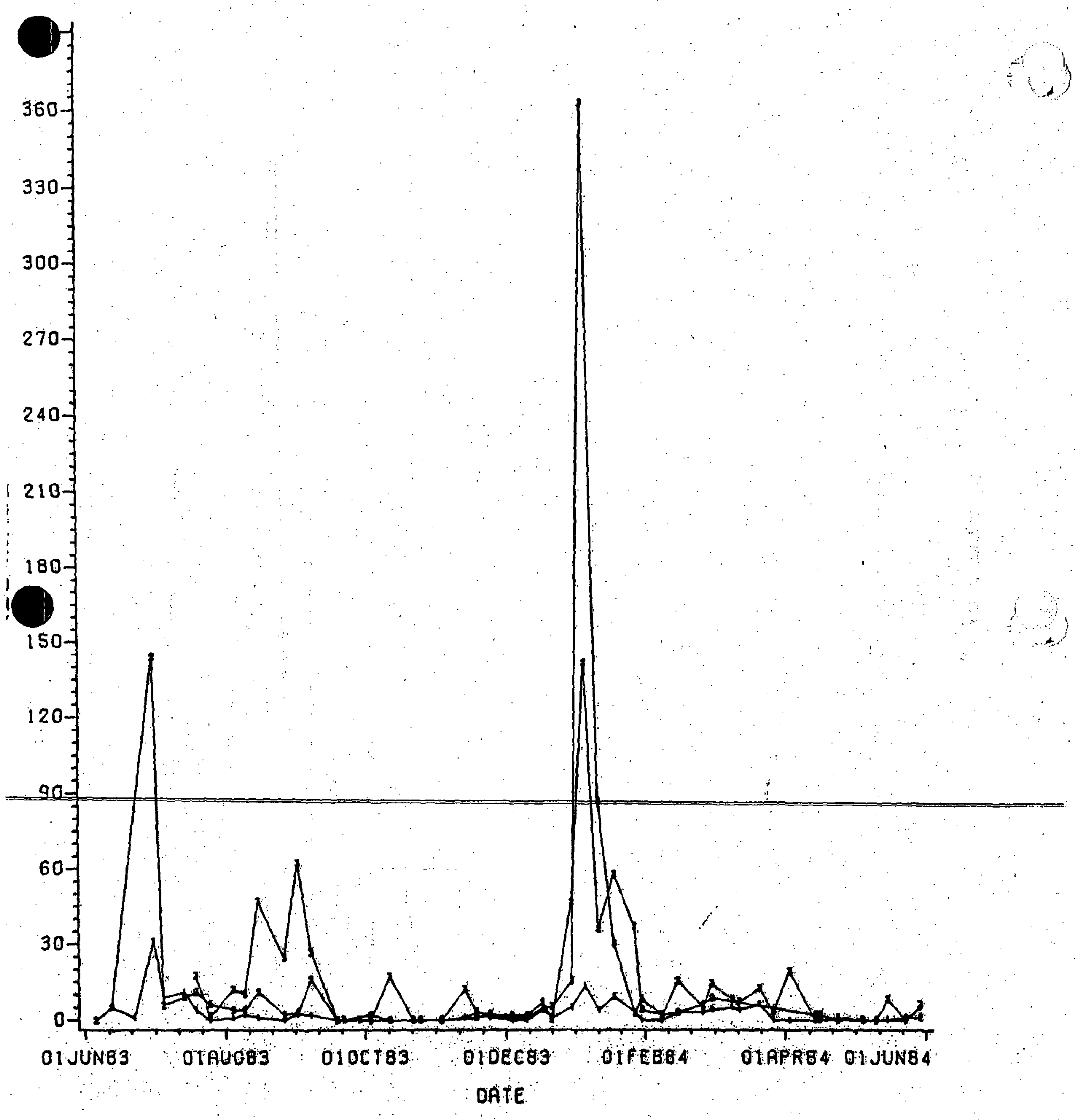

FIGURE 7.2-6
IMPINGEMENT BY DATE FOR
SILVER PERCH
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

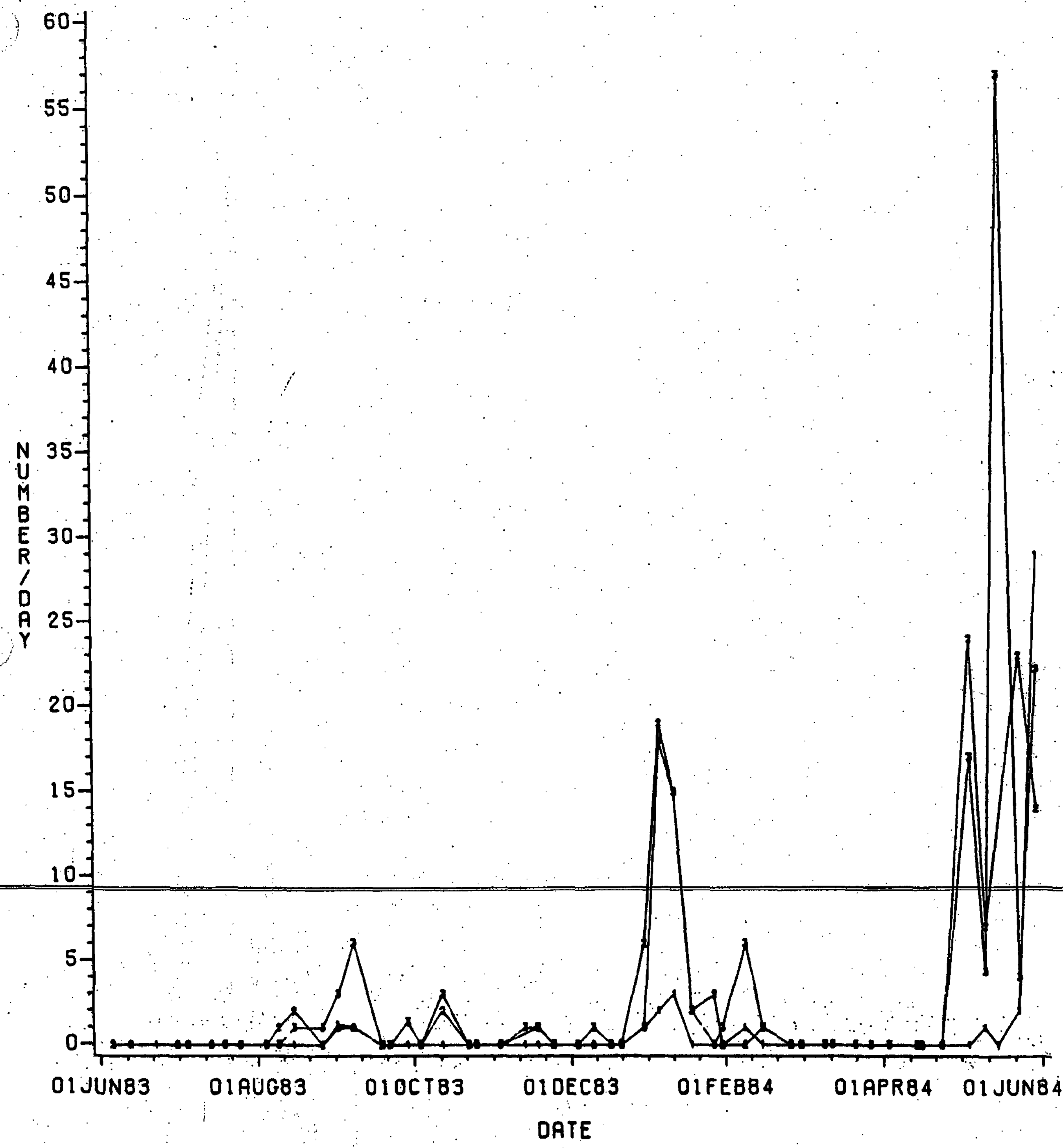

FIGURE 7.2-7
IMPINGEMENT BY DATE FOR
SPOTTED SEATROUT
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

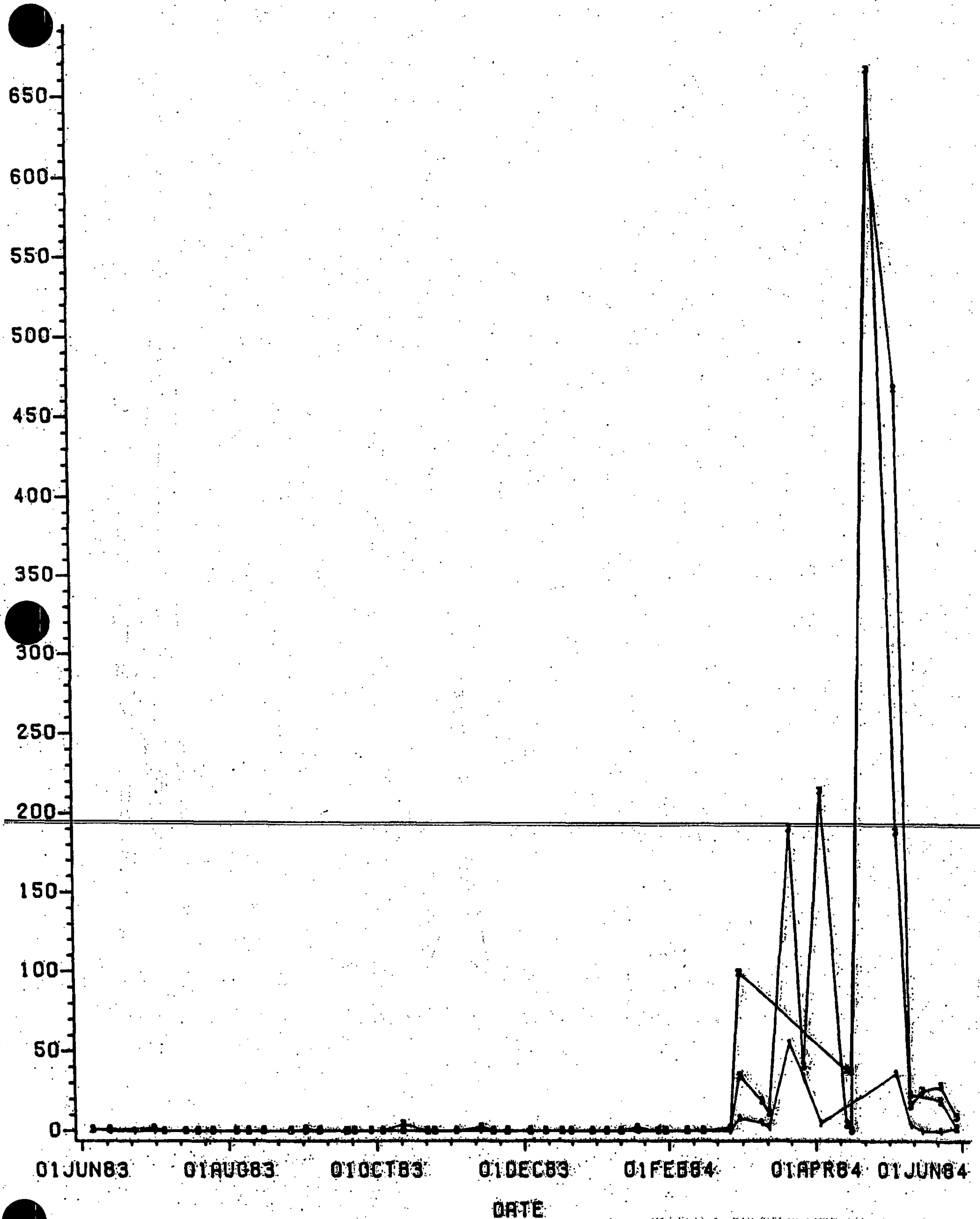

FIGURE 7.2-8
IMPINGEMENT BY DATE FOR
SPOT
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

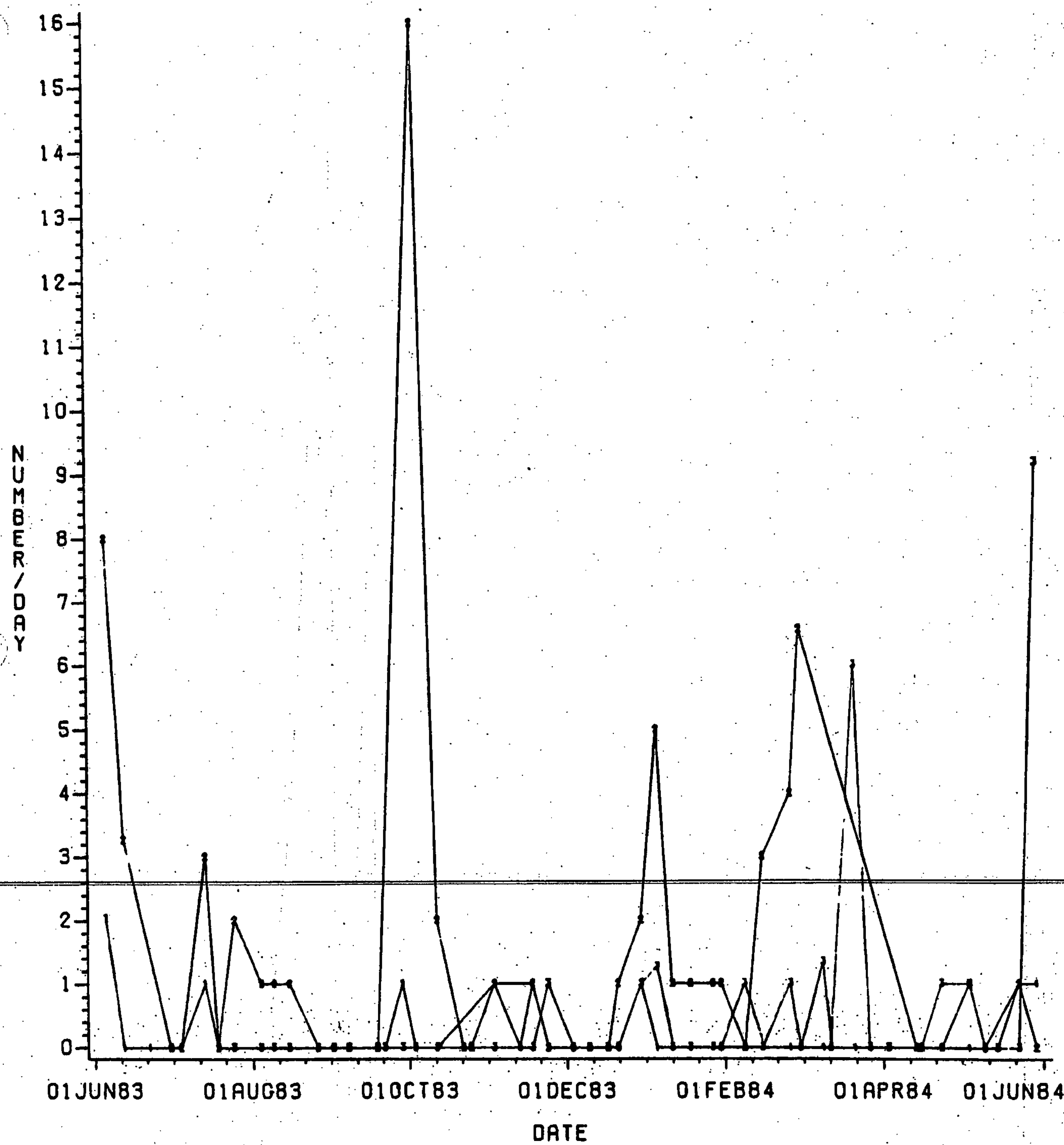

FIGURE 7.2-9
IMPINGEMENT BY DATE FOR
STRIPED MULLET
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

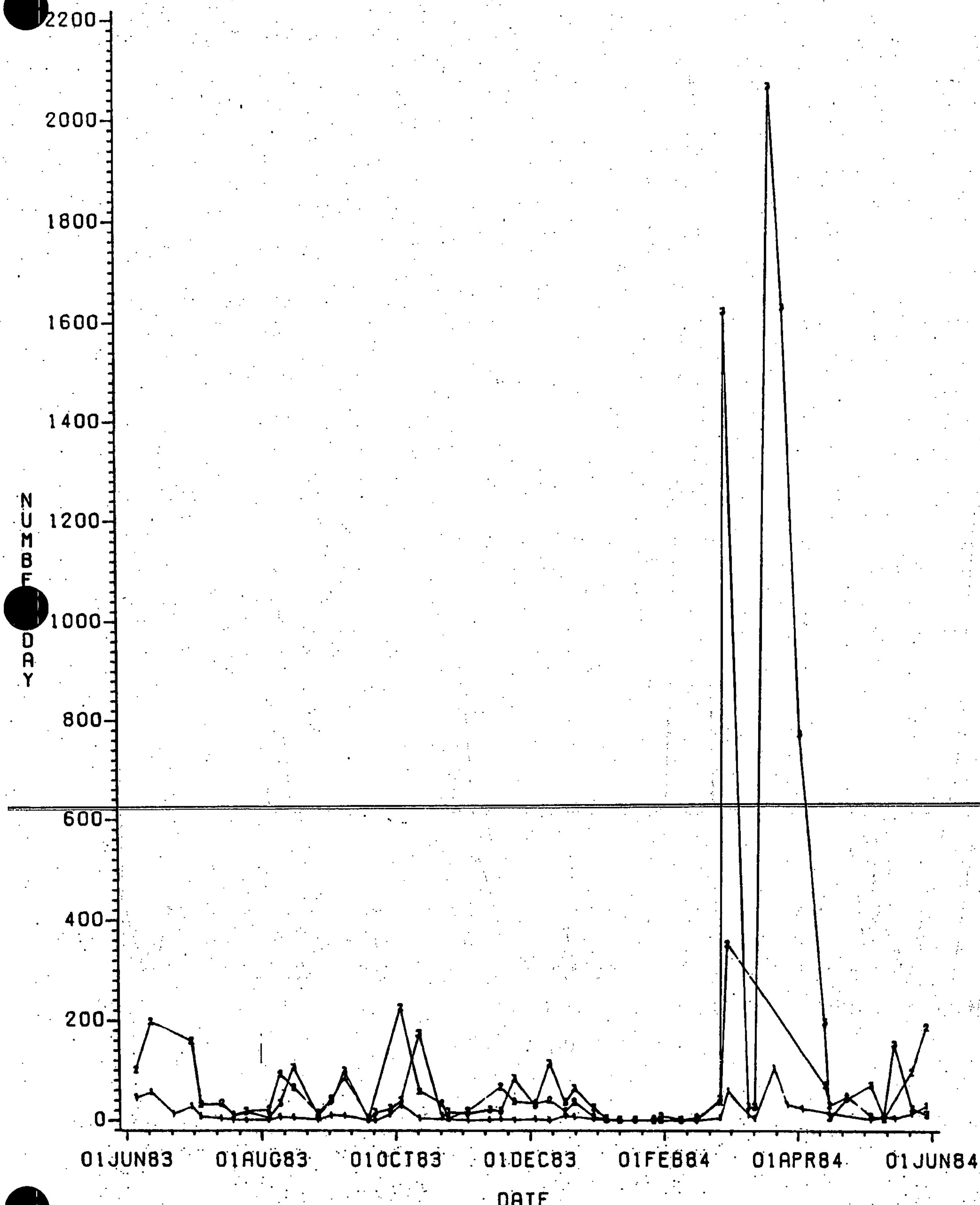

FIGURE 7.2-10
IMPINGEMENT BY DATE FOR
BRIEF SQUID
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

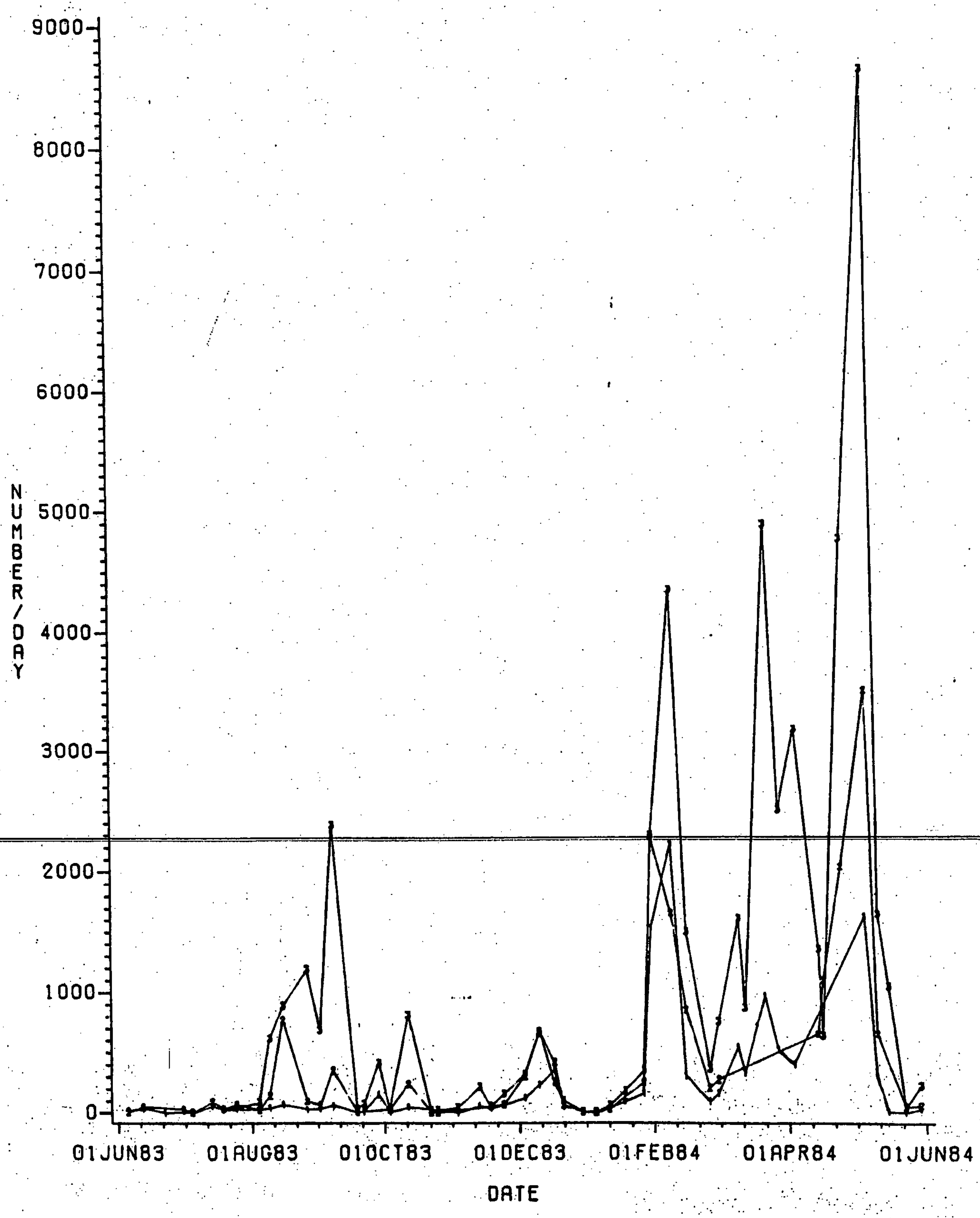

FIGURE 7.2-11
IMPINGEMENT BY DATE FOR
PINK SHRIMP
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

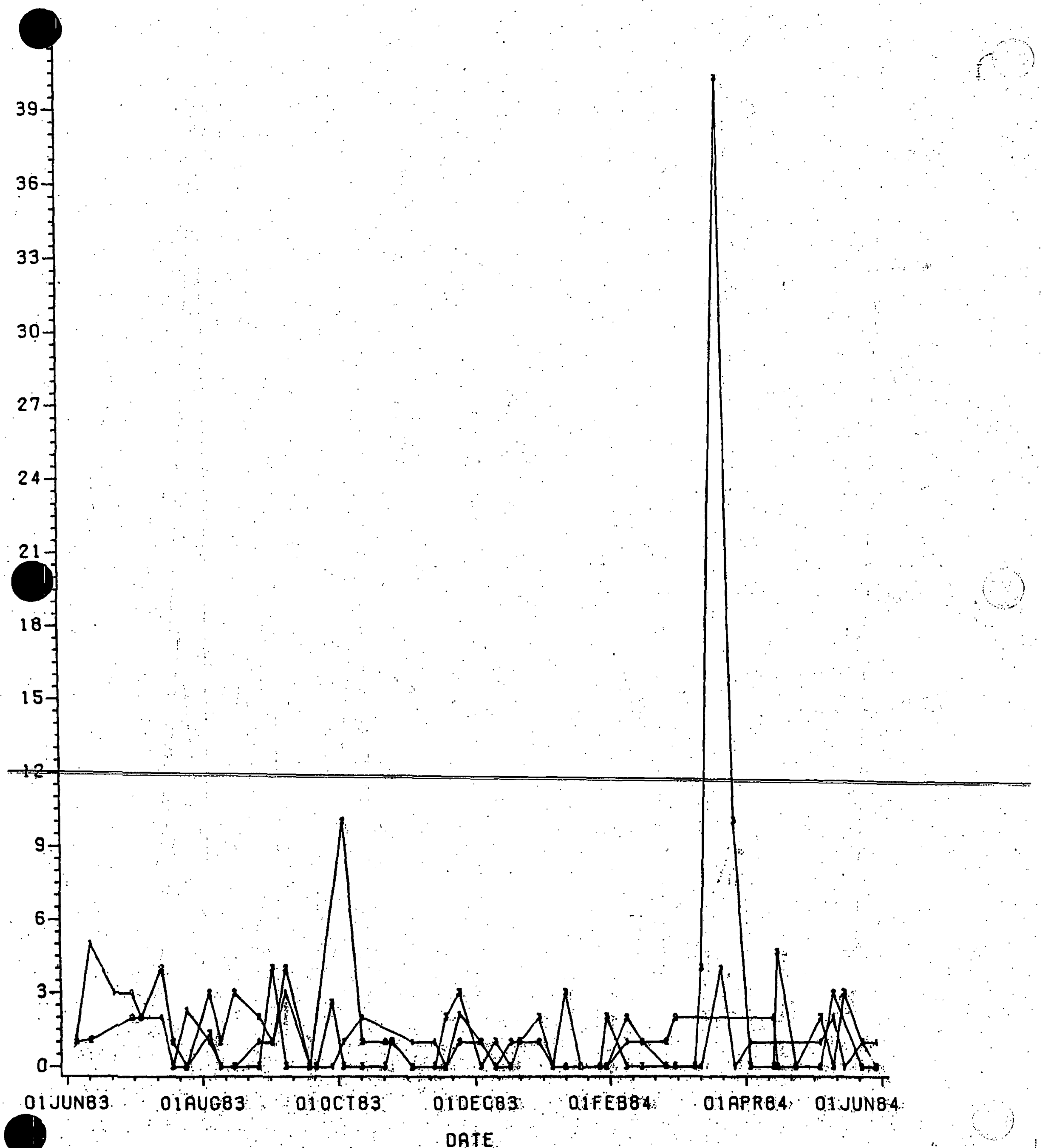

FIGURE 7.2-12
IMPINGEMENT BY DATE FOR
STONE CRAB
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

7.2 RESULTS

The number of organisms impinged each sampling day is shown graphically in Figure 7.2-1. Table 7.2-1 summarizes numbers of fish and invertebrates collected per 6 hour collection. The data are separated by unit and indicate that: 1) the impingement rate was highest for all units in the spring months (significant difference) and 2) the rate at Unit 3 was consistently higher than the rates for Units 1 and 2 (significantly different from Unit 1 only) throughout the study. Table 7.2-2 lists the calculated total annual impingement (fish and invertebrates combined) for each unit. The calculation assumes continuous plant operation with all pumps running. Based on these values, 60.9 percent of the total impingement occurred at Unit 3; Unit 2 accounted for 28.5 percent, and Unit 1 for 10.6 percent. Although the Units 1 and 2 intakes are immediately adjacent and much alike structurally, the number of organisms impinged at Unit 1 was consistently lower and significantly different from numbers at the other units.

Figures 7.2-2 through 7.2-13 summarize daily impingement data by unit for each SIO. Table 7.2-3 provides calculated impingement numbers and weights for each of these species. Both the seasonality of impingement and the unit at which a species was impinged in greatest numbers vary by species. Of the SIO fish species, bay anchovy was collected in the greatest numbers, mostly at Unit 3, and the number impinged peaked sharply in late March. Polka-dot batfish were second in abundance (first by weight), also peak in March, and are also most abundant at Unit 3. These two species account for over 72 percent of the annual impingement of SIO fish impinged.

Spot were the third most abundant species. Their peak numbers were impinged in late April and early May, at which time numbers at both Units 2 and 3 were high (about 650 per day). Projected annual impingement is slightly greater at Unit 2. Annual numbers at Unit 2 for impingement of pigfish, pinfish and striped mullet also exceed numbers at Unit 3. The numbers impinged at Unit 1 are consistently lowest. Silver perch showed the same seasonal pattern as bay anchovy and batfish but accounted for only 5 percent of the SIO fish total. Projected impingement is greater at Unit 3.

The number of SIO invertebrates impinged was much greater than the number of fish. SIO invertebrates represent 83.2 percent of the total number of SIO impinged annually and 42.3 percent of the total number of organisms impinged. Relatively few stone crabs (Figure 7.2-12) were impinged and brief squid (Figure 7.2-10) occurred in low numbers except during a March 1984 peak. In contrast, both pink shrimp (Figure 7.2-11) and blue crab (Figure 7.2-13) occurred throughout the spring in high numbers. For most collection dates and on an annual basis, the highest numbers of all invertebrate SIO were impinged at Unit 3.

The use of supplemental 3 mm mesh collection baskets yielded a limited number of organisms and relatively few species. Tables 7.2-4 and 7.2-5 provide the numbers of fish and invertebrates collected. A total of 113 specimens of fish representing 10 taxa and 109 invertebrates of 15 taxa were collected in the finer mesh. Of these organisms, all except Anachis sp. is represented by other specimens of the same taxa in the coarser mesh collection baskets. Species caught in larger numbers in the fine mesh were also caught in larger numbers in the coarse mesh.

The GLM for impingement rates, both in terms of total numbers and for the SIO, included a number of variables in addition to unit and season. Preliminary analyses included turbidity, salinity, and dissolved oxygen concentration, however, impingement rate did not vary significantly with these variables and they were eliminated from further analysis. Independent variables tested further were barge traffic, day/night, wind (velocity and direction), tide stage, temperature, and combinations of season, unit, and day/night. Results of the ANOVA are provided in Table 7.2-6. There was no significant difference in impingement relative to day/night, however, temperature, barge traffic, and wind are highly correlated. Significantly higher rates of impingement occurred at lower temperatures.

The significance of temperature relative to impingement rate could have been influenced by the low temperatures which occurred at Crystal River in December and January. Temperatures at Crystal River dropped quickly over the night of December 24, 1983, reaching -7.5°C the following morning. Freezing temperatures were recorded through December 27 and again on December 31 and January 1. Water temperatures dropped to 9-10°C from previous values in the 15-20°C range. When impingement sampling took place on December 29, large numbers of dead and decomposing fish and invertebrates, mostly jellyfish, burrfish and puffers, were observed in the water and appeared irregularly in collections during the 24 hour period. Because of their condition and numbers, they were treated as debris and not counted as part of the sample. The samples at this time contained primarily batfish, with relatively high numbers of catfish, tomtate, spotfin mojarra and silver jenny. Although no evidence remained of the fish kill when impingement sampling next took place (January 4-5, 1984), numbers of pinfish and silver perch collected then were the highest found during the program. Spotted seatrout also occurred in relatively high numbers.

The GLM evaluated the effect of barge traffic by season. Traffic in or out within 2 hours of a sampling was considered. Only in spring, when most fish and invertebrates are collected, was the correlation significant. Higher numbers of both fish and invertebrates impinged were positively correlated with barge traffic. Winds of 5, 10, 15, and 20 mph were analyzed. Most of the data available were for 5 mph, and at that velocity wind from the west showed the highest positive correlation with number impinged. At higher velocities, the same trend appeared.

Tables 7.2-7 and 7.2-8 summarize the species and numbers of fish and invertebrates collected during impingement sampling. A total of 130 taxa of fish and 53 invertebrate taxa were identified. Highest total impingement values coincided both with highest meroplankton densities in the spring and to a lesser extent with the secondary peak in the fall (see Section 8.2). For a number of SIO, impingement peaks coincide with peak trawl catches (pink shrimp, blue crab, spotted seatrout, spot and pinfish in 1984, and pigfish). For bay anchovy, the March-April plankton density peak coincides with peak impingement. In several cases (squid, blue crab, silver perch, pinfish), impingement peaks are followed by peak plankton densities.

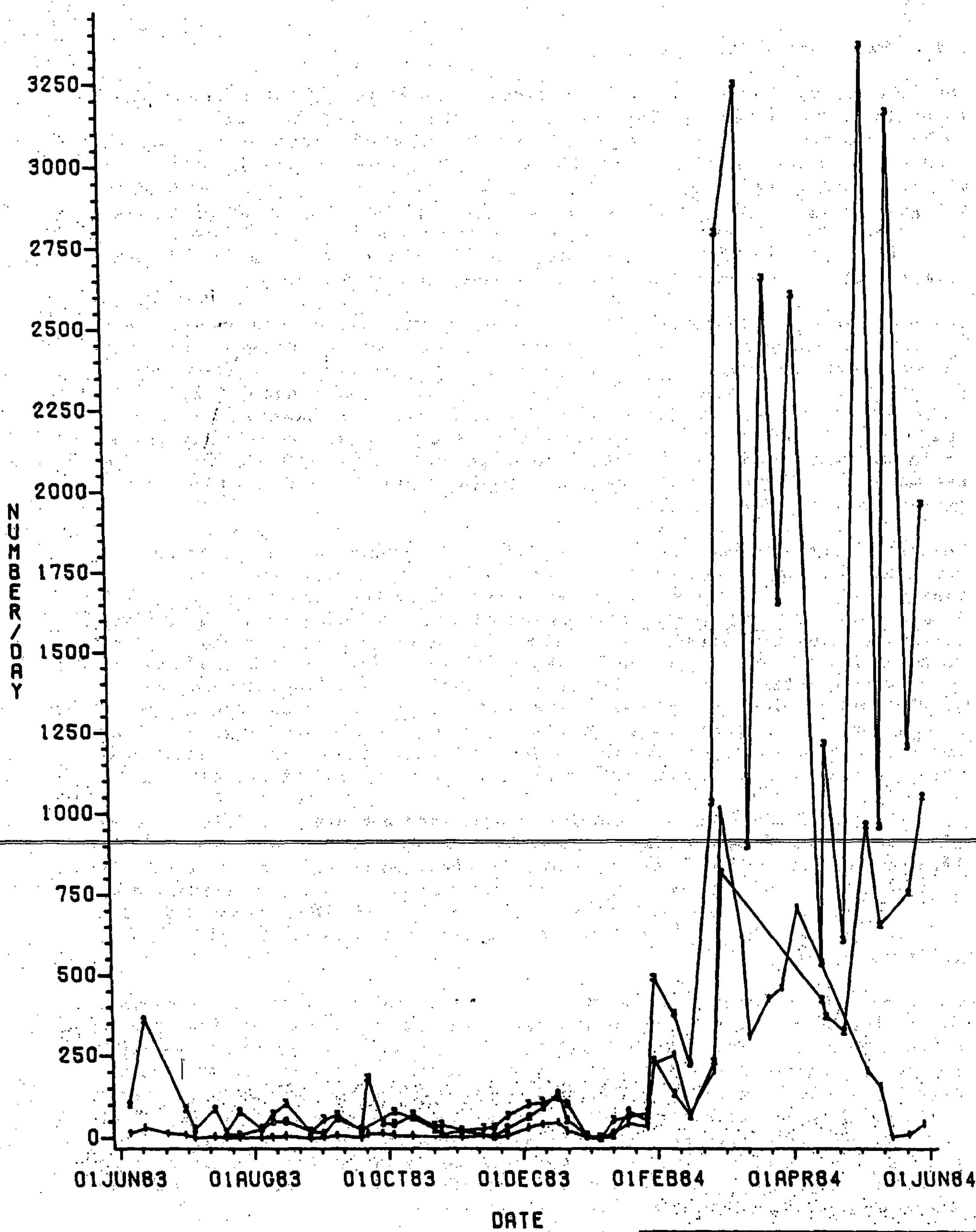

FIGURE 7.2-13
IMPINGEMENT BY DATE FOR
BLUE CRAB
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

7.3 IMPACT ASSESSMENT

The data reported in Table 7.2-2 for annual impingement of SIO has been used to evaluate the impact of impingement at Units 1, 2 and 3, combined. The numbers provided are conservative in the assumption of continuous operation, however, as noted in Section 2.0, the amount of time each unit is offline is minimized and circulating water flows are often maintained even if the unit is not generating electricity. In general, flows throughout the sampling year were close to or just below the maximum flow values (see Table 2.0-2). Exceptional periods of lower flows were usually of not more than 2 or 3 weeks duration other than during Units 3's shutdown in June and July 1983.

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The data utilized represent a single year of collection, and thus do not address year-to-year variation. However, a previous impingement study was conducted at the same units sampled by the present study (NUS 1978). Projected annual impingement of pinfish and invertebrates was 2,642,732 and 721,053, respectively, with a total weight of 35,692 kg. These numbers can be compared to those in Table 7.2-1 for the current program. The total weight of organisms impinged is within 1760 kg or 5 percent of the 1983-84 value. The estimated total number of organisms impinged in 1977-78 was 28 percent greater than the 1983-84 number.

Several differences between sampling periods are apparent. Invertebrates are now taken in larger numbers than fish. Of the invertebrates, pink shrimp ranked first in both years, blue crab is now second but was previously fourth in abundance, *Metoporhaphis calcarata* ranked third in both years. Thus, given the similar species' rankings and higher current projections, it would appear that at least the most commonly impinged invertebrates were impinged in relatively greater numbers in 1983-84. Of the fish species impinged, scaled sardine was previously impinged in greatest numbers but is no longer common. Pinfish and silver perch have also decreased in relative ranking, while bay anchovy, spot and batfish have increased. The major difference in the present study is the lack of a major influx of scaled sardine and thread herring.

The impact of impingement on each SIO is addressed whenever possible in terms of a comparison between estimated annual impingement and local commercial landings or recreational catch. These values are used as an available indication of the local population size and of the yield being sustained by that population. Commercial landings cited are for 1982 (NOAA undated a), the most recent available. Similarly, the most recent catch data for 1980 is used (NOAA undated b).

For two SIO, no landings or catch data are available. It is estimated that 87,978 bay anchovy are impinged annually. Impinged specimens of this species average 0.004 lb. Thus the impinged fish represent about 350 lb of potential forage for aquatic species at higher trophic levels. The impingement rate can also be compared to seine collections. In September 1983, two seine hauls collected 1456 bay anchovy. Thus 121 seine hauls yielding similar numbers of bay anchovy would account for the number annually impinged. Overall, the species is a wide ranging one, occurring in large numbers in many areas including Crystal Bay, and the local impingement is probably small in comparison to the population size.

Batfish are also not a commercially important species and no catch or landings data are available. Based on impingement data, the species appears to be present at the site throughout the year. Based on fisheries data (Section 9.0), the species was not collected in large numbers in any gear at any time during the year. This occurred despite collection of almost 9,000 specimens in the impingement sampling. These results would indicate the presence of a moderate population of batfish in Crystal Bay, perhaps in the intake canal, not readily sampled by fishing gear. The losses to this population can not be quantified but would be judged large based on offshore samples. At the same time, this level of loss has been sustained since at least 1977-78 and presumably can continue to be sustained.

Pigfish are impinged in relatively low numbers. The projected annual impingement of 3697 fish is less than three times the number of fish collected in the fisheries gear during this program. There is no local fishery for pigfish but Florida west coast landings in 1982 amounted to 2158 pounds. Since the estimated annual weight of pigfish impinged is 34.6 lb, this equals 1.6 percent of the landings. This level of impingement loss should not adversely impact the fishery.

Annual impingement of pinfish is estimated to be 15,235 fish (174 lb). While there is no commercial fisheries data available, the marine recreational catch in 1980 in Region 4 (Taylor-Manatee Counties) was 6,395,000 fish. Thus the annual impingement would amount to 0.2 percent of the regional catch. A loss of this level should have no short or long-term adverse impact on the population. Large numbers of the species were taken offshore, particularly by trawl along the southern transect, throughout the study period with the plant operating.

Silver perch impingement is estimated to equal 12,000 fish (141.8 lb) per year. No commercial landings were recorded in 1982, however, the 1980 marine recreational catch in Region 4 was 3,491,000 fish. Thus the impingement at Crystal River amounts to 0.3 percent of the recreational catch, a level too low to adversely effect the population or fishery.

Spotted seatrout are estimated to be impinged in relatively low numbers. A total of 2,804 fish weighing 28 lb are projected. Seatrout are subject to both a commercial fishery and a recreational fishery. The 1982 landings in Citrus-Pasco and Levy Counties equaled 86,278 lb. The Region 4 recreational catch in 1980 was 1,849,000 fish. Given these values, the projected impingement would equal 0.03 percent of the commercial landings or 0.15 percent of the recreational catch. By either comparison the impact of impingement would be considered nominal.

Spot annual impingement is estimated to be 28,094 fish (138.3 lb). These values are strongly influenced by values at two sampling dates in May 1984. The number impinged is less than three times the number of spot taken by fisheries gear during the sampling program. Recreational catch data are not available for spot but the 1982 commercial landings in Citrus-Pasco and Levy Counties equalled 17,474 lb. Therefore, the number of spot impinged is equal to 0.8 percent of the commercial landings and should not adversely affect the fishery or the population.

A single red drum was impinged. When extrapolated to an annual value, it is estimated that 8 red drum are impinged. The 1980 Region 4 recreational catch was 229,000 fish and the 1982 Citrus-Pasco and Levy Counties commercial landings were 31,023 lb. The 8 fish equal 0.003 percent of the recreational catch. Using a weight of 1.07 lb per fish obtained from the seine samples, the weight of red drum impinged equals 0.03 percent of the commercial catch. By either indicator, the Crystal River impingement is negliglible.

A total of 1120 striped mullet (74.1 lb) are estimated to be impinged annually. This can be compared to the commercial landings of 2,656,954 lb in 1982 in Citrus-Pasco and Levy Counties and the impinged weight of mullet equals 0.003 percent of the landings. The marine recreational catch in 1982 in Region 4 is reported as 1,415,000 "mullets" but the proportion by species is not available. Based on the commercial landings, impingement at Crystal River would have a negligible effect on the commercial fishery.

Pink shrimp are impinged in large numbers at Crystal River. The annual impingement is estimated to be 640,887 shrimp (6788.5 lb). No recreational catch data for shrimp are available and the commercial data are more difficult to use than for some species since shrimp taken in the Citrus County area may be sold at docks in many different counties. Landings are also reported as bait and saltwater shrimp (heads-on), which are combined here. The reported 1982 landings in Citrus-Pasco and Levy Counties amounted to 1,076,759 lb. Based on this value, the Crystal River impingement would equal 0.6 percent of the commercial catch. Thus the plant is probably not adversely affecting the fishery.

A total of 383,560 blue crabs (28,900 lb) are estimated to be impinged annually. Recreational catch data are not available but the 1982 Citrus-Pasco and Levy Counties commercial landings amounted to 3,877,040 lb. This is the combined total of hard and soft crabs. The Crystal River impingement would equal 0.7 percent of this total. This level of impingement should not adversely effect the fishery or the population.

Stone crab were impinged in relatively small numbers. A total of 1535 crabs (136.9 lb) are calculated to be impinged annually. The number impinged is equal to 24.5 percent of the number of crabs taken offshore in 4 months of trapping. Recreational catches are not available but the Citrus-Pasco and Levy Counties commercial landings were 949,076 lb. The annual impingement would be equal to 0.01 percent of the commercial landings, a level too low to adversely affect the fishery. It is recognized that commercial landings represent a weight of claws while the impinged weight is for whole crabs. The loss percentage, therefore, should be conservative, since claw weight from impinged specimens, even accounting for potential regeneration, is unlikely to exceed 137 lb.

Brief squid are impinged at Crystal River in relatively large numbers. An annual impingement of 86,954 squid (931.8 lb) is projected. There is a local commercial fishery in Citrus-Pasco but it amounted to only 202 lb in 1982. Because local demand for squid is limited, this would not be considered a valid indication of the local population size or viability. Using the 1982 Florida West Coast landings as a better indication of the fishery for this species, the impingement estimate is 1.8 percent of the commercial landings (52,231 lb). While this is a small percentage of the Florida west coast fishery, it is not clear how it relates to the Crystal Bay area. This species is known to migrate (Laughlin and Livingston 1982) and the short, month-long period of peak impingement (Figure 7.2-10) would suggest that the squid found locally are part of a broadly distributed population. This would reduce potential for any adverse impact to the population as a result of a localized loss.

REFERENCES FOR 7.3

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NOAA. Undated a. Florida Landings by Districts, 1982. Florida Landings by Counties, 1982. National Marine Fisheries Service, Washington, D. C.

NOAA. Undated b. Estimated Total Number of Fish Caught by Marine Recreational Fishermen by Species Group and Planning Region, Jan. 1980 - Dec. 1980. National Marine Fisheries Service, Washington, D.C.

NUS. 1978. Impingement Report, March 13, 1977 to March 13, 1978. Crystal River, Unit 3. Environmental Technical Specifications. Report to Florida Power Corporation.

8.0 ENTRAINMENT

Plankton samples were collected every 2 weeks throughout the study period to define the existing conditions and to evaluate the extent and potential impacts of plankton entrainment into the cooling water systems of Units 1, 2 and 3. The assessment of entrainment effects emphasizes selected organisms as defined in Section 7.1.

8.1 SAMPLING AND LABORATORY ANALYSIS

8.1.1 Sampling Procedures

Plankton samples were collected at 15 stations in the vicinity of the Crystal River Power Station (Figure 8.1-1). Stations were sampled once during the day and once at night, every other week for 15 months. Sampling times varied to allow collections during both high and low tide conditions. Measurements of water temperature, turbidity, salinity, and dissolved oxygen were made at each station prior to sample collection. Water depth, tidal stage, and meteorological conditions were also noted.

A standard 1 m mouth diameter, 505 um mesh plankton net fitted with a calibrated General Oceanics Model 2030 digital flowmeter was used to sample at 11 stations (Stations A-K). A digital flowmeter was also suspended from the tow boat in such a way as to monitor unobstructed water flow past the moving boat during sampling. Tows were made obliquely through the water column. The weighted net was allowed to sink to near the bottom and then towed horizontally until it reached the surface. Tows were timed with a stopwatch to ensure that each tow was of equal duration (approximately 3 minutes, or to filter approximately 100 m^3 of water). Four replicates were collected serially at each station with one replicate intended as a backup.

Four replicate samples were collected during the daytime and at night in each of two tidal creeks (Stations N, P). Samples were collected with a 505 um mesh net fitted with a calibrated flowmeter attached to a frame which was lowered into the water to rest on the creek bottom. A second flowmeter mounted on the boat was used to monitor net clogging. The stationary net fished the tidal currents of the creeks.

Two stations in seagrass beds (Stations L and M) were sampled every other week during the day and at night. Samples were collected with a sled fitted with 505 um mesh netting and a calibrated flowmeter. Four replicate samples were collected by towing the sled across the seagrass bed. The location of Station L shown on Figure 8.1-1 was sampled as of October 24, 1983. Prior to that date, the station was located in Basin 1 at a grassbed which disappeared.

8.1.2 Laboratory Analysis

For all samples collected, entire replicate samples were analyzed where practicable. When large amounts of detritus, algae, or plankton necessitated subsampling, samples were fractionated using a random plankton splitter. The sample was agitated thoroughly, and aliquots were drawn off into a gridded petri dish. Each aliquot was examined twice, with agitation between examinations.

When meroplankton was abundant, samples were fractionated to the extent that approximately 100 specimens of each species were sorted. Subsamples were sorted consistently; that is, they were completely sorted for any fish eggs or larval organisms, for which less than 100 specimens had been picked from the sample.

Invertebrate meroplankton and ichthyoplankton was sorted, identified, and enumerated. Identification was made to the lowest practical taxon (usually family for eggs, species for larvae). Sorting, identification, and enumeration of the invertebrate plankton was limited to those taxa which are of commercial value in later lifestages. Developmental stages of SIO were separated, identified, and enumerated. Fish larvae of SIO were measured for standard length.

Identification of egg and larval specimens was made through the use of standard literature sources and MML's reference collection. Voucher specimens were referred to external taxonomic specialists for identification or confirmation as necessary. A reference collection of taxonomically confirmed species was maintained.

8.1.3 Statistical Analysis

For meroplankton density data, SAS was used to compare densities among stations, seasons, day/night, temperature, tide, and interactions of these variables. Tukey's HSD tests were used to compare means of station and season of sampling. The same procedures were also applied to densities of various life stages of SIO. These analyses were conducted only for stages or time periods when results would yield significant information. As with impingement data, pertinent data from Stations C, D, or E were annualized by using densities over a period of occurrence and the appropriate volume of flow through the units' circulating water system.

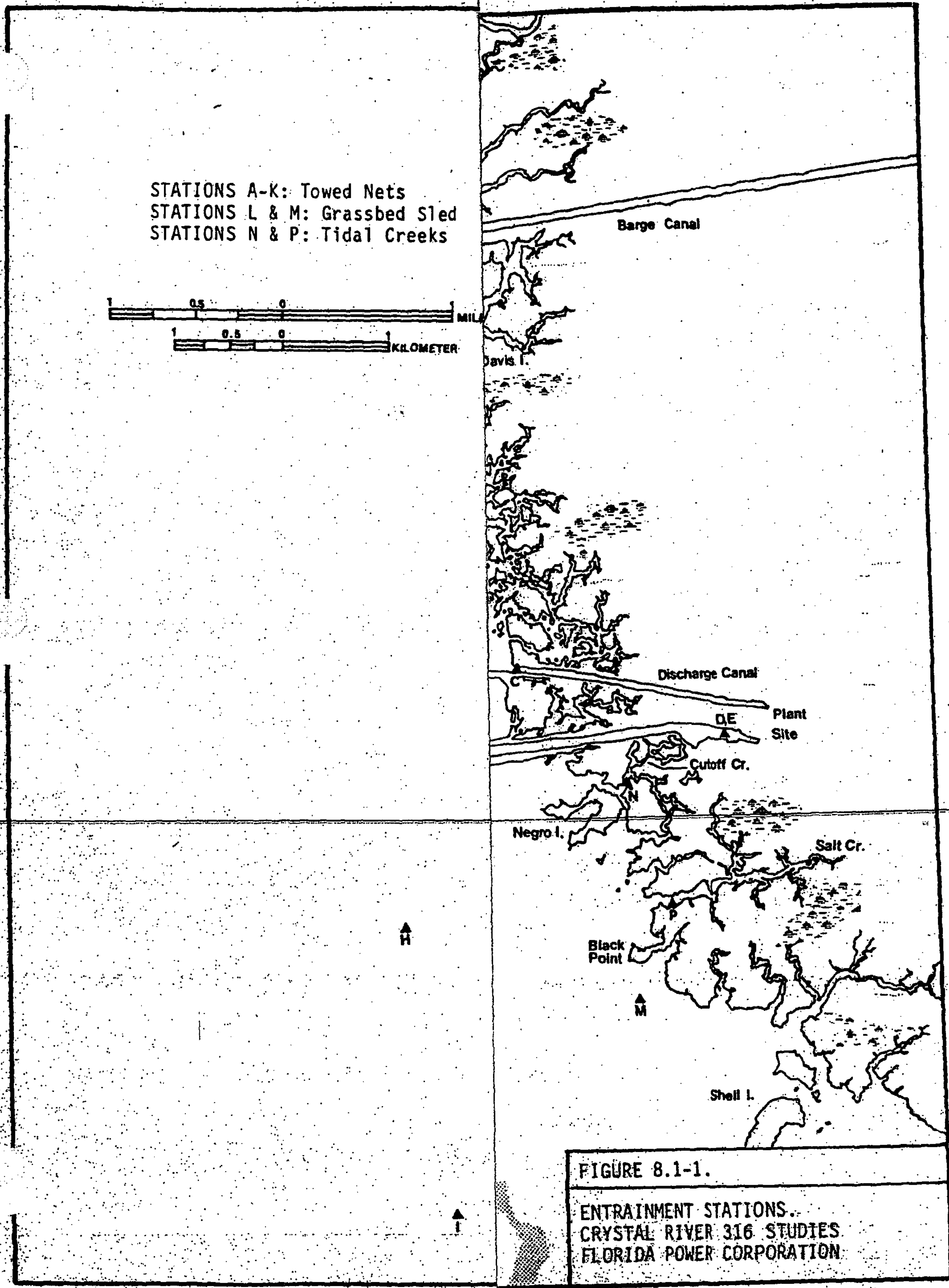


FIGURE 8.1-1.

ENTRAINMENT STATIONS.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

8.2 RESULTS

Entrainment sampling was initiated in the middle of the 1983 spawning season and was terminated before the end of the 1984 spawning season. As a result, density data and seasonal variations must be carefully interpreted. Particular difficulty occurs with species for which spawning activity extends from before June 1 to after September 1.

8.2.1 Sampling at Stations A-K

Figure 8.2-1 summarizes the average plankton density at Stations A-K over the sampling period. Monthly average densities of total meroplankton from June into September 1983 were moderate (3.7-19.3 per m^3) compared to 1984 values (16.7-32.7 per m^3). Densities declined through September and October to significantly lower levels (less than 1 per m^3) which continued into March 1984. In early March, total meroplankton density increased rapidly, reaching significantly higher values in April (42.5 per m^3) and May. Densities from June through August were lower than in April 1984 but higher than in 1983.

Fish eggs, which comprise the majority of the ichthyoplankton, follow the same seasonal pattern defined for total plankton. Fish postlarvae did not reach the same levels as eggs in 1983 but the peaks occurred at the same times. In 1984, postlarvae increased in density in mid-March, reached a minor peak in April (3.2 per m^3), decreased in density through early June, and then increased to a maximum monthly average value in August (7.3 per m^3). In the study period, fish prolarval densities approached a monthly average of 1 per m^3 only in April 1984; a secondary, lower peak occurred in August (0.4 per m^3). Juveniles were in low numbers throughout the sampling periods (less than 0.25 per m^3).

Invertebrate meroplankton occurred in moderate densities from June to October 1983 (0.8 to 8.8 per m^3). Values were similar to those for fish eggs at this time. Low densities (less than 0.1 per m^3) continued from October through early May 1984 at which time densities increased to a moderate peak in July (5.2 per m^3) and a maximum value in August (10.2 per m^3).

Figures 8.2-2 through 8.2-12 summarize density data for each Selected Important Organism (SIO). The patterns of occurrence vary but are all characterized by sharp peaks, often representing a single sampling date. Bay anchovy spawning dominated plankton collections as indicated by comparing relative densities. For eggs, in particular, the pattern of densities over time for bay anchovies is essentially the pattern for total plankton. Other species contribute a smaller portion of the plankton at a particular time.

A limited amount of information on early life stages of most SIO is available from the Crystal River plankton collections. This may result from the species lifestage simply not occurring in the area, but more usually results from the inability to distinguish taxonomically between eggs and prolarvae of closely related species. Unidentifiable life stages were lumped at the lowest possible taxon. As a result, pigfish and red drum were only found as postlarvae; spot, spotted seatrout, and pinfish were found as postlarvae and juveniles; batfish were collected only as juveniles; and no silver perch eggs and few prolarvae were identified.

Invertebrate SIO plankton was dominated by stone crab larvae. Larval densities decreased with increasing life stage and generally peaked in late summer. Brief squid were the second largest component of the SIO invertebrate plankton. They occurred in low (less than 0.25 per 100 m^3), variable densities with highest densities in late fall and late spring. Blue crab larvae were identified only as megalops; these were collected during the summer.

The distribution of total meroplankton within the study area was defined primarily by the distribution of bay anchovy eggs and larvae, sciaenid eggs and larvae, and stone crab larvae. Other taxa contributed pulses of high density for shorter periods and perhaps at only a few stations, e.g., Gobiosoma robustum in spring and early summer, Brevoortia sp. in January and February, and spot in January.

From initiation of sampling in June 1983 through early September the spatial pattern of total plankton distribution on each sampling date was consistent (Figure 8.2-13). Concentrations at inshore Stations B, C, D, E, F, and J were relatively low; highest values were consistently at offshore Stations A, H, and K. By late September, values at all stations except K were less than 8 per m^3, and in October, values at all stations were down to less than 1.3 per m^3; this continued through February. In early March, large numbers of bay anchovies were collected only inshore to the south at Station J (66.5 per m^3). By late March, bay anchovies were concentrated at Stations D, G, I, and K. In early April, large numbers of bay anchovies were collected at B and G (136 and 31.6 per m^3), while sciaenids occurred in large numbers offshore at Stations I and K (39.2 and 42.8 per m^3). By the next collection, bay anchovies dominated and numbers peaked at inshore Stations D, E, F, G, and J. By May the pattern identified in 1983 was reestablished with low densities (less than 10 per m^3) inshore and high values (up to 90 per m^3) offshore (Figure 8.2-14). This continued through the end of sampling with the exception of early August when values at D, E, and G (inshore) were also high (33-85 per m^3), primarily as a result of stone crab and bay anchovy densities. Stone crabs and sciaenids also contributed significantly to levels reached offshore at Stations H, I, and K.

Statistical analyses of total plankton densities throughout the sampling period used a square root transformation of mean densities to reduce variations in the residuals and considered variation with season, station, day/night, temperature, tide and with season-station, season-day/night, and station-day/night. Results of the ANOVA are provided in Table 8.2-1. Densities did not vary significantly with tide. Season was a highly significant variable as were station and station-season. Day/night was also positively correlated but accounts for less of the variation. Temperature had an even smaller effect, but the analyses had already considered season.

Seasonal variation in density has been described above. Densities at night were significantly higher than those collected during the day. Analyses by station indicate that offshore Stations K, A, I, and H had the highest overall values and were not significantly different from one another. All were significantly different from inshore Stations E, D, F, C, and B. The observed seasonal grouping of Station J with the inshore stations was not apparent from this analysis. Station J was significantly different from the inshore stations and from Station K offshore but was similar to Stations A, G, H, and I.

Analyses of the effect of season, station, day/night, temperature, tide, and interactions on density were conducted using the mean densities. The analyses were run for selected life stages for each SIO during their periods of occurrence when enough data were available. Bay anchovy densities were analyzed for four life stages (Tables 8.2-2 to 8.2-5). Egg densities did not vary significantly with tide, temperature, or day/night. The density distribution was fairly uniform; Station A had the highest densities (17.16 per m^3) but was not significantly different from Stations B, E, F, G, J, and K. Station C had the lowest density (1.36 per m^3) but was significantly different only from offshore Stations A and J. Anchovy prolarvae were similarly uniform in distribution with no significant differences found between any stations. The distribution of postlarvae was similar to that of eggs with high values at Station A (2.2 per m^3), which was significantly different only from low values at B and C (0.67 and 0.57 per m^3). Juvenile bay anchovy were much less common than other stages. On the two dates when they did occur in significantly higher densities (max. 0.62 per m^3), they were concentrated at Stations B and G. All three later stages occurred in significantly higher numbers at night.

Sciaenid egg densities were analyzed and showed significant differences by season, tide stage, night/day, and station (Table 8.2-6). Offshore Stations K and I did not differ from one another but had significantly higher densities (9.96 and 8.62 per m^3) than other stations. Station B had the lowest densities (0.05 per m^3), but the value did not differ significantly from densities at Stations C-G and J.

Data on the number of postlarvae of spotted seatrout (Table 8.2-7), silver perch (Table 8.2-8), pinfish (Table 8.2-9), and spot (Table 8.2-10) collected were analyzed. Seatrout densities were highest offshore (Stations H, I, and K) (maximum 0.02 per m^3) and lowest at Stations B-F inshore. Pinfish densities were significantly higher at Stations G and F (0.17 and 0.08 per m^3) but otherwise uniform in distribution. Spot postlarval densities were highest at Station E (0.05 per m^3), but the value at that station was not significantly different from densities at Stations A, D, F, G, and I. Low densities at Station H (0.002 per m^3) were only different from values at E and I. Thus, values were generally low and fairly uniform. Densities of silver perch postlarvae were significantly higher at H (0.09 per m^3) and lower at E (0.004 per m^3), but intermediate values did not differ significantly.

The densities of all stages of stone crabs were combined and the data analyzed (Table 8.2-11). Neither tide nor day/night variation was significant. Highest densities were at Station K (14.3 per m^3), but values at Stations K, A, H, and I did not differ significantly. Low values at Station B (1.1 per m^3) did not differ significantly from Stations C-G and J. Shrimp postlarvae were similarly analyzed (Table 8.2-12) but their distribution was uniform except at Stations B and G where mean densities were higher (0.1 and 0.13 per m^3).

Stations D and E were located immediately in front of the intakes for Units 3 and 1 and 2, respectively. Thus, values from these stations can be utilized in assessing the effects of entrainment. In addition, samples taken at

Station C, because of its location and the local hydrodynamic conditions, are assumed to have contained organisms which may have passed through the units. Considered as a group, densities at these stations in 1983 showed moderate peaks in early July (stone crab) and late August (bay anchovy and stone crab), relatively low values for the remainder of the summer, and very low values from mid-October through February 1984 (see Figures 8.2-15 and 8.2-16). In late March, numbers increased to a sharp peak in April (bay anchovy) and then fell to very low values throughout May. Values increased slowly through June and July with a significant peak being reached in mid-August (bay anchovy and stone crab).

Differences between stations were not consistent, but peaks at Station C and to a lesser extent D were influenced primarily by stone crabs while peaks at D and sometimes E are dominated by bay anchovy. In July 1983, the highest densities were at Station C but by August, the bay anchovy densities were high throughout Crystal Bay and highest at Station E. In 1984, the March-April values peaked at D and E (bay anchovy); in August, the values again peaked at E and D and resulted primarily from bay anchovy and stone crab.

Other than for bay anchovy and stone crabs, SIO meroplankton densities were relatively low at Stations C, D, or E. Silver perch were taken in greatest numbers at C and pinfish at E. Spotted seatrout were evenly distributed. Spot were collected in highest densities at E and squid at C and E. Some species were collected in very small numbers. Batfish were collected only at E, pigfish and red drum at C, and blue crabs only at C and D. Mullet and shrimp were not collected at C, D, or E.

Ambient concentrations of each SIO were used to calculate an annual number entrained for each life stage at Stations C, D, and E. The results are provided in Tables 8.2-13, 14, and 15. The numbers are obtained by taking the average density during each sampling period, multiplying by the total flow (100%) for the three units, and adding the values for each sampling period to determine the annual entrainment (Reimann integration). Data from June through August 1984 were combined with 1983 data for the comparable time period. This effectively reduced the sampling periods used from two weeks to about one week.

Because of problems associated with identifying the early life stages of some species it is appropriate to consider the next highest taxon which could contain SIO. Tables 8.2-16, 17, and 18 present annual entrainment data for these taxa at Stations C, D, and E. Anchoa sp. probably contains very small larvae of A. mitchilli and larger damaged specimens as well as other species. Values for Haemulidae (including pigfish) and Mugillidae (including striped mullet) are for eggs and for postlarvae and juveniles, respectively. Each value is based on a single collection date. Numbers for Sciaenidae are significant but represent eggs and prolarvae of a number of species not restricted to SIO. Postlarvae and juveniles could be identified. Only the megalops stage of blue crabs were identified in the study area. The Callinectes sp. numbers can represent a number of species.

8.2.2 Sampling at Stations L, M, N, and P

Grassbed plankton sampling at Stations L and M yielded low densities (less than 5 per m^3) throughout 1983 (see quarterly tables). Both stations had comparable values. In 1984, values up to 45 per m^3 were recorded beginning in late March. Through April and again from mid-July through mid-August values at Station L were highest. Values at M were higher only in May. Species diversity at both L and M was less than diversity in offshore net tows, at most yielding 30 taxa and generally less than 20. Densities at Station L were dominated by bay anchovies and to a lesser extent by stone crabs and gobies. Collections at Station M were dominated primarily by gobies.

Collections made in Cutoff (Station N) and Salt Creeks (Station P) yielded low densities throughout the study. With the exception of the first two collections when Station N had high numbers of stone crabs and then bay anchovies, values at both stations were similar. Diversity was also similar at both stations; no more than 20 taxa were ever collected. Gobies frequently comprised the largest portion of the samples at both stations. Cutoff Creek also occasionally yielded blennies, which were not common at Salt Creek.

TABLE 8.2-1

TOTAL PLANKTON

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SQUARE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	111	822219.47253050	7407.38263541	19.39	0.0001	0.526324	81.9003
ERROR	1937	739972.24544041	382.01974468		ROOT MSE		SQUARE MEAN
CORRECTED TOTAL	2048	1562191.71797091			19.54532539		23.86477083

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
SEASON	7	478491.42686787	178.93	0.0001	7	231700.25878913	86.64	0.0001
STATION	10	121458.36286226	31.79	0.0001	10	122645.18390898	32.10	0.0001
DN	1	33444.66177809	87.55	0.0001	1	32019.13444763	83.82	0.0001
SEASON*STATION	70	122712.34075223	4.59	0.0001	70	124145.22694732	4.64	0.0001
SEASON*DN	7	37612.04860204	14.07	0.0001	7	35402.92089036	13.24	0.0001
STATION*DN	10	17743.60260536	4.64	0.0001	10	16100.31277922	4.21	0.0001
TEMP	1	7853.36217603	20.56	0.0001	1	7878.36998742	20.62	0.0001
TIDE	5	2903.66680667	1.52	0.1790	5	2903.66680667	1.52	0.1790

TABLE 8.2-2

BAY ANCHOVY-EGGS

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SUMDEN

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	85	2645212740.2703809	31120149.8855339	4.51	0.0001	0.219918	316.7758
ERROR	1360	9382955624.8027970	6899232.0770609		ROOT MSE		SUMDEN MEAN
CORRECTED TOTAL	1445	12028168365.0731780			2626.6389316		829.17916321

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
SEASON	5	751080364.3887545	21.77	0.0001	5	720394628.8391129	20.88	0.0001
STATION	10	272749242.7943199	3.95	0.0001	10	302006470.0592446	4.38	0.0001
DN	1	6528326.4193280	0.95	0.3309	1	7084457.9743267	1.03	0.3111
SEASON*STATION	50	822460294.8539739	2.38	0.0001	50	865114179.6271774	2.51	0.0001
SEASON*DN	5	545456151.1021438	15.81	0.0001	5	534648339.2008721	15.50	0.0001
STATION*DN	10	135105513.7035924	1.96	0.0344	10	130606017.5773013	1.89	0.0421
TEMP	1	21877078.9683724	3.17	0.0752	1	14581282.1837330	2.11	0.1462
TIDE	3	89955768.0398959	4.35	0.0049	3	89955768.0398959	4.35	0.0049

TABLE 8.2-3

BAY ANCHOVY-PROLARVAE

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SUMDEN

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	49	2428739.75893670	49566.11752932	4.14	0.0001	0.189087	375.0740
ERROR	871	10415833.35984838	11958.47687698		ROOT MSE		SUMDEN MEAN
CORRECTED TOTAL	920	12844573.11878508			109.35482100		29.15553529

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
SEASON	2	533165.27894867	22.29	0.0001	2	392401.13272431	16.41	0.0001
STATION	10	227051.20173871	1.90	0.0420	10	585171.15637760	4.89	0.0001
DN	1	169661.23272726	14.19	0.0002	1	320417.26755194	26.79	0.0001
SEASON*STATION	20	795735.46246991	3.33	0.0001	20	761081.19757986	3.18	0.0001
SEASON*DN	2	348157.57603516	14.56	0.0001	2	294840.76791345	12.33	0.0001
STATION*DN	10	205173.06931105	1.72	0.0729	10	210863.84549267	1.76	0.0633
TEMP	1	125192.60944490	10.47	0.0013	1	131709.41387268	11.01	0.0009
TIDE	3	24603.32826104	0.69	0.5646	3	24603.32826104	0.69	0.5646

TABLE 8.2-4

BAY ANCHOVY-POSTLARVAE

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SUMDEN

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	73	39868304.61550998	546141.15911658	4.70	0.0001	0.216373	263.4953
ERROR	1243	144389277.70230388	116161.92896404		ROOT MSE		SUMDEN MEAN
CORRECTED TOTAL	1316	184257582.31781386			340.82536432		129.34779803

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
SEASON	4	9623863.78561706	20.71	0.0001	4	9937648.75841503	21.39	0.0001
STATION	10	3484741.01786677	3.00	0.0009	10	5623100.87621933	4.84	0.0001
DN	1	7974675.69957590	68.65	0.0001	1	7785797.34269059	67.03	0.0001
SEASON*STATION	40	8680118.10835452	1.87	0.0009	40	8703177.79052628	1.87	0.0009
SEASON*DN	4	3058408.60337458	6.58	0.0001	4	2936745.42708730	6.32	0.0001
STATION*DN	10	4372220.30543122	3.76	0.0001	10	4241143.87626479	3.65	0.0001
TEMP	1	2222619.21900139	19.13	0.0001	1	2150889.68074984	18.52	0.0001
TIDE	3	451657.87628855	1.30	0.2735	3	451657.87628855	1.30	0.2735

TABLE 8.2-5

BAY ANCHOVY-JUVENILES

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SUMDEN

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	72	338645.60388574	4703.41116508	8.46	0.0001	0.703389	276.4538
ERROR	257	142802.80464760	555.65293637		ROOT MSE		SUMDEN MEAN
CORRECTED TOTAL	329	481448.40853333			23.57229171		8.52666667

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DATE	4	8109.62171212	3.65	0.0065	4	8277.33218907	3.72	0.0058
STATION	10	110890.88949333	19.96	0.0001	10	96393.85642441	17.35	0.0001
DN	1	23900.33503030	43.01	0.0001	1	19225.51436354	34.60	0.0001
DATE*STATION	40	73348.84396121	3.30	0.0001	40	73112.97684561	3.29	0.0001
DATE*DN	4	8146.46607576	3.67	0.0064	4	9355.91056473	4.21	0.0026
STATION*DN	10	110975.45872970	19.97	0.0001	10	85963.45993135	15.47	0.0001
TEMP	1	343.69436058	0.62	0.4323	1	291.01327346	0.52	0.4699
TIDE	2	2930.29452273	2.64	0.0735	2	2930.29452273	2.64	0.0735

TABLE 8.2-6

SCIAENID EGGS

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SUMDEN

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	73	470122633.34303320	6440036.07319224	9.70	0.0001	0.363598	278.2807
ERROR	1240	822851421.98566180	663589.85644005		ROOT MSE		SUMDEN MEAN
CORRECTED TOTAL	1313	1292974055.32869500			814.61024818		292.72972603

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
SEASON	4	34983088.56316099	13.18	0.0001	4	32672465.88632432	12.31	0.0001
STATION	10	150582960.40980291	22.69	0.0001	10	148428878.16135836	22.37	0.0001
DN	1	58004536.29874186	87.41	0.0001	1	62053776.08873319	93.51	0.0001
SEASON*STATION	40	117975469.38893882	4.44	0.0001	40	117679464.37825978	4.43	0.0001
SEASON*DN	4	19058136.21396735	7.18	0.0001	4	12810948.78078237	4.83	0.0007
STATION*DN	10	72865468.34713550	10.98	0.0001	10	74246959.65125877	11.19	0.0001
TEMP	1	3456329.41774113	5.21	0.0226	1	3104594.70122553	4.68	0.0307
TIDE	3	13196644.70354479	6.63	0.0002	3	13196644.70354479	6.63	0.0002

TABLE 8.2-7

SPOTTED SEATROUT-POSTLARVAE

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SQUARE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	133	1365.08601008	10.26380459	15.33	0.0001	0.796831	62.5897
ERROR	520	348.05699213	0.66934037		ROOT MSE		SQUARE MEAN
CORRECTED TOTAL	653	1713.14300221			0.81813224		1.30713579

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DATE	9	234.77917569	38.97	0.0001	9	113.48762680	18.84	0.0001
STATION	10	301.07862148	44.98	0.0001	10	237.14971569	35.43	0.0001
DN	1	111.51198763	166.60	0.0001	1	95.70779210	142.99	0.0001
DATE*STATION	90	448.80248349	7.45	0.0001	90	448.77483530	7.45	0.0001
DATE*DN	9	75.93010607	12.60	0.0001	9	75.80466737	12.58	0.0001
STATION*DN	10	187.51420222	28.01	0.0001	10	154.31251751	23.05	0.0001
TEMP	1	0.50951371	0.76	0.3834	1	0.26363402	0.39	0.5305
TIDE	3	4.95991979	2.47	0.0601	3	4.95991979	2.47	0.0601

TABLE 8.2-8

SILVER PERCH-POSTLARVAE

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SUMDEN

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	73	27008.61036864	369.98096395	3.74	0.0001	0.516103	226.9082
ERROR	256	25323.25139045	98.91895074		ROOT MSE		SUMDEN MEAN
CORRECTED TOTAL	329	52331.86175909			9.94580066		4.38318182

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DATE	4	5474.88933333	13.84	0.0001	4	4099.03311297	10.36	0.0001
STATION	10	2603.00288909	2.63	0.0046	10	2137.39531298	2.16	0.0206
DN	1	2686.98400758	27.16	0.0001	1	2767.30292452	27.98	0.0001
DATE*STATION	40	8235.79165333	2.08	0.0004	40	8873.70809038	2.24	0.0001
DATE*DN	4	5257.80164242	13.29	0.0001	4	5360.37287163	13.55	0.0001
STATION*DN	10	1925.23148909	1.95	0.0397	10	2154.72162063	2.18	0.0196
TEMP	1	29.15513348	0.29	0.5877	1	58.70341619	0.59	0.4418
TIDE	3	795.75422030	2.68	0.0466	3	795.75422030	2.68	0.0466

TABLE 8.2-9

PINFISH-POSTLARVAE

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SUMDEN

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	55	35251.77635171	640.94138821	9.43	0.0001	0.774549	146.5807
ERROR	151	10260.90130916	67.95298880		ROOT MSE		SUMDEN MEAN
CORRECTED TOTAL	206	45512.67766087			8.24336029		5.62376812

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DATE	3	10979.34796052	53.86	0.0001	3	3638.68712439	17.85	0.0001
STATION	10	4440.75108424	6.54	0.0001	10	4658.39559906	6.86	0.0001
DN	1	1871.48292910	27.54	0.0001	1	1268.93698029	18.67	0.0001
DATE*STATION	25	9662.48611756	5.69	0.0001	25	8177.35727845	4.81	0.0001
DATE*DN	2	3167.14734880	23.30	0.0001	2	4772.74018666	35.12	0.0001
STATION*DN	10	3869.86646215	5.69	0.0001	10	3382.68780853	4.98	0.0001
TEMP	1	226.33169601	3.33	0.0700	1	742.81300640	10.93	0.0012
TIDE	3	1034.36275333	5.07	0.0024	3	1034.36275333	5.07	0.0024

TABLE 8.2-10

SPOT-POSTLARVA

GENERAL LINEAR MODELS PROCEDURE.

DEPENDENT VARIABLE: SUMDEN

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	55	2980.30093187	54.18728967	3.95	0.0001	0.589914	209.3122
ERROR	151	2071.79374445	13.72048837		ROOT MSE		SUMDEN MEAN
CORRECTED TOTAL	206	5052.09467633			3.70411776		1.76966184

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DATE	3	115.96706737	2.82	0.0405	3	72.13458235	1.75	0.1570
STATION	10	554.89148824	4.04	0.0001	10	724.34974309	5.28	0.0001
DN	1	3.43946936	0.25	0.6173	1	11.54173183	0.84	0.3605
DATE*STATION	25	1365.24637358	3.98	0.0001	25	1315.76461170	3.84	0.0001
DATE*DN	2	125.92635657	4.59	0.0116	2	159.95998985	5.83	0.0036
STATION*DN	10	704.81387787	5.14	0.0001	10	678.64885240	4.95	0.0001
TEMP	1	13.94598298	1.02	0.3150	1	11.54926835	0.84	0.3604
TIDE	3	96.07031591	2.33	0.0750	3	96.07031591	2.33	0.0750

TABLE 8.2-11

STONE CRAB-ALLSTAGES

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SUMDEN

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	61	507534148.32861200	8320231.93981331	6.10	0.0001	0.273709	192.6289
ERROR	988	1346751913.64716500	1363109.22433924		ROOT MSE		SUMDEN MEAN
CORRECTED TOTAL	1049	1854286061.97577710			1167.52268686		606.09930476

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
SEASON	3	72088328.41075621	17.63	0.0001	3	65787483.89156937	16.09	0.0001
STATION	10	271670321.89273368	19.93	0.0001	10	292930926.71033113	21.49	0.0001
DN	1	792728.18028907	0.58	0.4459	1	1016871.00325960	0.75	0.3880
SEASON*STATION	30	118677149.64739511	2.90	0.0001	30	120813792.90175252	2.95	0.0001
SEASON*DN	3	1509195.34551343	0.37	0.7783	3	1351368.74279376	0.33	0.8056
STATION*DN	10	16461643.18342847	1.21	0.2816	10	14124456.43176733	1.04	0.4104
TEMP	1	26074561.26688104	19.13	0.0001	1	25656665.45421696	18.82	0.0001
TIDE	3	260228.40161532	0.06	0.9735	3	260228.40161532	0.06	0.9735

TABLE 8.2-1

PINK SHRIMP-POSTLARVAE

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SUMDEN

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	49	39225.48679345	800.52013864	11.21	0.0001	0.450512	211.8144
ERROR	670	47843.13691641	71.40766704		ROOT MSE		SUMDEN MEAN
CORRECTED TOTAL	719	87068.62370986			8.45030574		3.98948611

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
SEASON	2	502.28033564	3.52	0.0302	2	292.35952695	2.05	0.1299
STATION	10	10744.75117337	15.05	0.0001	10	9353.93505471	13.10	0.0001
DN	1	10117.28601442	141.68	0.0001	1	7364.82996027	103.14	0.0001
SEASON*STATION	20	5333.58234882	3.73	0.0001	20	4624.44978615	3.24	0.0001
SEASON*DN	2	586.05308166	4.10	0.0169	2	1333.63492759	9.34	0.0001
STATION*DN	10	10808.92482383	15.14	0.0001	10	11545.08679613	16.17	0.0001
TEMP	1	9.59345137	0.13	0.7141	1	1.24616865	0.02	0.8949
TIDE	3	1123.01556435	5.24	0.0015	3	1123.01556435	5.24	0.0015

TABLE 6.2-13

ANNUAL NUMBERS ENTRAINED (IN MILLIONS) BY SPECIES AND LIFESTAGE

BASED ON DENSITY AT STATION C

SPECIES NAME	LIFESTAGE	DAY ENTRAINMENT	NIGHT ENTRAINMENT	TOTAL ENTRAINMENT
TOTAL FISH	EGGS	1624	1657	3281
	PROLARVAE	38.06	57.24	95.3
	POSTLARVAE	836.5	1843	2679
	JUVENILES	.9875	169.3	170.3
TOTAL INVERTEBRATES	ALL	1685	589.3	2274
BAY ANCHOVY	EGGS	1538	513.1	2051
	PROLARVAE	34.3	53.14	87.44
	POSTLARVAE	54.09	212	266.1
	JUVENILES	.0000	154.6	154.6
POLKA-DOT BATFISH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
PIGFISH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.7552	.7552
	JUVENILES	.0000	.0000	.0000
PINFISH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.9726	2.742	3.714
	JUVENILES	.0000	.1157	.1157
SILVER PERCH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0846	.0846
	POSTLARVAE	2.388	19.25	21.64
	JUVENILES	.0000	.2173	.2173
SPOTTED SEATROUT	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	2.061	3.258	5.32
	JUVENILES	.0000	.0000	.0000

SPOT	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	2.966	2.966
	JUVENILES	.2927	.1173	.4101
RED DRUM	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.2951	.2951
	JUVENILES	.0000	.0000	.0000
STRIPED MULLET	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
PINK SHRIMP	MYSIS	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
BLUE CRAB	STAGE1	.0000	.0000	.0000
	STAGE2	.0000	.0000	.0000
	STAGE3	.0000	.0000	.0000
	STAGE4	.0000	.0000	.0000
	STAGE5	.0000	.0000	.0000
	MEGALOPS	.1014	.0000	.1014
STONE CRAB	STAGE1	1593	529.1	2122
	STAGE2	75.66	26.22	101.9
	STAGE3	11.47	8.403	19.87
	STAGE4	2.471	1.45	3.921
	STAGE5	.2934	.0852	.3786
	MEGALOPS	.1092	.0699	.1791
BRIEF SQUID	ALL	.2598	.6462	.9060

TABLE 8.2-14

ANNUAL NUMBERS ENTRAINED (IN MILLIONS) BY SPECIES AND LIFESTAGE

BASED ON DENSITY AT STATION D

SPECIES NAME	LIFESTAGE	DAY ENTRAINMENT	NIGHT ENTRAINMENT	TOTAL ENTRAINMENT
TOTAL FISH	EGGS	3789	8589	12378
	PROLARVAE	78.36	731.9	810.3
	POSTLARVAE	736.6	1186	1923
	JUVENILES	5.568	13.35	18.92
TOTAL INVERTEBRATES	ALL	2012	751.6	2764
BAY ANCHOVY	EGGS	3744	7930	11674
	PROLARVAE	65.46	702.3	767.8
	POSTLARVAE	130.4	194.8	325.2
	JUVENILES	.0000	.2550	.2550
POLKA-DOT BATFISH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
PIGFISH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
PINFISH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	4.92	3.475	8.394
	JUVENILES	.0000	1.705	1.705
SILVER PERCH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	1.023	1.086	2.11
	JUVENILES	.0000	.0000	.0000
SPOTTED SEATROUT	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	3.921	2.241	6.161
	JUVENILES	.0000	.0000	.0000

SPOT	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	2.616	1.159	3.775
	JUVENILES	.0000	.0000	.0000
RED DRUM	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
STRIPED MULLET	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
PINK SHRIMP	MYSIS	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
BLUE CRAB	STAGE1	.0000	.0000	.0000
	STAGE2	.0000	.0000	.0000
	STAGE3	.0000	.0000	.0000
	STAGE4	.0000	.0000	.0000
	STAGE5	.0000	.0000	.0000
	MEGALOPS	.1782	.1850	.3631
STONE CRAB	STAGE1	1807	684.5	2491
	STAGE2	170.3	26.02	196.3
	STAGE3	27.23	4.192	31.42
	STAGE4	5.889	.2796	6.168
	STAGE5	.0000	.1170	.1170
	MEGALOPS	.0000	.0000	.0000
BRIEF SQUID	ALL	.0891	.0000	.0891

TABLE 8.2-15

ANNUAL NUMBERS ENTRAINED (IN MILLIONS) BY SPECIES AND LIFESTAGE

BASED ON DENSITY AT STATION E

SPECIES NAME	LIFESTAGE	DAY ENTRAINMENT	NIGHT ENTRAINMENT	TOTAL ENTRAINMENT
TOTAL FISH	EGGS	6106	6433	12538
	PROLARVAE	61.09	395.1	456.2
	POSTLARVAE	1390	1253	2643
	JUVENILES	15.39	8.97	24.36
TOTAL INVERTEBRATES	ALL	2672	734.7	3407
BAY ANCHOVY	EGGS	6062	5378	11440
	PROLARVAE	50.6	188.7	239.3
	POSTLARVAE	534.3	152.3	686.6
	JUVENILES	.8850	.0000	.8850
POLKA-DOT BATFISH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.1944	.0000	.1944
PIGFISH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
PINFISH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	13.93	2.753	16.69
	JUVENILES	1.571	.5836	2.154
SILVER PERCH	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	1.265	1.265
	JUVENILES	.0000	.0000	.0000
SPOTTED SEATROUT	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	4.197	2.301	6.497
	JUVENILES	.0000	.0000	.0000

SPOT	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	10.99	1.292	12.28
	JUVENILES	.4559	1.277	1.733
RED DRUM	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
STRIPED MULLET	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
PINK SHRIMP	MYSIS	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
BLUE CRAB	STAGE1	.0000	.0000	.0000
	STAGE2	.0000	.0000	.0000
	STAGE3	.0000	.0000	.0000
	STAGE4	.0000	.0000	.0000
	STAGE5	.0000	.0000	.0000
	MEGALOPS	.0000	.0000	.0000
STONE CRAB	STAGE1	2388	641	3029
	STAGE2	222	32.62	254.6
	STAGE3	44.93	7.085	52.01
	STAGE4	13.44	1.405	14.84
	STAGE5	.0000	.3771	.3771
	MEGALOPS	1.412	.9391	2.351
BRIEF SQUID	ALL	.1183	.6862	.8044

TABLE 8.2-16

ANNUAL NUMBERS ENTRAINED (IN MILLIONS) BY SPECIES AND LIFESTAGE

FOR SELECTED GROUPS NOT IDENTIFIED TO THE SPECIES LEVEL

BASED ON DENSITY AT STATION C

SPECIES NAME	LIFESTAGE	DAY ENTRAINMENT	NIGHT ENTRAINMENT	TOTAL ENTRAINMENT
ANCHOA SP.	EGGS	.0000	.0000	.0000
	PROLARVAE	.6822	.1701	.8523
	POSTLARVAE	216.7	376	592.7
	JUVENILES	.0000	.0000	.0000
HAEMULIDAE	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
SCIAENIDAE	EGGS	32.98	1069	1102
	PROLARVAE	.1892	1.163	1.352
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
MUGILLIDAE AND MUGI	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
PENAEUS SP.	MYSIS	.0000	.2173	.2173
	POSTLARVAE	1.962	16.87	18.83
	JUVENILES	.0000	.8453	.8453
CALLINECTES SP.	STAGE1	.0000	.0000	.0000
	STAGE2	.0000	.0000	.0000
	STAGE3	.0000	.0000	.0000
	STAGE4	.0000	.0000	.0000
	STAGE5	.0000	.0000	.0000
	MEGALOPS	.3587	5.277	5.636

TABLE 8.2-17

ANNUAL NUMBERS ENTRAINED (IN MILLIONS) BY SPECIES AND LIFESTAGE
FOR SELECTED GROUPS NOT IDENTIFIED TO THE SPECIES LEVEL
BASED ON DENSITY AT STATION D

SPECIES NAME	LIFESTAGE	DAY ENTRAINMENT	NIGHT ENTRAINMENT	TOTAL ENTRAINMENT
ANCHOA SP.	EGGS	.0000	.0000	.0000
	PROLARVAE	2.133	.2699	2.403
	POSTLARVAE	222.7	579	801.7
	JUVENILES	.0000	.0000	.0000
HAEMULIDAE	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
SCIAENIDAE	EGGS	9.791	588.2	598
	PROLARVAE	4.666	9.964	14.63
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
MUGILLIDAE AND MUGIL	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
PENAEUS SP.	MYSIS	.0000	.0000	.0000
	POSTLARVAE	.0862	6.222	6.308
	JUVENILES	.0000	.6575	.6575
CALLINECTES SP.	STAGE1	.0000	.0000	.0000
	STAGE2	.0000	.0000	.0000
	STAGE3	.0000	.0000	.0000
	STAGE4	.0000	.0000	.0000
	STAGE5	.0000	.0000	.0000
	MEGALOPS	1.487	29.21	30.7

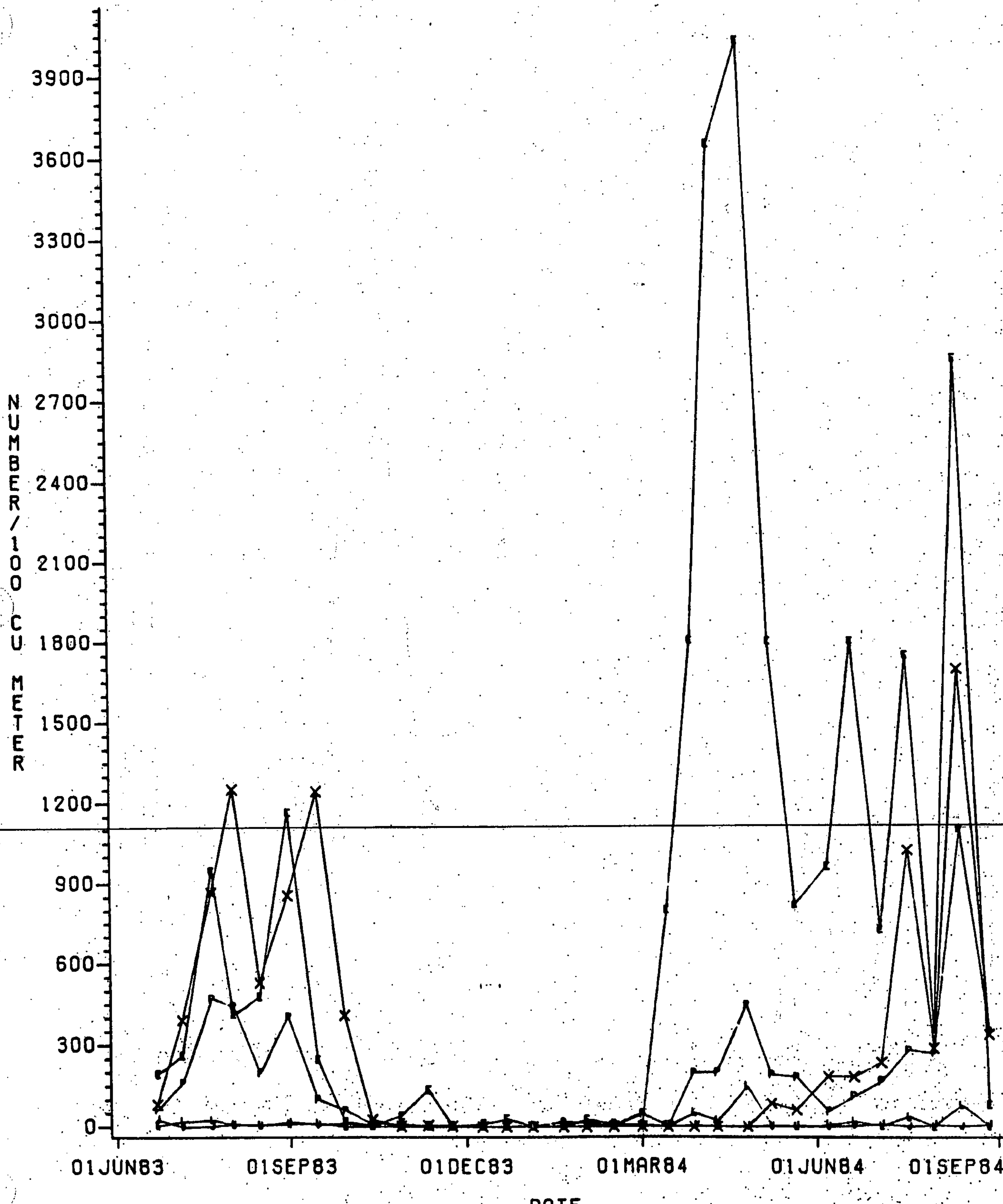
TABLE 8.2-18

ANNUAL NUMBERS ENTRAINED (IN MILLIONS) BY SPECIES AND LIFESTAGE

FOR SELECTED GROUPS NOT IDENTIFIED TO THE SPECIES LEVEL

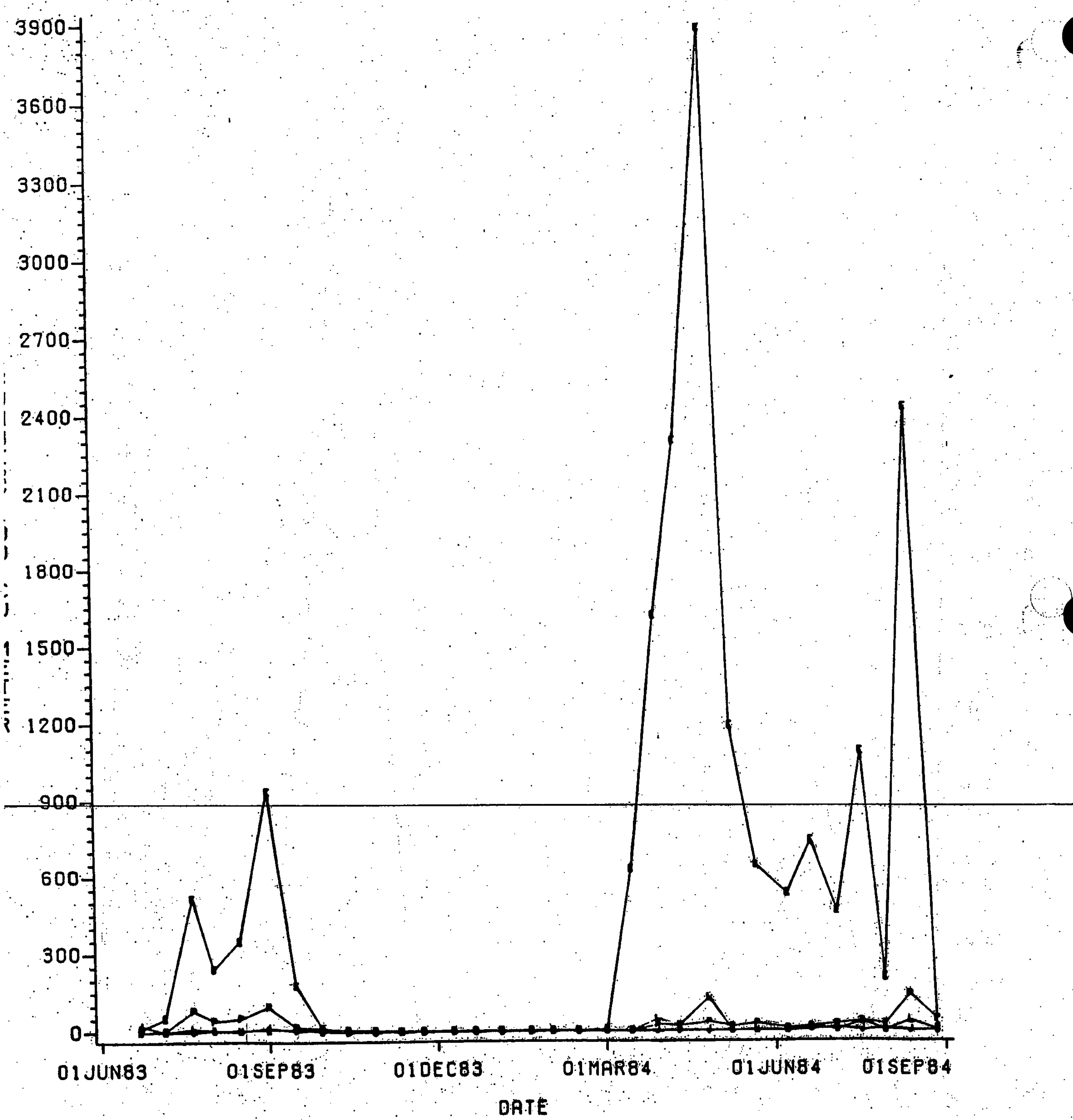
BASED ON DENSITY AT STATION E

SPECIES NAME	LIFESTAGE	DAY ENTRAINMENT	NIGHT ENTRAINMENT	TOTAL ENTRAINMENT
ANCHOA SP.	EGGS	.0000	.0000	.0000
	PROLARVAE	1.761	190.9	192.6
	POSTLARVAE	522.3	566	1088
	JUVENILES	.0000	.0000	.0000
HAEMULIDAE	EGGS	.0000	433.5	433.5
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
SCIAENIDAE	EGGS	14.11	529.5	543.6
	PROLARVAE	1.923	10.84	12.76
	POSTLARVAE	.0000	.0000	.0000
	JUVENILES	.0000	.0000	.0000
MUGILLIDAE AND MUGIL	EGGS	.0000	.0000	.0000
	PROLARVAE	.0000	.0000	.0000
	POSTLARVAE	.5699	.0000	.5699
	JUVENILES	3.503	.0000	3.503
PENAEUS SP.	MYSIS	.0000	.0000	.0000
	POSTLARVAE	.0000	16.18	16.18
	JUVENILES	.0000	1.023	1.023
CALLINECTES SP.	STAGE1	.0000	.0000	.0000
	STAGE2	.0000	.0000	.0000
	STAGE3	.0000	.0000	.0000
	STAGE4	.0000	.0000	.0000
	STAGE5	.0000	.0000	.0000
	MEGALOPS	1.981	32.85	34.83



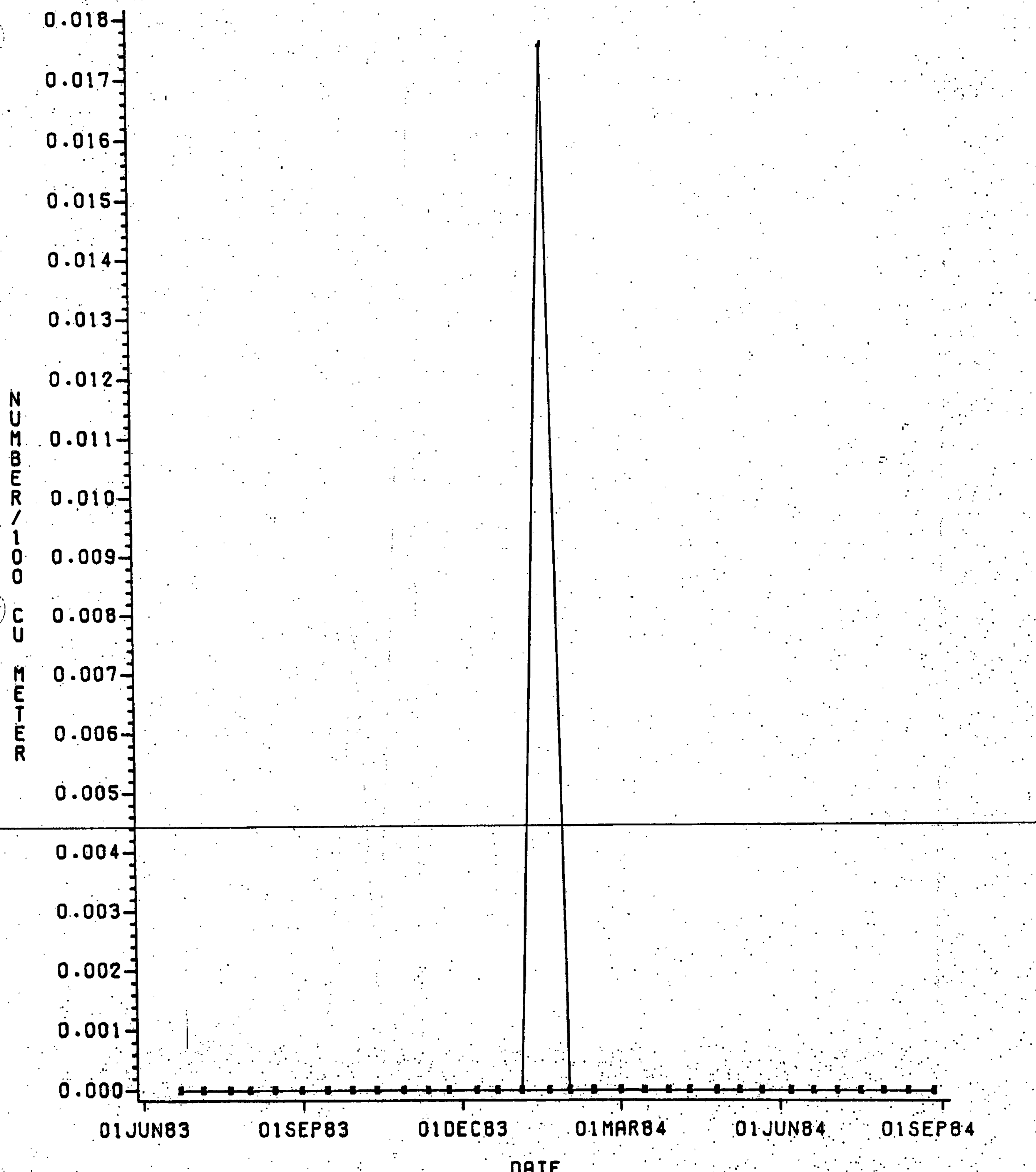
E=FISH EGGS
L=FISH PROLARVAE
P=FISH POSTLARVAE
J=FISH JUVENILES
X=INVERTEBRATES

FIGURE 8.2-1
AVERAGE PLANKTON DENSITY
BY LIFESTAGE AND DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



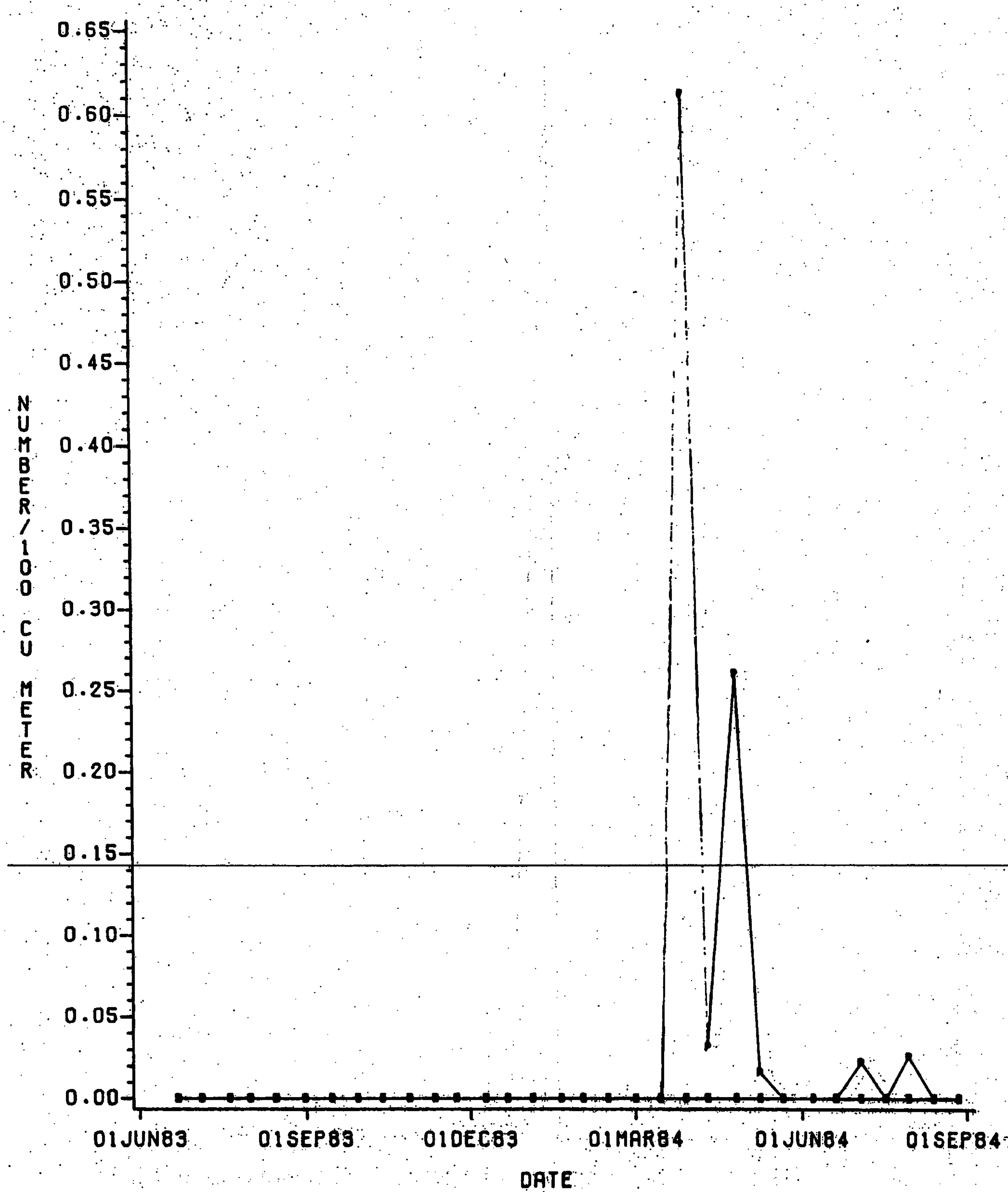
E=FISH EGGS
L=FISH PROLARVAE
P=FISH POSTLARVAE
J=FISH JUVENILES

FIGURE 8.2-2
BAY ANCHOVY DENSITY
BY LIFESTAGE AND DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



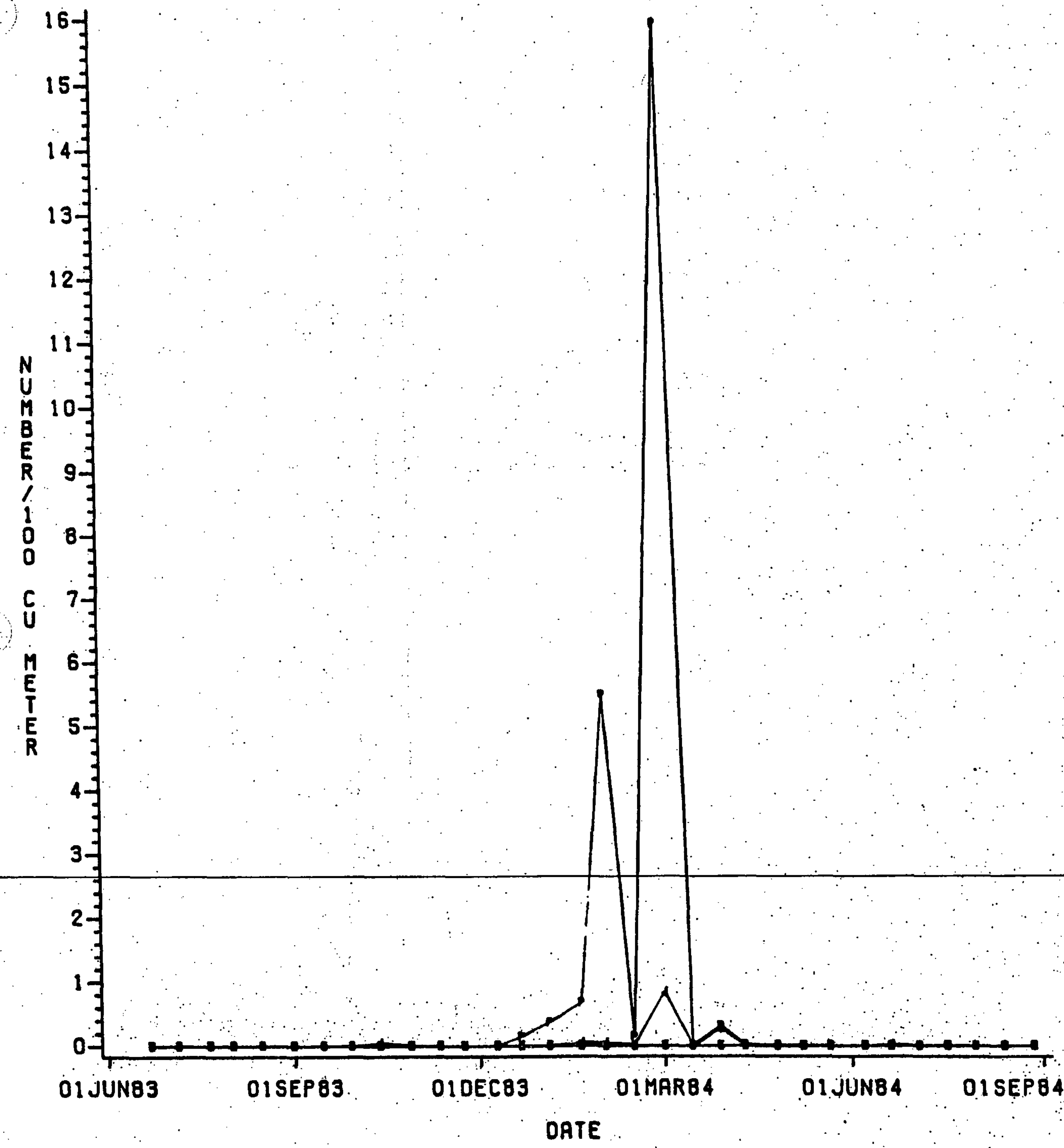
E=FISH EGGS
L=FISH PROLARVAE
P=FISH POSTLARVAE
J=FISH JUVENILES

FIGURE 8.2-3
POLKA-DOT BATFISH DENSITY
BY LIFESTAGE AND DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



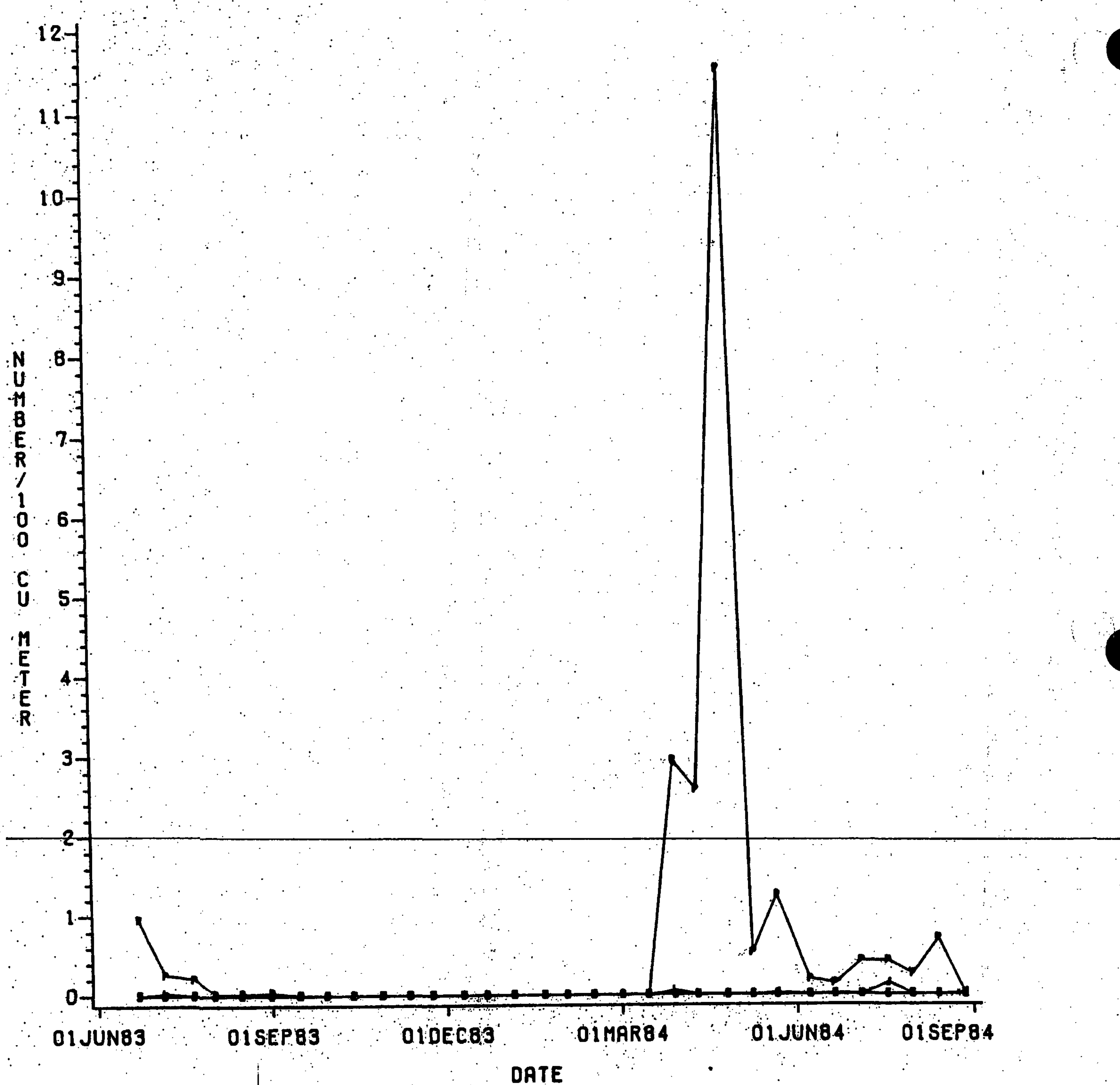
E=FISH EGGS
L=FISH PROLARVAE
P=FISH POSTLARVAE
J=FISH JUVENILES

FIGURE 6.2-4
PIGFISH DENSITY
BY LIFESTAGE AND DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



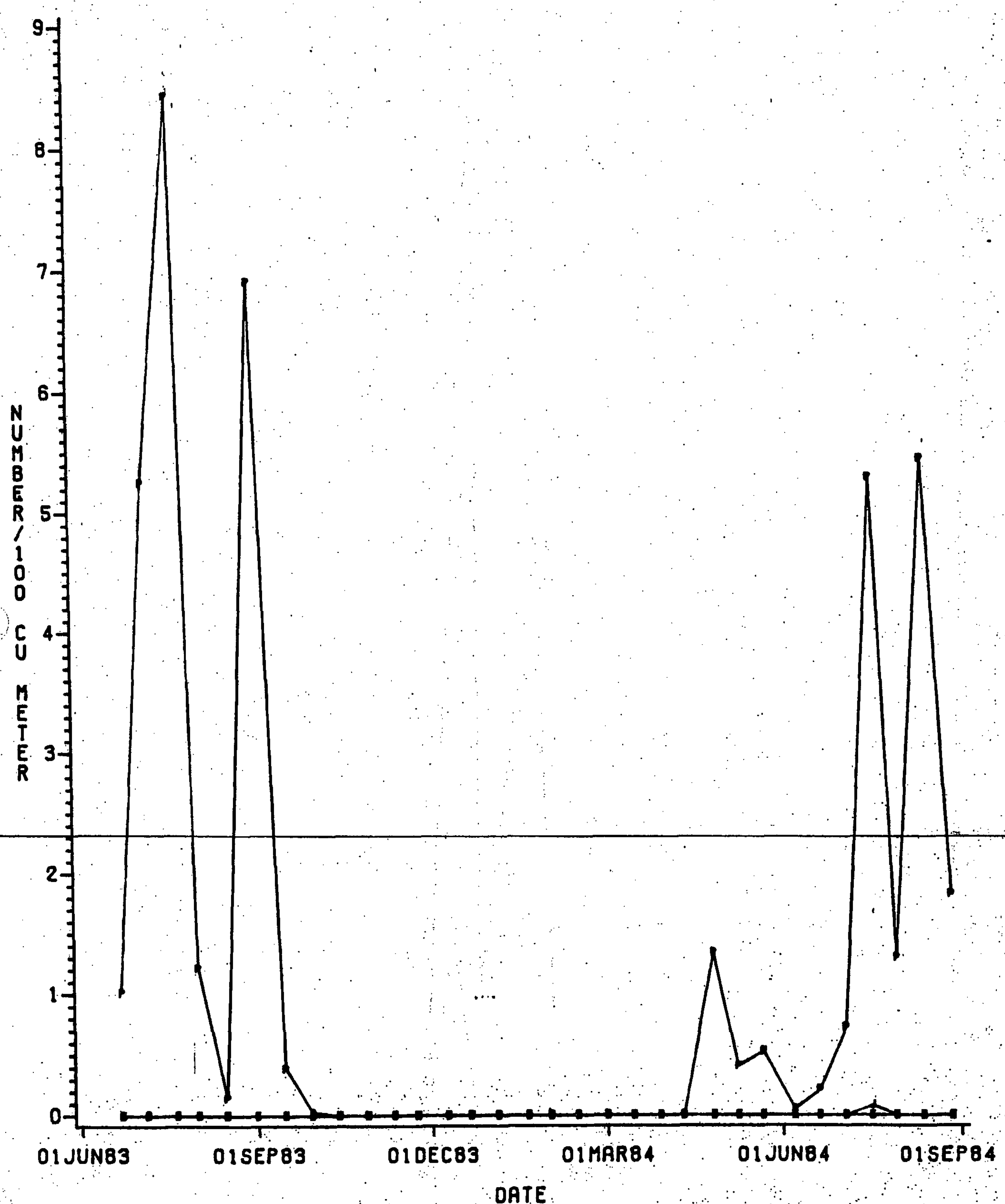
E=FISH EGGS
L=FISH PROLARVAE
P=FISH POSTLARVAE
J=FISH JUVENILES

FIGURE 8.2-5
PINFISH DENSITY
BY LIFESTAGE AND DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



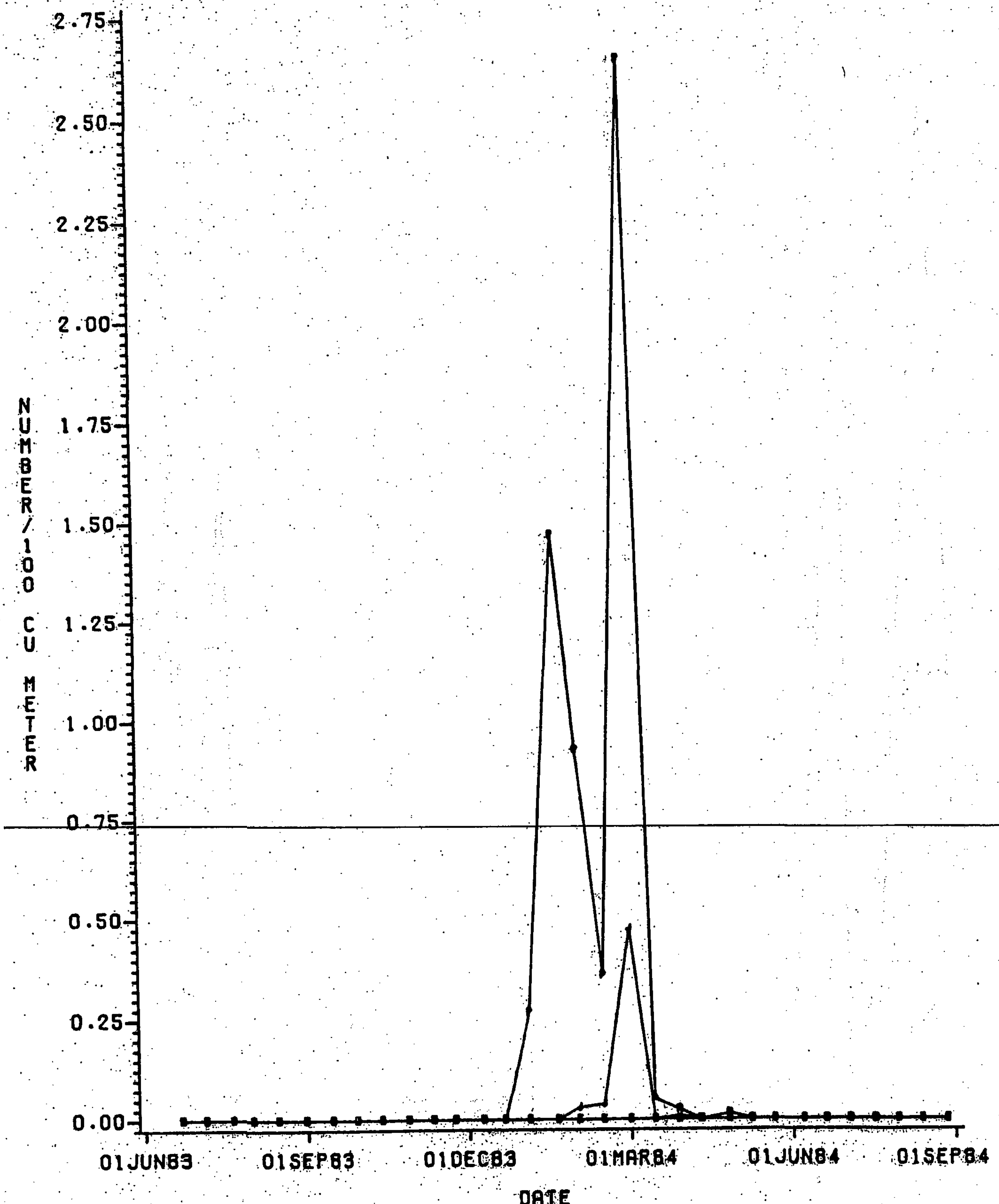
E=FISH EGGS
L=FISH PROLARVAE
P=FISH POSTLARVAE
J=FISH JUVENILES

FIGURE 8.2-6
SILVER PERCH DENSITY
BY LIFESTAGE AND DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



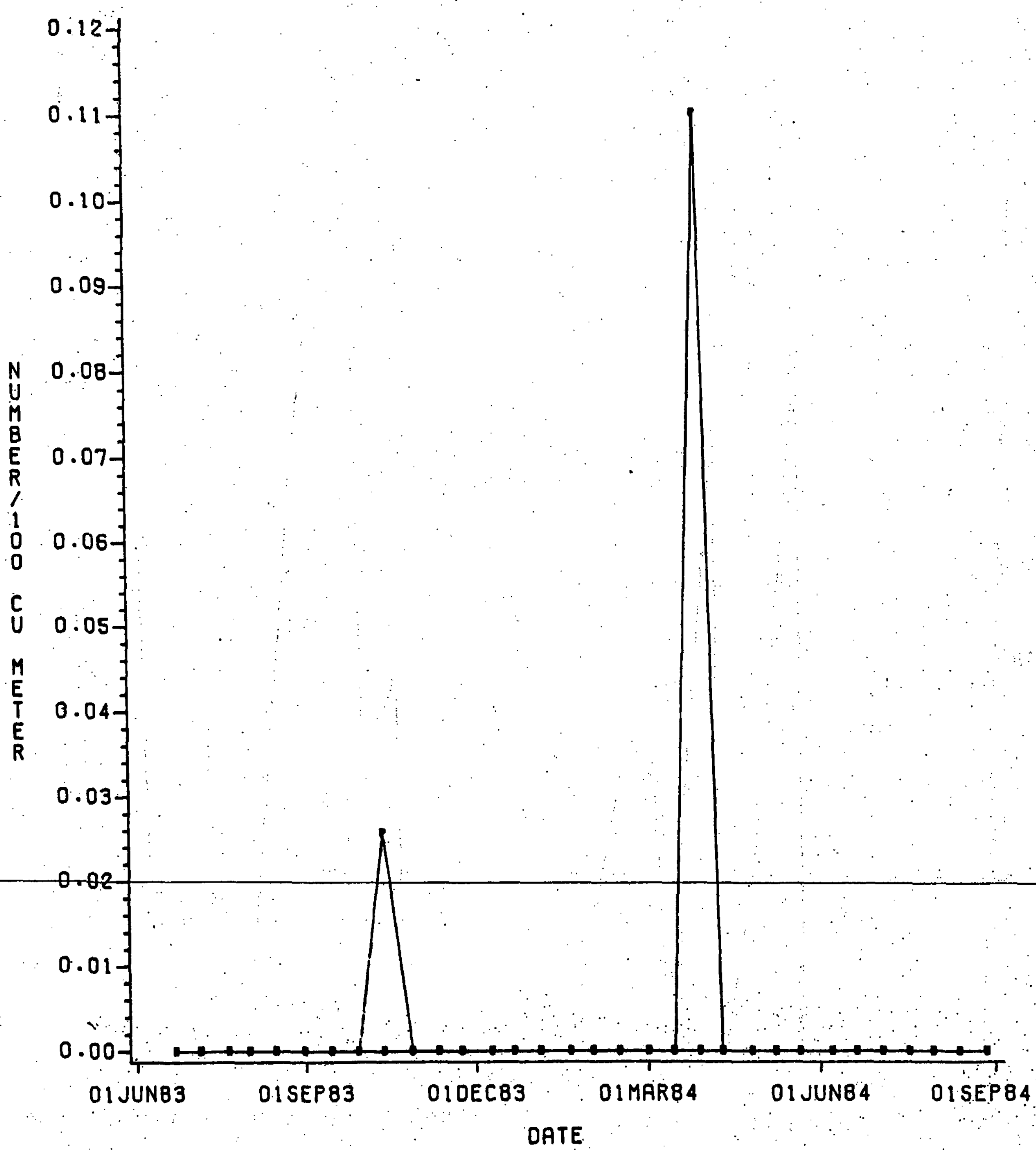
E=FISH EGGS
L=FISH PROLARVAE
P=FISH POSTLARVAE
J=FISH JUVENILES

FIGURE 8.2-7
SPOTTED SEATROUT DENSITY
BY LIFESTAGE AND DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



E=FISH EGGS
L=FISH PROLARVAE
P=FISH POSTLARVAE
J=FISH JUVENILES

FIGURE 8.2-8
SPOT DENSITY
BY LIFESTAGE AND DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



E=FISH EGGS
L=FISH PROLARVAE
P=FISH POSTLARVAE
J=FISH JUVENILES

FIGURE 8.2-9
RED DRUM DENSITY
BY LIFESTAGE AND DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

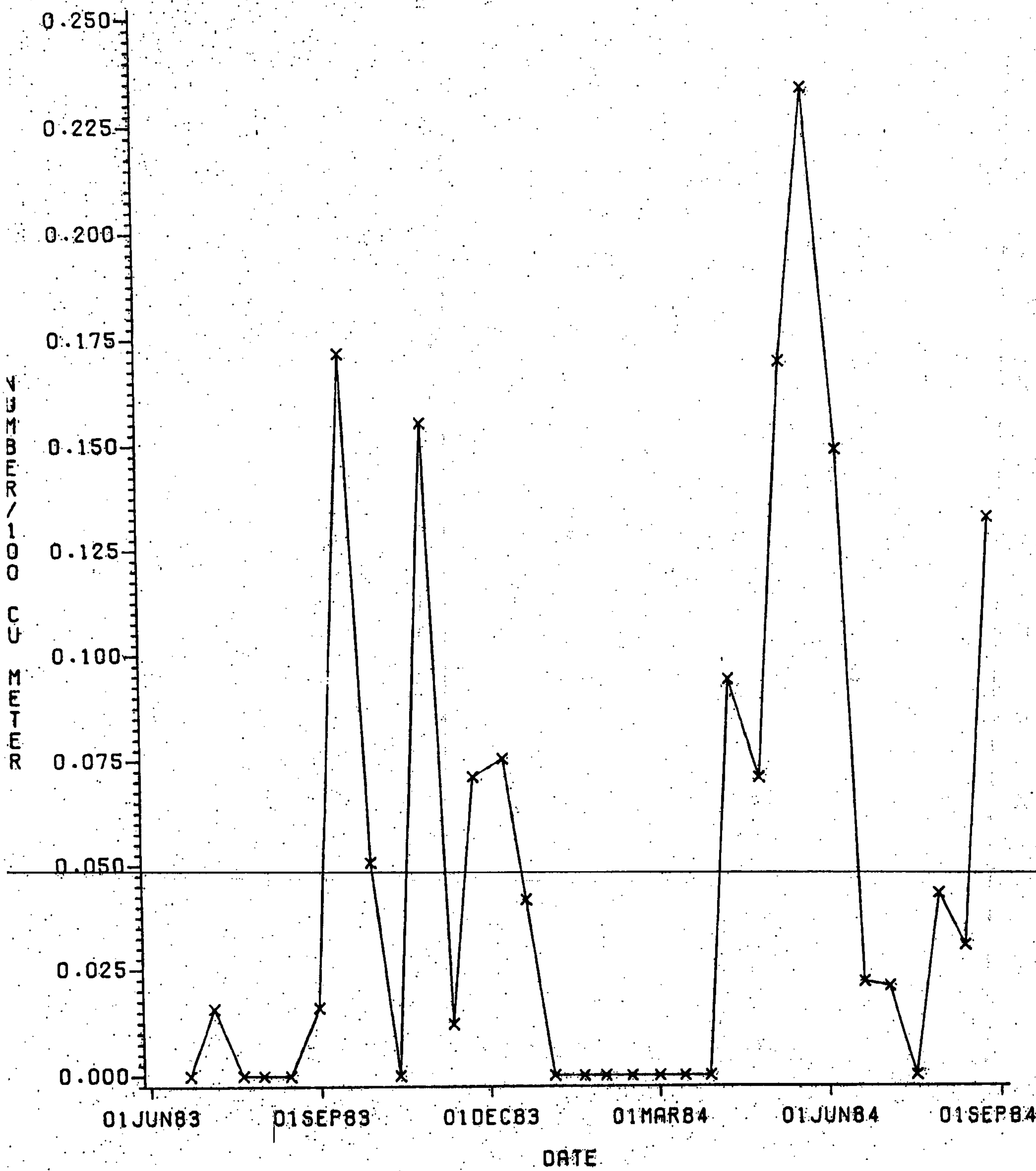
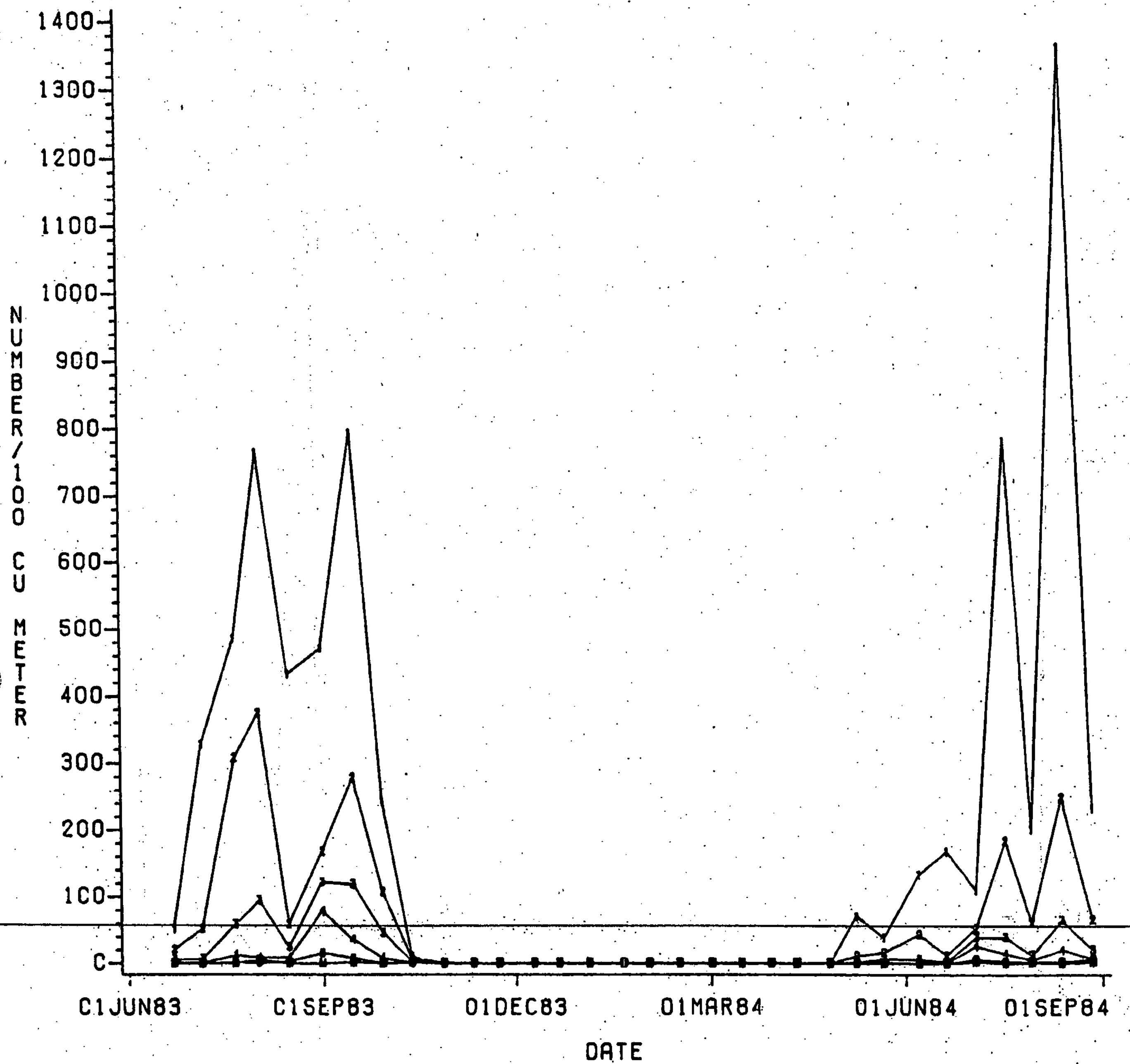


FIGURE 8.2-10
BRIEF SQUID PLANKTON
DENSITY BY DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



1=STAGE 1
2=STAGE 2
3=STAGE 3
4=STAGE 4
5=STAGE 5
M=MEGALOPS

FIGURE 8.2-11
STONE CRAB DENSITY
BY LIFESTAGE AND DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

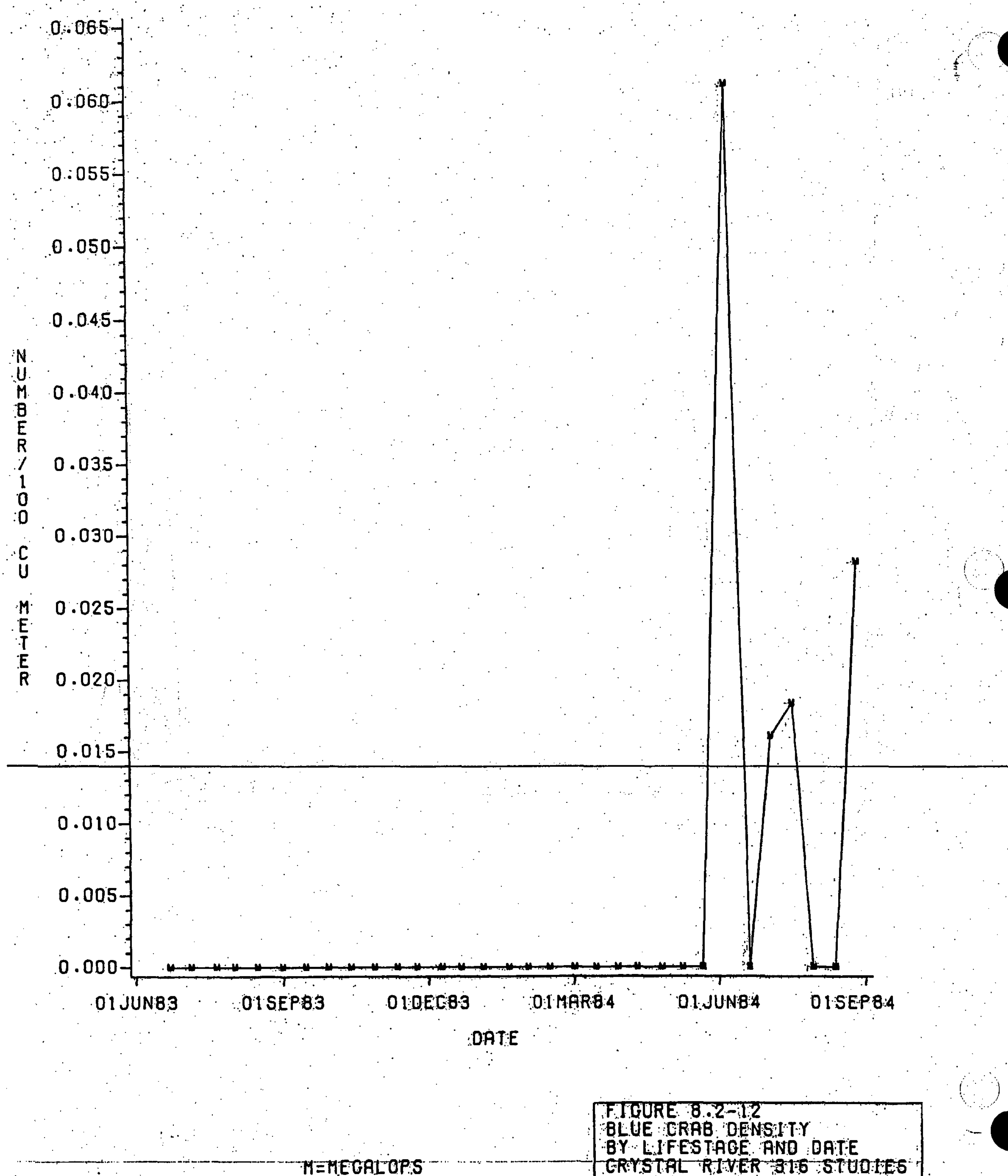


FIGURE 8.2-12
BLUE CRAB DENSITY
BY LIFESTAGE AND DATE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

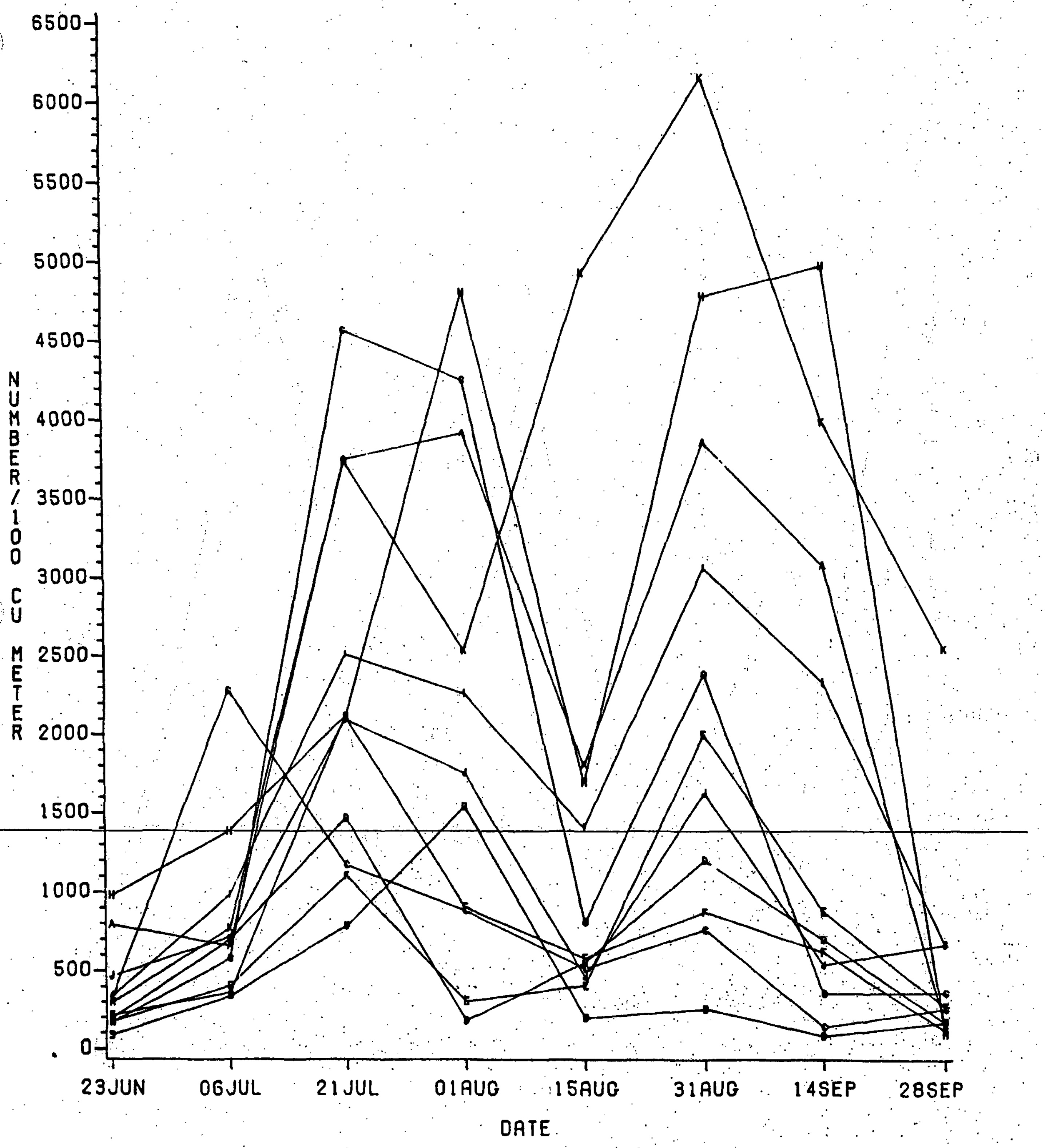


FIGURE 8.2-13
TOTAL PLANKTON DENSITY
BY STATION AND DATE-1983
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

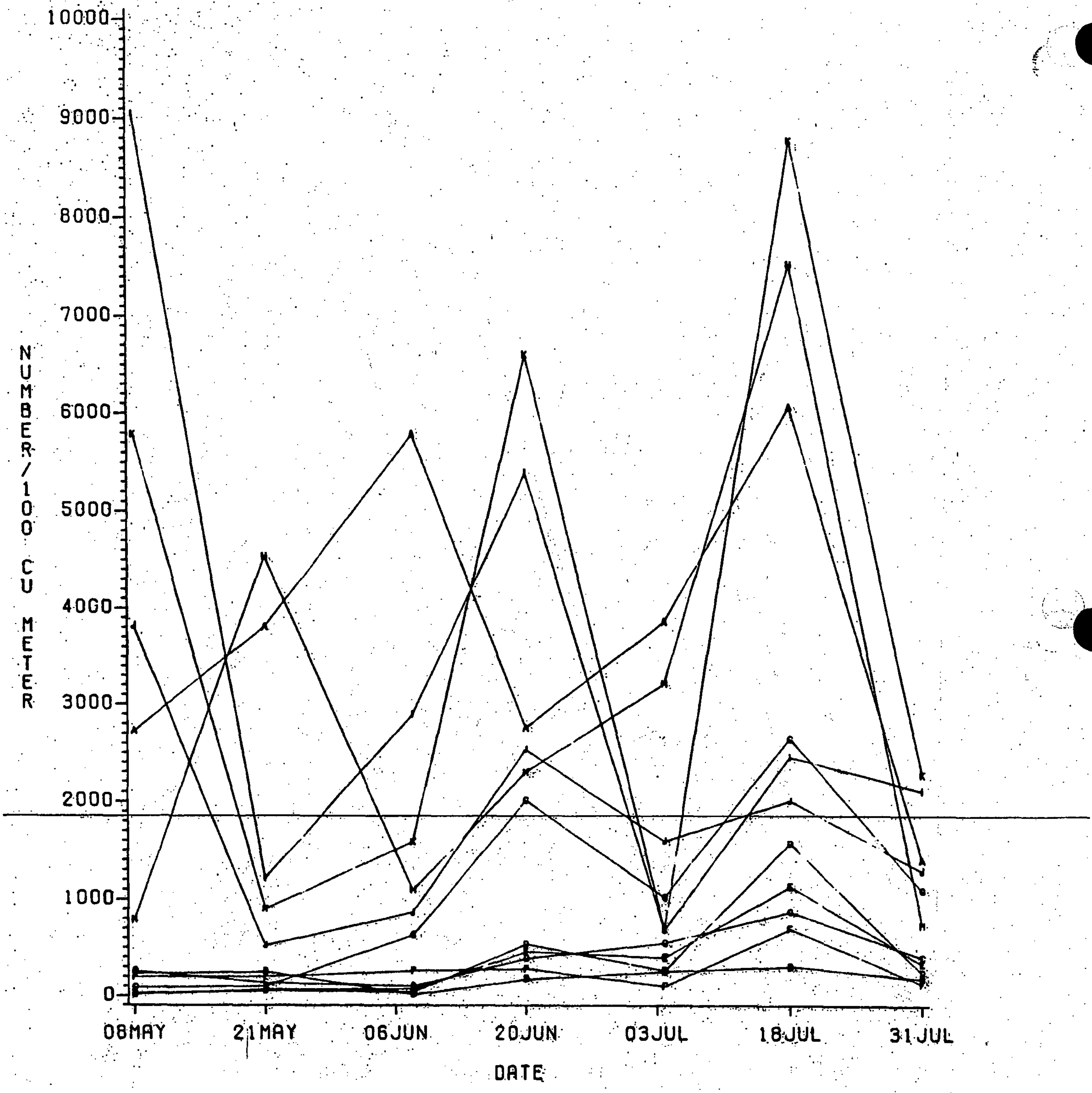


FIGURE 8.2-14
TOTAL PLANKTON DENSITY
BY STATION AND DATE-1984
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

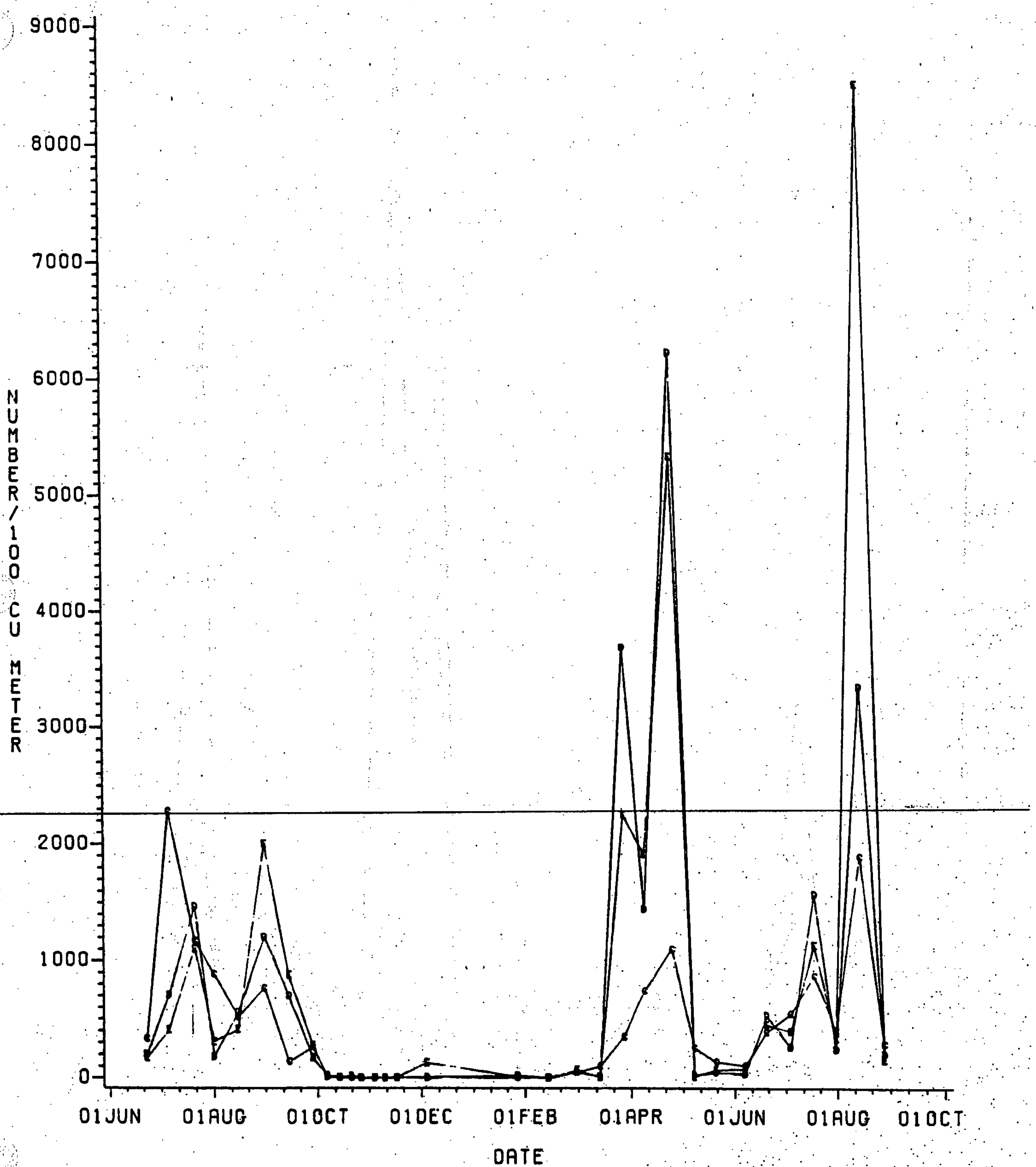


FIGURE 6.2-15
TOTAL PLANKTON DENSITY
AT STATIONS C,D AND E
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

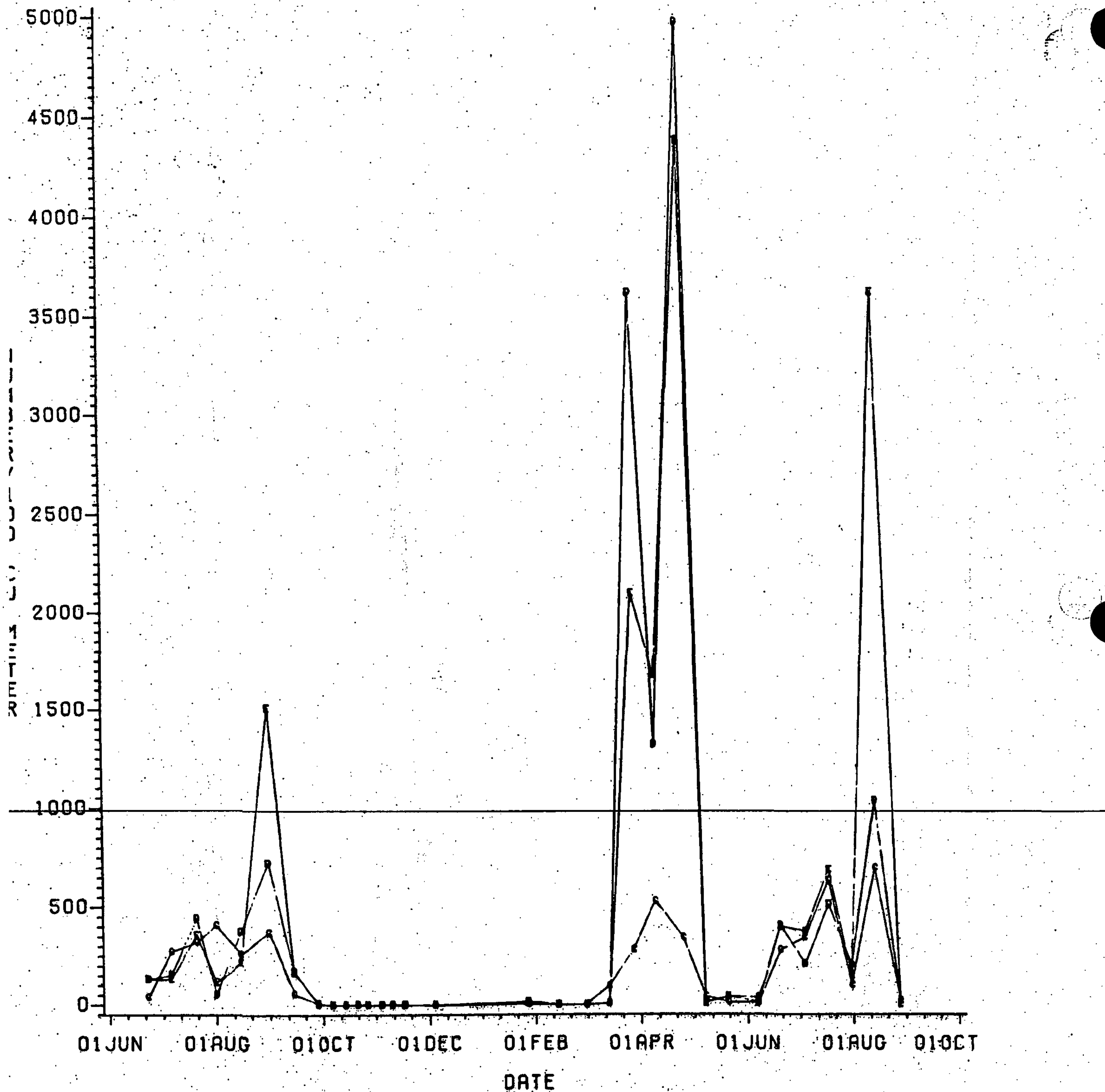


FIGURE 8.2-16
FISH EGG DENSITY
AT STATIONS C,D AND E
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

8.3 IMPACT ASSESSMENT

To estimate the effect of entrainment on the SIO a conservative approach was undertaken, which results in an overestimate of potential entrainment effects by substituting conservative assumptions where information is limiting. For example, organisms identifed only to family were added to organisms identified for selected species to obtain total entrainment estimates. In addition, the station, either C, D, or E, which provided the highest entrainment estimate was utilized in the entrainment calculations. In general, these were intake stations for early life stages and the discharge station for later life stages.

Densities calculated from the field collections during a species period of occurrence were multiplied by the flow of the power station to estimate the number or organisms entrained. The calculation assumes units are operating at 100 percent flow capacity, which represents the maximum situation. Tables 8.2-13 to 8.2-15 present total entrainment estimates utilizing Stations C, D, and E, respectively, for organisms identified to species. Tables 8.2-16 to 8.2-18 present information for organisms identified to family. Table 8.3-1 presents the maximum value for Tables 8.2-13 to 8.2-15 by species and life stage, which forms the basis of the entrainment assessment. Table 8.3-2 presents similar information for unidentified SIO.

Once the number of organisms entrained is estimated, the number of adults that could have potentially developed from these entrained individuals is calculated under the conservative assumptions of the equivalent adult model. This model, first formulated by Horst (1975 and 1978), has been widely reviewed and used in the assessment of entrainment effects (Dahlberg 1978; Saunders 1978; Taylor 1978). Goodyear (1978) has produced a U.S. Fish and Wildlife Service guide on the use of the equivalent adult model for assessing the effects of entrainment.

The actual formulation of the model is very simple: in equilibrum, the fecundity of a breeding pair will be reduced in one generation to two breeding adults: i.e.,

$$2 = S_e \times F \qquad (8.3\text{-}1)$$

where

S_e is the survival from egg to adult,

F is the fecundity of a female during her life.

or

$$S_e = 2/F \qquad (8.3\text{-}2)$$

The survivorship from egg to adult is equal to the product of the suvivorship from egg to larvae (E) and the survivorship from larvae to adult (S_1):

$$S_e = E \times S_1 \qquad (8.3\text{-}3)$$

Therefore, if the entrained life stage is larvae, then F in Equation 8.3-2 must be multiplied by the survival from egg to larvae to give the survivorship from larvae to adult.

$$S_1 = 2/E \times F \qquad (8.3\text{-}4)$$

The number of entrained larvae (N_1) is multiplied by S_1, and the number of entrained eggs (N_e) is multiplied by S_e. The products are added together to give the number of adults (N_a) that would have resulted, assuming no density dependence.

$$N_a = S_1 \times N_1 + S_e \times N_e \qquad (8.3\text{-}5)$$

The model formulation relies on the following assumptions:

1. The population is in equilibrium, such that the number of fish in the population at any time and the proportion of fish at any age are constant, with stable age distribution. If the historical information on the fish population shows an increasing or decreasing trend in population size, the numerator of Equation 8.3-2 can be appropriately modified.

2. The lifetime of a fish in the population is the most probable age to which a fish will live or the mean generation time of the population.

3. The reference to a breeding pair applies to a situation where the number of males equals the number of females. If a skewed sex ratio exists in the population, Equation 8.3-2 can be altered accordingly.

4. The exploitation of eggs and larvae occurs at the times eggs are laid and larvae hatch.

5. The number of equivalent adults represents the annual loss in an equilibrium density-independent population with a stable age distribution. This loss is distributed in proportion to the stable age distribution.

Therefore, the minimal information required for the equivalent adult model is age of sexual maturity, longevity, and average fecundity. Fecundity is a relatively easy parameter to estimate and is generally available for most species.

Another perspective on entrainment can be seen in Section 10.6. The hydrodynamic model was utilized to investigate the effect of entrainment on the abundance patterns in the area of the plant. Several initial density gradients were utilized to correspond to the results of field sampling for the SIO (Section 8.2). Since the entrainment occurs at the intake and any organisms which suffer mortality will be absent at the discharge, abundance differences associated with entrainment occur at the discharge. Water with zero-density plankton was input to the model at the POD and mixed with water containing plankton at the previously established concentrations (dependent on initial density gradients). The results of the analysis described in Section 10.6 clearly show that the major source of organisms is offshore.

This conclusion is reached since entrainment effects are localized and do not extend throughout the area modeled. This result can only occur if the plankton concentrations within the modeled area are high enough to counteract the input of zero-density water at the POD. The use of three separate cases provides an indication of the differential effect of entrainment mortality on plankton concentrations to the northwest, to the southwest, or evenly distributed across the study area. The results indicate that populations concentrated offshore are less affected by entrainment, and populations concentrated offshore, in the northwest section of the study area, are affected least of all. For all three cases, this analysis clearly shows that even under conservative assumptions, entrainment has localized effects.

8.3.1 Assessment of SIO Entrainment

The following sections present available information on population parameters for each SIO. These data were utilized as input to the equivalent adult model and to evaluate the effects of plant operation on the species population in the Crystal Bay area. To assist in evaluating the assumption of 100 percent through-plant mortality and the existing distributions near the discharge area, available information on thermal tolerances of SIO has been summarized and provided in Appendix VI.

8.3.1.1 *Anchoa mitchilli* (Bay anchovy)

Spawning occurs in the Delaware River estuary from about May to September (Stevenson 1958). In the Tampa Bay area, Springer and Woodburn (1960) took almost ripe individuals in July, September, and December. Gunter (1945), working in Texas, took nearly ripe individuals from March until August when sampling was terminated. This indicates a very long breeding season. Spawning is reported to be protracted year-round in warmer waters (Hoese and Moore 1977). Houde (1974) collected anchovy eggs from Florida waters at all seasons of the year.

Anchovies migrate to shallow waters during the spring and summer (Stevenson, 1958). During spawning, the sex ratio is 1:1, but at other times there is a statistically significant larger number of females than males (Stevenson, 1958). Eggs are pelagic when spawned. Hildebrand and Cable (1930) reported that the eggs hatch at the surface and some young appear to descend to the bottom at a very early age. Kuntz (1914) reported that 12 to 16 hours after spawning, the eggs begin to sink. Stevenson (1958) gave numbers of eggs per 1/25th of the right ovary for 15 specimens; he estimated that 7 percent of the eggs in the ovary are spawned. Calculating from these numbers, the number of eggs spawned per right ovary ranges from 731 at a standard length of 51 mm to 1080 at a standard length of 75 mm. Numbers of eggs per individual are at least double this since the right ovary is generally smaller than the left. A regression of fecundity on standard length is also given (Stevenson 1958). In the present study, nine gravid first year females were found to have 1173 to 4387 eggs per female (aver. 2240).

Length-frequency tables from Springer and Woodburn's (1960) studies in Tampa Bay indicated that there were usually two and some times three year classes; this is in agreement with Gunter's (1945) findings. Stevenson (1958) concluded that individuals that were spawned early in the season could themselves spawn the next year at age one, while others first spawned at age two. Hildebrand and Cable (1930) reported spawning individuals of 2 1/2 to 3 months of age; however, Stevenson (1958) inferred that these fish were actually spawned very late the previous season. Sexual maturity is attained at a length of 35 to 40 mm in Delaware Bay (Stevenson, 1958); 40 to 50 mm in Chesapeake Bay (Hildebrand and Cable, 1930); 45 to 60 mm off North Carolina (Hildebrand, 1963, cited in FPC 1977); and 56.3 mm (males) and 60.0 mm (females) off Texas (Gunter, 1945).

The equivalent adult calculation assumes a one year life cycle with average fecundity of 2240. The eggs have a short duration; one day was assumed for the calculation. Based on Houde (1977), the eggs were estimated to have a 92 percent hatching success and 40 percent survival from prolarvae to post-larvae.

Equivalent adult estimates were derived from conservative assumptions which underlie Table 8.3-1. All life stages (eggs, prolarvae, postlarvae, and juveniles) were represented in the entrainment estimate. Bay anchovy was the most abundant organism entrained. The equivalent adults associated with the eggs, prolarvae and postlarvae are 10.4, 0.75, and 6.7 million, respectively. The loss of juveniles, assuming they are at the midpoint between postlarvae and adult, would result in 3.8 million equivalent adults.

Table 8.3-2 provides calculated entrainment numbers for those organisms not identified to species. For the bay anchovy, those organisms identified as Anchoa sp. were considered as bay anchovy. The prolarvae and postlarvae of Anchoa sp. are entrained in numbers comparable to those for the same life stages of A. mitchilli. Therefore, the addition of these unidentified organisms would not change any conclusions for bay anchovy.

8.3.1.2 Polka-dot Batfish

There is little life history information on this species, therefore, no equivalent adult calculation has been made. The effect of entrainment is very minor. Juveniles were the only life stage collected and the occurrence was short in duration and comprised of a few individuals. Station E was the only entrainment station at which any life stage was caught (Tables 8.2-13 and 8.2-15). The juvenile polka-dot batfish total entrainment was 190,000 (Table 8.3-1).

8.3.1.3 Orthopristis chrysoptera (Pigfish)

In the area of the Crystal River Generating Station, pigfish were present only 6 months of the year, being scarce during the cooler months (Grimes & Mountain 1971). In the Cedar Key area, pigfish were caught all year except January and were most abundant during the warm months (Reid 1954). In St. Andrew Bay, Florida, however, pigfish were least abundant in summer (Pristas et al 1978). Pigfish are winter-spring spawners (Hoese and Moore 1977) and spawning at Crystal River probably begins in March (Grimes and Mountain, 1971). Hildebrand and Schroeder (1928) reported spawning in June in Cheasapeake Bay. However, Joseph and Yerger (1956) felt that in Alligator Harbor, Florida, pigfish spawn several months earlier than this, and by June the young are approximately 40 mm in length. A statistically significant larger number of females than males was observed in fall in St. Andrew Bay (31.6% male), but not in winter or spring (summer not tested) (Pristas et al 1978). Three gravid females taken at Crystal River had 17302 to 28160 eggs per female (average 21660).

Since only pigfish postlarvae were identified, there is no effect projected to the earlier life stages. Table 8.3-1 shows that the largest number of larvae (760,000) was at Station C. Assuming that the average life expectancy is 2 years, the survival from egg to adult would be 9.23×10^{-5}. There is no available information on the survival of egg and prolarval pigfish. If it is assumed that about 10 percent of each life stage survives, then the entrained postlarvae would represent about 71,000 equivalent adults.

These projections can be compared with the 1982 commercial landings of 2158 lb for the west coast of Florida, using an average weight of pigfish of 0.032 lb derived from the trawl collections at Crystal River. The number of adults lost through entrainment is roughly equivalent to the incidental commercial catch.

Consideration of all unidentified Haemulidae eggs (Table 8.3-2) as pigfish would add eggs as an entrainable life stage for the species. This would result in 40,000 equivalent adults. While adding the unidentified individuals increases the estimate of equivalent adults, it does not change the conclusion that entrainment effects are acceptable.

8.3.1.4 Lagodon rhomboides (Pinfish)

Pinfish apparently move offshore to spawn (Cameron, 1969) in November and December in the Crystal River area (Grimes and Mountain, 1971). Spawning begins early in December and lasts through March (Grimes and Mountain 1971). Fall spawning was reported by Reid (1954) for the Cedar Key region. Larvae migrate inshore to estuarine nursery areas between spring and fall (Kjelsen and Johnson 1976; Cameron 1969). Small larvae (less than 11 mm) are rarely found within estuaries, but postlarval stages (11-22 mm) do occur in nearshore and estuarine waters. Joseph and Yerger (1956) reported pinfish of 17 mm were first collected in Alligator Harbor in the latter part of May and were still common as late as July. Age 0 fish move away from the shallows to deeper water as cooler temperatures approach (Grimes and Mountain 1971).

Pinfish were most abundant in St. Andrew Bay in spring and fall; no statistically significant difference in numbers of males vs females were detected in spring, summer, or fall (winter not tested) (Pristas et al 1978). Cameron (1969) made reference to two age classes and presented growth curves from a number of studies. Spawning has apparently not been observed in nature, nor have ova or recently hatched larvae been described (Schimmel, 1977).

Caldwell (1957) reported the fecundity of pinfish as 90,000 and stated that spawning occurs at age 3. There is no information on the survival of eggs and larvae of pinfish, so a 10 percent survival was assumed for each life stage. Table 8.3-1 provides estimates for total entrainment. The equivalent adults associated with the entrainment of postlarvae is 37,000 and of juveniles is 47,000. Equivalent adults associated with entrainment represent slightly more than 1 percent of the recreational catch for Region 4 (Taylor-Manatee Counties) in 1980 which consisted of 6,395,000 individuals.

8.3.1.5 Bairdiella chrysoura (Silver perch)

Silver perch are found in deeper waters offshore in winter and move inshore to bays and coastal lagoons in spring to spawn (Gunter 1945; Springer and Woodburn 1960). Hildebrand and Cable (1930), though, found spawning in various North Carolina locations including harbors, estuaries, and sounds up to 15 miles out to sea. In the Tampa Bay area, Springer and Woodburn (1960) believed spawning to be in April and early May. Joseph and Yerger (1956) concluded that silver perch have a long spawning season in Alligator Harbor (northern Florida) since young were taken in June and September. Grimes and Mountain (1971) working in the Crystal River area reported spawning in the spring. Ripe individuals and eggs were taken at temperatures from 19.4^{o} to 28^{o}C (Miller 1965; Kuntz 1914). The eggs are pelagic (Welsh and Breder 1923; Kuntz 1914). Hatching time is temperature dependent; 40 to 50 hours at 18 to 21^{o}C (Welsh and Breder 1923) as compared to 18 hours at higher temperatures (Kuntz 1914). Larvae have been taken at temperatures between 16.4 and 31.8^{o}C (Jannke 1971), and juveniles between 4.8 and 32.5^{o}C (Thomas 1971).

Silver perch attain a length of about 140 mm SL by the end of their first year, and perhaps gain an additional 60 mm during their second year. Sexual maturity is reached after the second year at a length of 150 to 210 mm SL (Welsh & Breder 1923; Hildebrand & Schroeder 1928). Fecundity of a mature female (140 mm SL) was estimated at 52,800 eggs (Hildebrand and Schroeder 1928). According to Moe and Martin (1965), longevity is slightly more than 2 years; however, older fish, including a 230 mm specimen (age VI), have been reported (Welsh and Breder 1923). Eleven females collected at Crystal River had from 17920 to 147050 eggs per female (average 48140).

Silver perch are sexually mature at age 2 with specimens as old as age VI collected. Silver perch was assumed to spawn 3 times at the average fecundity of 48,140. Eggs were assumed to have a 50 percent survivorship in view of the short duration of this life stage. Other life stages were assumed to have a 10 percent survival.

The entrained prolarvae, postlarvae, and juveniles (Table 8.3-1) are equivalent to 2, 6,000 and 600 adults, respectively. This is a very small fraction (0.19 percent) of the 1980 recreational catch for Region 4.

Unidentified sciaenid eggs and prolarvae, while a portion may be silver perch have been assumed for conservatism to be spot.

8.3.1.6 Cynoscion nebulosus (Spotted seatrout)

Spawning season as reported in various locations is as follows: Pearson (1929, in Texas - March to October, with peak in April and May; Klima and Tabb (1959), in northwest Florida - late April through September, with a peak in late May and early June; Moffet (1961) in west Florida (Fort Myers, Cedar Key, Apalachicola) - May through September, peaking in summer; Sundararaj and Suttkus (1962), in Louisiana - July and August; Springer and Woodburn (1960) in Tampa Bay - first occurs in April. Spawning occurs in bays and lagoons (Gunter, 1945), in less turbulent portions of estuaries (Tabb 1966), in bays and lagoons somewhat offshore in water not over 10-15 feet deep (Pearson 1929), at night close to shore (Pearson 1929), and in estuaries well above the reach of daily tides (Tabb 1966). Jannke (1971) indicated that spawning may occur year round in the Everglades. Eggs are initially buoyant (Fable et al 1978; Pearson 1929) but soon sink (Fable et al 1978; Tabb 1966; Futch 1970; Guest and Gunter 1958). The young are usually hatched inshore, but if hatched offshore they move inshore (Hildebrand and Cable 1934).

Estimates of fecundity are as follows: Pearson (1929) in Texas specimens: two nearly ripe seatrout of 48 and 62 cm, 427,819 and 1,118,000 eggs, respectively; Tabb (1961) in the west coast Florida and Texas samples: 15,000 eggs at 32.5 cm standard length, 150,000 at 44.2 cm, 400,000 at 50.0 cm, and 1,100,000 at 62.5 cm. Sundararaj and Suttkus (1962) in Louisiana reported: age I, 283 mm total length, 140,485 eggs (N=8); age II, 376 mm, 354,325 eggs (N=9); age III, 450 mm, 660,960 eggs (N=8), and age IV, 504 mm, 1,144,492 eggs (N=3). Miles (1950) in Texas found , age II, 100,000 eggs; age III, 300,000 eggs, and age IV, 560,000 eggs. Moody (1950) in Cedar Key, Florida reported: 464,000 almost mature eggs in a female of 397 mm. Sundararaj and Suttkus (1962) also give the percentage of total eggs spawned for each age group: I-8.6 percent, II-24.5 percent, III-40.6 percent, and IV-26.8 percent.

The growth rate of female spotted seatrout is greater than for males (Moffet 1961; Tabb 1961; Moody 1950) and the females apparently outlive the males (Moffet 1961). The sex ratio changes throughout the lifespan (Tabb 1961). Males are outnumbered by females nearly 2 to 1 in the first 3 year classes. By the sixth year males may be outnumbered by as much as 8 to 1 (Klima and Tabb 1959).

Distributions of lengths by gender for specimens from Laguna Madre, Texas were presented by Klima and Tabb (1959) as were average lengths by age class. Moffet (1961) presented mean standard lengths by age class and sex. Welsh and Breder (1923) and Pearson (1929) (cited in Moody 1950) presented average lengths by age class for the first six and eight winters, respectively. Futch (1970) graphed length vs age for a composite of six populations of spotted seatrout.

Most of the males die by the age of 5 or 6 years (Moffett 1961). Female longevity is estimated at 8 to 9 years (Moffett 1961; Pearson 1929), or perhaps 10 years (Tabb 1961). Sundararaj and Suttkus (1962) estimate longevity at 5 years for females and 3 years for males. Excluding the first year (age group 0), about 90 percent of the females are evenly distributed between age groups I and III (Sundararaj and Suttkus 1962); these also represent the largest spawning classes (Guest and Gunter 1958).

The only life stage of spotted seatrout identified in entrainment samples at Crystal River was postlarvae. Table 8.3-1 provides the estimate of 6.5 million for total entrainment. Utilizing an average fecundity from Sundararaj and Suttkus (1962), a 2 year reproductive life, and an assumed 10 percent survival for the egg and larval life stages resulted in an estimated 900 equivalent adults lost. This number of equivalent adults is a very small fraction (0.05 percent) of the recreational catch for 1980 for Region 4.

Identified sciaenid eggs and prolarvae, while a portion may be seatrout, have been assumed to be spot. The allocation of all unidentified organisms in this taxon to one species results in a conservative analysis.

8.3.1.7 Leiostomus xanthurus (Spot)

In the Cedar Key area spawning apparently takes place in winter and early spring (Reid 1954). Kilby (1950, cited in Reid 1954) indicated a breeding season of the January through March for the same area. Young were taken in January and February and were found in shallow waters, channels, and both deep and shallow flats (Reid 1954). Adults were present inshore most of the year but were scarce in mid-winter (Reid 1954; Pristas and Trent 1978). In St. Andrew Bay, Pristas and Trent (1978) found significantly fewer males in autumn and winter (26.3 percent and 35.6 percent males, respectively). Sundaravaj (1960, cited in Thomas 1971) assumed that the majority of spot died before reaching three years of age. Pacheo (1962, cited in Thomas 1971) suggested a mortaility rate of 50 percent after the first year for spot in Chesapeake Bay. Thomas (1971) presented some length-frequency data.

Spot have a fecundity of 70,000 to 90,000 (an average of 80,000 was used for analysis) and an average life expectency of 3 years. Spot were assumed to spawn once and have a 10 percent survival rate for early life stages. The entrainment of spot postlarvae and juveniles (Table 8.3-1) resulted in an estimated loss of 280,000 and 410,000 equivalent adults, respectively. Together these represent 20,700 lbs assuming an average weight equivalent to that derived from the trawl catch (0.03 lbs). This is approximately equivalent to the 1982 commercial landings for Citrus-Pasco and Levy Counties.

All unidentified sciaenid eggs and prolarvae were conservatively assumed to be spot. The unidentified individuals exceeded the identified individuals and were for earlier life stages. The effect of entrainment of eggs and prolarvae (Table 8.3-2) results in 27,500 and 360 equivalent adults, respectively. While this addition increases the estimates of equivalent adults, due to the conservatism of the analysis, this addition should not alter entrainment conclusions.

8.3.1.8 Sciaenops ocellatus (Red drum)

Pearson (1929) indicated, based on the occurrence of larvae and very young red ~~drum, that spawning occurs from mid-October to mid-November off the coast of~~ Texas. Theiling and Loyacano (1976) stated that it is generally accepted that red drum spawn from September through November. The eggs are buoyant (Vetter and Hodson 1983; Holt et al 1981a, 1981b) though they will sink at salinities of less than 25 ppt (Holt et al 1981b; Vetter and Hodson 1983). Spawning apparently occurs in the Gulf of Mexico near passes leading into tidal marshes (Pearson 1929; Bass and Avault 1975; Holt et al 1981a; Holt et al 1981b). Yolksac larvae are negatively buoyant (Holt et al 1981a). The young move shoreward to bays and lagoons which are used as nursery areas (Holt et al, 1981a; Bass and Avault, 1975; Pearson, 1929). The young remain inshore until six months of age in Louisiana (Bass and Avault 1975). They remain inshore for an indefinite period in Texas (Pearson 1929), while Osburn et al (1982) indicated that essentially non-migrating populations of immature fish (year classes I-III) are found in the bays. Mature adults are apparently remain offshore in the Gulf (Pearson, 1929; Simmons and Breuer 1962 cited in Osburn et al 1982; Yokel 1966 cited in Theiling and Loyacano 1975; Ross et al 1983).

Maturity does not occur until at least age IV, probably age V (Pearson 1929) at a total length of at least 75 cm. Modal total lengths for the first three year classes are approximately 34, 54, and 64 cm, while fish in the fourth year class have a mode of probably 75 cm; by the end of the fifth year the average length is 83 to 85 cm (Pearson 1929). A weight of 10 pounds or more is attained before first spawning (Pearson 1929). Using two methods of calculation, Pearson estimated fecundity of about 3,382,886 to 3,410,000 eggs for a female 90 cm long. Holt et al (1981a) stated that maturity is reached in 3-5 years, with the average female producing 1/2 to 2 million eggs per season. Vetter and Hodson (1983) reported one female which spawned in the lab produced approximately 10^6 eggs.

Only red drum postlarvae were identified from meroplankton collected at Stations C, D, or E. Table 8.3-1 provides an estimate of 300,000 for annual entrainment. An average fecundity of 3,400,000 for one reproductive period was used for analysis. A 10 percent survival of eggs and larvae was assumed. The entrainment of postlarvae results in the loss of 18 equivalent adults, which is an insignificant fraction of the 229,000 red drum reported in the recreational catch in 1980 for Region 4.

8.3.1.9 Mugil cephalus (Striped mullet)

Although many authors have reported that striped mullet spawn inshore or within a few miles of the beach, it seems that spawning occurs offshore on the northwest coast of Florida (Finucane et al 1978; Anderson 1958 cited in Finnucane 1978; Arnold and Thompson 1958; Broadhead 1953). The eggs are pelagic (Finucane et al 1978). According to Gunter (1945) spawing occurs off the Texas coast from late October to early January, peaking in late November and early December. Moore (1974), on the other hand, indicated that spawning occurs from December to May off Port Aransas, Texas and that individuals may spawn more than once in the same spawning season. Finucane, et al (1978), indicated spawning occurs in early winter in the northwest Gulf of Mexico off Texas. Fish with mature or maturing gonads were mostly found to be three or more years old (Moore 1974). Prejuveniles leave the open ocean and enter intertidal estuarine areas (Major 1978).

Since no life stages were identified from meroplankton collections at Stations C, D, or E, there is no effect of entrainment calculated for the striped mullet population.

If all the Mugillidae noted in Table 8.3-2 are assumed to be striped mullet, the entrained life stages would be postlarvae and juveniles. Assuming a fecundity of 1.2 million (Futch 1966) and a 10 percent survival between life stages, the entrainment of postlarvae and juveniles results in 95 and 5800 equivalent adults. This represents a minor fraction of the over 2.5 million pounds of stripped mullet landed by commercial fisherman in Citris - Pasco and Levy Counties in 1982.

8.3.1.10 Penaeus duorarum (Pink shrimp)

Pink shrimp spawn offshore (Costello and Allen 1970; Tabb et al 1972; Williams 1955 in waters of 10-20 fathoms at temperatures between 19 and 31°C (Tabb et al 1972; Eldred et al 1965) at minimal bottom temperatures of 23.9°C (Williams 1965).

During spawning, eggs are cast free and drift for about one-half hour and then become demersal for approximately 14-16 hours prior to hatching (Tabb et al 1972). The highest spawning rate was observed from April to July in Florida (Tortugas area) (Cummings 1961), and spawning probably occurs year round in the Tortugas grounds (Perez-Farfante 1969). Eldred et al (1961) reported peak spawning to occur in the Tampa Bay area from April through September, with limited spawning in February and December. High temperatures may suppress spawning and more optimal temperatures probably cause peaks in spring and fall (Eldred et al 1961).

Fecundity estimates from a regression of fecundity and total length range from 66,000 (105 mm) to 460,000 (187 mm) ova for shrimp from the Tortugas and Sanibel fishing grounds (Martosubroto, 1974). Regressions on body weight and ovary weight were also given. Females probably spawn more than once during their lifespan (Cummings 1961; Perez-Farfante 1969), and a small female which spawns in the spring may spawn again in the fall after attaining a larger size (Eldred et al 1961). Kutkuhn (1962) also indicated semiannual spawning peaks. Males and females may achieve sexual maturity at minimum total lengths of 75 and 85 mm respectively at 9 or 10 weeks old (Eldred et al 1961). Kutkuhn (1962) gave an age estimate of 15 weeks and 107 mm total length as the age of recruitment to the Tortugas fishery. He also estimated 83 weeks to be the maximum lifespan. Juveniles inhabit coastal bays, estuaries, and as they grow, gradually move into deeper water (Costello & Allen 1966).

Survival rates of larvae on the Tortugas shelf average 83 percent per day (Munro et al 1968). From mark-recovery experiments on the Sanibel and Tortugas grounds of Florida, Costello and Allen (1966) estimated shrimp fishing mortality for Sanibel shrimp to be 6.8 percent for each 2-week period and all other losses were estimated to be 14.8 percent. For the Tortugas, fishing mortality was 13.1 percent for each 2-week period and all other losses were 19.7 percent. The instantaneous rates are: for Sanibel, .0689 for the fishery and .1644 for all others; for Tortugas, .1385 for the fishery and .2185 for all others. These rates, as the investigators pointed out, cannot be readily accepted as estimates of natural mortality since they include other losses such as migration and mortality from marking, handling, or releasing procedures. Also, true natural mortality may shift with changes in the fishing industry. Iversen (1962) reports the catchability of untagged shrimp (e.g., the instantaneous mortality due to fishing) from the Tortugas grounds to be .02393 and the instantaneous rate of emigration and natural mortality (e.g., instantaneous mortality rate due to other causes) to be .05998.

The sex ratio of males to females is about 1:1 for inshore populations (Tabb et al 1962; Eldred et al 1961; Saloman 1965) but varies geographically, seasonally, and with size class (Eldred et al 1961). As they mature, the larger shrimp move offshore; females attain larger size than males (Iversen and Idyll 1960; Williams 1955).

Since no life stages of pink shrimp were identified in meroplankton collections at Stations C, D, or E, there is no effect of entrainment calculated for the pink shrimp population.

Assuming that all *Penaeus* sp. are pink shrimp, the entrainment estimates from Table 8.3-2 have been used to estimate equivalent adults. An average lifetime fecundity of 200,000 was utilized, and 10 percent survival between life stages was assumed. The equivalent adults associated with mysis, postlarvae, and juveniles are 22, 18830, and 10230, respectively. Utilizing the average weight from the trawl samples at Crystal River of 0.007 lbs, the equivalent adults represent an insignificant fraction of the more than one million lbs of pink shrimp landed in Citrus-Pasco and Levy Counties in 1982.

8.3.1.11 *Callinectes sapidus* (Blue crab)

Williams (1965) reported that blue crabs mature in about 14 months and attain a maximum age of 3 years. Most spawn at about age 2 (Williams 1965; Pearson 1945; Churchill 1919.) Spawning occurs from late April (Williams 1965) and mid-May (Pearson 1948) until early or mid-September (Williams 1965; Pearson 1948). Some females produce two sponges (egg masses)in the same summer (Pearson 1948; Williams 1965). A third sponge may be produced the following year, at age 3 (Williams 1965; Pearson 1948; Churchill 1919). Williams reported the spawning peak to occur in June. Generally, gravid females move offshore where eggs hatch at higher salinities (Churchill 1919). Estimates of the number of eggs per sponge are given as 700,000 to two million by Williams (1965), 1,750,000 to 2,000,000 for a sponge of usual size by Churchill (1919), and up to 2,000,000 by Davis (1965). Of the eggs spawned, Van Engel (1958 cited in Oesterling 1976) estimated only about one ten-thousandth of one percent (.000001) will survive to become adults. Based on a study spanning 13 generations, Pearson (1948) reported the lack of a significant correlation between the abundance of the spawning stock and the number of offspring. Rather, there is a significant correlation between the volume of water discharged from the James and Potomac Rivers during the spawning season with the index of abundance for the resulting adults. This implies that salinity may be the important factor affecting survival of the young, at least at the level of fishing existing at the time.

Williams (1965) reported year round spawning occurs in Texas with peaks in June or early July. Nicols and Keney (1963, cited in Futch 1965) reported that spawning occurs primary throughout the year in Florida waters, but peaks from May through November. Oesterling (1976) reported that spawning occurs primarily during the spring and summer months, and is generally considered to occur in areas of higher salinity at the mouths of estuaries and offshore. However, unlike reports for the eastern seaboard, female crabs move, not offshore, but northward alongshore to a spawning area. There appears to be one primary spawning ground for the Gulf Coast in the Apalachicola Bay region, although spawning does occur all along the coast. In the St. Johns River, many if not all females spawn twice either in the same season or over two seasons, though few live more than one year past maturity (Tagatz 1968). The maximum age is little more than four years and crabs reach harvestable size in less than one year. Eggs number between one and two million per sponge (Tagatz 1968), while Futch (1965) reported that Florida female crabs produce about two million eggs per sponge.

Only megalops were identified from meroplankton collections at Stations C, D, or E. Table 8.3-1 provides an estimate of 360,000 entrained annually. The survival to megalops was assumed to be 10 percent and two sponges were assumed during the average life time. Therefore, the loss due to entrainment is about

2 equivalent adults. This is a nonsignificant fraction of the almost 4 million pounds of commercial landings in 1982 for Citrus-Pasco and Levy Counties.

The unidentified Callinectes sp. were assumed to be entrainable life stages of blue crab. The megalops (Table 8.3-2) entrained would represent about 200 additional equivalent adults. This addition does not change the conclusions for blue crab entrainment.

8.3.1.12 Menippe mercenaria (Stone Crab)

In North Carolina ovigerous females have been taken from May to August (Williams 1965). Futch (1966) reported that in Florida spawning apparently occurs throughout the spring and summer. Females, migrate offshore to spawn and are capable of producing six egg masses in 69 days, each containing 500,000 to one million viable eggs (Williams 1965). The postlarvae migrate inshore to bays and estuaries.

In the Cedar Key areas, however, it appears that females may remain inshore on the grass-flats to spawn. Spawning occurs from March through October with peaks in June and September (Bender 1971). In the Anclote area zoea were collected from March to November with peak densities from July to September, and megalops were collected from May to November, with most taken in July (FPC 1977). Juveniles under 8 mm carapace length were collected in Florida Bay from October through April indicating an extended spawning season (Manning 1960). Savage and Sullivan (1978) reported that sexual maturity is reached in about 10 months. Powell and Gunter (1968) reported a changing sex ratio in the number of males to females over the year at a jetty in the Port Aransas, Texas area. The ratios were 4.28 to 1 for December-January 1947-1948, 5.00 to 1 for May-June, and 2.65 to 1 for July - August.

The equivalent adult estimate for stone crabs utilized a fecundity of 750,000 and a lifetime production of 5 egg masses. Total survival was taken from Porter (1960), and a 10 percent survival from the last zoeal stage to megalops was assumed.

The equivalent adult estimate of less than 3,700 is mostly the result of Stage 1 zoeal entrainment (Table 8.3-1). The equivalent adult estimates are 3297, 6, 15, 6, 5 and 313 for zoeal Stages 1 to 5 and megalops, respectively. This number represents an insignificant fraction of the almost 950,000 lb landed in 1982 in Citrus-Pasco and Levy Counties.

8.3.1.13 Lolliguncula bevis (Brief squid)

Little is known about the ecology of brief squid in terms of short-term and long-term distribution patterns (Laughlin and Livingston 1982). Early life history data is also limited (Vecchione 1982). An eight year study of the brief squid's spatial and temporal distribution was conducted in the Apalachicola estuary by Laughlin and Livingston (1982). The most suitable habitat in the estuary was concluded to be channels and/or passes with high current velocity and salinities of 20-30 ppt. Small numbers occurred from January to April during times of relatively low salinities and temperatures. Abundance increased dramatically in May when mean salinities were intermediate and water temperatures high (22-25°C). A similiar situation was noted in October and November. While migration onshore and offshore is strongly correlated with temperature and salinity, fluctuations within the estuary were related to abunadnce of zooplankton (Laughlin and Livingston, 1982). Dragovich and Kelley (1964) reported that juvenile squid, which comprise most of the squid catches in estuaries (90%) feed preferentially on zooplankton.

Little life history information is available on the brief squid. It produces egg capsules that may contain up to 200 eggs per capsule and hundreds of the capsules are found in groups. Assuming a life time production of 500 eggs per individual, the entrainment estimate (Table 8.3-1) results in about 3600 equivalent adults. The brief squid was represented in low numbers from April to December at many stations. Therefore, the effect of entrainment can have only a minor effect on the population.

8.3.2 Entrainment Conclusions

The results of the entrainment estimates under conservative assumptions have provided the basis for equivalent adult projections. Where possible, these projections have been compared to other forms of population exploitation, such as commercial or sport fishing statistics. These analyses for the SIO demon-strate that for most species the entrainment effects represent a small fraction of present exploitation. Hydrodynamic modeling indicates that the source for the entrained organisms is not limited to the area immediately surrounding the plant. Therefore, entrainment is expected to have an acceptable level of exploitation on the SIO.

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TABLE 8.3-1

MAXIMUM ENTRAINMENT FOR EACH SIO BY LIFESTAGE
ANNUAL NUMBER ENTRAINED IN MILLIONS

Species	Life Stage	Total Entrainment	Station
Bay anchovy	Eggs	11674	D
	Prolarvae	767.8	D
	Postlarvae	686.6	E
	Juveniles	154.6	C
Polka-dot batfish	Juveniles	0.19	E
Pigfish	Postlarvae	0.76	C
Pinfish	Postlarvae	16.69	E
	Juveniles	2.15	E
Silver perch	Prolarvae	0.08	C
	Postlarvae	21.64	C
	Juveniles	0.22	C
Spotted seatrout	Postlarvae	6.50	E
Spot	Postlarvae	12.28	E
	Juveniles	1.73	E
Red drum	Postlarvae	0.30	C
Blue crab	Megalops	0.36	D
Stone crab	Stage 1	3029.43	E
	Stage 2	254.63	E
	Stage 3	52.01	E
	Stage 4	14.84	E
	Stage 5	0.38	C
	Megalops	2.35	E
Brief Squid	All	0.91	C

TABLE 8.3-2

MAXIMUM ENTRAINMENT FOR UNIDENTIFIED SIO TAXA

Species Name	Life Stage	Total Annual Entrainment (Millions)	Station
Anchoa sp.	Prolarvae	192.6	E
	Postlarvae	1088	E
Haemulidae	Eggs	433.5	E
Sciaenidae	Eggs	1102	C
	Prolarvae	14.63	D
Mugillidae	Postlarvae	0.57	E
	Juveniles	3.5	E
Penaeus sp.	Mysis	0.22	C
	Postlarvae	18.83	C
	Juveniles	1.023	E
Callinectes sp.	Megalops	34.83	E

9.0 FISHERIES

Samples of juvenile and adult fish were collected by using four different gear types at various locations throughout the study area. The data are intended to provide information on the local fish community and to support evaluation of thermal, impingement and entrainment effects on fish populations. As in the impingement and entrainment evaluations, selected species are emphasized.

The fisheries program included a short-term effort to collect blue and stone crabs and to tag and recapture blue crabs. These data were intended primarily to identify patterns of local movement and coastal migration.

9.1 SAMPLING AND LABORATORY ANALYSIS

9.1.1 Sampling Procedures

Fisheries samples were collected in the vicinity of the Crystal River Power Station at monthly intervals from June 1983 through May 1984. Several gear types, including otter trawls, beach seines and a drop net, were used. Open water otter trawls were collected at night. Tidal creek trawls and all other fisheries samples were collected during the day. Station locations are shown in Figure 9.1-1.

A 3.05 meter otter trawl constructed of 3.8 cm mesh in the body, 1.3 cm mesh in the cod end and a 6.5 mm mesh nylon cod end liner was used for the open water trawling. Seven samples were collected at each station. The net was released from a moving boat and dragged along the bottom for 2 minutes (per haul).

Duplicate beach seine collections were made at each station using a 22.9 meter long by 1.8 meter deep seine constructed of 6.5 mm mesh. The seine was deployed in the following manner: an anchor attached to the end of the seine was placed on the beach. The seine was payed out as the other end was walked perpendicular to the beach. When approximately three-quarters of the length of the seine had been deployed, the net was walked in a semicircular formation. After the distal wing was on the beach, the two ends of the net were drawn together and the net was hauled onto the beach.

The drop net apparatus consisted of a portable frame from which a 1.6 mm mesh net was suspended and then remotely triggered to enclose a 16 m^2 water column. The trigger line was pulled after an acclimation period of approximately 2 hr. After the net was dropped, the enclosed area was swept five times with a 6.5 mm mesh seine. This was followed with a series of three sweeps with a 1.0 mm mesh seine. Two replicates were collected on each sampling date.

Four creeks were sampled with a 3.05 meter otter trawl constructed of 3.8 cm mesh in the body, 1.3 cm mesh in the cod end, with a cod end liner of 3.2 mm mesh nylon. Seven samples were collected at each site. The net was released from a moving boat, and dragged along the bottom for 2 minutes (per haul).

A blue crab tagging/recapture study was conducted during a 16 week period from September through December 1983. A total of 120 plastic coated standard wire mesh crab traps were set and retrieved weekly along four transects, designated A through D, within the study area. Each transect consisted of 30 individual traps, which were evenly spaced into six groups containing five traps each. Each group of five traps along a transect was designated as an individual station (Figure 9.1-2).

Each individual crab trap was baited with shad. Traps were retrieved, emptied, and reset every 7 days, at which time all healthy viable blue crabs were tagged and released. To avoid tag loss due to molting or death, only mature healthy female crabs and healthy male crabs larger than 127 mm carapace width were tagged. Tags were fastened to the carapace of the blue crab with 40 pound test monel. The tags were sequentially numbered and contained information pertinent to how the tag was to be returned. The tag number, date, and location of capture, carapace width to the nearest millimeter, sex, and general appearance of each tagged crab were recorded. Crabs were released approximately 200 m from the point of capture. When previously tagged crabs were recaptured, the tag number, sex, carapace width, date, time, and location of recapture were recorded and the crab was then released.

In addition to tagged blue crabs, any stone crabs (Menippe mercenaria) which were captured, as well as any blue crabs which could not be tagged, were measured for carapace width, sex was noted, and the specimens released.

To supplement the number of blue crabs tagged, all blue crabs impinged on the travelling screens during a 24 hr period were collected once weekly during the tagging study. The dates and times of collection were designated to correspond with the regular impingement sampling schedule. During this time, all viable blue crabs were placed in a divided water table. At the end of a minimum 24 hr holding period, each healthy crab was removed and tagged in the same manner as described previously. All blue crabs, dead or alive, were also measured for carapace width and total weight for the impingement study. The total number of crabs held, as well as percent mortality, were recorded. Tagged impinged crabs were then divided randomly into three equal groups and transported to three predetermined release points within the study area. These release points were designated as Stations E, F, and G (Figure 9.1-2).

Along with the field work, an extensive public notification program was initiated in cooperation with the Florida Department of Natural Resources (FDNR). Notices of the tagging project were sent to local licensed commercial crabbers, bait shops, docks, and processing houses in an attempt to enhance the number of tag returns. Included in this notification was a description of the study and the tags used, and the announcement of a nominal reward for tag returns with desired information. FDNR coordinated the tag returns to provide consistency with their statewide program.

9.1.2 Laboratory Analysis

All fish and macroinvertebrates were identified, counted, and weighed by species. Identifications were made utilizing standard literature sources and MML's reference collection. Nomenclature of fishes followed that established by the American Fisheries Society. Taxonomy was based on external characteristics as given in major taxonomic keys. A voucher specimen for each species was retained. The identifications of any questionable specimens were verified by external taxonomic specialists. A reference collection of all taxonomically confirmed species was maintained.

In addition to the general analyses, selected important organisms were examined in detail and analyzed for length-weight relationships, overt parasites, and disease. Additionally, certain species were analyzed for sex, reproductive condition, fecundity, and age as shown in Table 9.1-1.

Twenty-five individuals from each of the nine selected important species obtained by beach seining and trawling in each experimental (north of the intake canal) or control (south of the canal) area during each month were examined for obvious instances of parasitism and disease. External sexual characteristics were noted. Each species was also sexed internally, their stages of maturity recorded, and their reproductive condition examined. The latter was reported following standard classifications: immature, mature, ripe/gravid, or spent. Fecundity of ripe or gravid fish was determined by the gravimetric method. Age was determined using otoliths or scales for fish species subjected to fecundity analyses. Analyses were performed for each month of the study. Sex and reproductive state (e.g., gravid, egg-bearing) of important macroinvertebrates were recorded where possible.

TABLE 9.1-1

DETAILED STUDIES OF SELECTED IMPORTANT ORGANISMS

Species	Sex	Reproductive Condition	Fecundity	Age	Length-Width	Disease and Parasites
Polka-dot batfish	X	X			X	X
Pigfish	X	X	X	X	X	X
Pinfish	X	X	X	X	X	X
Silver perch	X	X	X	X	X	X
Spotted seatrout	X	X	X	X	X	X
Spot	X	X	X	X	X	X
Red drum	X	X	X	X	X	X
Striped mullet	X	X	X	X	X	X
Bay anchovy	X	X	X	X	X	X
Blue crab	X	X				
Stone crab	X	X				
Pink shrimp		X				

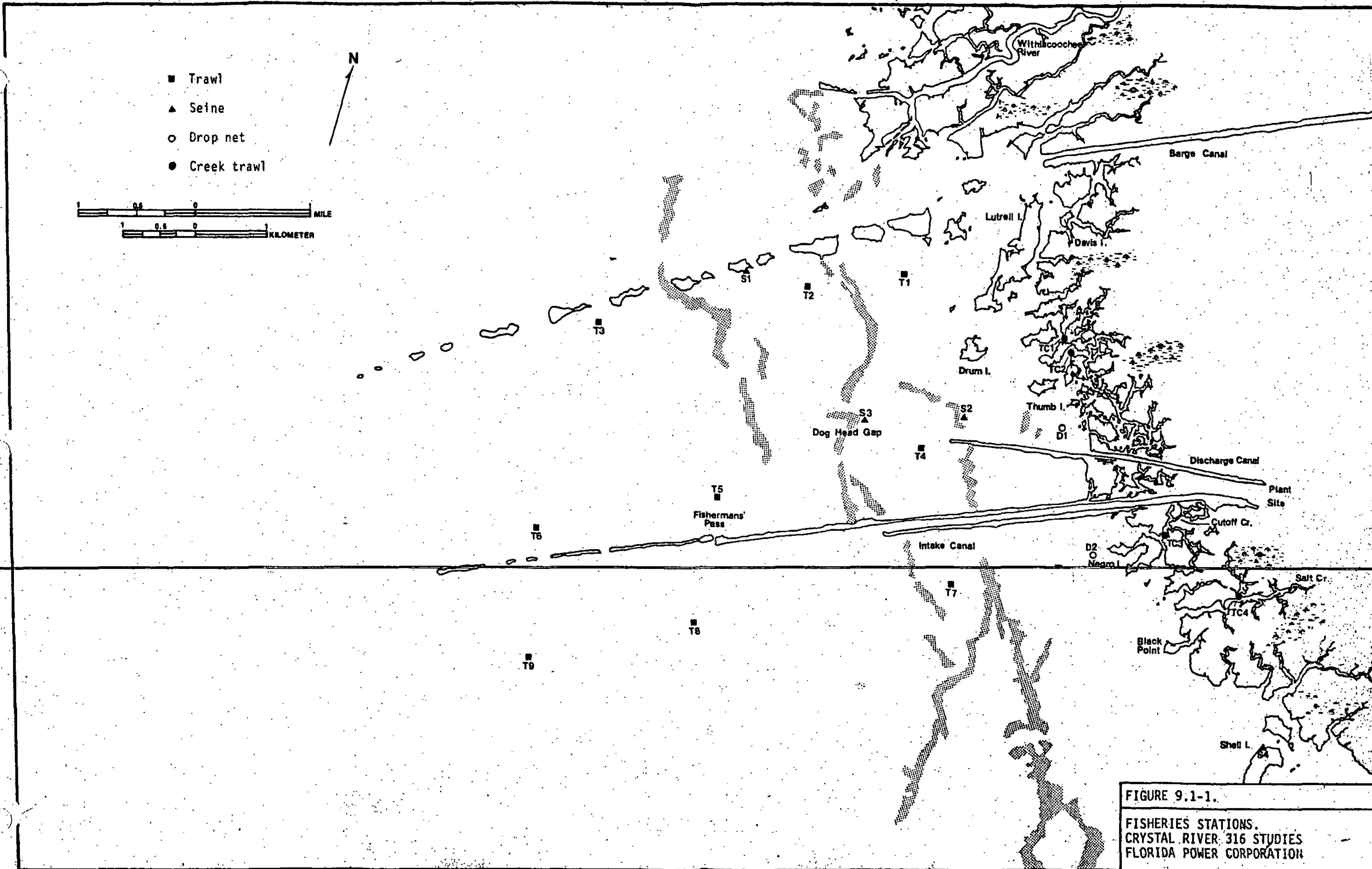


FIGURE 9.1-1.

FISHERIES STATIONS.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

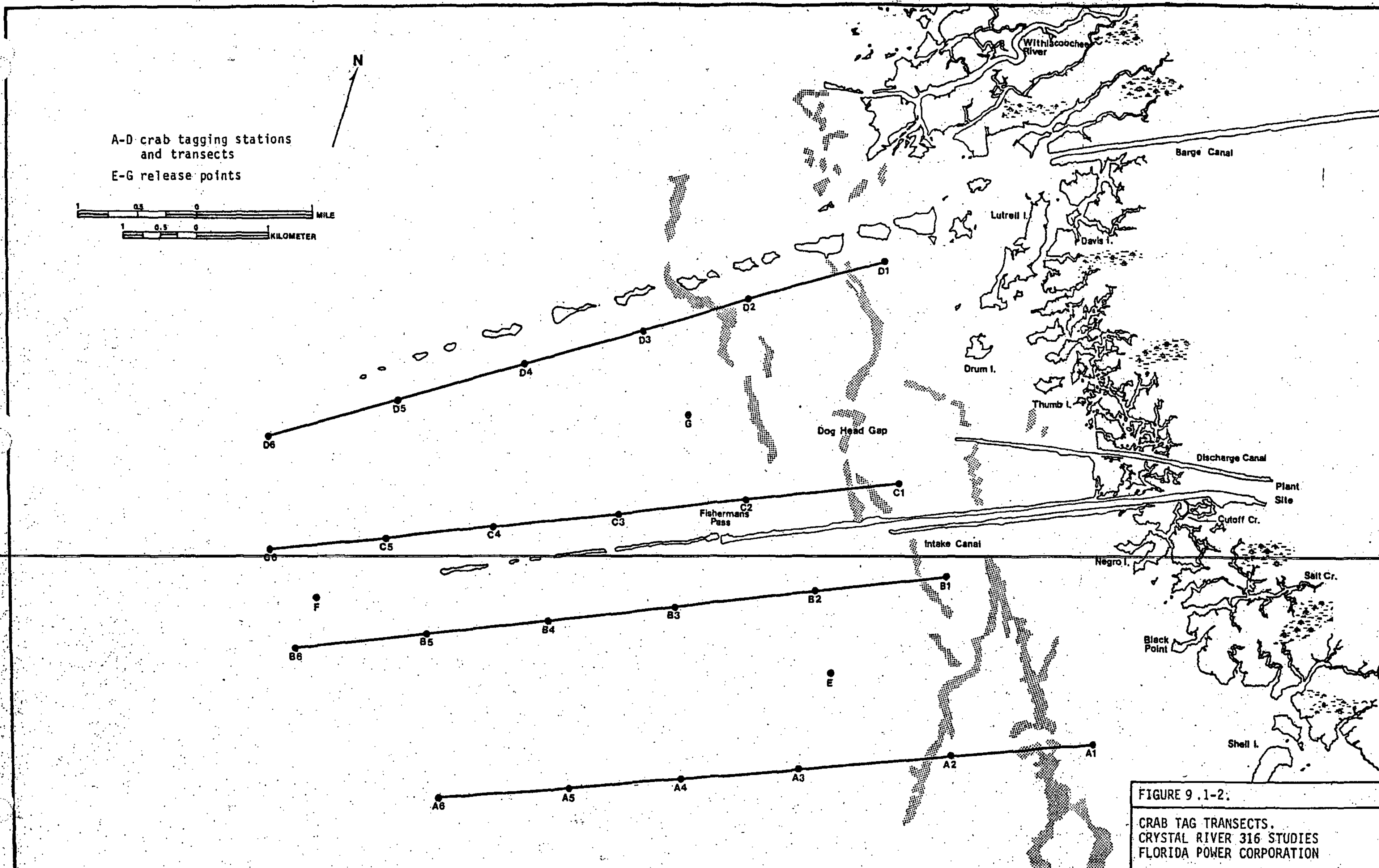


FIGURE 9.1-2.

CRAB TAG TRANSECTS.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

9.2 RESULTS

Fish and invertebrate numbers and biomass have been provided in quarterly reports by gear type, month, and station. Summary tables for SIO are provided in Appendix VII. In general, numbers were small, although occasional large collections did occur. As a result, one or two samples have a large effect on total values. Quantitative analyses which can be performed are limited. The following sections report the results of fisheries sampling by gear type.

9.2.1 Trawl

The trawls captured a total of 98 species of fish and 108 species of invertebrates. The total catch of fish varied seasonally with lowest numbers in January and February (see Figure 9.2-1). The peak number at any one station occurred in May (Station T9), but similarly high densities occurred in April, June, July, and August (Table 9.2-1). Highest densities at all stations occurred in late spring and summer (May, August, September, June). Invertebrate densities followed a similar seasonal pattern although low densities found in December and January continued through June, and then increased to a peak in July and August.

Fish biomass followed the same general seasonal pattern seen in the density data (see Figure 9.2-2). Invertebrate biomass was lowest from December through February, however, peak values occurred from March through May rather than in summer.

The variability in the data associated with capturing a school of fish can efffectively mask patterns of distribution. For example, trawling in April at Station T4 yielded 502 spot which was 91 percent of the catch at the station and 38 percent of the catch at all stations. At the same time, some general patterns do appear consistently from month to month. Comparisons among transects (northern, T1-3, central, T4-6, southern, T7-9) indicate the lowest densities of both fish and invertebrates along the central transect (see Tables 9.2-2 and 3). The transects to the north and south had similar numbers overall. Highest numbers of fish were collected to the north in 1983 and to the south in 1984. Numbers of invertebrates were consistently higher to the south. Fish biomass was highest to the south except in the fall. Based on average fish weights, the larger fish were collected along the central or southern transects.

Within transects, distributional trends vary from month to month, but to the north, Stations T1 or T2 generally had the highest numbers and T3 the lowest. On the central transect, the variation was similar with highest densities inshore at Station T4 and lowest offshore at Station T6. To the south, the offshore station (T9) frequently had the highest numbers and the central station (T8) had the lowest.

Diversity (Shannon-Weaver) evenness (after Pielou 1975) and richness (number of species) were calculated for each trawl station in each sampling month. A summary table is included in Appendix VII (Table VII-23). Comparing across transects, richness was often lower along the central transect and was considerably higher along the southern transect in 1984. Evenness was slightly higher on the central transect in the winter and spring. Diversity was generally similar on all three transects. During 1983, diversity within transects increased with distance offshore along the north and central transects. Evenness and richness also increased offshore. Along the southern transect, diversity was highest inshore until April 1984 at which time the offshore station was most diverse. Evenness was frequently highest at T8 and richness was highest at T7 or T9.

In addition to evaluating population parameters for trawl data, total density and biomass, the data for each SIO were summarized (see Appendix VII, Tables VII-1 to 22). Several species were captured in very low numbers precluding detailed evaluation of their distributions; these included squid, stone crab, and polka-dot batfish. Blue crab occurred in low numbers but peaked in April and May; they were most consistently found at T1 and T2. Spotted seatrout numbers were also low, peaked in May and concentrated at T1-3 and T5. Bay anchovy were rarely collected in trawls; numbers peaked in the summer with most anchovies taken at Stations T1-4.

Other SIO were collected in greater numbers. Spot was present throughout the year with highest numbers in spring and summer at Stations T1-4. Based on biomass values, the smaller specimens were inshore at Station T1 and T4 and the largest spot were at Station T3. Pigfish were collected primarily in spring and summer, but their concentration was to the south. Pinfish occurred at about the same time, and they were also collected primarily at the southern stations. Moderate numbers of pinfish were also taken at Stations T1 and T2.

Silver perch were most common in summer and fall with the highest densities inshore at Stations T1, T2, and T7. Based on average weight comparisons, the smaller specimens were found at these stations. Pink shrimp were taken throughout the program with highest densities occurring in the summer. Numbers were higher inshore at that time but showed considerable variation at other times.

9.2.2 Seine

Seine collections yielded 49 species of fish and 15 species of invertebrates. Figure 9.2-1 provides a summary by month of the total number of fish collected. In general, the seines sampled a limited number of species, and of the species collected, many occurred in small numbers. Invertebrates were rare except at Station S1 in February when several species of shrimp common in grassbed habitats were collected (see Table 9.2-1). Fish captured in large numbers were usually juveniles of schooling species. Large numbers were taken in March at Station S1 (clupeids, spot) and S2 (clupeids), in February at Station S1 (spot), and in September at Station S2 (bay anchovy). Excluding these particularly large catches, lowest densities occurred from November through April and the highest in June and July. No clear pattern of distribution emerged. Station S2 did have the lowest density and biomass seen at the site in any given month over half of the time, but values at other stations were rarely much higher. The highest density per sampling date occurs most frequently at Station S1.

Diversity, evenness, and richness (see Appendix VII, Table VII-46) were very variable, both across stations and month to month. Diversity remained relatively high at S4 and tended to be highest at Station S1 or S4. Lowest values in winter were at Station S2. Richness was highest in winter at Station S4 and in spring at Station S1.

SIO information from seines is very limited (Tables VII-24 to 45). Stone crab, pink shrimp, red drum, and pigfish were collected only on one date. Silver perch were collected twice. Small numbers of batfish were collected over 5 months; all but one occurred at Station S1. Low numbers of blue crabs were found at all stations over 8 months.

Spot were collected mostly in February and March with highest numbers at Station S1. Pinfish were also collected in highest numbers in February and March at Station S1. Bay anchovy were collected in all months except January, February, and April. The station at which the maximum density occurred varied over time but was most often S2. Striped mullet occurred in varying numbers, mostly from August through February. Only four specimens were collected at Station S2.

9.2.3 Drop Net

Drop nets sample primarily small, shallow water inhabitants and species which move into shallow areas with the tide. Drop net collections contained 42 species of fish and 24 species of invertebrates. Numbers of organisms were generally low and variable (see Figure 9.2-1). Highest numbers were collected in February, November, October, and September (see Table 9.2-1). Lowest numbers occurred in December and January. The number of fish caught at Station D1 generally exceeded the number at Station D2, except in June, August, January, and December. Fish biomass was also usually higher at Station D1; exceptions were in July, April, and March when biomass was greater at Station D2. In contrast, more invertebrates were consistently taken at D2. Biomass of invertebrates was also generally higher at Station D2.

Diversity at drop net stations was highest at D2 in 10 of 12 months (Table VII-67). Diversity was lower at Station D1 in the spring despite higher richness. Evenness was correspondingly lower. Richness was generally higher at D2.

Selected species were uncommon in drop net collections (see Tables VII-47 to 66). Seatrout and bay anchovy were taken only at Station D1. Mullet, batfish, and silver perch were collected only at Station D2. Of the species collected at both stations, spot occurred in larger numbers at Station D1 and pigfish and pink shrimp were mostly at Station D2. Pinfish and blue crabs were about evenly distributed.

9.2.4 Creek Trawl

Given the locations and conditions sampled, this gear sampled organisms moving in and out of the creeks on a relatively high tide. Forty-three species of fish and 27 species of invertebrates were collected. Juvenile fish predominated. The largest numbers of fish were collected from January through May with the peak in March (see Figure 9.2-1). Invertebrate numbers were highest from November through March (Table 9.2-1). Fish biomass was highest in the spring; a secondary peak occurred in November.

Fish densities tended to be lowest at Station TC4 and at Station TC1. Peak densities tended to be at Station TC2. The same pattern was observed for the invertebrates collected.

Diversity in creek trawl samples was almost always higher at TC4 or TC1 and lowest at TC2 (see Table VII-86). Evenness tended to be lowest at TC2 or TC3. Richness increased at TC2 in the fall and early winter; in the spring, highest richness was at TC1 or TC2.

Mullet, spotted seatrout, pigfish, and bay anchovy were collected in small numbers (see Tables VII-68 to 85). Silver perch were generally rare but a large number were collected in May at Station TC1. Pink shrimp were taken at all stations over all months with the largest numbers collected at Station TC2. Blue crabs showed similar seasonal and spatial patterns; numbers were slightly higher at TC1. Spot were collected in only 5 months but in relatively high numbers. Peak numbers were in February and March at Stations TC1 and TC2. Pinfish was the most commonly collected SIO with highest numbers from February through May, at Station TC2. These peak values were made up of small fish which began to appear in January. Average weight continued to increase through May.

9.2.5 Crab Traps

During the 4 months of trapping, 7294 blue crabs and 6251 stone crabs were captured (Table 9.2-4). Of the blue crabs, 6123 were collected in crab traps, tagged, and released. An additional 220 crabs were impinged, tagged, and released. These results and subsequent analyses utilize collection data without correction for Catch Per Unit Effort (CPUE). CPUE by station and week of sampling was reviewed and evaluated statistically, but the results and conclusions described below and displayed in subsequent tables were unchanged.

Only about 17 percent of the blue crab captures occurred in September and October. At the same time, 43 percent of the stone crabs were caught (Table 9.2-5). In general, blue crabs were captured in larger numbers inshore on all four transects. In September and October, Stations A1, B1, C1, D1, and D2 accounted for about 73 percent of the catch. Numbers generally decreased at stations toward the offshore end of each transect. Stone crabs were concentrated toward the offshore end and center of the transects. Densities along Transect B were somewhat more homogeneous in having comparable numbers of stone crabs at B1-3 and B6, but the largest numbers were at B4 and B5.

In November and December, stone crabs maintained the pattern of largest numbers offshore and in the center of the transects (see Table 9.2-6). Blue crabs continued to be caught in large numbers at the inshore stations, but similar numbers were taken at the first four stations on each transect indicating an increase in densities 4-7 kms offshore.

Highest numbers of blue crabs were trapped at Transect D throughout the study. Transect A yielded the next highest number. Transects B and C had similar numbers, with B yielding slightly more overall. Stone crabs were most abundant at Transect B and least abundant at Transect D.

Data from crab traps were also evaluated in terms of sex and carapace size. Overall, stone crabs were 65 percent males, the percentage lower in November and December (61 percent) compared to September and October (70 percent) (see Tables 9.2-7 to 9.2-10). The distribution along a transect is similar for both sexes; male stone crabs were collected in higher numbers along Transects A and B while females were least dense on Transect A. At almost all stations, females were smaller than males.

The blue crabs collected were about 74 percent females. In September and October, however, only about 48 percent were females. The population in November and December was about 79 percent females. Both males and females were most dense inshore in September and October. Later, the males contined to be most dense inshore while females occurred in larger numbers toward the center of the transects. Highest numbers of both males and females were at Transect D, lowest numbers were at Transects B and C. Female blue crabs were generally larger than males, but no pattern of distribution based on size was apparent.

Immature blue crabs were not collected in September but then appeared in increasing numbers through December. They made up less than 4 percent of the catch. Parasitized specimens were also taken in increasing numbers each month and represented 3 percent of the blue crabs collected. Parasitized specimens averaged 110.5 mm.

A total of 3422 tagged blue crabs were recaptured. One hundred thirty-three crabs were recaptured initially by MML; of these, 68 were recaptured more than once. Most of these multiple captures involve only a second recapture although one crab was taken four times. The number of crabs recaptured represented 54 percent of the tagged crabs; 96 percent of the recaptures were from fishermen while 4 percent were taken by MML crab traps. Of all the recaptures, about 67 percent came from Crystal Bay. Of the Crystal Bay recaptures, about 79 percent were females.

Numbers of crabs recaptured in Crystal Bay are shown by release location in Table 9.2-11. The table records multiple recaptures in terms of both the original release station and the secondary release point for each recapture. The recapture location numbers refer to grid elements as shown in Figure 9.2-3. For recaptures reported by fishermen, locations are approximated based on information reported with the tag return, conversations with fishermen, and field observations. Data on recaptures are also presented by sex, (Tables 9.2-12 and 9.2-13) but males are relatively few in number and the pattern of recaptures is similar for both sexes. Thus results are discussed in terms of total numbers. Comparing recaptures by transects provides the best indication of local north-south movement. Crabs released on Transect A are recaptured primarily on Transect A (39 percent) or Transect B (44 percent). Recaptures after release on Transect B were mostly (71 percent) on Transect B, recaptures from Transect C were either on Transect C (38 percent) or Transect D (54 percent), and those from Transect D were recaptured along Transect D (80 percent). The latter value is biased by the lack of traps further north. The data do indicate a movement of crabs to the north from all transects but particularly from A and C with more limited numbers released on Transect B being recaptured on C or D. There is also some movement to the south from Transects B, C, and D.

Within each transect, there was some east-west movement indicated. Crabs released at inshore stations, e.g., A1, B1, B2, D1, and D2, were often found further offshore. Crabs released at central stations, e.g., A4, B4, D3, and D4, tended to be recaptured inshore.

In Table 9.2-14, the release and recapture data is presented in terms of the average time between the two events in order to consider rate of movement. The times are highly variable, and the variation in number of crabs recaptured requires careful interpretation. For crabs released at a point on a given transect, recaptures occur more quickly on the same transect than on other transects. On Transect A, recaptures on Transects C or D occur over the same range of average times as recaptures on Transect B. It is possible, using weighted averages for recaptures on the four transects, to define the time from release along Transect A until recapture as increasing with distance north: Transect A (22.5 days), Transect B (29.1 days), Transect C (34.1 days), and Transect D (36.8 days).

In addition to recaptures in Crystal Bay, recaptures were recorded north and south. Table 9.2-15 provides a summary of the numbers of crabs recaptured at various locations. The southern section of Crystal Bay accounted for only 0.5 percent of the recaptures. About 27 percent of the total recaptures were from Waccasassa Bay and less than 6 percent from further north. As would be expected, releases from northern transects in Crystal Bay accounted for higher numbers of recaptures to the north. Recaptures to the south came mostly from Transects A and B. Males accounted for all but one of the crabs recaptured to the south but only about 5 percent of the crabs moving north.

Average time between release and recapture is provided in Table 9.2-16. In general, crabs were recaptured most quickly in Crystal Bay with the time span increasing with distance from Crystal Bay. Maximum times occurred with crabs recaptured near Apalachicola River (about 225 km NW). Crabs recaptured to the south (10 km) had unexpectedly high times, similar to times seen about 200 km northwest.

Over 900 crabs were recaptured in Waccasassa Bay. A comparison was made of recapture times in Waccasassa Bay and release stations along Transects B and C. For each comparably located station, the time to recapture is less from Transect B than Transect C. Comparing Transects D and B, three of the comparable stations on B have shorter times until recapture in Waccasassa Bay. Crabs from Transect A take longer than crabs from B but sometimes more and sometimes less time than crabs from C and D. Comparing weighted average times by transect indicates the shortest recapture time from Transect B (43.8 days) and the longest time from Transect C (52 days). The average time from Transect D (45 days) is similar to that from Transect B but lower than from Transect A (49.7 days).

9.2.6 Special Studies of SIO

Evidence of disease or parasitism was encountered in only two species. Fifty-seven batfish, all with an intestinal nematode, were collected and sacculinid parasites were found on 76 blue crabs of 422 collected. All but one batfish was from trawl collections, the largest number occurred at Station T7, and parasitized fish were taken in 10 of the 12 collections. Almost 72 percent of the parasitized batfish were collected in the control area. All but two of the blue crabs reported were also from trawl collections, the largest number were taken at Station T9, and they occurred in all months with higher numbers in April and May. In other gear, only 2 of 115 crabs were parasitized. In the trawls, a significantly greater percentage of parasitized crabs occurred in the thermal area (56 percent) compared to the control area (44 percent). This pattern was reversed only in the spring (control, 63 percent; thermal, 37 percent).

Gravid females of only three species were collected and analyzed; all were less than 1 year old. Three pigfish were collected in March 1984 at Stations T7 and T9. Fecundity ranged from 17302 to 28160 (average 21660) eggs per female. Nine bay anchovies were found to have 1173 to 4387 (average 2290) eggs per female. One specimen was taken in June 1983 at Station T4, three were collected in March 1984 at Stations T1 and T2, and the remainder were at Stations T7 and T8 in April. Eleven silver perch ranged from 17920-147050 (average 48140) eggs per female. All were collected in March at Stations T1 and T4 or in April at Stations T1, T4, T8. While the numbers involved are too small to warrant quantitative analysis, it can be noted that the March occurrence of silver perch and bay anchovy was at stations closest to the thermal discharge.

The SIO collected for special studies were analyzed for several other parameters to identify possible differences between thermal and control areas. For these analyses, thermal stations were defined as T1, T2, T4, S2, S3, D1, TC1, and TC2. These were compared to fish collected at Stations T7, T8, T9, S4, D2, TC3, and TC4.

Age

Each SIO was evaluated by age class in each month of the study. The number of specimens was generally small and variable. Bay anchovy were all first year fish. In all months when they were found only in one area (July, September, November, January, February), the fish were in the thermal area. In March and April higher numbers occurred at control stations while in May, August, and October, numbers were higher at thermal stations. Pigfish were 0-3 year classes; older fish were generally found at the control stations. Young-of-the-year were also most commonly at control stations.

Pinfish were of the 0 or 1 year classes. Numbers of young fish were highest at control stations except in early summer when comparable numbers were collected in both areas. Older specimens were more common at control stations. Silver perch were 0, 1, or 2 year classes; young fish occurred in higher numbers at the thermal stations throughout the year. Spotted seatrout were 0, 1, or 3 year classes but fish for which age was determined were too uncommon to consider distribution. One spot was in its second year; all others were young-of-the- year. Numbers were either equal in both areas (November, February, March, April, May) or higher at thermal stations. Mullet were 0, 1, or 2 year classes, but generally occurred in low numbers in one area or the other. Only two red drum were collected; both were age 1.

Sex

Each SIO for which sex was determined was considered in terms of total numbers at thermal or at control stations. Results are shown in Table 9.2-17. The ratio of females to males was higher in the thermal area compared to the control area for bay anchovy, batfish, silver perch, and pink shrimp. The ratio was lower for pigfish, pinfish, seatrout, mullet, and blue crab.

Reproductive Condition

The reproductive condition of specimens analyzed for each SIO was considered in terms of total numbers in control and thermal areas. Most species were either not collected in comparable conditions in both areas or were collected in similar numbers in both areas. Immature specimens found in larger numbers at thermal stations included bay anchovy, silver perch, spotted seatrout, spot, pink shrimp, and blue crabs. Immature batfish, pigfish, and pinfish were more common in control areas. Numbers of mature pinfish were higher in the control area. Mature bay anchovies had higher numbers in the thermal area.

Only bay anchovies, pigfish, pinfish, and silver perch were found in significant numbers for any condition other than immature. More mature silver perch tended to be collected in the thermal area; pinfish and pigfish were the reverse. Anchovies in all conditions were either in similar numbers in both areas or in higher numbers in the thermal area.

Length-Weight

The length-weight and condition index data were available in sufficient abundance for analysis of six species: bay anchovy, batfish, pigfish, pinfish, silver perch, and spot. The analysis examined differences in length-weight and condition factor by sex, season, and location (thermal vs control). The analysis is a regression of log of weight on log of length using one of the above factors as a covariate.

The analysis of the effect of sex on the length-weight relationship indicated that significant differences existed only for silver perch. Silver perch females have a greater rate of increase in weight by length (slope) than male silver perch.

In the analysis of the effects of season on the length-weight relationship a separate seasonal analysis was conducted for each sex for silver perch and for all specimens of the other five species. These tests revealed differences in log weight vs log length slopes for four species. For bay anchovy, the fall and spring specimens had a lower slope than summer and winter collected specimens. Mean size also differs with season with the smaller specimens being collected in the summer. Summer collected pinfish were large in size and had a weight-length slope greater than all other seasons. Fall collected pinfish were also large in size and had significantly greater slope than winter and spring collected specimens. Silver perch females were significantly smaller in the summer, but the larger spring specimens had a lower weight-length slope than specimens collected at other times of the year. Spot collected in the spring, while moderate in size, had weight-length slope significantly greater than specimens collected at other times of the year.

In the analysis of the effects of thermal vs control areas, four species displayed significant differences. In spring and fall, bay anchovy in the thermal area had a significantly lower weight-length slope than those collected in the control area. Spot collected in summer, fall, and winter showed the same pattern, but significantly larger specimens were collected in the thermal area. Female silver perch collected in summer, fall, and winter in the thermal area had a significantly greater weight-length slope than specimens collected in the control area. Pigfish showed the same pattern and were significantly smaller in size in the thermal area.

Reference for 9.2

Pielou, E. C. 1975. Ecological Diversity. John Wiley and Sons, New York. 165 pp.

TABLE 9.2-1

FISHERIES SAMPLING DATA
NUMBERS OF FISH (F) AND INVERTEBRATES (I)

Month	Sampling Gear							
	Trawl		Seine		Creek Trawl		Drop Net	
	F	I	F	I	F	I	F	I
June	1742	625	1342	4	-	-	190	379
July	1277	2005	1084	-	444	172	151	501
August	2130	1834	559	13	334	129	42	79
September	1912	989	2047	1	314	117	410	-
October	1004	455	576	3	233	79	449	122
November	679	392	108	3	555	354	533	1021
December	554	269	36	26	80	807	28	292
January	121	605	67	2	788	2865	40	42
February	435	855	2898	147	1644	889	1418	6
March	1033	890	9846	7	3575	386	76	1
April	1304	774	75	13	636	125	136	-
May	2448	449	1028	10	1489	326	56	-

TABLE 9.2-2

NUMBER OF FISH COLLECTED BY TRAWL

Location	Month												
	J	J	A	S	O	N	D	J	F	M	A	M	
Northern Transect:													
T1	540	375	362	369	83	60	74	8	96	335	96	318	
T2	327	226	475	377	201	139	112	25	52	41	68	311	
T3	62	121	139	191	86	109	17	7	25	24	33	280	
Transect Total	929	722	976	937	370	308	203	40	173	400	197	909	6164
Central Transect:													
T4	82	28	67	197	105	92	169	15	25	40	551	103	
T5	49	61	158	144	59	29	58	8	13	23	20	154	
T6	19	24	68	41	26	21	24	6	18	19	37	107	
Transect Total	150	113	293	382	190	142	251	29	56	82	608	364	2660
Southern Transect:													
T7	145	97	215	155	111	99	12	17	89	152	358	249	
T8	46	31	231	49	140	59	72	16	56	64	61	156	
T9	472	314	415	389	193	71	16	19	61	335	80	770	
Transect Total	663	442	861	593	444	229	100	52	206	551	499	1175	5815

TABLE 9.2-3

NUMBER OF INVERTEBRATES COLLECTED BY TRAWL

Location	Month												
	J	J	A	S	O	N	D	J	F	M	A	M	
orthern Transect:													
T1	72	489	217	166	25	30	31	45	127	50	36	36	
T2	88	186	264	85	28	24	18	73	92	129	132	74	
T3	40	409	120	40	28	16	13	28	41	89	79	48	
ransect Total	200	1084	601	291	81	70	62	146	260	268	247	158	3468
entral Transect:													
T4	30	214	108	75	39	28	4	4	20	92	102	20	
T5	47	164	73	25	23	15	25	17	27	26	41	42	
T6	13	99	76	30	29	16	33	22	27	13	22	12	
ransect Total	90	477	257	130	91	59	62	43	74	131	165	74	1653
outhern Transect:													
T7	77	165	248	145	86	137	13	83	249	216	204	45	
[illegible]	40	41	218	56	67	19	56	99	92	69	54	25	
[illegible]	218	238	510	367	130	107	76	234	180	206	104	147	
ransect Total	335	444	976	568	283	263	145	416	521	491	362	217	5021

TABLE 9.2-5

NUMBER AND AVERAGE WIDTH OF CRABS TRAPPED

THROUGH OCTOBER 31, 1983

STATION	BLUE CRAB NUMBER	BLUE CRAB WIDTH (MM)	STONE CRAB NUMBER	STONE CRAB WIDTH (MM)
A1	228	141.6	2	84.5
A2	56	138.9	97	79.7
A3	23	142.3	131	80.7
A4	25	140.2	123	82.2
A5	3	141.7	127	85.6
A6	0	.	92	87.4
B1	147	149.8	115	82.3
B2	28	148.7	115	77.7
B3	14	148.0	144	78.7
B4	15	154.0	223	81.5
B5	4	150.8	240	83.1
B6	0	.	105	81.8
C1	119	137.2	74	78.0
C2	23	146.7	56	77.5
C3	30	151.1	107	79.3
C4	26	148.2	161	80.4
C5	13	150.7	117	79.8
C6	5	147.6	164	83.6
D1	211	153.8	1	70.0
D2	182	146.0	9	82.4
D3	38	145.1	107	78.8
D4	13	160.9	122	80.9
D5	5	163.8	132	80.4
D6	4	148.8	106	80.6

TABLE 9.2-4

NUMBER AND AVERAGE WIDTH OF CRABS TRAPPED

FROM SEPTEMBER 1983 THROUGH JANUARY 2, 1984

	BLUE CRAB		STONE CRAB	
STATION	NUMBER	WIDTH (MM)	NUMBER	WIDTH (MM)
A1	742	142.9	11	79.8
A2	333	144.2	252	80.7
A3	325	148.5	368	80.3
A4	462	149.7	271	82.2
A5	63	153.2	362	82.8
A6	58	149.9	295	84.5
B1	533	146.1	238	81.9
B2	370	149.8	287	79.1
B3	312	147.6	288	79.3
B4	209	149.1	409	81.1
B5	100	147.8	464	81.6
B6	0	.	382	80.6
C1	351	140.5	144	78.3
C2	174	148.3	175	76.5
C3	435	149.4	185	78.3
C4	224	151.3	276	79.7
C5	111	145.5	332	79.4
C6	50	153.2	340	81.3
D1	574	152.8	6	82.7
D2	765	152.5	17	81.1
D3	605	148.2	148	79.2
D4	378	148.3	246	79.9
D5	95	148.2	344	80.1
D6	25	153.3	411	79.7

TABLE 9.2-6

NUMBER AND AVERAGE WIDTH OF CRABS TRAPPED

FROM NOVEMBER 1, 1983 THROUGH JANUARY 2, 1984

STATION	BLUE CRAB NUMBER	BLUE CRAB WIDTH (MM)	STONE CRAB NUMBER	STONE CRAB WIDTH (MM)
A1	514	143.4	9	78.8
A2	277	145.2	155	81.3
A3	302	148.9	237	80.1
A4	437	150.2	148	82.3
A5	60	153.8	235	81.3
A6	58	149.9	203	83.2
B1	386	144.8	123	81.6
B2	342	149.9	172	80.0
B3	298	147.6	144	80.0
B4	194	148.7	186	80.7
B5	96	147.6	224	79.9
B6	0	.	277	80.1
C1	232	142.1	70	78.6
C2	151	148.6	119	76.0
C3	405	149.3	78	76.9
C4	198	151.7	115	78.8
C5	98	144.9	215	79.1
C6	45	153.9	176	79.2
D1	363	152.3	5	85.2
D2	583	154.5	8	79.6
D3	567	148.4	41	80.2
D4	365	147.8	124	79.0
D5	90	147.3	212	79.9
D6	21	154.1	305	79.4

TABLE 9.2-7

NUMBER AND AVERAGE WIDTH OF FEMALE CRABS TRAPPED

THROUGH OCTOBER 31, 1983

STATION	BLUE CRAB NUMBER	BLUE CRAB WIDTH (MM)	STONE CRAB NUMBER	STONE CRAB WIDTH (MM)
A1	105	145.6	1	90.0
A2	31	144.9	4	74.8
A3	16	143.1	18	74.7
A4	13	150.5	21	75.0
A5	2	154.0	12	76.9
A6	0	.	3	75.0
B1	67	159.8	8	78.3
B2	12	161.6	46	73.7
B3	9	156.6	64	77.3
B4	14	154.8	52	74.1
B5	4	150.8	63	77.3
B6	0	.	7	81.4
C1	40	142.8	19	75.5
C2	15	142.7	27	78.1
C3	18	156.4	51	76.5
C4	24	149.5	66	75.9
C5	11	156.1	41	75.4
C6	5	147.6	28	78.2
D1	29	146.3	0	.
D2	86	157.7	2	86.0
D3	23	154.0	73	77.2
D4	8	159.1	61	78.0
D5	4	165.3	61	77.0
D6	4	148.8	46	77.1

TABLE 9.2-8

NUMBER AND AVERAGE WIDTH OF MALE CRABS TRAPPED

THROUGH OCTOBER 31, 1983

STATION	BLUE CRAB NUMBER	BLUE CRAB WIDTH (MM)	STONE CRAB NUMBER	STONE CRAB WIDTH (MM)
A1	107	141.4	1	79.0
A2	23	133.6	93	79.9
A3	7	140.4	113	81.6
A4	11	130.5	102	83.7
A5	1	117.0	115	86.5
A6	0		89	87.8
B1	71	143.5	99	82.6
B2	14	142.7	69	80.4
B3	5	132.6	80	79.8
B4	1	143.0	171	83.8
B5	0		177	85.2
B6	0		98	81.8
C1	58	143.1	52	79.3
C2	8	154.0	26	77.5
C3	11	144.2	45	83.7
C4	2	132.5	77	84.1
C5	2	121.0	63	83.0
C6	0		111	85.0
D1	181	155.3	1	70.0
D2	70	144.7	7	81.4
D3	10	141.6	34	82.2
D4	4	166.8	61	83.8
D5	1	158.0	71	83.2
D6	0		60	83.3

TABLE 9.2-9

NUMBER AND AVERAGE WIDTH OF FEMALE CRABS TRAPPED

FROM NOVEMBER 1, 1983 THROUGH JANUARY 2, 1984

	BLUE CRAB		STONE CRAB	
STATION	NUMBER	WIDTH (MM)	NUMBER	WIDTH (MM)
A1	212	157.6	1	89.0
A2	185	153.8	25	79.7
A3	251	152.4	58	76.8
A4	409	151.0	56	76.9
A5	57	155.5	84	76.1
A6	54	151.4	60	77.1
B1	192	155.8	15	81.9
B2	273	155.4	49	76.2
B3	264	150.3	59	78.2
B4	186	149.7	72	76.8
B5	88	151.0	113	77.7
B6	0		92	76.7
C1	95	151.9	8	79.6
C2	104	152.4	46	74.3
C3	365	151.6	43	75.7
C4	184	153.2	56	76.1
C5	78	149.1	117	77.0
C6	40	157.8	86	75.4
D1	64	162.6	0	
D2	411	160.6	6	77.5
D3	496	151.2	26	81.5
D4	335	149.8	64	75.7
D5	84	148.8	98	75.6
D6	19	155.0	147	78.4

TABLE 9.2-10

NUMBER AND AVERAGE WIDTH OF MALE CRABS TRAPPED

FROM NOVEMBER 1, 1983 THROUGH JANUARY 2, 1984

	BLUE CRAB		STONE CRAB	
STATION	NUMBER	WIDTH (MM)	NUMBER	WIDTH (MM)
A1	228	137.1	8	77.5
A2	49	141.4	130	81.7
A3	30	143.5	179	81.2
A4	20	146.8	92	85.5
A5	1	132.0	151	84.2
A6	1	128.0	143	85.7
B1	149	137.6	108	81.5
B2	33	139.3	123	81.6
B3	17	144.9	85	81.2
B4	4	138.8	101	83.6
B5	3	125.3	111	82.2
B6	0		185	81.8
C1	118	139.7	62	78.5
C2	40	145.0	73	77.0
C3	21	138.2	35	78.3
C4	6	147.2	59	81.4
C5	8	145.5	98	81.7
C6	3	126.0	90	82.9
D1	288	151.3	5	85.2
D2	129	148.1	2	86.0
D3	35	139.8	15	77.9
D4	14	142.7	60	82.6
D5	4	132.3	114	83.6
D6	2	146.0	158	80.4

TABLE 9.2

TOTAL NUMBER OF CRABS RECAPTURED

RECAPTURE LOCATION	RELEASE LOCATION																										
	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D1	D2	D3	D4	D5	D6	E	F	G
01	.	.	2	3	.	.	.	1	1	2	.	.	2	.	7	.	4	.	1	6	2	8	.	1	.	.	.
03	.	.	1	.	.	.	.	.	1	.	.	.	1	.	2	.	.	.	.	.	.	1	.	.	.	.	.
04	.	3	.	1	.	.	.	.	3	1	.	.	.	.	1	2	.	.	.	1	4	6	.	.	.	.	.
05	6	2	6	3	1	3	5	7	5	4	4	.	14	10	43	12	6	2	19	63	86	16	8	3	2	2	.
06	4	1	.	6	.	.	3	6	2	2	1	.	9	6	12	2	4	3	7	48	23	14	1	.	.	3	6
07	.	.	.	1	.	.	.	2	2	.	.	.	1	1	2	.	1	.	1	14	3	1	.	1	.	.	.
08	.	.	.	1	.	.	1	.	.	1	.	.	5	2	5	.	.	.	67	10	.	1	1	.	1	1	1
09	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.
11	14	9	14	25	1	3	27	10	18	18	2	.	6	1	2	4	2	1	3	5	2	5	.	.	1	2	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
13	.	.	1	.	.	.	.	.	1	1	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	1	.	.	1	1	.	.	.	.	1	.	2	.	.	.	.	.	.	.	.	.	.	1
15	.	.	.	.	.	.	2	.	1	.	.	.	.	.	3	1	.	.	.	1	.	.	1	1	.	.	.
16	1	.	6	8	.	2	2	.	1	2	3	.	10	8	2	.	1	.	.	.	.	.	.	.	.	1	.
17	1	1	1	3	.	.	.	.	.	.	1	.	12	11	.	2	2	1	37	5	2	1	1	1	.	.	.
18	.	.	.	.	.	.	.	.	.	1	.	.	21	6	5	4	2	.	8	8	2	3	1	.	.	1	.
19	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
21	3	4	2	6	1	2	.	.	6	1	.	.	.	.	.	.	.	.	.	1	1	.	.	.	2	.	.
22	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
23	3	3	3	8	2	6	11	10	3	.	8	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.
24	13	15	17	33	9	6	37	65	38	42	13	.	3	.	1	.	1	.	.	1	.	.	.	.	4	1	.
25	15	7	16	25	2	3	15	25	18	9	5	.	.	.	2	3	.	.	.	.	1	.	.	.	1	.	.
26	5	9	6	7	.	2	10	4	12	4	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27	27	9	11	20	6	1	37	33	9	2	3	.	.	1	1	2	.	.	1	.	.	1	.	.	3	4	.
28	13	8	2	6	1	.	37	7	.	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	.
29	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.
30	3	.	.	.	.	.	7	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	18	14	25	15	.	1	.	8	11	5	1	.	.	.	2	1	1	.	1	.	.	2	.	.	2	.	.
38	73	26	4	4	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	2	.
39	28	10	1	4	.	1	3	2	2	1	.	.	.	.	.	.	1	.	.	.	2	.	.	.	.	1	.
40	44	12	10	6	1	1	10	6	3	1	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.

TABLE 9.2-12

NUMBER OF FEMALE CRABS RECAPTURED

RECAPTURE LOCATION	RELEASE LOCATION A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D1	D2	D3	D4	D5	D6	E	F	G
01	.	.	1	3	.	.	.	1	1	2	.	.	2	.	7	.	4	.	1	5	2	8	.	1	.	.	.
03	.	.	1	.	.	.	.	.	1	.	.	.	1	.	2	.	.	.	.	.	.	1	.	.	.	.	.
04	.	3	.	1	.	.	.	.	3	1	.	.	.	.	1	2	.	.	.	1	4	5	.	.	.	.	.
05	5	2	6	3	1	3	4	5	5	4	3	.	11	9	40	12	5	2	11	52	78	16	8	2	2	2	.
06	3	1	.	6	.	.	2	6	2	2	1	.	7	6	11	2	4	3	4	39	23	12	1	.	.	1	4
07	.	.	.	1	.	.	.	2	1	.	.	.	.	1	2	.	1	.	.	3	3	1	.	1	.	.	.
08	.	.	.	1	.	.	1	.	.	1	.	.	1	.	4	.	.	.	1	.	.	1	1	.	.	.	.
09	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	14	9	14	25	1	3	24	10	16	18	2	.	5	1	2	4	2	1	.	5	2	5	.	.	1	1	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
13	.	.	1	.	.	.	.	.	1	1	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	1	.	.	1	1	.	.	.	.	1	.	2	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	1	.	1	.	.	.	.	.	3	1	.	.	.	1	.	.	1	1	.	.	.
16	1	.	6	8	.	2	2	.	1	2	3	.	7	7	1	.	.	.	.	.	.	.	.	.	.	1	.
17	1	.	1	3	.	.	.	.	.	.	1	.	6	6	.	2	2	1	3	2	2	1	1	1	.	.	.
18	.	.	.	.	.	.	.	.	.	1	.	.	14	4	5	3	2	.	1	3	2	3	.	.	.	1	.
19	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	3	2	6	1	2	.	.	6	1	.	.	.	.	.	.	.	.	.	1	1	.	.	.	2	.	.
22	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
23	3	3	3	8	2	6	8	10	3	.	8	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.
24	10	12	17	31	9	6	34	56	36	42	13	.	1	.	1	.	1	.	.	1	.	.	.	.	3	1	.
25	12	7	14	25	2	3	11	25	17	9	5	.	.	.	2	3	.	.	.	.	1	.	.	.	1	.	.
26	3	6	6	7	.	2	8	4	12	4	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27	18	8	11	18	6	1	27	30	6	2	3	.	.	.	.	2	.	.	.	.	.	1	.	.	2	2	.
28	7	8	2	6	1	.	8	5	.	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30	1	.	.	.	.	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	12	12	24	12	.	1	.	7	10	4	1	.	.	.	2	1	.	.	1	.	.	1	.	.	2	.	.
38	53	22	2	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	1	.
39	10	8	.	3	.	1	2	2	2	1	.	.	.	.	.	.	1	.	.	.	2	.	.	.	.	.	.
40	18	10	10	6	1	1	8	4	3	1	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.

TABLE 9.2

NUMBER OF MALE CRABS RECAPTURED

RELEASE LOCATION

RECAPTURE LOCATION	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D1	D2	D3	D4	D5	D6	E	F	G
01	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
04	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
05	1	.	.	.	.	.	1	2	.	.	1	.	3	1	3	.	1	.	8	11	8	.	.	1	.	.	.
06	1	.	.	.	.	.	1	.	.	.	.	.	2	.	1	.	.	.	3	9	.	2	.	.	.	2	2
07	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	1	11	.	.	.	.	.	.	.
08	.	.	.	.	.	.	.	.	.	.	.	.	4	2	1	.	.	.	66	10	.	.	.	.	1	1	1
09	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.
11	.	.	.	.	.	.	3	.	2	.	.	.	1	.	.	.	.	.	3	.	.	.	.	.	.	1	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
15	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	3	1	1	.	1	.	.	.	.	.	.	.	.	.	.
17	.	1	.	.	.	.	.	.	.	.	.	.	6	5	.	.	.	.	34	3	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	7	2	.	1	.	.	7	5	.	.	1	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
21	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
22	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24	3	3	.	2	.	.	3	9	2	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	1	.	.
25	3	.	2	.	.	.	4	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
26	2	3	.	.	.	.	2	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27	9	1	.	2	.	.	10	3	3	.	.	.	.	1	1	.	.	.	1	.	.	.	.	.	1	2	.
28	6	.	.	.	.	.	29	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
29	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.
30	2	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	6	2	1	3	.	.	.	1	1	1	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.
38	20	4	2	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
39	18	2	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
40	26	2	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

TABLE 9.2-14

AVERAGE TIME BETWEEN RELEASE AND RECAPTURE IN DAYS

RECAPTURE LOCATION	RELEASE LOCATION A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D1	D2	D3	D4	D5	D6	E	F	G
01	.	.	40	42	.	.	.	40	35	24	.	.	78	.	36	.	43	.	39	40	39	28	.	49	.	.	.
03	.	.	102	.	.	.	.	.	8	.	.	.	45	.	21	.	.	.	.	.	.	16	.	.	.	.	.
04	.	36	.	14	.	.	.	.	14	46	.	.	.	.	4	15	.	.	.	11	6	8	.	.	.	.	.
05	26	63	10	26	69	39	30	16	22	17	50	.	37	24	22	23	27	20	29	25	22	19	30	60	10	18	.
06	45	14	.	46	.	.	26	16	37	23	18	.	54	34	22	20	20	34	46	26	21	28	17	.	.	18	34
07	.	.	.	98	.	.	.	45	58	.	.	.	21	36	32	.	63	.	25	22	24	33	.	16	.	.	.
08	.	.	.	14	.	.	36	.	.	15	.	.	22	8	17	.	.	.	18	24	.	22	7	.	14	5	9
09	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	7	.	.	.	.	.	.	.
11	21	21	19	18	18	20	22	22	17	18	26	.	57	28	33	24	19	26	99	49	40	29	.	.	11	18	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.	.	.	.	.	.	.	.	.
13	.	.	34	.	.	.	.	.	28	28	16	.	.	.	.	28	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	46	.	.	28	14	.	.	.	.	35	.	7	.	.	.	.	.	.	.	.	.	.	24
15	.	.	.	.	.	.	16	.	14	.	.	.	.	.	7	7	.	.	.	64	.	.	6	6	.	.	.
16	111	.	89	87	.	84	131	.	92	84	74	.	18	7	25	.	79	.	.	.	.	.	.	.	.	89	.
17	5	52	52	52	.	.	.	.	.	.	48	.	26	15	.	53	47	47	50	49	52	52	83	47	.	.	.
18	.	.	.	.	.	.	.	.	.	81	.	.	24	48	67	49	78	.	48	38	63	46	6	.	.	105	.
19	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13	.	.	.	.	.	.	.
21	30	45	27	47	54	42	.	.	19	23	.	.	.	.	.	.	.	.	.	103	41	.	.	.	22	.	.
22	.	.	101	.	.	.	.	.	.	.	.	.	140	.	.	.	.	.	.	.	.	.	.	.	.	.	.
23	55	13	54	32	6	30	10	19	16	.	11	.	.	.	.	8	.	.	.	.	.	.	9	.	.	.	.
24	29	27	25	27	17	34	15	11	17	26	21	.	23	.	11	.	9	.	.	63	.	.	.	.	39	24	.
25	22	10	27	25	3	17	28	17	12	14	17	.	.	.	32	49	.	.	.	.	4	.	.	.	25	.	.
26	21	18	24	21	.	17	31	13	9	14	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27	23	36	37	21	12	20	22	15	41	32	24	.	.	92	58	40	.	.	71	.	.	28	.	.	26	44	.
28	46	69	25	60	149	.	69	49	.	128	128	.	.	51	.	.	.	.	.	.	.	.	.	.	203	.	.
29	64	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	80	24	.
30	8	.	.	.	.	.	13	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	19	27	25	31	.	24	.	30	22	26	24	.	.	.	43	82	36	.	107	.	.	44	.	.	11	.	.
38	17	10	15	16	10	.	12	.	.	.	.	.	.	.	.	.	.	.	.	15	.	.	.	.	27	19	.
39	20	25	104	4	.	23	31	20	6	19	.	.	.	.	.	.	3	.	.	.	6	.	.	.	.	12	.
40	25	33	37	66	25	92	24	16	13	36	.	.	.	.	.	.	.	.	119	59	.	.	.	.	.	.	.

TABLE S[illegible]15

TOTAL NUMBER OF CRABS RECAPTURED

RELEASE LOCATION

RECAPTURE LOCATION	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D1	D2	D3	D4	D5	D6	E	F	G
SOUTH CRYSTAL BAY	5	1	1	1	.	.	8	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.
CRYSTAL BAY	274	133	130	188	27	31	208	188	138	98	51	.	85	48	90	37	26	7	148	167	128	59	14	7	20	19	8
WACCASASSA BAY	16	14	21	38	9	7	25	37	37	21	14	.	21	40	85	45	21	17	37	133	136	104	31	10	7	11	16
SUWANEE SOUND	1	1	2	4	1	.	.	.	2	1	.	.	.	1	8	1	.	1	1	15	12	7	2	.	.	2	1
HORSESHOE COVE	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	1	.	.	.	.	.	1
DEADMAN BAY	.	.	.	.	1	.	.	1	1	.	.	.	1	.	2	1	.	.	1	3	6	1	2	.	.	2	.
FENHOLLOWAY RIVER AREA	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	4	3	.	.	.	1	1
APALACHEE BAY	2	1	1	7	.	.	1	1	5	1	.	.	3	1	9	7	4	3	.	8	7	7	5	.	4	.	3
DOG SOUND	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	1	2	1	.	.	.	.	.
APALACHICOLA RIVER AREA	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
WEST OF CAPE SAN BLAS	.	.	.	1	.	.	.	1	.	1	.	.	.	.	1	.	.	.	.	3	1	.	.	.	.	.	.

TABLE 9.2-16

AVERAGE TIME BETWEEN RELEASE AND RECAPTURE IN DAYS

RECAPTURE LOCATION	RELEASE LOCATION A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D1	D2	D3	D4	D5	D6	E	F	G
SOUTH CRYSTAL BAY	134	150	157	177	.	.	148	.	.	.	.	.	.	.	.	.	.	.	.	157	.	.	.	.	.	15	.
CRYSTAL BAY	24	26	31	31	23	34	31	17	19	26	26	.	34	25	26	30	35	31	34	28	23	25	26	42	38	32	30
WACCASASSA BAY	33	57	43	58	45	55	54	46	45	35	30	.	59	52	47	52	76	40	38	49	44	39	67	28	82	46	81
SUWANEE SOUND	22	18	70	60	78	.	.	.	69	40	.	.	.	121	82	81	.	63	70	54	87	71	69	.	.	82	27
HORSESHOE COVE	.	.	125	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	31	100	93	.	.	.	.	.	59
DEADMAN BAY	.	.	.	.	96	.	.	104	107	.	.	.	158	.	68	101	.	.	83	60	83	79	80	.	.	70	.
FENHOLLOWAY RIVER AREA	.	.	.	.	.	.	.	.	.	.	.	.	.	.	119	.	.	.	.	78	101	61	.	.	.	115	73
APALACHEE BAY	100	181	147	175	.	.	102	131	109	108	.	.	133	133	116	118	125	98	.	138	142	105	84	.	173	.	79
DOG SOUND	.	.	.	.	.	.	126	103	.	.	.	.	.	.	.	.	.	.	.	108	123	100	.	.	.	.	.
APALACHICOLA RIVER AREA	.	.	.	189	.	.	.	.	.	187	.	.	.	.	.	.	.	.	.	181	198	.	.	.	.	.	.
WEST OF CAPE SAN BLAS	.	.	.	141	.	.	.	130	.	108	.	.	.	.	180	.	.	.	.	147	135	.	.	.	.	.	.

TABLE 9.2-17

NUMBERS OF SIO IN THERMAL AND CONTROL AREAS

Species	Male		Female	
	Thermal	Control	Thermal	Control
Bay anchovy	45	34	142	83
Polka-dot batfish	1	14	15	26
Pigfish	30	141	36	220
Pinfish	124	253	100	262
Silver perch	98	105	217	115
Spotted seatrout	6	4	5	4
Spot	239	69	213	61
Red drum		1	1	
Striped mullet	20	1	34	8
Pink shrimp	339	284	369	276
Blue crab	85	37	132	89
Stone crab		9	2	5

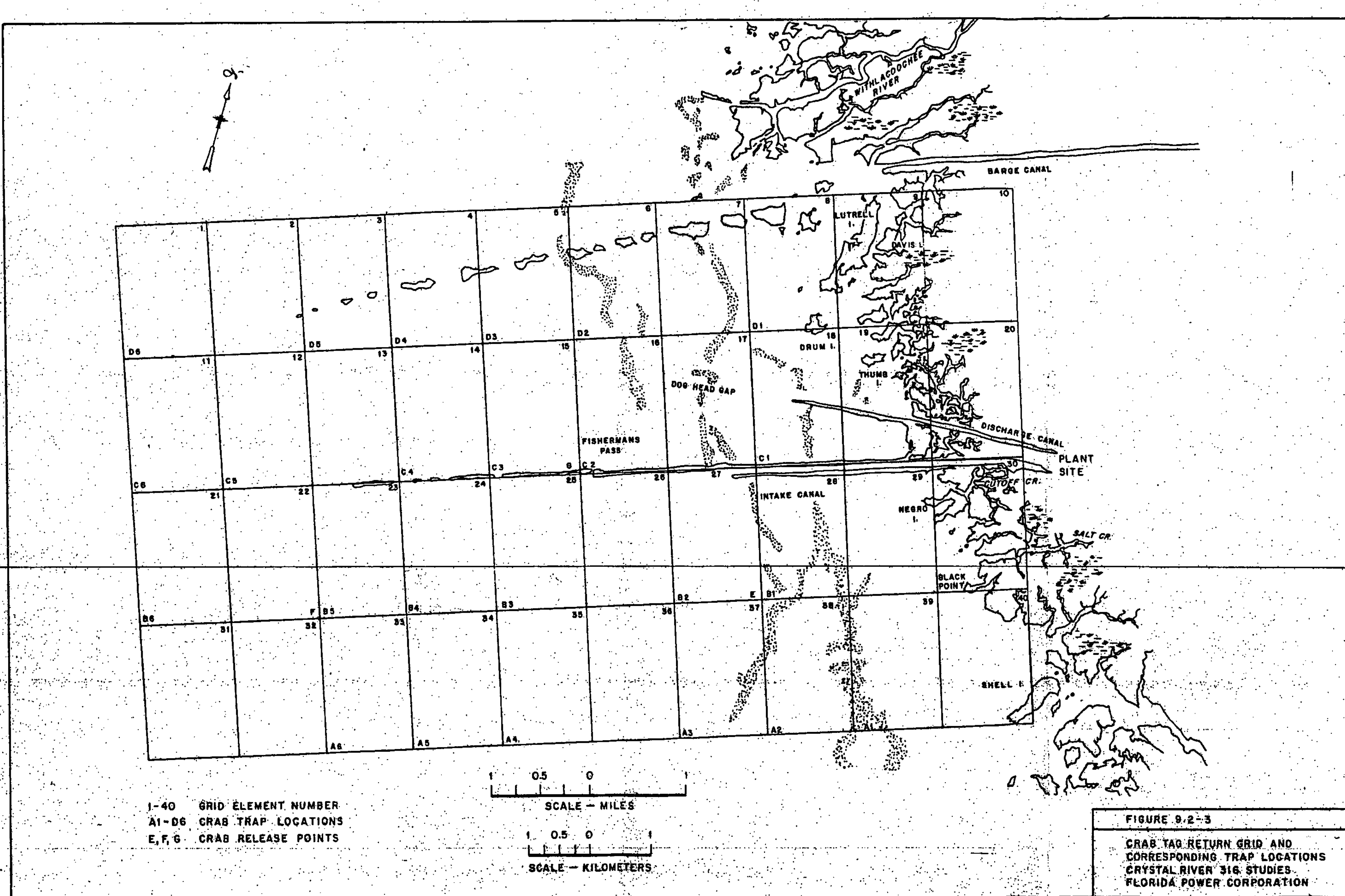
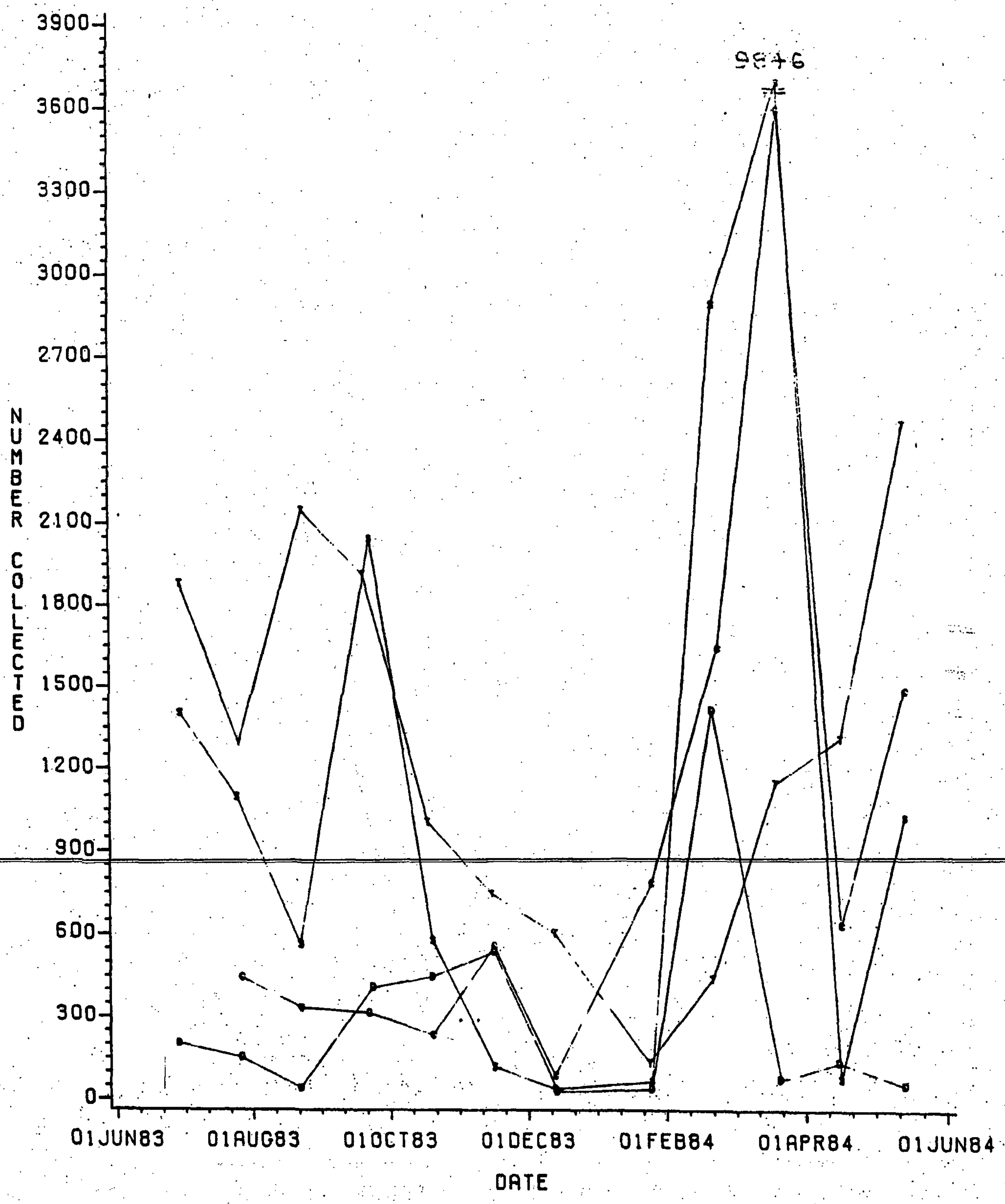


FIGURE 9.2-3

CRAB TAG RETURN GRID AND CORRESPONDING TRAP LOCATIONS CRYSTAL RIVER 316 STUDIES FLORIDA POWER CORPORATION



T=TRAWL
C=CREEK TRAWL
S=SEINE
D=DROP NET

FIGURE 9.2-1
NUMBER OF FISH COLLECTED
EACH MONTH BY GEAR TYPE
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

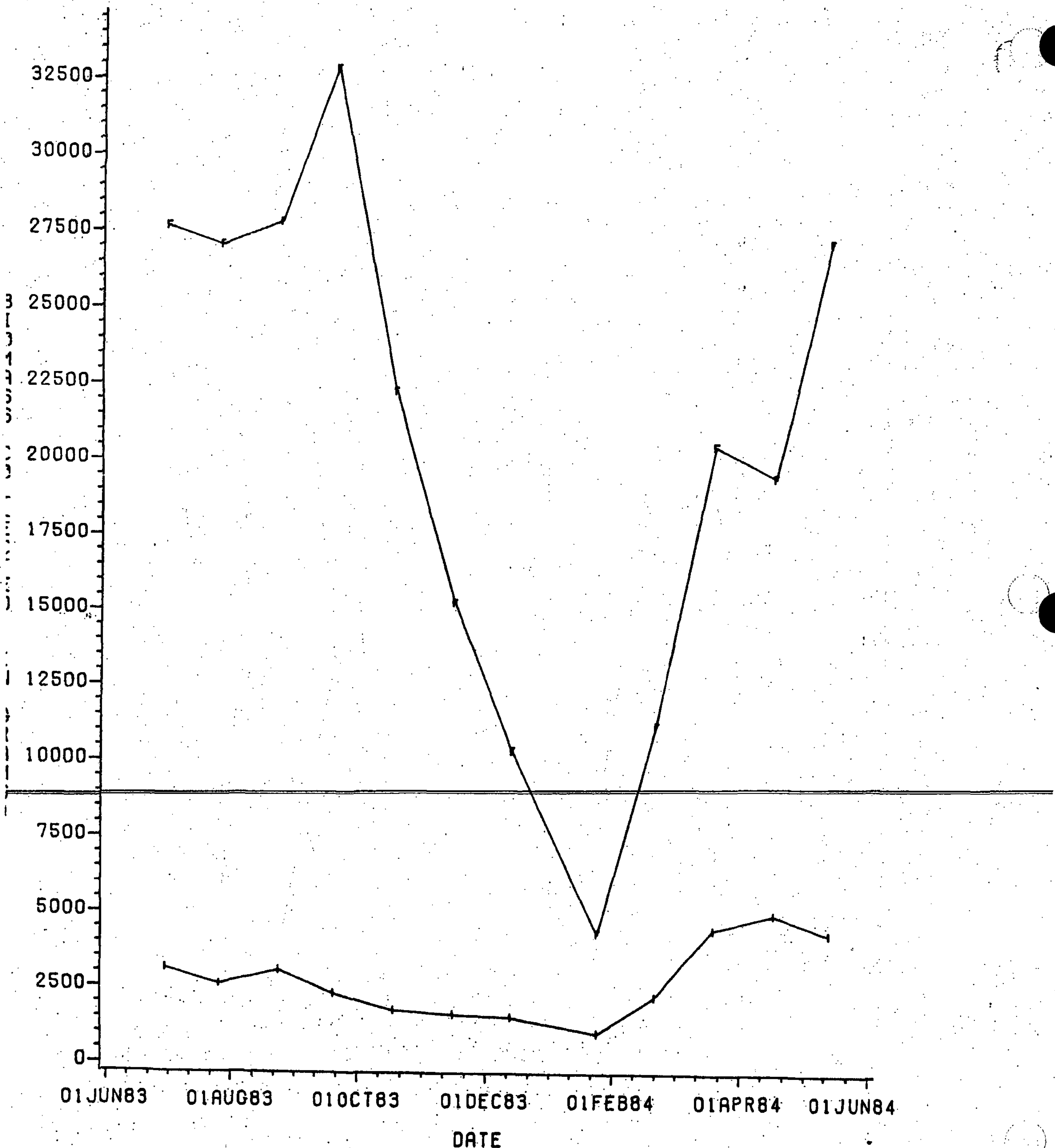


FIGURE 9.2-2
FISH AND INVERTEBRATE
TRAWL BIOMASS
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

9.3 IMPACT ASSESSMENT

The fish and invertebrate populations sampled by fisheries gear are subject to direct impacts of station operation in the form of impingement and entrainment. These subjects have been dealt with previously in Sections 7.3 and 8.3. Indirect effects associated with the thermal discharge and the intake spoil will be discussed in this section.

9.3.1 Thermal Discharge

The fisheries' samples contain juveniles and adults of species which either inhabit Crystal Bay all year or migrate to and from the area. Both short-distance, onshore-offshore movements and wider ranging migrations occur. Given the ability of these species to move and the continuing operation of Units 1, 2, and 3 over several years, the sampling results are indicative of established patterns of movement and other activities in response to the local environment. Comparisons of SIO distributions sampled in the area of the thermal discharge to their distribution in areas unaffected by the discharge can provide an indication of the ability of each species to adapt to the conditions of the discharge. Additional information can be gained by considering thermal-control differences in disease or parasitism, age, sex ratio, reproductive condition, and the weight-length relationship.

The interpretation of sampling results is limited by two key factors: 1) the relatively low numbers of several of the SIO in all or some of the sampling gear and 2) the complex nature of Crystal Bay which confounds possible thermal effects with other environmental parameters. The low numbers of some species, such as red drum or squid preclude statements on effects of the thermal discharge. Higher but limited numbers of species like batfish or striped mullet force reliance on trends in the existing data and limit the value of conclusions.

Habitat differences within Crystal Bay complicate interpretation of results by providing other factors to which the SIO respond and modify their distributions. Freshwater inflows from Crystal River to the southeast and the Withlacoochee River to the northeast appear, based on water quality data, to create strong localized influences and broader areas of steep salinity gradients. Such gradients could be a stronger influence on distribution than the plant discharge. Squid, for example, have been reported to migrate in response to temperature and salinity (Laughlin and Livingston 1982). Another important factor may be the presence or absence of attached submerged vegetation which can provide cover and food. While the absence or limited amount of vegetation in the present discharge area could have been directly influenced by the plant discharge (see Section 6.3), its present distribution has a secondary influence on fish and inverterate species which seek out such areas. Such species in Crystal Bay would be found offshore of the thermal discharge, assuming depth is not a controlling factor, or south of the intake where attached vegetation is widely distributed over all depths. A variety of other factors such as depth, substrate type, use of deeper channels for onshore-offshore movement or exposure of shallow areas at low tide could also influence a given species' distribution.

Each SIO for which fisheries information are available to address thermal discharge effects will be considered separately. Overall distribution of fish and invertebrates in Crystal Bay has been noted in Section 9.2 and will not be addressed further, since the SIO are considered representative and individual species preferences and avoidances are the ultimate influence on total species distribution.

Evidence, primarily from seine and drop net collections, indicate that bay anchovy occur primarily in the thermal area, potentiallly experiencing ΔT's of 4-7°C. Summer conditions did not eliminate the species from the discharge area. Females occurred in relatively higher abundance in the discharge area. Gravid females were found inshore in the spring and were in both thermal and control areas. Young-of-the-year, both immature and mature, were more common in the thermal area, except in the spring. Of specimens analyzed, those in the thermal area did not weigh as much at the same length as specimens in the control area. Overall, bay anchovy appear to prefer the thermal area and may grow (length) faster there than elsewhere.

Batfish were rare offshore but more were found north or south of the discharge area than in the thermal area. The ratio of females to males was higher in the thermal area and immature specimens were most common in the control area. Parasitism occurred in all specimens. Preference for or avoidance of the thermal area is not clearly indicated.

Data on pigfish distribution comes primarily from trawl collections in which larger numbers were taken in the spring and summer at the southern stations. At other times, a more uniform distribution existed. Females, including gravid ones, predominated at stations to the south. Older specimens, young-of-the-year, immature and mature individuals were more common to the south. Smaller specimens occurred in the thermal area but their weights by length were higher than in control areas in all seasons except spring. Thus, pigfish appear to avoid the thermal area in the spring and summer. Reproduction at the site probably occurs to the south and is not limited by the discharge. At other times of the year, pigfish do utilize the discharge area.

Pinfish are similar in distribution to pigfish. In trawls they were most common to the south and at T1 and T2 in the spring and summer. Numbers were higher inshore on the north and central transects and offshore to the south. In seines, lowest numbers were at the thermal stations. In the drop net, numbers at D2 were generally higher than in the thermal area; the exception was in February. In the creek trawls, highest numbers occurred in February through May at TC2; these were primarily small fish. Young-of-the-year, 1 year old, immature and mature fish were all more abundant in the control areas. Based on weight-length analyses, growth occurs most rapidly in summer and fall when fish are concentrated to the south, with samller numbers at T1 and T2. Pinfish generally tend to avoid the thermal area where ΔT's are in excess of about 2°C, but small specimens appear to utilize the creek habitat adjacent to the thermal area in the spring.

Silver perch were collected in largest numbers by trawl inshore to the north and south. These were generally smaller specimens. Few were collected in other gear except in May at TC1. Both mature and immature fish were most common in the thermal area (T1, T2). Females were more common than males in the thermal area, they were smaller than males, and grew more rapidly in the thermal area. The latter was not the case, however, over the entire study area. Gravid females were primarily at T1 and T4 in the spring. Young-of-the-year were most abundant in the thermal area. Generally, the species utilizes inshore areas to the north and south. The fish avoid the higher temperature areas of the discharge but utilize areas subject to 2-$3^{\circ}C$ ΔT. This appears to be particularly true for activities relating to reproduction.

Trawl collections provided the greatest number of spotted seatrout and the fish were primarily to the north (May at T1-3 and T5). All seatrout taken by drop net were in the discharge area (June, July, May). The few specimens taken by creek trawl were from TC1 or TC2. Immature seatrout were more common in the thermal area; of the mature specimens, males predominated in the thermal area. Overall, the species occurs primarily at the northern end of Crystal Bay. It is not excluded from the thermal area, but like the silver perch, the fish appear to utilize only the lower ΔT areas of discharge.

Spot were relatively common in all four gear types. The pattern of distribution from all gears is similar to that indicated for spotted seatrout and silver perch. Numbers were highest to the north and in the center of Crystal Bay and lower to the south. Smaller fish were inshore (T1) and the largest were offshore (T3). The analysis of immature fish indicated more in the thermal area. Growth (W-L) was lower in thermal than control areas in summer, fall, and winter. Thus, this species also appears to be using outer portions of the discharge area. Based on drop net collections, it may also be using higher T sections in early spring.

Data for red drum do not support any conclusions concerning thermal discharge impacts. Data on striped mullet is also limited and suggest only that the species may be more common in the northern section of Crystal Bay.

Pink shrimp data indicate a wide distribution in Crystal Bay with the location of peak numbers changing over time. Numbers at thermal trawl stations, even in the summer, do not indicate avoidance of this area. However, August drop net collections which sampled higher temperature water did not contain shrimp and more shrimp were generally collected at D2. This probably indicates avoidance of the warmest discharge temperatures. Creek trawls collected most shrimp at TC1 and TC2 indicating utilization of creeks adjacent to the discharge area.

Few blue crabs were taken by trawl or seine, but trawl, drop net and creek trawl collections, like the crab trapping, indicated peak abundance inshore. Numbers at the thermal drop net station were higher in the winter but lower in the summer than at the southern station. Comparisons of crab trap data indicate some reduction in numbers at thermally affected stations on Transect C. This was more apparent in September-October than in November-December. Thus, blue crabs appear to avoid the warmer parts of the discharge area, particularly during the summer, but they are not excluded from the discharge area and the population is probably not adversely affected.

Stone crabs were rarely taken in fisheries gear other than crab traps. Data from the traps indicate an offshore distribution which limits any thermal discharge effects. Comparison of inshore numbers by transect showed fewer stone crabs inshore on the northern transect and more inshore on the two southern transects. Numbers on Transect C, however, suggest that some factor other than the thermal discharge may be affecting the stone crab distribution, particularly on Transect D.

Brief squid were collected only in the trawls in low numbers. The numbers, distribution, and occurrence by month do not support conclusions on thermal discharge effects.

9.3.2 Intake Spoil

Questions have been raised concerning the effect of the intake spoil at Crystal River on longshore migration of female blue crabs. The present study was designed to address local and longer distance movements of the crabs and to consider adverse impacts associated with the presence of the spoil. The excellent return rate of tagged crabs should permit answers to these questions.

Local crab movements, as determined from tag returns from commercial crabbers, is strongly influenced by the location of crabbers' traps. Oesterling (1976) noted, and it is still the case, that traps are most concentrated along the southern side of the intake spoil and on the southern side of spoil islands bordering the CFBC. This results in: 1) large numbers of recaptures being reported in these locations and 2) a potential reduction in time to recapture from certain release points where crabs quickly encounter and are captured in the high density of fishermen's traps. The former did occur but the latter was not particularly evident.

The patterns of recaptures in Crystal Bay indicates a general west and north movement from the release points. This is most evident from releases on Transects A and C. Releases on Transect B are often recaptured to the west along the same transect. Releases from Transect B are often recaptured to the west along the same transect. Releases from Transect B were also common in grid element 11 (Figure 9.2-1), which is farthest offshore, and along Transect D. A similar pattern occurs for releases from Transect A. Thus, it appears that crabs to the south of the spoil move offshore and around the spoil. Subsequent movement is then north and northeast.

The pattern of movement noted indicates that the intake spoil does represent a structure to be bypassed and the original capture and recapture data indicate that the spoil could influence the number of crabs occurring in the area of Transect C and perhaps D. However, if crabs in the area of Transect A are considered representative of longshore migrants, data on time to recapture after release on Transect A show that the time to recapture on Transect C is about 6 days more than for recapture on Trasect B. At the same time, recapture on Transect B takes about 6 days more than recapture on Transect A. Based on distance between transects, it is clear that some delay is taking place, on the order of 2.5 days, but the delay is relatively short. In addition, movement is taking place past the intake spoil in spite of the concentration of traps.

Longer distance migrations are represented in recaptures of Crystal Bay releases north of Crystal Bay. About 33 percent of the recaptures by crabbers took place north of Crystal Bay indicating significant movement from the area. Larger numbers of recaptures resulted from the release at Transects A and B than from Transects C and D. In addition, as noted in Section 9.2, recaptures in Waccasassa Bay occurred more quickly from Transect B than from any other transect and more quickly from Transect A than from Transect C. Therefore, it can be concluded that the intake dike is little if any obstacle to movement to the north beyond Crystal Bay. It is also suggested that the local movements which result in blue crabs moving out and around the intake spoil may result in migration further offshore and perhaps more directly to areas north than the route available to crabs north of the intake spoil but still south of the CFBC spoil islands.

REFERENCE FOR 9.3

Laughlin, R. Q. and R. J. Livingston. 1982. Environmental and Trophic determinants of the spatial/temporal distribution of the brief squid (Lolliguncula brevis) in the Apalachicola estuary (North Florida, USA). Bull. Mar. Sci. 32(2): 489-497 pp.

Oesterling, M. 1976. Population structure, dynamics, and movement of the blue crab (Callinectes sapidus Rathbun) at Crystal River, Florida. Thesis, Univ. of Florida. 88 p.

10.0 PHYSICAL STUDIES

The physical studies conducted in Crystal Bay were primarily associated with data collection for and implementation of hydrodynamic and hydrothermal models. The models were specifically designed to characterize hydrodynamic conditions within the study area, and using that data, to simulate the thermal discharge resulting from operation of Crystal River Units 1, 2 and 3. The following sections detail field collection methods; describe results or define the means by which the results are incorporated into the modeling; describe the models, their calibration and verification; and discuss the simulation results. A source water body analysis, performed using results from the entrainment analyses (Section 8.0) as input to CAFE-1 and DISPER-1, is also discussed.

10.1 FIELD COLLECTION

10.1.1 Thermographs

This effort was designed to provide comprehensive, synoptic thermal data at a series of stations throughout the study area. Thermographs were deployed at 51 stations (Figure 10.1-1) to measure near-surface water temperatures. At 21 of these stations, thermographs also were deployed to measure subsurface temperature for detection of stratification.

Ryan Model J-90 (10-40°C) thermographs were deployed as shown in Figure 10.1-2. Charts were retrieved on a monthly basis, returned to the laboratory and copied to produce an archival record. They were then sent to Envirodata Corporation where each chart was digitized using a Bendix Datagrid system. The data were reduced to hourly averages with each hourly average calculated from a minimum of ten points per hour. After inspection and validation, tables of hourly average data by station and date were produced. These tables were then reviewed by SWEC and minor editing took place to remove outliers. These were related primarily to the first few hours of unit operation or to units recording values below any other values found throughout the study area. The edited dataset was then used to generate tables of hourly average values, tables of weekly averages, figures of chart replots, figures of daily averages and temperature ranges, and a computer tape.

10.1.2 Meteorological Station

Meteorological data were collected at the site. The parameters measured include: incident solar radiation flux, air temperature, wind speed and direction, relative humidity, barometric pressure, and rainfall. The meteorological station began operation the week of June 4, 1983, and it was removed from service the week of September 2, 1984.

A Weathertronics Automatic Weather Station was installed according to National Weather Service specifications. Basic components included: wind vane, wind anemometer, pyranometer with radiation shield, mast with crossarm, thermistor, rain gauge, barometric sensor, humidity probe, data acquisition system with tape recorder and printer, and a power system (battery, charger, lightning arrestor). The system was calibrated by the manufacturer and programmed according to the manufactuer's specifications. Hourly and instantaneous observations (daily checks performed by the operator) were automatically recorded on data-quality cassette tapes along with 24-hr summaries. The tapes were changed approximately every 6 weeks. A Weathertronics Cassette/Module Reader was used to transfer the analog-recorded data to ASCII text files from which 9-track computer tapes were generated. The 9-track tapes were then used for analysis.

Data from FPC's meteorological tower were used to supplement records from the on site station for August 1983.

10.1.3 Bathymetry

Three bathymetric mapping projects were carried out in support of the hydrodynamic modeling efforts:

- o general bathymetric mapping of the study area
- o intensive near-field mapping of the discharge area
- o major tributary and channel cross-sections

Twenty-one transects were surveyed running perpendicular to the shoreline using a Raytheon 719B fathometer, Autotrack Depth Digitizer, and a Motorola Mini Ranger for positioning. Digitized depth printouts and chart recordings were produced. Staff gauge readings for tide heights were recorded regularly throughout the conduct of the surveys. In Basin 1, an additional seven north-south transects were surveyed using a Sitex-Honda HE-356 recording fathometer with an adjustable transducer mounted on a 16 ft Jon Boat.

The Withlacoochee River, Cross Florida Barge Canal, discharge and intake canals, and Crystal River were traversed and surveyed adjacent to Stations 8-12 (Figure 10.1-3) using the equipment described for the Basin 1 mapping.

The digitized bathymetric data were plotted on a map of the general study area showing transect locations and recorded depths along each transect. The chart recordings of Basin 1 were tabulated at 20 ft intervals except for Transect 12 which was at 40 ft intervals and plotted on a map of the discharge basin. The chart recordings of the channel cross-sections were tabulated at 20 ft intervals, but were not plotted.

10.1.4 Short-Term Physical Studies

10.1.4.1 In Situ Currents and Tides

This task was designed to provide current and tide data for calibration and verification of mathematical models for the site. Two 1-month periods (August 1983 and January 1984) were comprehensively and synoptically sampled by the deployment of in situ instruments at 16 locations (Figure 10.1-3). Sea Data Model TDR tide gauges and Endeco Model 174 current meters were deployed in paired arrays (Figure 10.1-4). The stations were revisited weekly to verify presence and operation of the current meters (via an acoustic link). The tide gauges were serviced (battery and tape change) at 2 week intervals. The current meters were capable of continuous operation for the 1 month period but were visually inspected during the tide gauge servicing.

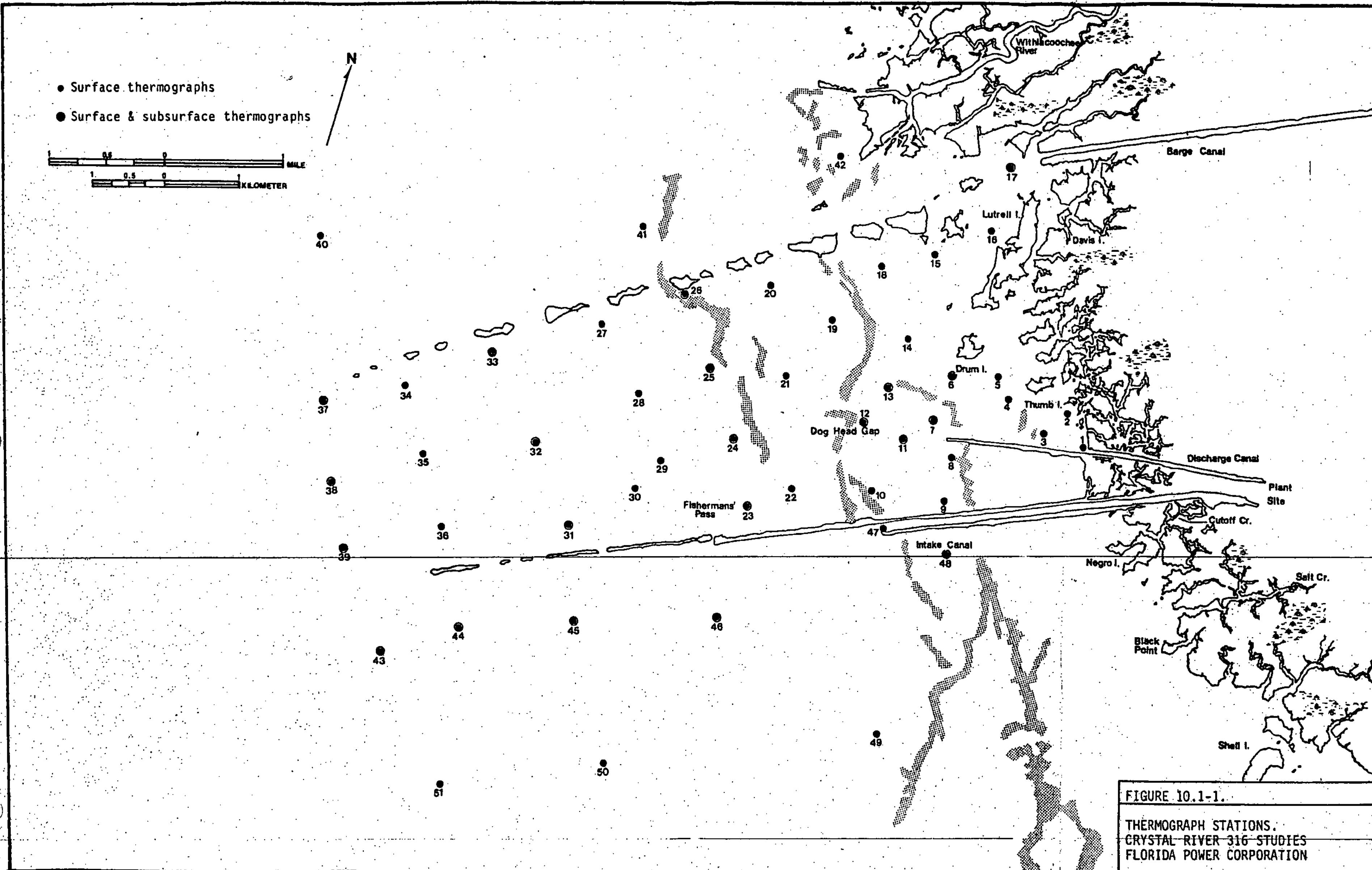


FIGURE 10.1-1.

THERMOGRAPH STATIONS.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

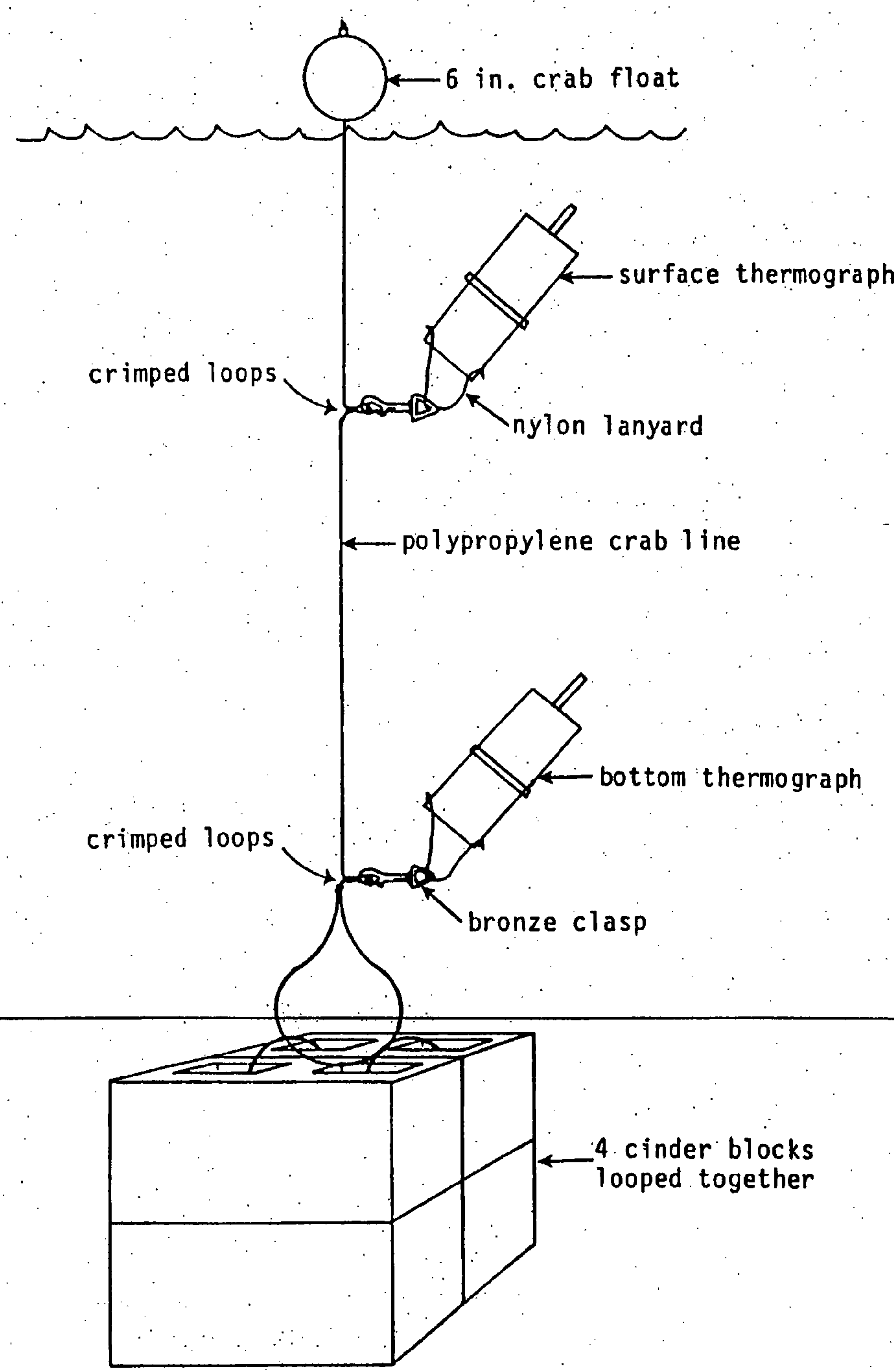


FIGURE 10.1-2.

THERMOGRAPH ARRAY.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

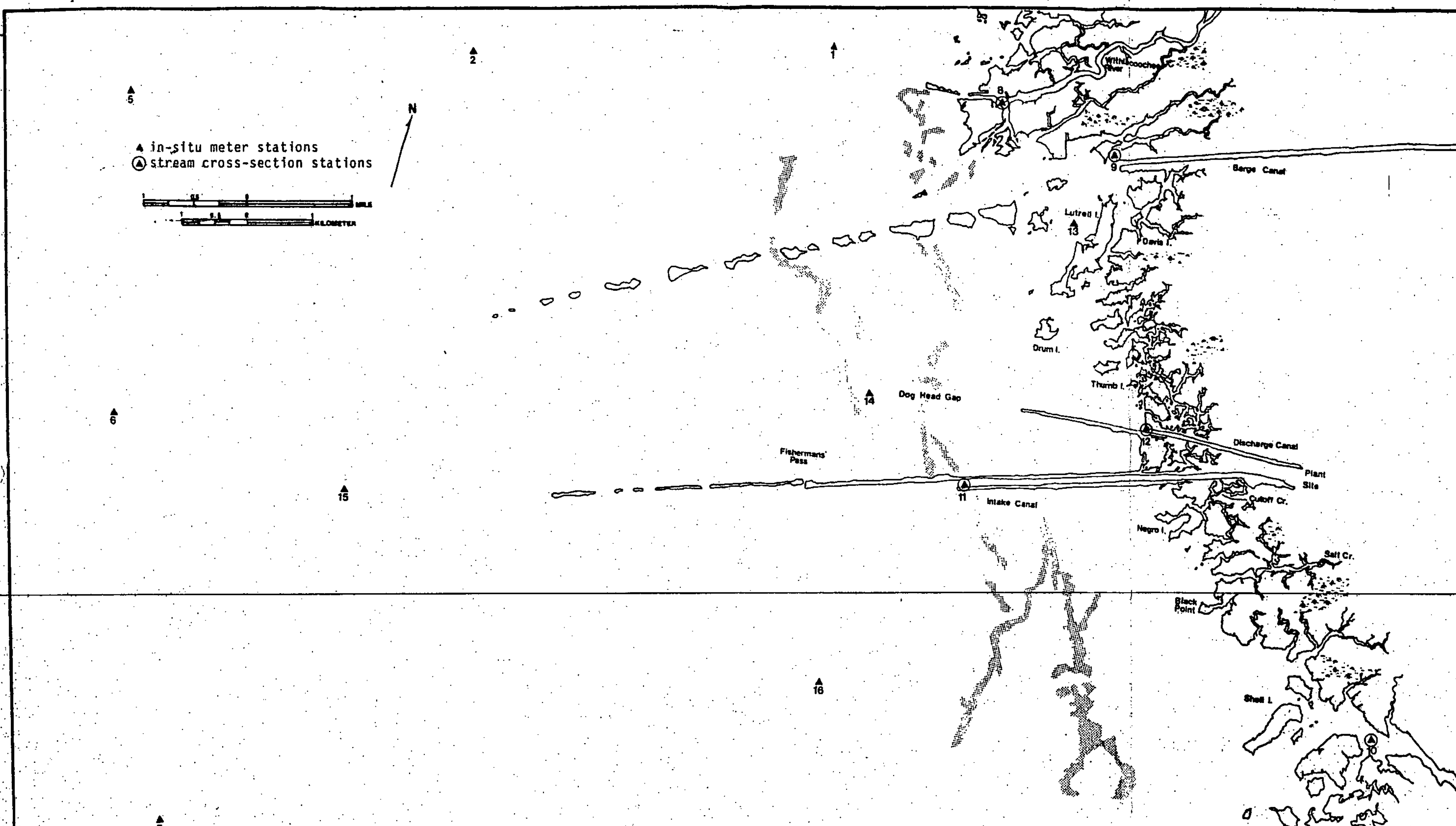


FIGURE 10.1-3.

IN SITU METER STATIONS.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

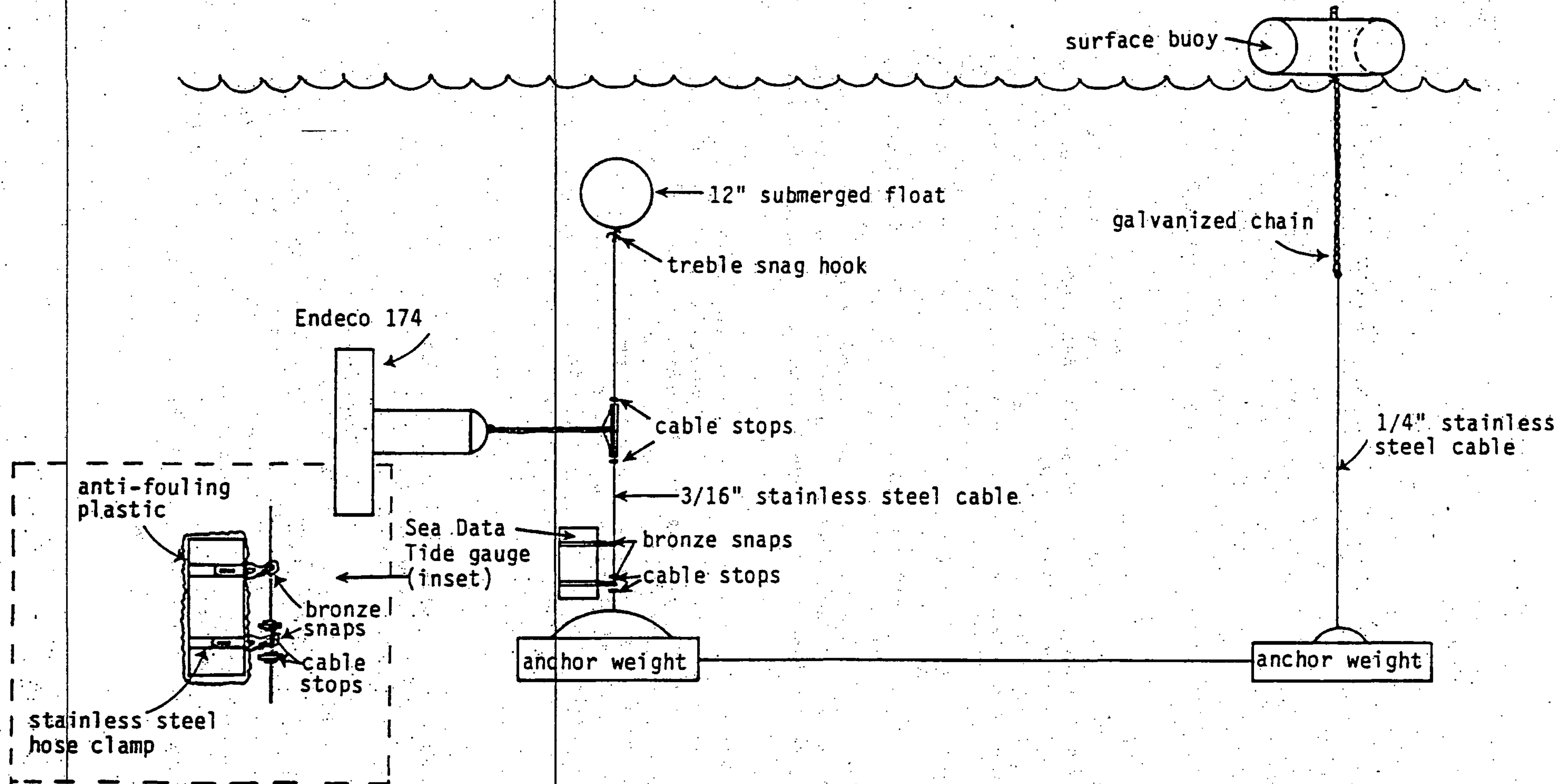


FIGURE 10.1-4.

IN SITU METER ARRAY.
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

10.2 RESULTS OF FIELD COLLECTIONS

10.2.1 Thermographs

Thermograph data were collected to provide a long-term, continuous record of temperatures throughout the study area. While the data are available for comparison with data from any other study component, other means of measuring temperature were used to provide values for needed correlations with biological and water quality data. Therefore, data from the thermograph units serve primarily as a supplement to thermal plume delineation data and as a data base which can be used to examine short-term phenomena not measurable by sampling which is not continuous.

Over the sampling period, data are reported for about 87 percent of the potential parameter days, although monthly returns vary from 71.2 to 95.3 percent. Tables of hourly average thermograph data were presented in the Fifth Quarterly Progress Report (SWEC 1984d). Tables summarizing the weekly range of values and mean temperature for each station are provided in Appendix VIII. The Appendix also includes two sets of figures for Stations 1, 3, 12S, 12B, 29, and 38S. These stations approximate a transect beginning at the POD and extending offshore and provide a sample of the data collected in the discharge area, in an area intermittantly affected by the thermal discharge and in a relatively unaffected distant area. Data for Station 12 provide an indication of surface to bottom variation. August and January were chosen because these months coincide with the period of other in situ data collection. The figures show data collected in August 1983 and January 1984 in terms of: 1) chart replots in a calendar format and 2) graphs of daily temperature ranges and means.

The amount of data available cannot be readily summarized; however, the tables of hourly averages are particularly suited for identifying thermally affected areas, defining concurrent temperatures in other parts of the study area and recording tidal and diurnal variation. After reviewing several days' data, a sense can be gained of stations regularly affected by the station discharge. A precise delineation of the discharge area, however, is improbable because of the considerable variation seen over time, particularly at "fringe" stations which are affected by the discharge only under certain conditions.

Several cautions relative to interpretation of the thermograph data are appropriate:

a) Crystal Bay is a complex site with several features which affect data from specific stations. Certain stations, e.g., Station 2, are dry on a low tide, and the unit then may read air temperature (at night), a sun-induced, higher temperature (during the day) or some intermediate value. Other units located at very shallow stations, e.g., Station 3 or 5, may be subject to solar heating around mid-day or may float with the probe partially exposed at low tide when extra play occurs in the buoy line. Two stations (42 and 48) frequently yield results which may result from freshwater inflows near the stations. Such station-specific variation requires care in interpreting station-to-station differences.

cross-sectional profiles in the discharge channel were used in the application of the near-field model.

10.2.4 Short-Term Physical Studies

10.2.4.1 In Situ Currents and Tides

In situ current meter and tide data collected in the field were processed and analyzed in order to prepare the data for use in the far-field models, CAFE-1 and DISPER-1. Data files in the form of time series were produced. All records that did not contain data values were removed, the data were confirmed to be in proper order with no blocks missing, and the contents of each block were confirmed to be complete. Where data were missing, a data missing code was inserted.

Time-average data files with one entry for each 30-minute interval were then developed. Values which showed a large departure from the majority of values collected during any one interval were identified. If a sufficient number of values remained (neither disqualified nor recorded as missing), the arithmetic mean was determined. Otherwise a data missing code was entered for that 30-minute interval. The data files then were plotted, and any outliers which had not been eliminated by the program procedure were manually replaced with the data missing code.

A final program prepares a summary of both the processed current meter data and the processed tide gauge data. All unit conversions occur here. Conductivity is converted to salinity with the appropriate temperature correction. Tide pressure is converted to tide height with salinity and barometric pressure incorporated into the calculation.

Hard copy output of the summary data files were prepared for all 16 stations for the purpose of far-field modeling. Many of the files were also plotted as an aid to studying the results. Plots of tide and current data used in model calibration and verification are shown in Figures 10.2-1 through 10.2-14. A sufficient number of key stations produced usable data in order to successfully complete the calibration and verification of the far-field models, as described in Section 10.4.

10.2.4.2 Vertical Current Profiles

Current profiling data were obtained at each of the in situ current measurement stations as described in Section 10.1.4. For stations that were not located in channels, currents were measured from top to bottom in order to obtain vertical information on the current structure in the vicinity of each station. The intent of these measurements was to determine vertically averaged velocity values that could be compared to the point measurements from the in situ meters. A ratio of speed values and a correction factor for direction were determined from each pair of velocity values. These were used to develop an average speed ratio and an average direction correction factor for each station. These correction factors were then used to adjust in situ values to provide vertically averaged velocities at each station. The adjusted velocities and the corresponding depths at boundary stations were then used to develop boundary flux data as discussed in Section 10.4. A typical set of data is shown on Table 10.2-2. Measurements were not used in

REFERENCES FOR 10.2

Carder, K. L., S. L. Palmer, B. A. Rodgers, and P. J. Behrens, 1976. Calibration of a Thermal Enrichment Model for Shallow, Barricaded Estuaries. Final Report to Office of Water Research and Technology, Dept. of the Interior. September 1976.

SWEC. 1984a. Second Quarterly Progress Report. Crystal River Studies. Report to FPC, January 1984.

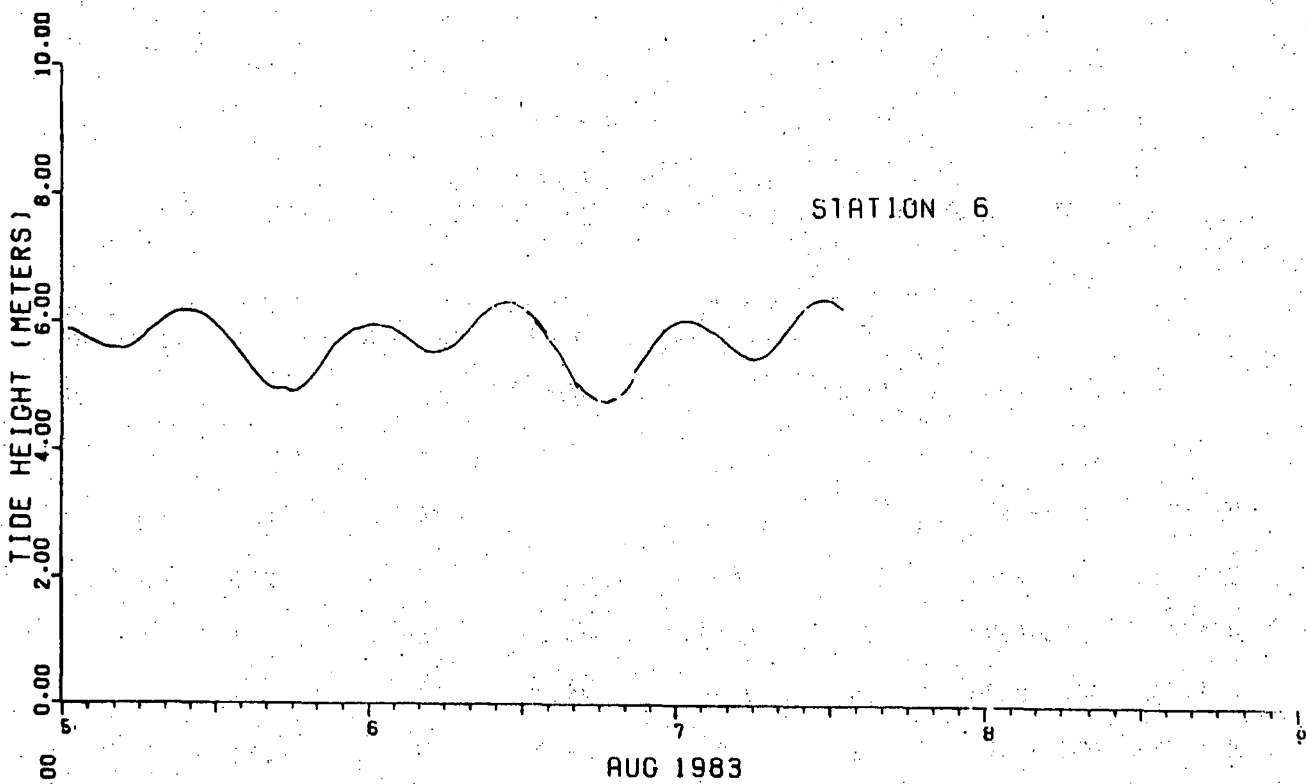
SWEC. 1984b. Third Quarterly Progress Report. Crystal River Studies. Report to FPC, April 1984.

SWEC. 1984d. Fifth Quarterly Progress Report. Crystal River Studies. Report to FPC, November 1984.

TABLE 10.2-2

COMPARISON OF IN SITU AND
VERTICALLY AVERAGED PROFILING DATE - STATION 5, AUGUST 1983

Date	Time	Vertical Average Speed (cm/sec)	Vertical Average Direction	In Situ Speed (cm/sec)	In Situ Direction	Speed Ratio	Direction Difference
8/4/83	1515-1523	38.1	240°	32.8	240°	1.162	0°
8/5/83	0733-0744	22.1	61°	27.0	71°	0.819	-10°
8/5/83	1533-1539	37.6	251°	30.0	244°	1.253	7°
8/11/83	0825-0830	34.0	243°	25.3	246°	1.344	- 3°
8/11/83	1304-1310	39.1	58°	35.3	65°	1.108	- 7°
8/11/83	1349-1354	35.0	65°	35.4	67°	0.989	- 2°
				Average Value		1.112	- 2.5°



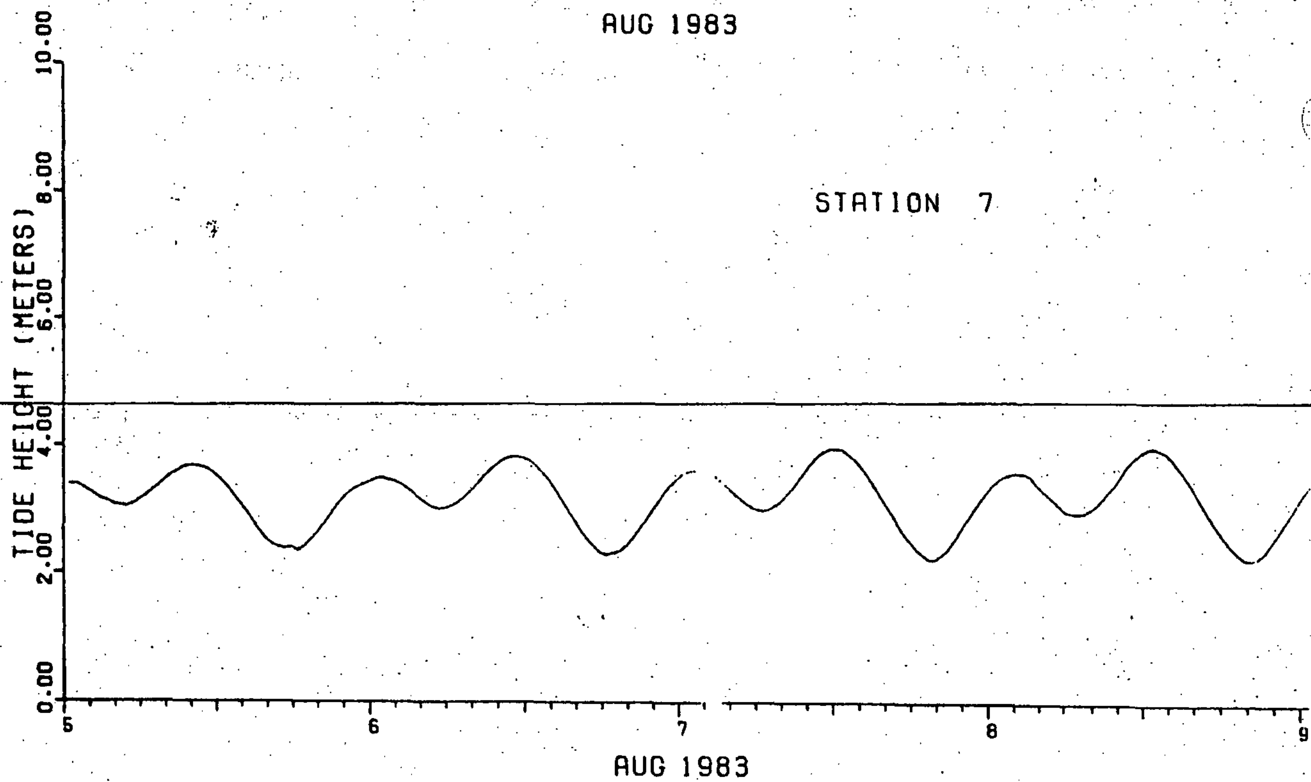


FIGURE 10.2-2

IN SITU TIDE DATA - STATIONS 6 AND 7, AUGUST 1983
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

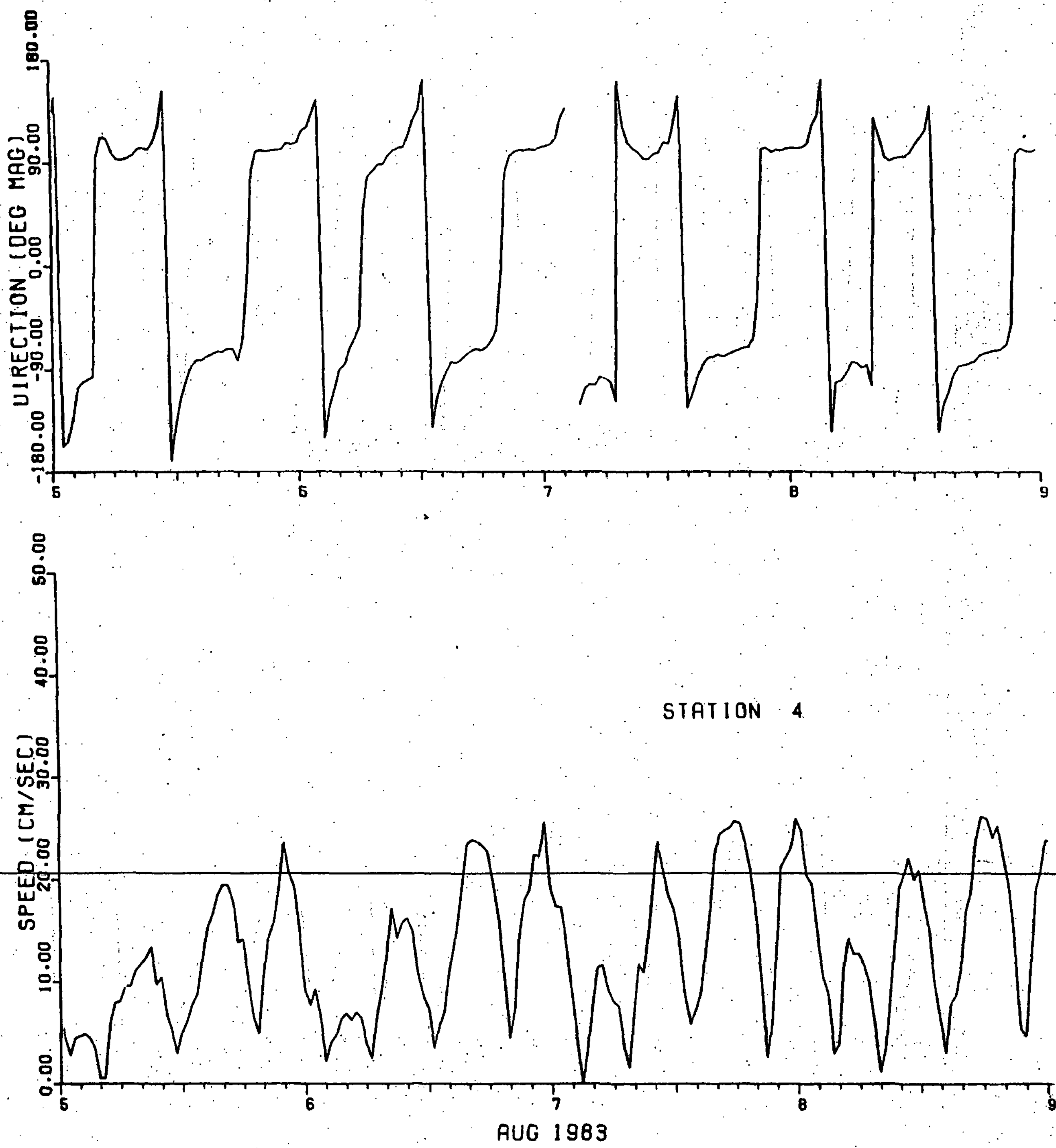


FIGURE 10.2-4

IN SITU CURRENT DATA-
STATION 4, AUGUST 1983
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

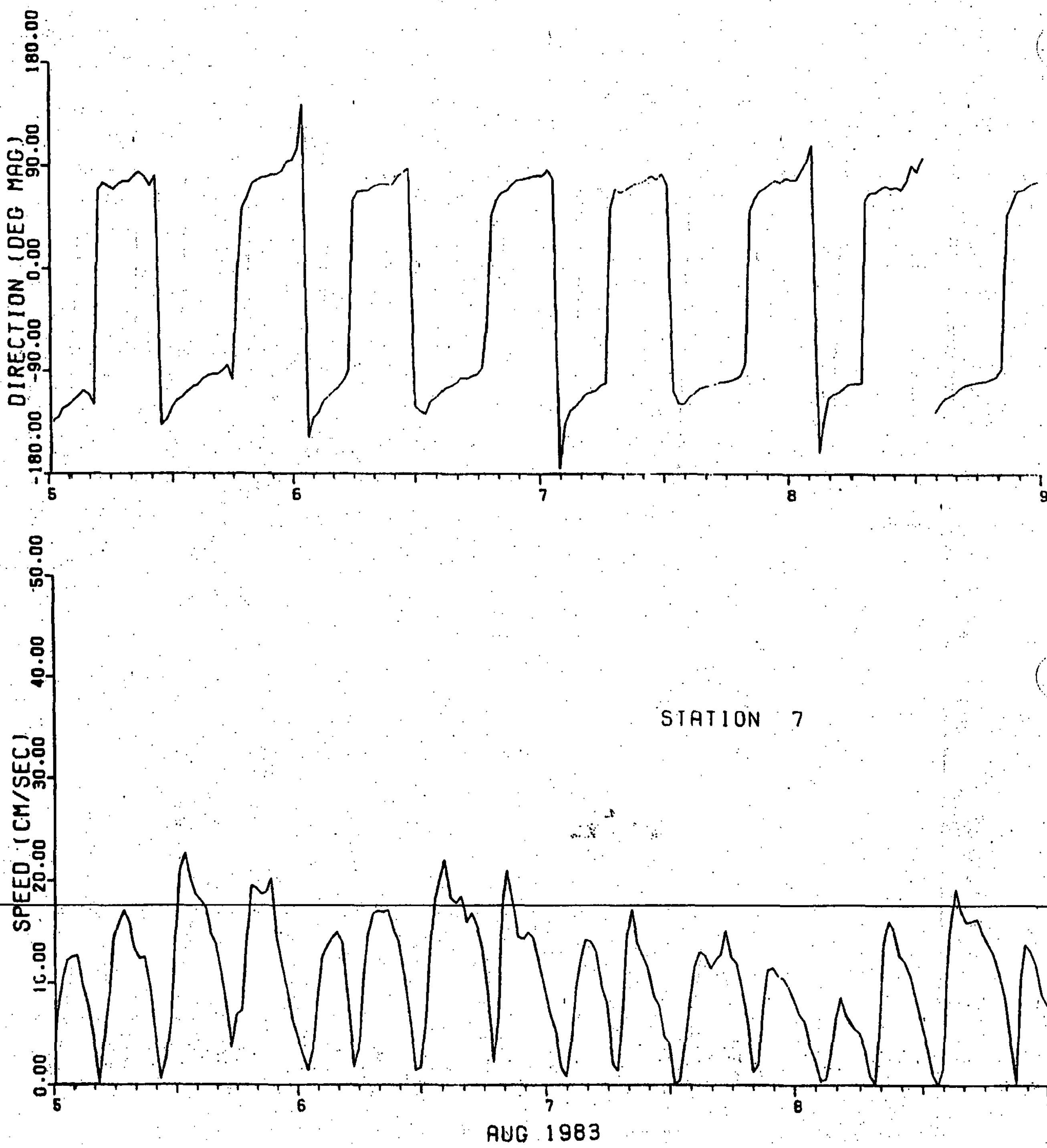
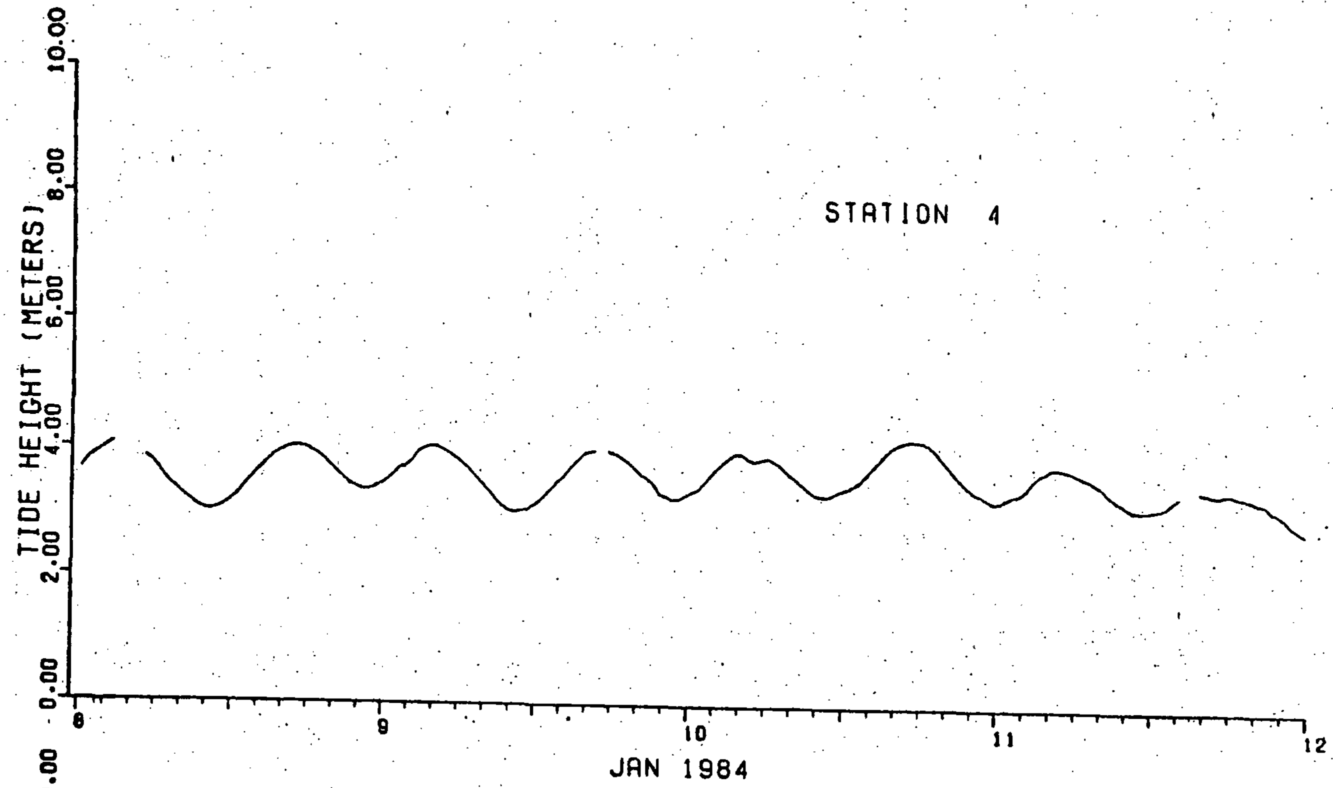


FIGURE 10.2-6

IN SITU CURRENT DATA-
STATION 7, AUGUST 1983
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



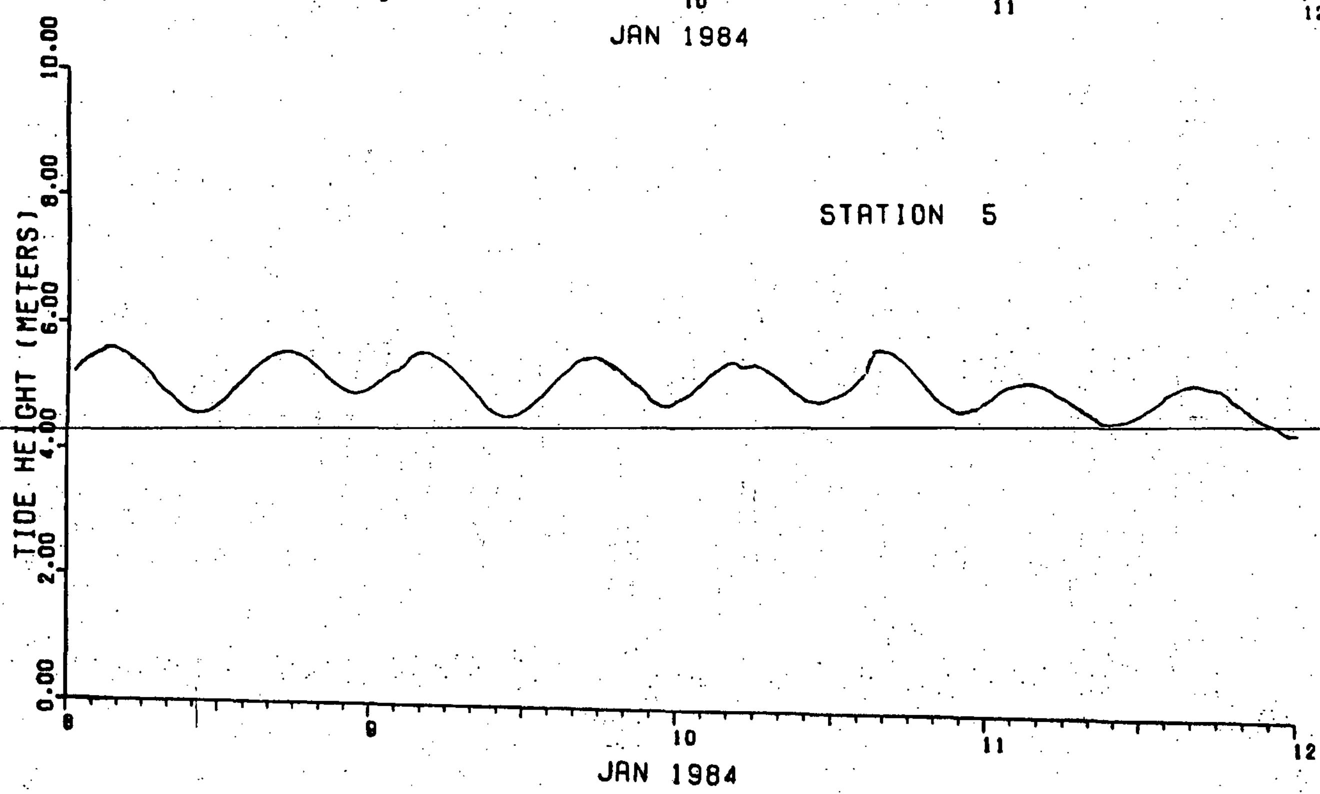


FIGURE 10.2-8

IN SITU TIDE DATA – STATIONS 4 AND 5, JANUARY 1984
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

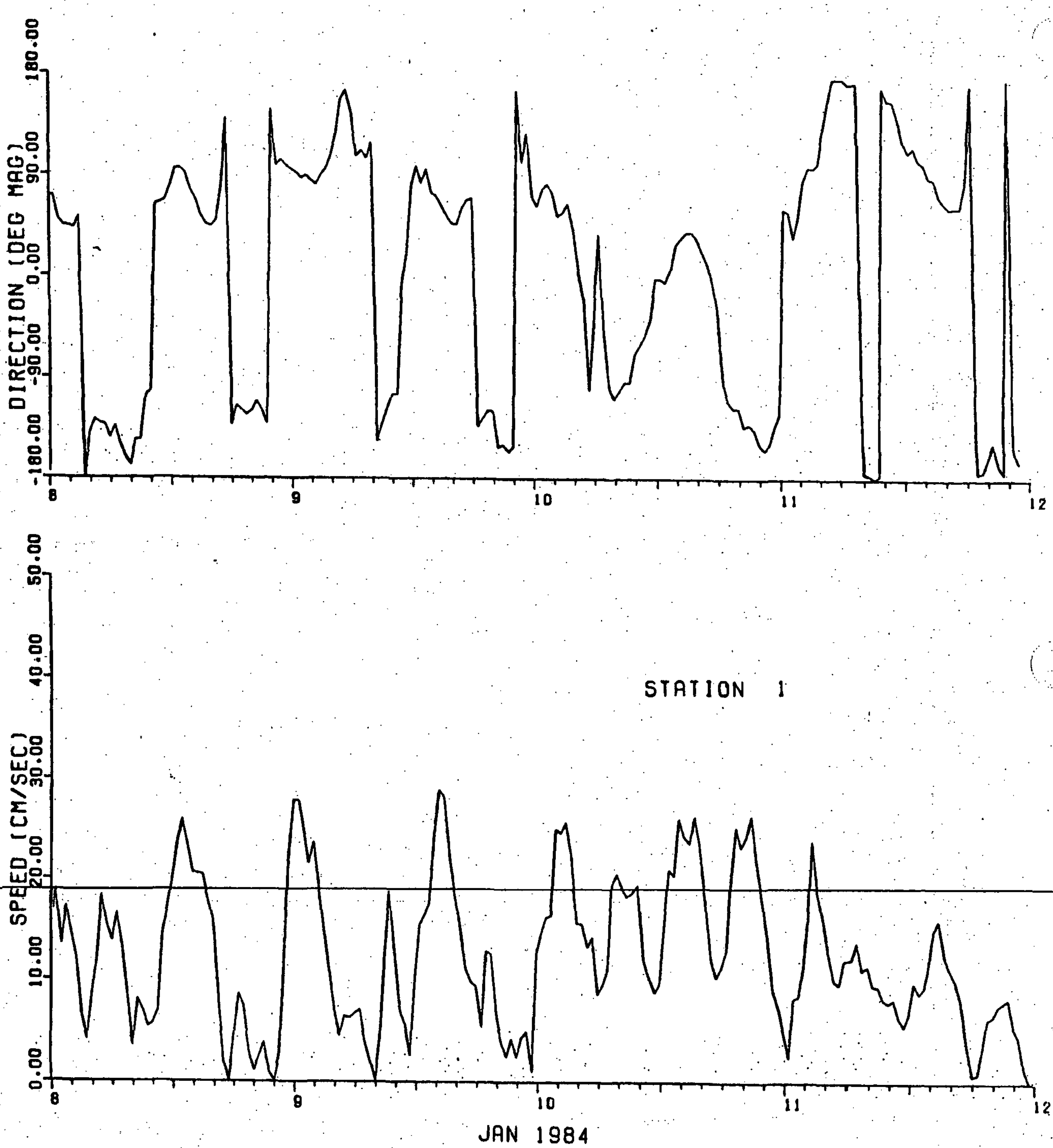


FIGURE 10.2-10

IN SITU CURRENT DATA-
STATION 1, JANUARY 1984
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

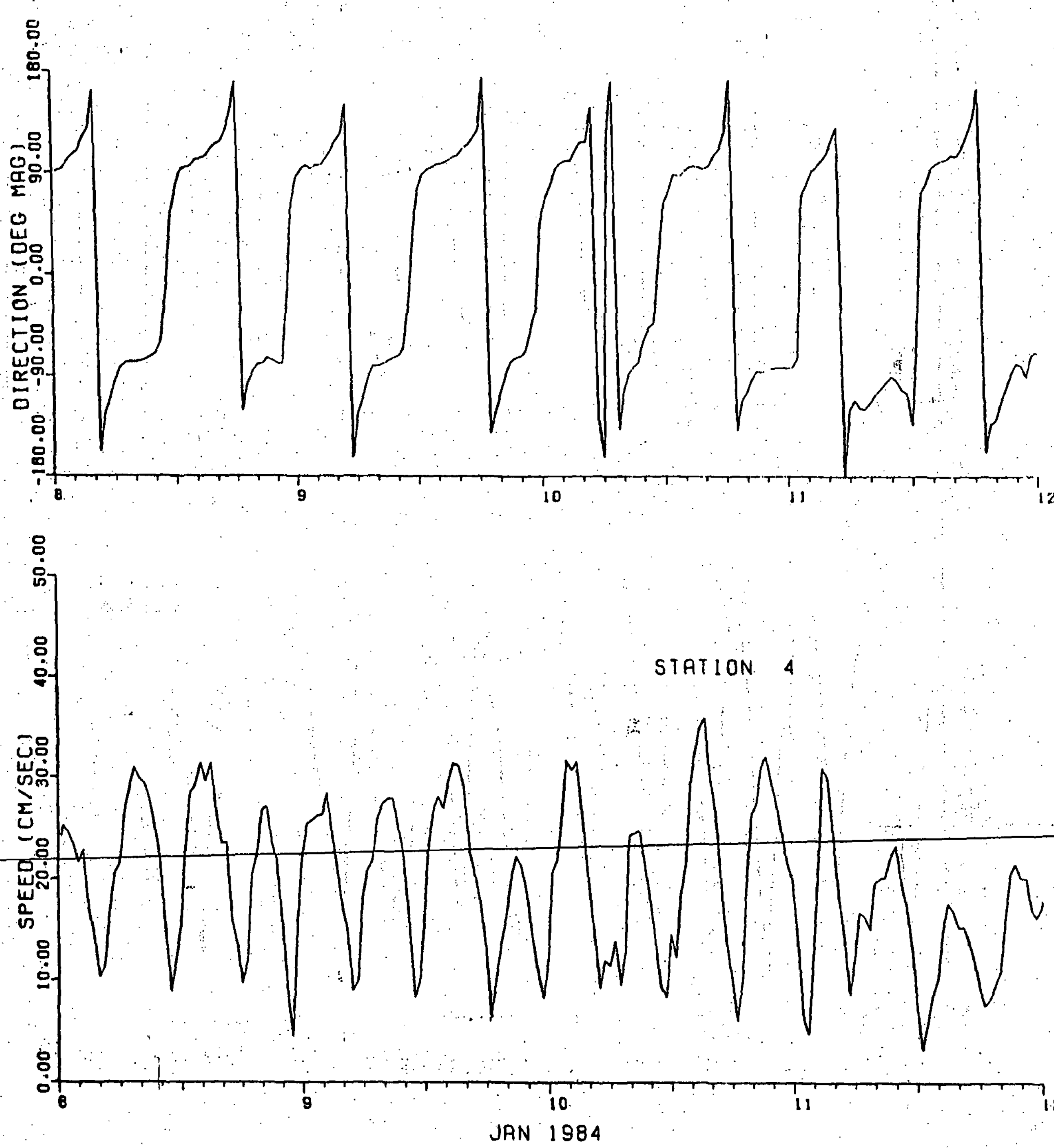


FIGURE 10.2-12

IN SITU CURRENT DATA - STATION 4, JANUARY 1984
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

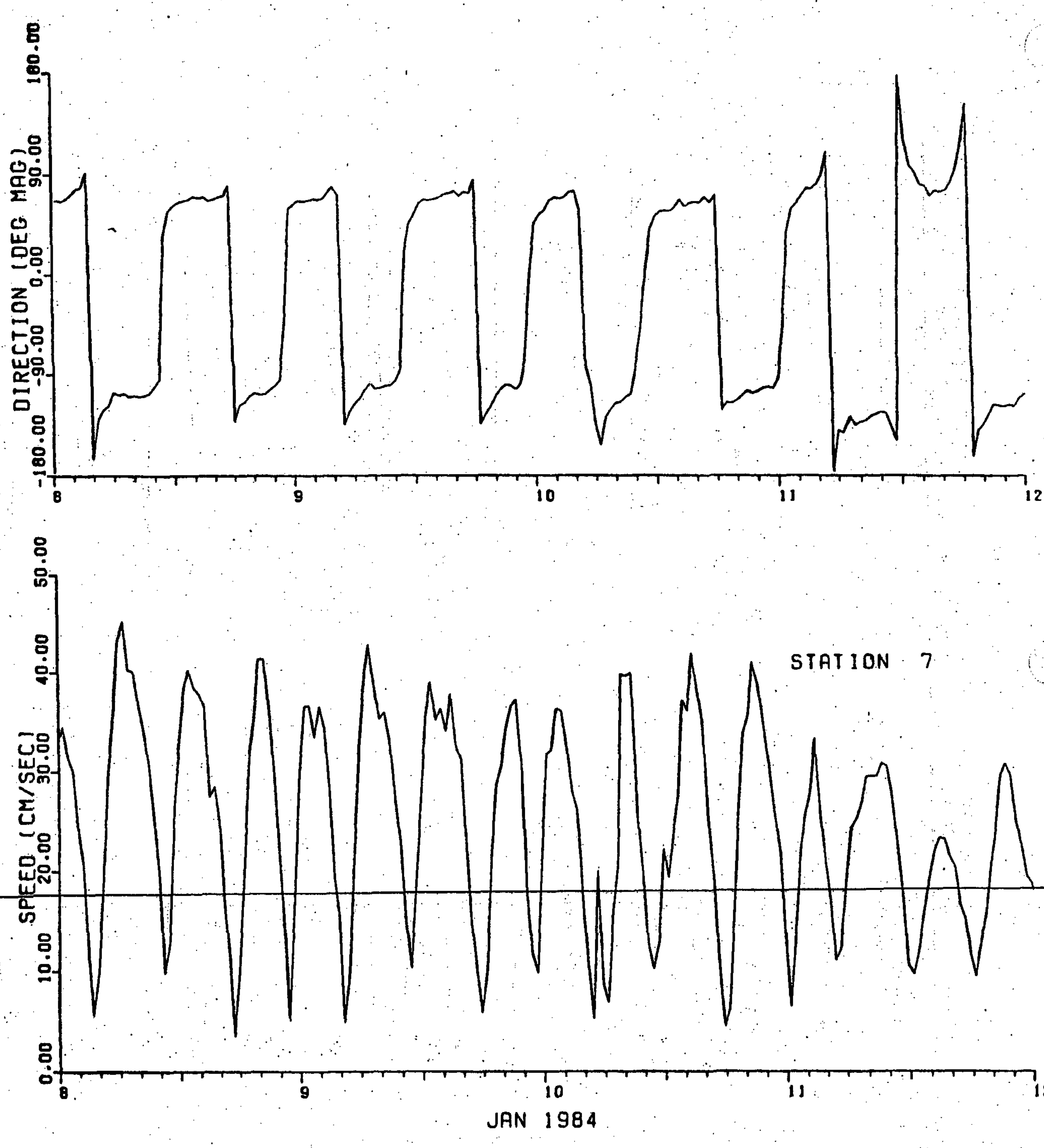


FIGURE 10.2-14

IN SITU CURRENT DATA-
STATION 7, JANUARY 1984
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

y equilibrium (10.3-3)

$$q_{y,t} + (\bar{V}q_x)_{,x} + (\bar{V}q_y)_{,y} - fq_x - F_{xy,x} + (F_p - F_{yy})_{,y}$$
$$+ \frac{1}{\rho o}(\tau_y^{\,s} - \tau_y^{\,b}) - \bar{M}_y - \frac{1}{\rho o}(p^s H_{,y} + \Delta\rho\, g\, H\, h_{,y}) - g\eta h_{,y} = 0$$

where (10.3-4)

$$F_p = gh\eta + \tfrac{1}{2} g\eta^2 + \tfrac{1}{2}\frac{\Delta\rho}{\rho o} g\, H^2 + \frac{p^s}{\rho o} H$$

(10.3-5)

$$F_{x_i x_j} = E_{ij}\left(\frac{\partial q_i}{\partial x_i} + \frac{\partial q_i}{\partial x_j}\right) i,\ j = 1,2 \text{ no summing over } i,j$$

(10.3-6)

$$\tau_x^{\,b} = C_f\,\rho\,\left(q_x^{\,2} + q_y^{\,2}\right)^{\frac{1}{2}} \frac{q_x}{H}$$

(10.3-7)

$\tau_y^{\,b}$ $= C_f\,\rho\,\left(q_x^{\,2} + q_y^{\,2}\right)^{\frac{1}{2}} \frac{q_y}{H}$

$\tau_x, \tau_y^{\,s}$ = x, y components respectively of wind stress, ρ airC_D U_{10}

h = depth of water with respect to datum,

η = height of water surface with respect to datum,

H = h + η

q_x, q_y = x, y components of flux,

$\bar{U}$, $\bar{V}$ = x, y components of vertically averaged velocity,

q_I = source flux,

$\rho_o, \Delta\rho, \rho_{air}$ = respectively, average density of water, change in density of water, density of air,

E_{ij} = eddy viscosity coefficient matrix,

C_f = bottom friction factor,

C_D = wind drag coefficient.

In equations 10.3-1, 10.3-2, and 10.3-3, partial differentiation is written as a subscript comma followed by the independent variable.

The boundary conditions used in the model formulation are separated into two categories: discharge boundaries and force boundaries.

C_o = coefficient for flux due to orifice-like flows through the semi-permeable barrier

C_w = coefficient for flux due to weir-like flows over the top of the semi-permeable barrier

Application of the Model

Schematization of a finite-element model of a water body depends on the specific objectives of the simulation. Once the objectives have been clearly defined, the structure of elements, or the grid pattern, may be designed.

There were two objectives for the far-field modeling:

1. Determine the far-field thermal plume configuration.

2. Determine station effects on far-field meroplankton concentrations.

The element grid developed for the Crystal Bay study is shown on Figure 10.3-1. The grid was developed so as to provide resolution sufficient for meaningful and distinguishable variability in the results. Thus, the element sizes were chosen to be smaller than the scale of these phenomena but not so small as to provide excessive detail. In particular, the smallest grid elements were concentrated near the POD, larger elements were assigned in more remote locations, and the largest elements were assigned at the extremities of the study area. Oyster bars were simulated using the restricted flow simulation developed for this study. Oyster bars are represented in the grid as strings of node pairs which appear to be parallel line segments between sub-regions of the study area.

Bottom depths in the study region were specified using data described in Section 10.2.3. An average water depth was assigned to each node by considering the bathymetric readings in the vicinity of the node.

Five types of boundary conditions were specified in this application of CAFE-1. First, at the western boundary, tide data were derived from the in situ meters and tabulated in terms of tide heights and times of occurrence throughout a tidal cycle. Second, for fixed land boundaries, a no-flux condition, which assumes that the land is impermeable, was employed. Third, for the north and south boundaries, tabular values of fluxes and times of occurrence were specified based on in situ current and tide data. Fourth, for river inflows and the intake and discharge, fluxes perpendicular to the shoreline were assigned. Finally, at the semi-permeable boundaries representing oyster bars, fluxes perpendicular to the barrier were specified depending on the predicted water elevation difference across the barrier.

10.3.1.2 Dispersion Model: DISPER-1

General

The dispersion model DISPER-1 completes the set of two-dimensional finite-element models used for the far-field modeling. CAFE-1 provided current velocities and water levels for input to DISPER-1. DISPER-1, with the

Application of the Model

The grid used for the application of DISPER-1 was the same one used for CAFE-1. Development of this grid is discussed in Section 10.3.1. Water levels and velocities were obtained from output of CAFE-1. Applications of DISPER-1 for this study consisted of thermal simulations (Section 10.5) and meroplankton simulations for the source water body analysis (Section 10.6).

10.3.2 Near-Field Model

The selection of a near-field model for the Crystal River Power Station was based upon an examination of the results of the plume delineation surveys. No significant or consistent plume stratification could be detected due either to temperature or salinity. As noted in Section 6.1, temperature stratification with gradients up to 0.68°C was noted in mean quarterly water quality data. However, gradients of this magnitude are not sufficient to markedly affect hydrodynamic behavior. All candidate near-field models, which simulate rising or sinking plumes, were discarded, and a new near-field model was developed.

The near-field modeling was conducted with a portion of a model originally developed to describe the flow-away zone for a Tee diffuser in quiescent shallow water (Lee and Jirka 1980). The diffuser discharge portion of the model was discarded. The remainder left a model which describes a plume uniformly distributed over the water depth, having an initial momentum imparted at a rectangular outlet, but independent of what may have generated that initial condition.

10.3.2.1 Model Formulation

The equations of motion are written for a vertically uniform elementary length of the plume as follows:

Conservation of mass

$$\frac{d}{dx}\int_{o}^{b} u\,dy = - v_e \qquad (10.3\text{-}11)$$

Equilibrium of force and momentum flux

$$\frac{d}{dx}\int_{o}^{b} u^2 dy = - \frac{f}{8h}\int_{o}^{b} u^2 dy \qquad (10.3\text{-}12)$$

Conservation of heat

$$\left.\begin{aligned} c\,\frac{d}{dx}\,(u_c b) &= \alpha\, u_c \\ \frac{d}{dx}\,(u_c^2 b) &= -\frac{f}{8h}\,u_c^2 b = -\beta\, u_c^2 b \\ \frac{d}{dx}\,(u_c\,\Delta T_c b) &= 0 \end{aligned}\right\} \qquad (10.3\text{-}17)$$

where

$$c = \int_0^{\infty} \exp\,(-\eta^2)\,d\eta = \frac{\sqrt{\pi}}{2}$$

the solutions of which are

$$u_c = u_o \exp\,(-\beta x)\left[1 + \gamma\,(1 - \exp\,(-\beta x))\right]^{-1/2} \qquad (10.3\text{-}18)$$

$$b = b_o \exp\,(\beta x)\left[1 + \gamma\,(1 - \exp\,(-\beta x))\right] \qquad (10.3\text{-}19)$$

$$\Delta T_c = \Delta T_o \left[1 + \gamma\,(1 - \exp\,(-\beta x))\right]^{-1/2} \qquad (10.3\text{-}20)$$

where

u_o initial centerline velocity

b_o initial nominal half-width of the plume

ΔT_o initial centerline temperature rise

and

$$\gamma = \frac{2\alpha}{\beta\, c b_o} \qquad (10.3\text{-}21)$$

10.3.2.2 Model Applications

The results from the near-field model are used to modify the isotherm locations predicted by the far-field model. The far-field model does not simulate all of the transport mechanisms that occur in the near-field, nor does it attempt to deceptively resolve fine details through a fine grid

The bottom resistance coefficient, f, has been assigned to be 0.02. This value has also been adopted by Lee and Jirka (1980) as representative of coastal zone field conditions.

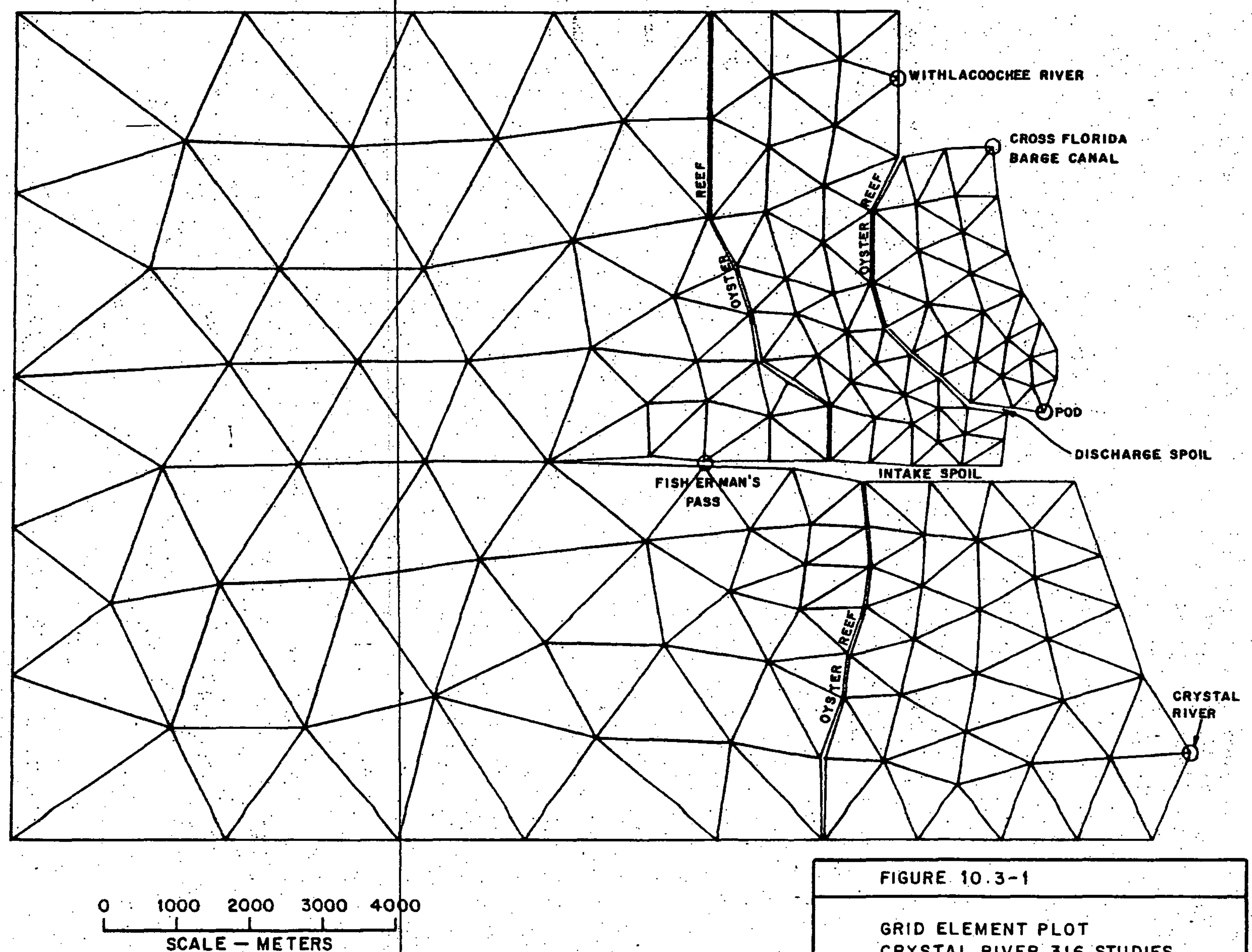


FIGURE 10.3-1

GRID ELEMENT PLOT
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

study area and the results indicate that the model correctly predicts the movement of water in the study region.

10.4.2 DISPER-1

DISPER-1 is generally calibrated by varying the dispersion coefficient until a good comparison between model results and field data is obtained. Various parameters or tracers can be used for this analysis, but it is always preferable to use a conservative constituent, such as salinity. Conditions under which salinity would be a good tracer would involve the presence of a significant lateral gradient, which exists in the study area. Temperature could be used as a tracer, but it is often difficult to determine both a precise value for the heat transfer coefficient and the distribution of ambient temperature.

The calibration period for DISPER-1 is the same as the calibration period for CAFE-1. Similarly, the verification period for DISPER-1 is the same as the verification period for CAFE-1. Each of the DISPER-1 simulations uses the corresponding output from CAFE-1 for water elevation and current velocity input. Boundary conditions for both simulations were obtained from the results of the plume delineation surveys and the in situ stations.

Results of the calibration study are shown on Figures 10.4-8 to 10.4-11. These figures show respectively the high water slack, ebb, low water slack and flood phases of tide. Figures 10.4-12 to 10.4-15 show corresponding tidal phases for the verification period. These figures compare salinity isopleths from model results with isopleths generated from field results. The plotted isopleths indicate that there is generally a favorable comparison between model and field results. Some of the comparisons are excellent, and all are acceptable. Of course, in the small region of the near-field during ebb and low water slack, no favorable comparison is expected. When comparing model results with field data, it should be emphasized that the distribution of parameters in the field is often of a transient, non-reproducible nature. That is, the distribution of parameters often will change from one tidal cycle to the next even if all the principal driving mechanisms (tides, inflow, alongshore currents, winds) remain unchanged. This is due to small-scale effects. These small-scale effects are represented in the model by the dispersion coefficient. Consequently, the model results probably will not match any one set of field data excactly but will represent an average of all the distributions that might occur under any one set of conditions.

The dispersion coefficients determined in this study range from 50 m^2 per sec in the near shore regions to 300 m^2 per sec in the furthest offshore area.

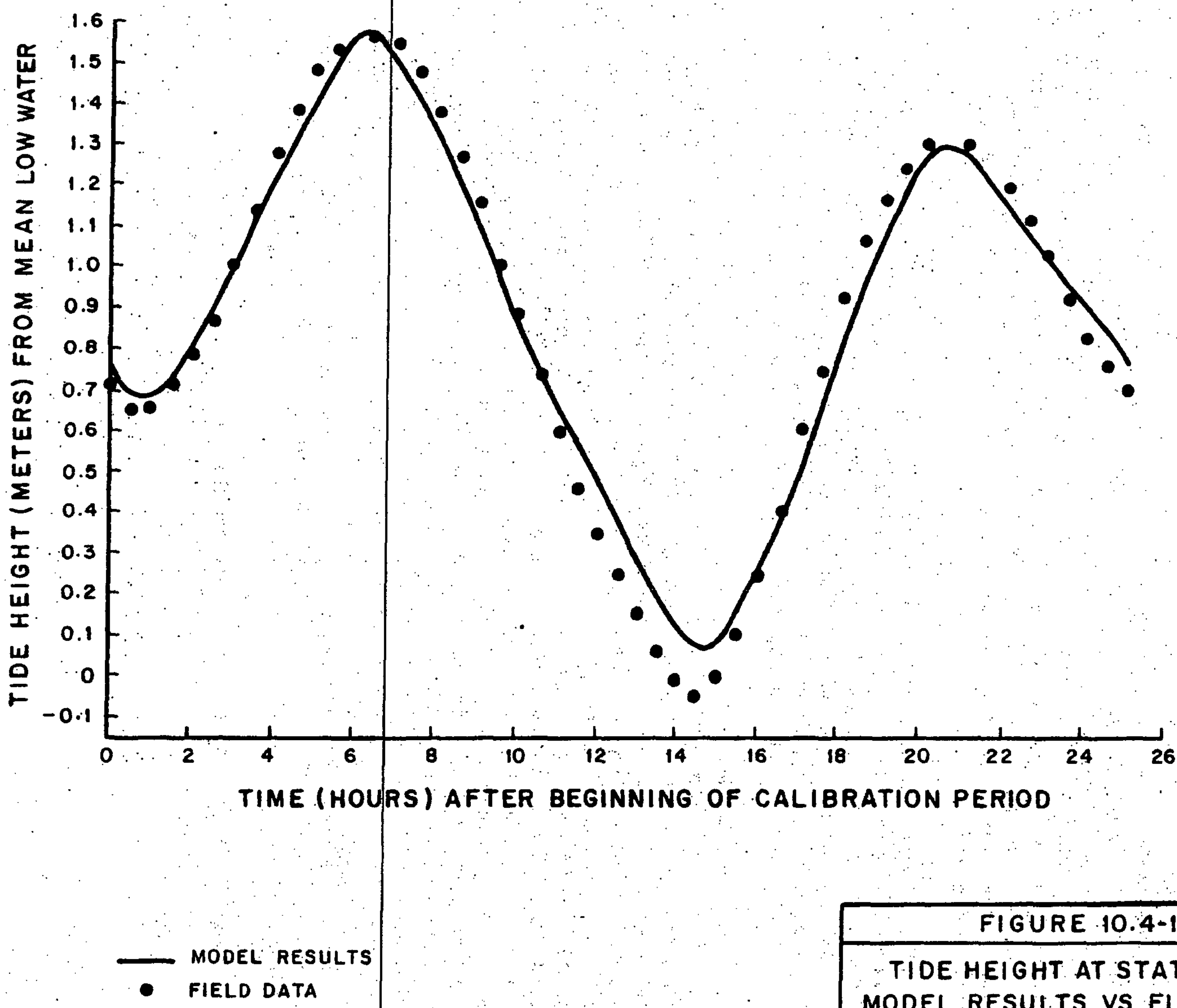


FIGURE 10.4-1

TIDE HEIGHT AT STATION 13
MODEL RESULTS VS FIELD DATA
—CALIBRATION PERIOD

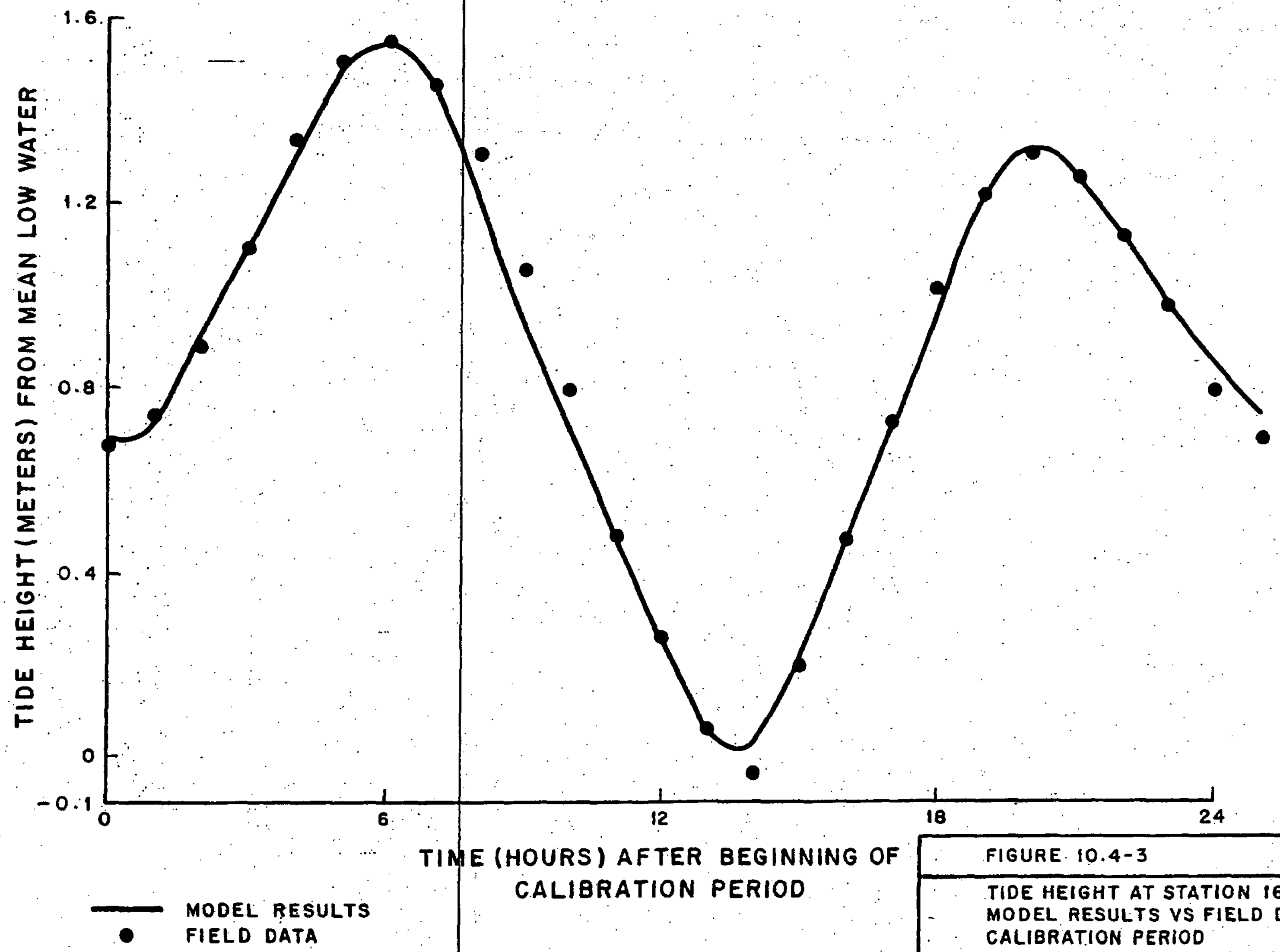


FIGURE 10.4-3

TIDE HEIGHT AT STATION 16
MODEL RESULTS VS FIELD DATA
CALIBRATION PERIOD
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

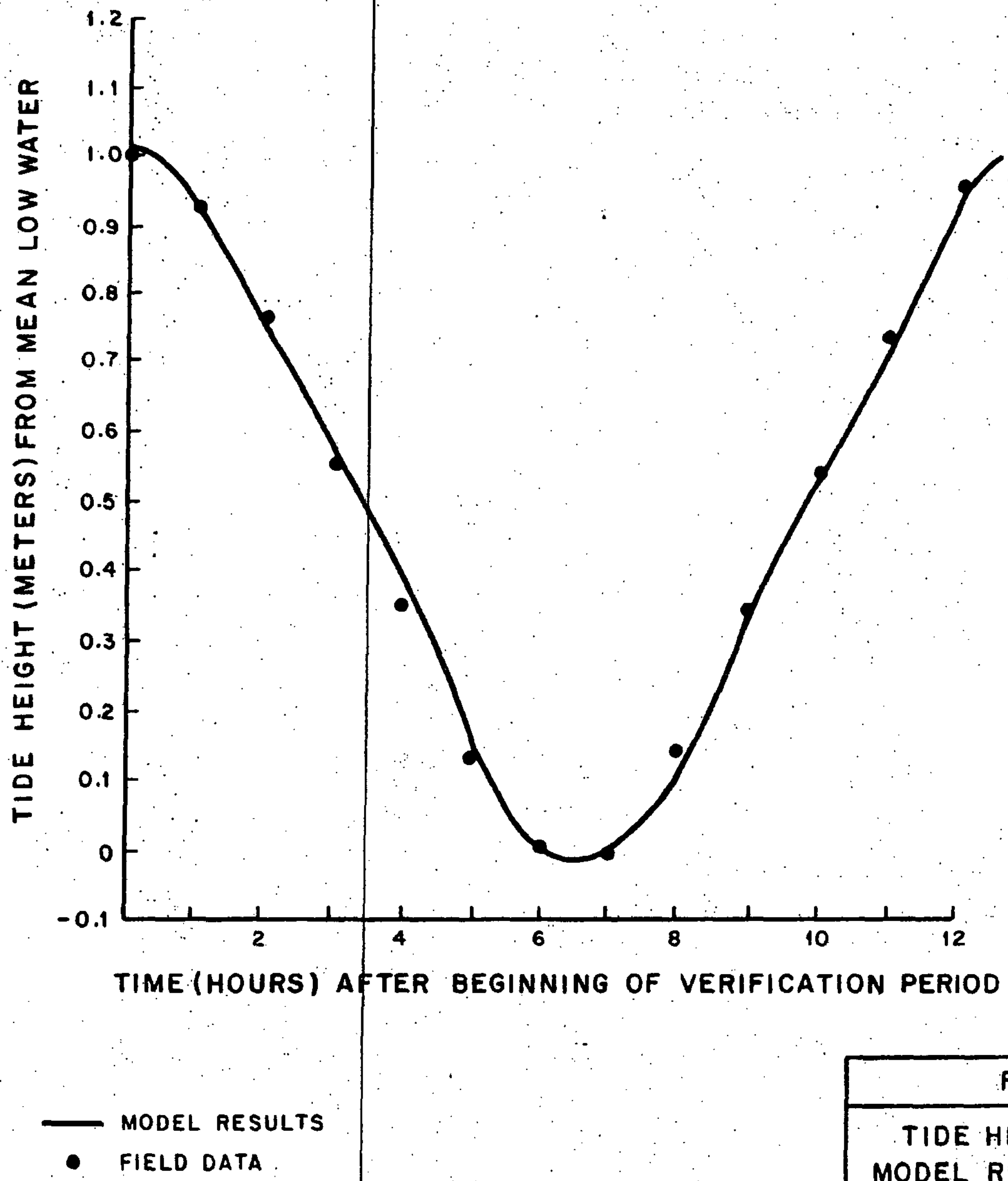


FIGURE 10.4-5

TIDE HEIGHT AT STATION 11
MODEL RESULTS VS FIELD DATA
—VERIFICATION PERIOD

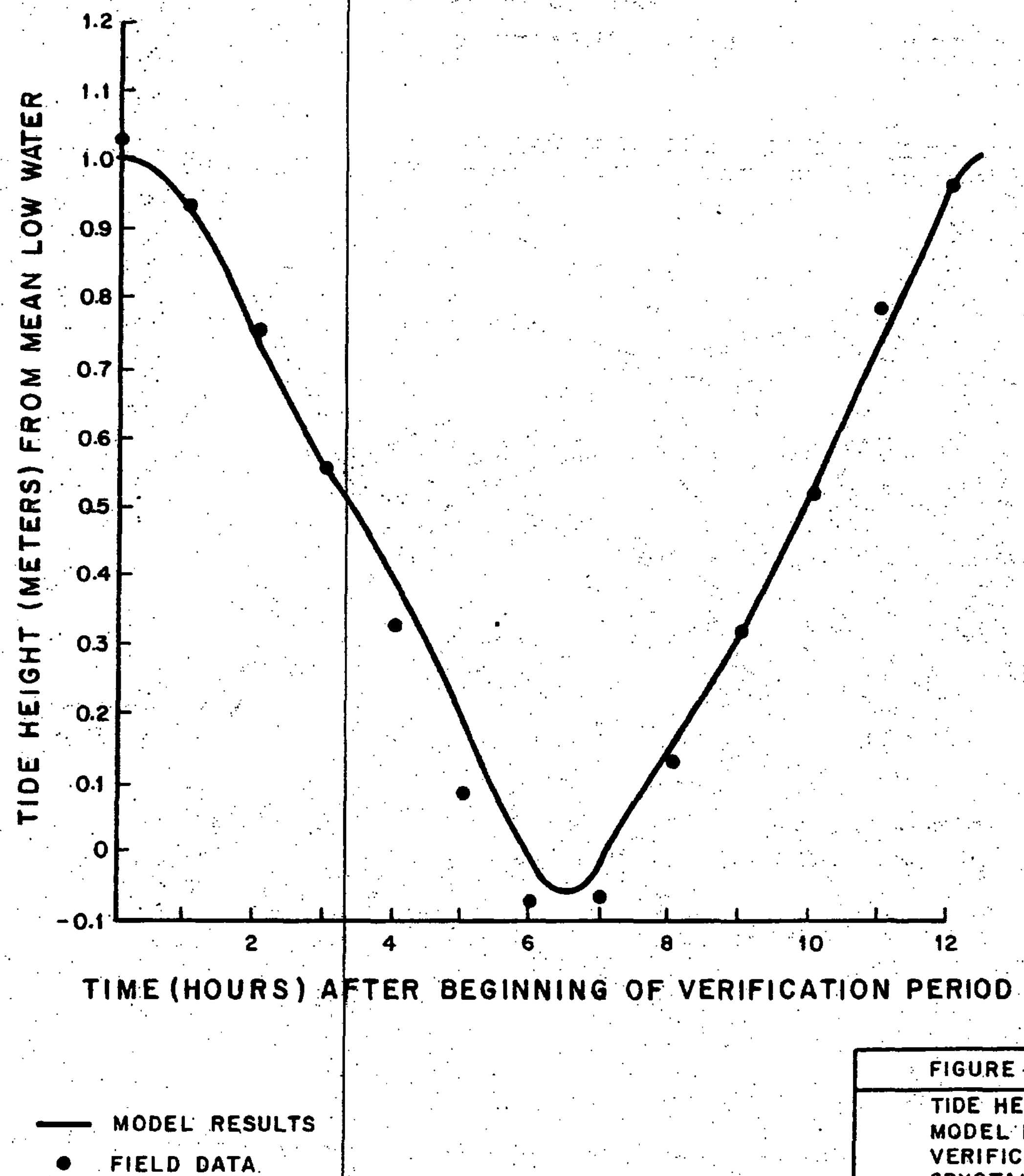


FIGURE 10-4-7

TIDE HEIGHT AT STATION 14
MODEL RESULTS VS FIELD DATA
VERIFICATION PERIOD
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

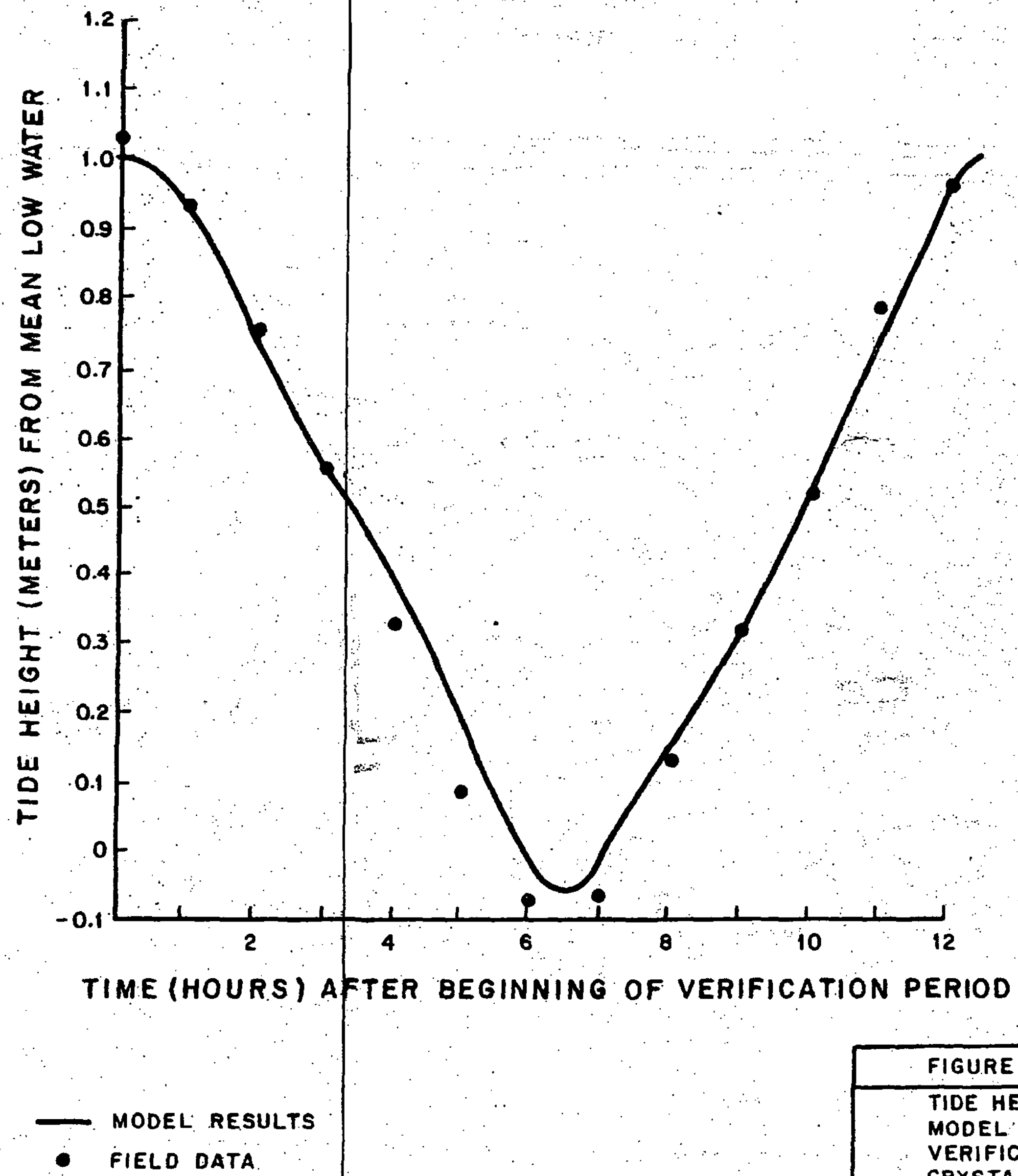
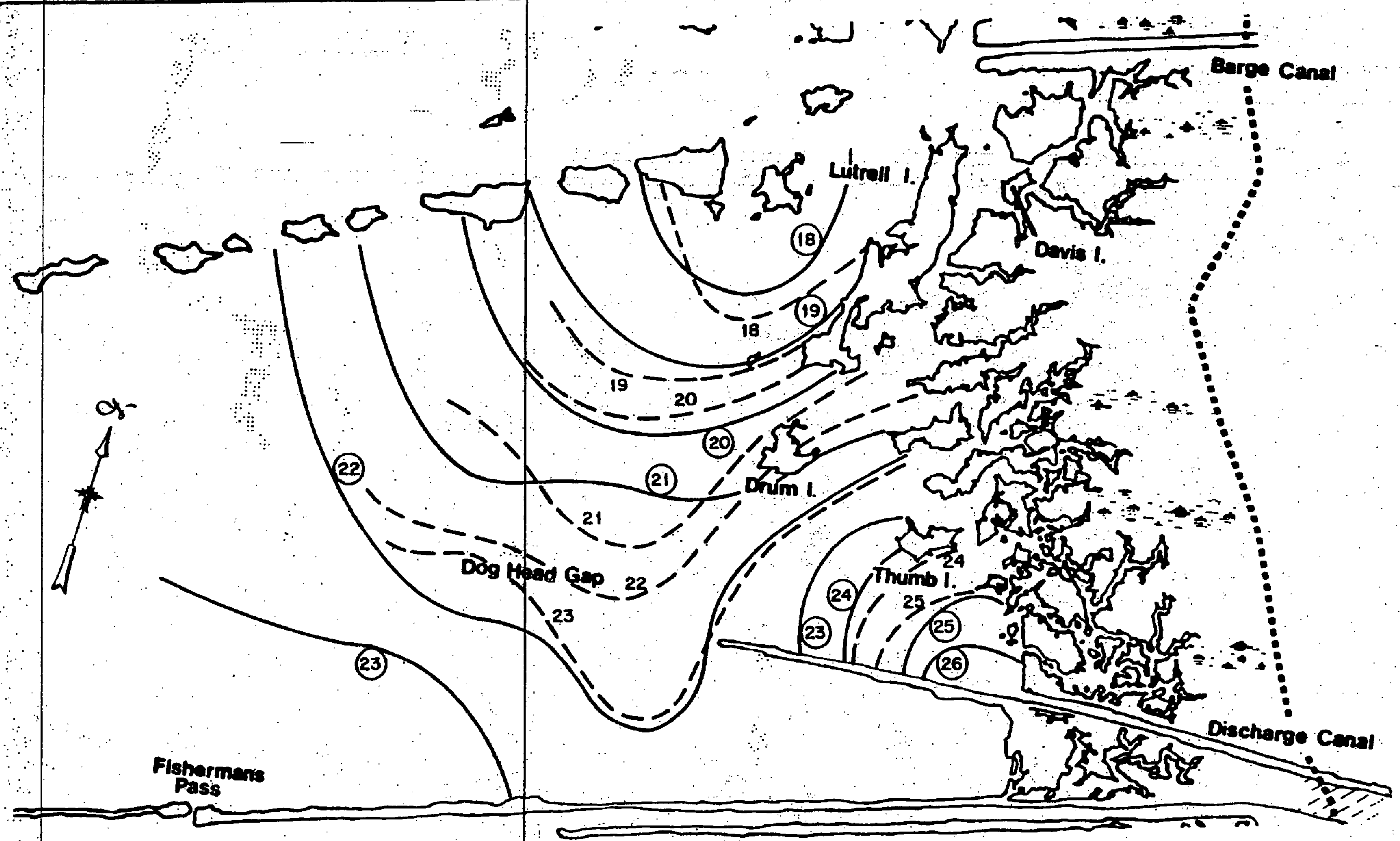


FIGURE 10.4-7

TIDE HEIGHT AT STATION 14
MODEL RESULTS VS FIELD DATA
VERIFICATION PERIOD
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION



0 1 2

SCALE — KILOMETERS

MODEL RESULTS

FIELD DATA

SALINITY IN PARTS PER THOUSAND

FIGURE 10.4-11

SALINITY ISOPLETHS DURING CALIBRATION PERIOD- MODEL RESULTS AND FIELD DATA-FLOOD
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

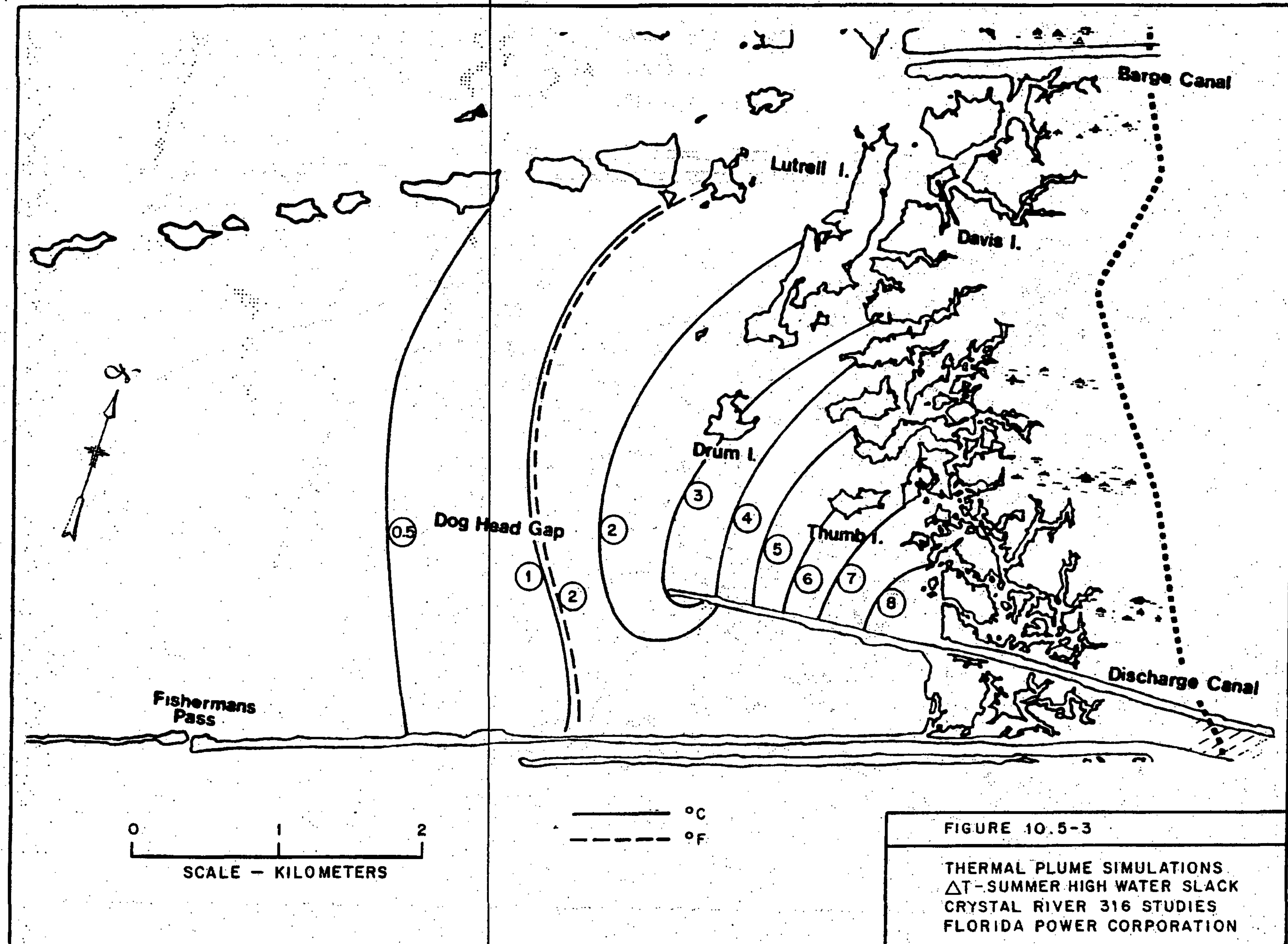


FIGURE 10.5-3

THERMAL PLUME SIMULATIONS
ΔT-SUMMER HIGH WATER SLACK
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

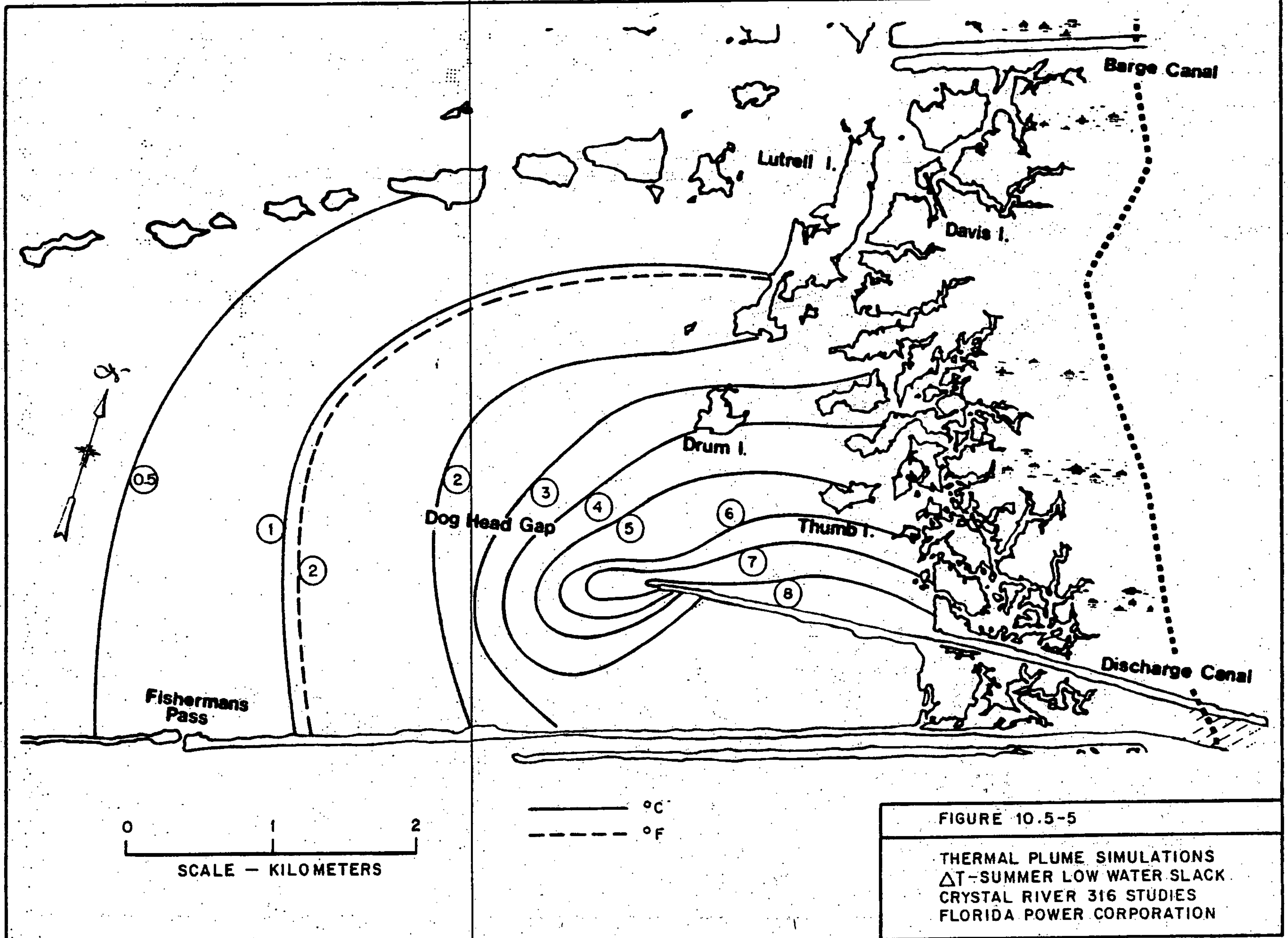


FIGURE 10.5-5

THERMAL PLUME SIMULATIONS
ΔT-SUMMER LOW WATER SLACK
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

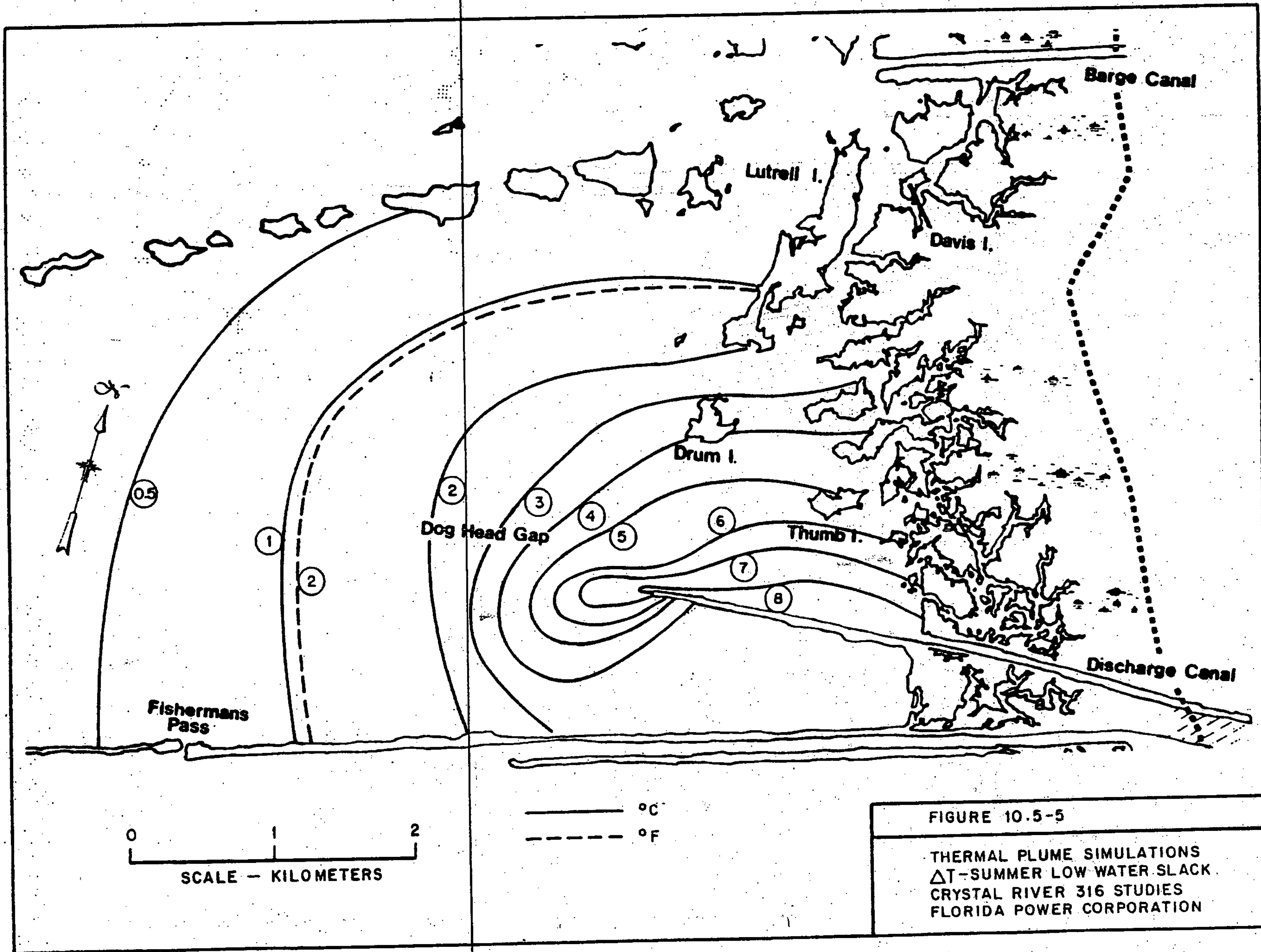


FIGURE 10.5-5

THERMAL PLUME SIMULATIONS
ΔT-SUMMER LOW WATER SLACK
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

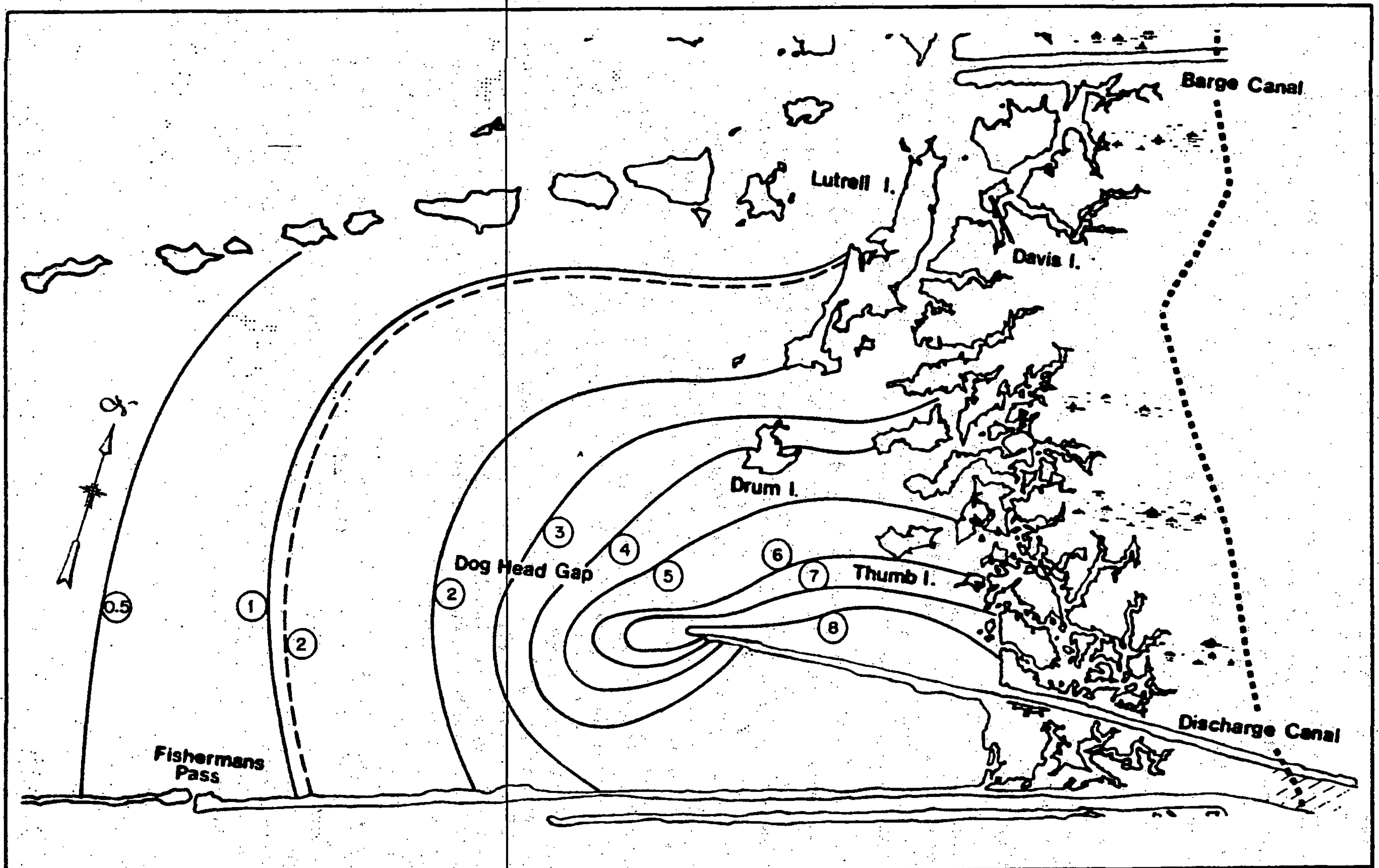


FIGURE 10.5-9

THERMAL PLUME SIMULATIONS
ΔT-WINTER-LOW WATER SLACK
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

10.6 MEROPLANKTON ENTRAINMENT AND SOURCE WATER BODY ANALYSIS

The hydrodynamic and dispersion models used to simulate the thermal discharge into Crystal Bay can also be applied to the evaluation of meroplankton distribution and the effects on that distribution of entrainment. The meroplankton entrainment analysis was performed using CAFE-1 and DISPER-1. These models are described in Section 10.3. The purpose of this analysis was to determine the effects of power plant operation on meroplankton concentrations in the study area and secondarily to evaluate the source of entrained organisms.

For the hydrodynamic CAFE-1 simulation, the same representative tidal cycle used for the thermal anlaysis (Section 10.5) was used here. This simulation included the hydrodynamic effects of the intake and discharge.

For the DISPER-1 simulations, meroplankton concentration patterns measured in the field studies (Section 8.2) were used to develop ambient boundary and initial conditions. It was conservatively assumed that none of the meroplankton drawn into the intake will survive and that there will be a zero concentration of meroplankton in the discharge water. The effect of the power plant was introduced at the discharge as a loss of meroplankton.

Three cases with different ambient conditions were considered in this analysis: (1) ambient concentrations constant throughout the study area (2) a concentration ratio of five in the southwest region of the study area to one in the northeast region and (3) a concentration ratio of five in the northwest region of the study area to one in the southeast region. These cases are representative of plankton distributions identified in Crystal Bay for various species. The results of these simulations are presented in Figures 10.6-1 to 10.6-6. Figures 10.6-1 and 10.6-2 show, respectively, the high water slack and low water slack results for Case 1. Similarly, Figures 10.6-3 and 10.6-4 show the results for Case 2 and Figures 10.6-5 and 10.6-6 show the results for Case 3. These figures indicate that generally the greatest effect of the power plant is experienced by meroplankton with an ambient concentration represented by Case 1, i.e., the concentrations established as ambient prior to inclusion of plant withdrawals are reduced by the greatest percentage. Plankton distributed as in Case 1 are thus least able to overcome reductions in the discharge area. The next greatest effect is on Case 2 meroplankton with Case 3 meroplankton experiencing the smallest effect. The ecological significance of these results is discussed in Section 8.3.

Figures 10.5-1 and 10.5-2 show the current velocities throughout the study area for the flood and ebb phases of the tidal cycle. These figures indicate that the effects of power plant water withdrawal on flow patterns in the study area are minimal. The source of the water that is drawn into the intake is determined mainly by the large scale driving mechanisms of tide and wind. The current patterns shown in Figures 10.5-1 and 10.5-2 indicate the source of water passing by the intake during flood and ebb.

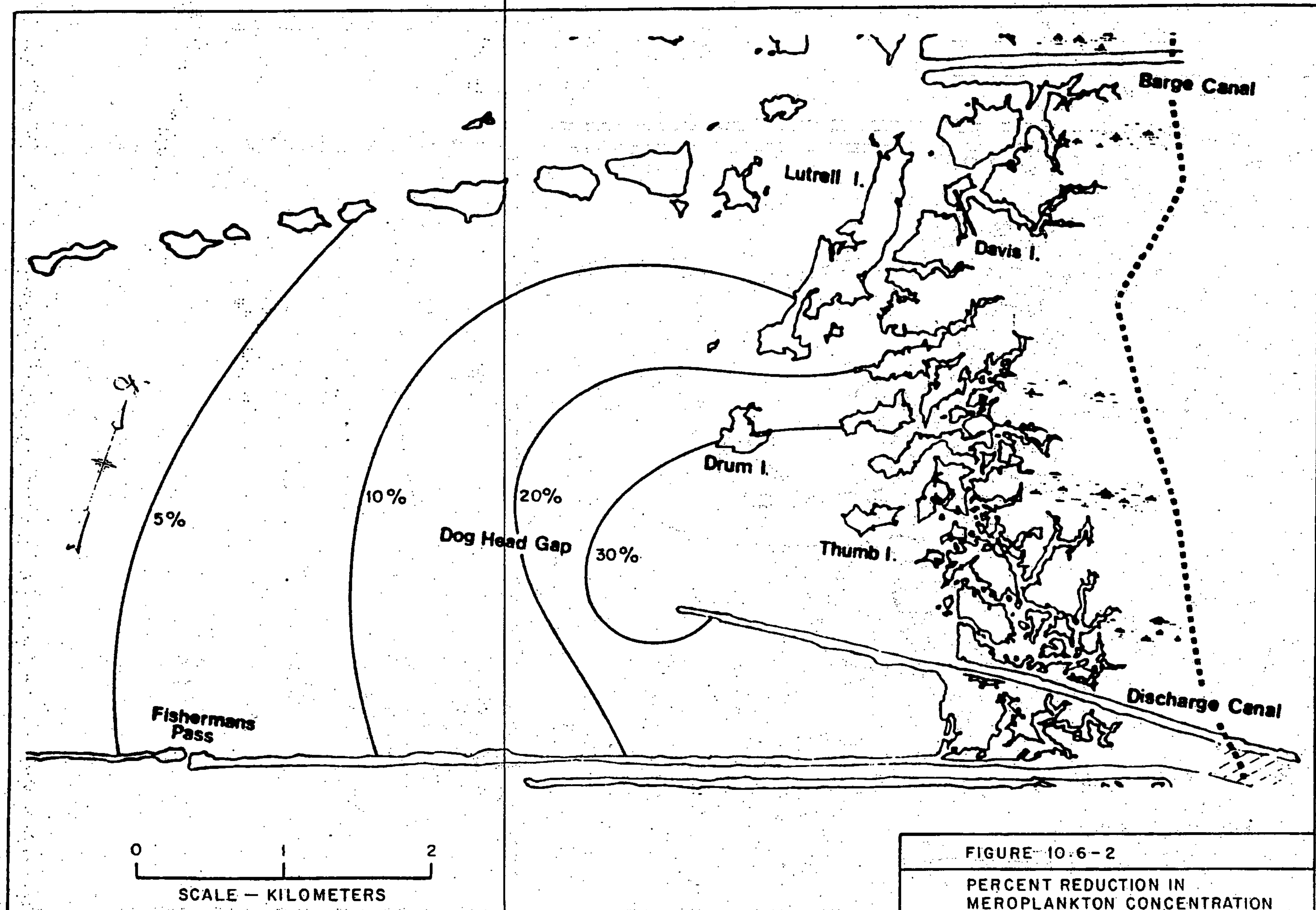


FIGURE 10.6-2

PERCENT REDUCTION IN MEROPLANKTON CONCENTRATION
CASE 1—LOW WATER SLACK
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

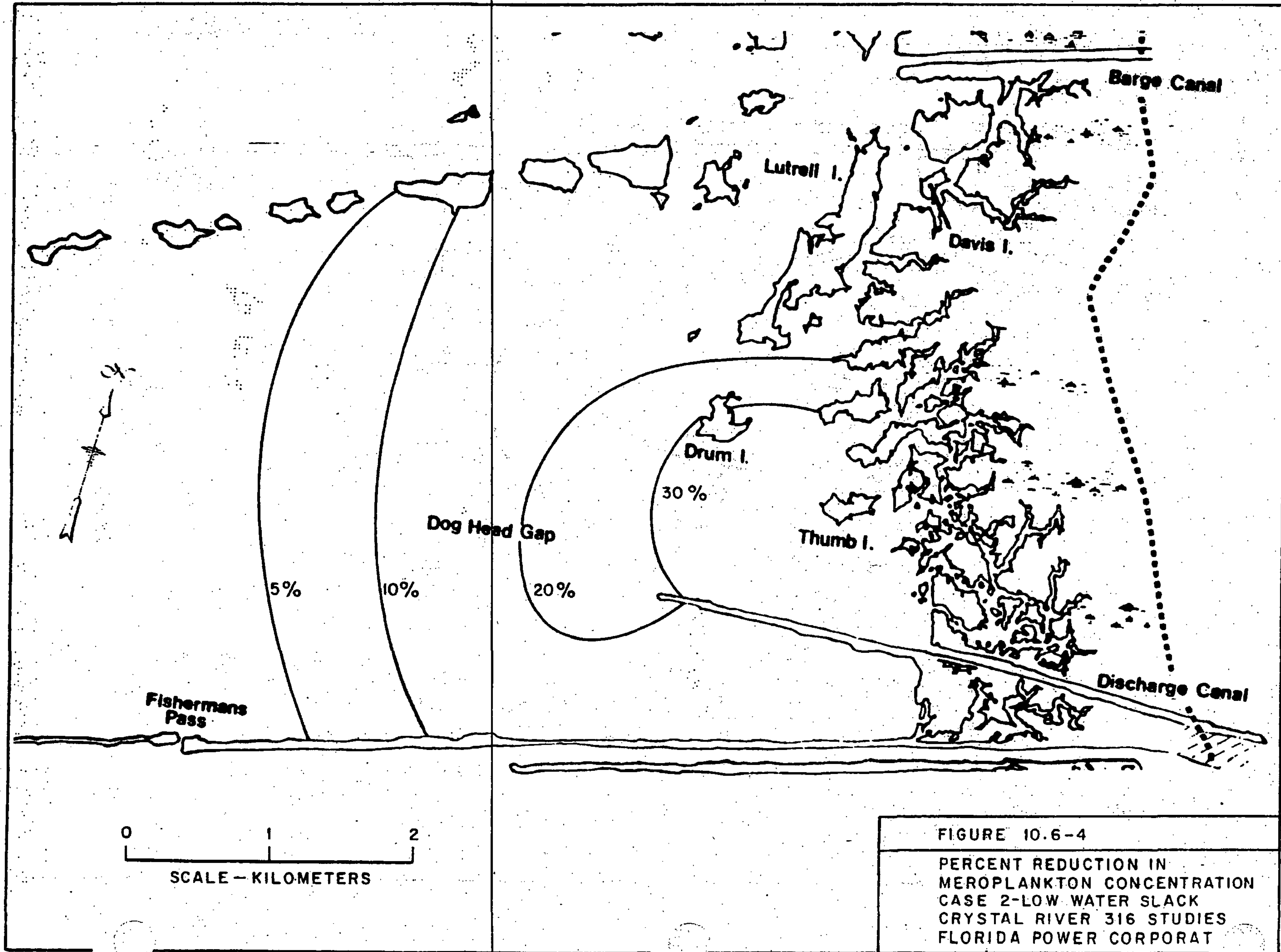


FIGURE 10.6-4

PERCENT REDUCTION IN MEROPLANKTON CONCENTRATION
CASE 2-LOW WATER SLACK
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORAT

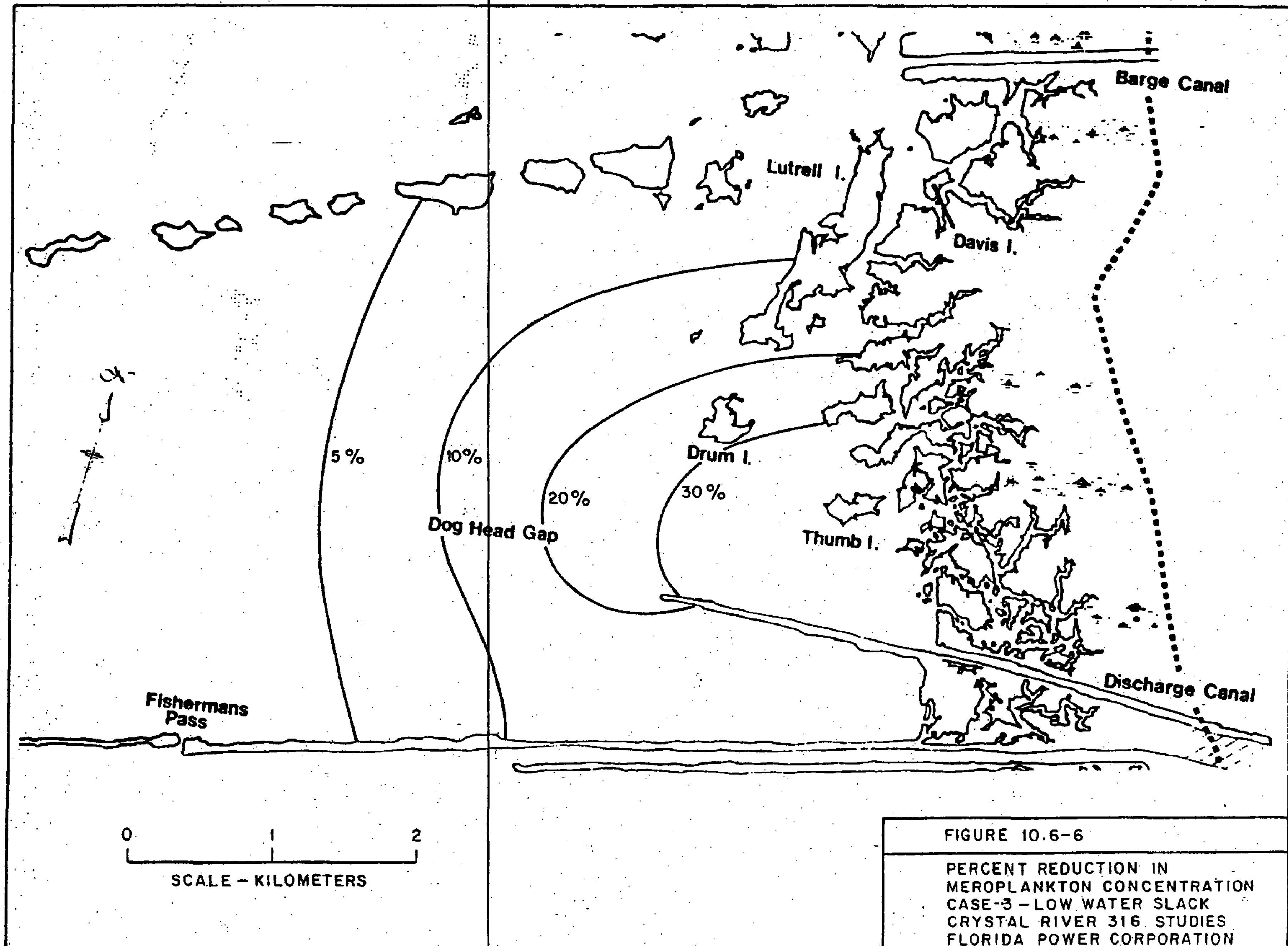


FIGURE 10.6-6

PERCENT REDUCTION IN MEROPLANKTON CONCENTRATION
CASE-3 – LOW WATER SLACK
CRYSTAL RIVER 316 STUDIES
FLORIDA POWER CORPORATION

11.0 SUMMARY

In response to conditions of discharge permit No. FL0000159 for Crystal River Units 1, 2, and 3, a study was designed to collect biological, physical, and chemical oceanographic data which would permit documentation of the effects of power plant operation on the local ecosystem. The study area encompassed about 10 square miles (see Figure 2.1-1). Study components identified in the report and summarized below were benthos, entrainment, impingement, fisheries, and physical studies. The data also served as input to hydrodynamic and hydrothermal mathematical models which would have the capability to simulate the station's thermal discharge under various operating conditions.

The effects of the discharge of heated water were investigated primarily in terms of benthic species of animals and plants which, depending on their location, would be chronically exposed to varying levels of elevated temperatures. In addition to monitoring water quality parameters including temperature, salinity, D.O., pH, turbidity, suspended solids, chlorophyll, and light penetration, biological data were collected on benthic infauna, macrophytes, salt marsh, and oyster reefs.

Thermal effects varied with the organisms involved but were identified within each component. In general, the effects were limited to an area within about 3.5 km of the point of discharge. The effects are summarized in Table 11.0-1. The results consistently indicated adverse effects due to the thermal discharge in Basin 1, Basin 3, and the southern section of Basin 2 (see Figure 2.1-1). Central areas of Basin 2 and the offshore edge of Basin 3 were found to be transitional with organisms showing limited, if any, adverse thermal effects.

Interpretation of results was complicated by other sources of stress, primarily low salinity and sedimentation, within Crystal Bay. Effects due to these sources were most evident in shallow northern areas near the Cross Florida Barge Canal and the Withlacoochee River. Particularly with benthic infauna, the effects of salinity and sedimentation are very similar to thermal effects, and thus there are numerous faunal similarities between the northern area and the area affected by the thermal discharge.

The thermal plume simulation results agreed well with results from the biological and water quality sampling. Basin 1, nearest the point of discharge consistently is exposed to water at the highest ΔT's, about 5-8°C. On ebb or low slack tides, however, the largest volume of the discharge is confined to the dredged channel adjacent to the discharge spoil and exits into Basin 3. The plume at that point tends toward the southwest, but rapidly becomes well mixed in the relatively shallow water. On flood or high tides, the plume effect in Basin 3 is lacking as the discharge spreads over Basin 1 and extends further north in southern Basin 2. Little variation is seen in the summer or winter cases. Simulations represent worst case, full load operation.

Meroplankton densities and distribution in space and time were sampled by towed nets. Densities of SIO taken at stations representing entrained populations were used to project annual entrainment (see Table 11.0-2), and the results were compared to available catch or landings data by estimating

11.0 SUMMARY

In response to conditions of discharge permit No. FL0000159 for Crystal River Units 1, 2, and 3, a study was designed to collect biological, physical, and chemical oceanographic data which would permit documentation of the effects of power plant operation on the local ecosystem. The study area encompassed about 10 square miles (see Figure 2.1-1). Study components identified in the report and summarized below were benthos, entrainment, impingement, fisheries, and physical studies. The data also served as input to hydrodynamic and hydrothermal mathematical models which would have the capability to simulate the station's thermal discharge under various operating conditions.

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Meroplankton densities and distribution in space and time were sampled by towed nets. Densities of SIO taken at stations representing entrained populations were used to project annual entrainment (see Table 11.0-2), and the results were compared to available catch or landings data by estimating the number of adults equivalent to the entrained life stages. For the majority of the species, the level of entrainment estimated represented a small percentage (up to 1.3) of the commercial landings or recreational catch. For other species like bay anchovy and polka-dot batfish, lack of life cycle or catch data precluded this comparison. In the case of spot and pigfish, the station entrains about the same number of fish reported in annual fisheries statistics.

Impingement at Units 1, 2, and 3 was monitored for 12 months and was evaluated in terms of SIO. Annual impingement numbers were projected and the results compared to commerical landings or recreational catch data, if available. For all species, the numbers impinged were either small and represented a nominal percentage (0.003-1.8) of the fishery or were larger and represented a more abundant species more likely to tolerate impingement losses.

Fisheries data were collected using trawls, seines, creek trawls, and drop nets. Results were evaluated in terms of any apparent effects of thermal discharge on the species collected. Data on age, sex, reproductive condition, parasitism, fecundity, and length/weight were collected; the data were limited but did not indicate a pattern of adverse effects for any SIO. Distributional data yeilded varying results for the individual species; generally species seemed to be more abundant outside the warmest portion of the discharge but did occur regularly in outer portions of the thermal plume.

Crab tagging conducted in Crystal Bay was highly successful with well over 50 percent recaptures. The data on initial capture and recapture were analyzed to evaluate the effect of the intake spoil on blue crab movements. In general, movement to the north predominated and primarily females were involved. Short distance movement, within Crystal Bay, did appear to be delayed by the spoil for up to several days, but local recapture data may be affected to some extent by the concentration of crab traps just south of the spoil. Longer distance migration, beyond Crystal Bay, was not delayed by the spoil.

TABLE 11.0-1

SUMMARY OF IMPACTS OF STATION OPERATION
BENTHOS

Study Component	Impact Assessment
Benthic infauna	Adverse thermal effects limited to area bounded by Stations 13, 17, and 18; community alterations (considered minimal) have occurred in larger area bounded by Stations 4, 5, 22, and 30.
Macrophytes	Thermal effects in the form of reduced percent cover and species richness of seagrasses and macroalgae occurred in Basins 1 and 3.
Salt Marsh	Thermal effects on *Spartina* and *Juncus* at Thermal, nearest the discharge; decreasing effects on *Spartina* at Fence, Thumb Island, and Midway and on *Juncus* at Thumb Island and Midway.
Oyster Reef	Higher oyster mortality and reduced abundance of associated fauna at Stations OR4 and OR5 in Basin 1 and to lesser extent at OR6; growth enhancement and higher condition index around Basin 3.
Water Quality	Area of greatest thermal influence defined as Stations 13, 17, 18, 19, 29; second grouping includes Stations 4, 5, 14, 20, 21, 22, 28, and 30. Turbidity and TSS were affected by storms but not by barge traffic.

TABLE 11.0-2

SUMMARY OF IMPACTS OF STATION OPERATION ON SELECTED IMPORTANT ORGANISMS

SOURCE OF IMPACT

	Annual Entrainment (No. Equivalent Adults)	Annual Impingement Number	Thermal Discharge
y Anchovy	13283×10^6 (22.65×10^6)	87978	abundant in thermal area
lka-Dot Batfish	0.19×10^6	74483	-
gfish	0.76×10^6 (71000)	3697	avoids discharge in warmest months
nfish	18.84×10^6 (84000)	15235	avoids highest Δ T's
lver Perch	21.94×10^6 (6602)	12000	avoids highest Δ T's; utilizes outer plume areas
otted Seatrout	6.5×10^6 (900)	2804	utilizes outer plume areas
ot	14.01×10^6 (690000)	28094	utilizes thermal area
d Drum	0.3×10^6 (18)	8	-
riped Mullet	-	1120	-
ief Squid	0.91×10^6 (3600)	86954	-
nk Shrimp	-	640887	avoids highest Δ T's; utilizes outer plume areas
one Crab	3353.6×10^6	1535	utilizes thermal area
ue Crab	0.36×10^6 (2)	383560	avoids highest Δ T's; utilizes outer plume areas