AB-442

FLORIDA POWER & LIGHT COMPANY

ST. LUCIE PLANT

ANNUAL NON-RADIOLOGICAL

AQUATIC MONITORING REPORT

VOLUME I

1982

APPLIED BIOLOGY, INC.
ATLANTA, GEORGIA
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AQUATIC MONITORING REPORT

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TABLE OF CONVERSION FACTORS FOR METRIC UNITS

To convert	Multiply by	To obtain
centigrade (degrees)	(°C x 1.8) + 32	fahrenheit (degrees)
centigrade (degrees)	°C + 273.18	kelvin (degrees)
centimeters (cm)	3.937×10^{-1}	inches
centimeters (cm)	3.281×10^{-2}	feet
centimeters/second (cm/sec)	3.281×10^{-2}	feet per second
cubic centimeters (cm^3)	1.0×10^{-3}	liters
grams (g)	2.205×10^{-3}	pounds
grams (g)	3.527×10^{-2}	ounces (avoirdupois)
kilograms (kg)	1.0×10^{3}	grams
kilograms (kg)	2.2046	pounds
kilograms (kg)	3.5274×10^{1}	ounces (avoirdupois)
kilometers (km)	6.214×10^{-1}	miles (statute)
kilometers (km)	1.0×10^{6}	millimeters
liters (l)	1.0×10^{3}	cubic centimeters (cm^3)
liters (l)	2.642×10^{-1}	gallons (U.S. liquid)
meters (m)	3.281	feet
meters (m)	3.937×10^{1}	inches
meters (m)	1.094	yards
microns (˜)	1.0×10^{-6}	meters
milligrams (mg)	1.0×10^{-3}	grams
milligrams/liter (mg/l)	1.0	parts per million
milliliters (ml)	1.0×10^{-3}	liters (U.S. liquid)
millimeters (mm)	3.937×10^{-2}	inches
millimeters (mm)	3.281×10^{-3}	feet
square centimeters (cm^2)	1.550×10^{-1}	square inches
square meters (m^2)	1.076×10^{1}	square feet
square millimeters (mm^2)	1.55×10^{3}	square inches

EXECUTIVE SUMMARY

INTRODUCTION

This document is the seventh consecutive annual report on biotic monitoring at the Florida Power & Light Company St. Lucie Plant. These reports have been prepared in response to the United States Nuclear Regulatory Commission's Environmental Technical Specifications found in Appendix B to Operating License No. DPR-67 and, beginning in 1982, to the United States Environmental Protection Agency's National Pollutant Discharge Elimination System Permit Number FL0002208.

The St. Lucie Plant is an electric generating station on Hutchinson Island in St. Lucie County, Florida. The plant consists of two nuclear-fueled 850-MW units; Unit 1 was placed on-line in March 1976 and Unit 2 is scheduled to be placed in operation in the summer of 1983. Both units are designed to withdraw condenser cooling water from, and discharge warmed water into, the Atlantic Ocean. The objective of the regulatory requirements, and of the study, is to assess the effects of plant construction and operation on the major biotic communities in the nearshore marine environment at the plant site.

NEKTON

Studies showed that fish were not accumulating in the intake canal and that, compared to the number of fish collected at the ocean intake structures, the number entrapped in the intake canal was low. This low entrapment was attributed to the velocity caps at the ocean intakes.

There were no significant differences in the numbers of fish collected by gill netting among ocean intake and discharge stations. Generally, more fish were found at intake than at discharge locations. Large numbers of fish were found during only part of the year, which showed that the intake and discharge structures were not important enough as fish attractants to offset natural fish movements and/or migratory instincts.

Gill netting and trawling at ocean Stations 0 through 5 were deleted from the biotic monitoring program in May 1982. Differences in the numbers of fish collected among these stations during the years of study have been attributed primarily to the chance occurrence of highly motile schooling species and to the distance of the stations from shore. The numbers of fish collected by beach seining, deleted from the program in 1982, have been similar among stations. No detrimental effects of the thermal plume on fish, including the commercially important migratory species, have been observed by any of these study methods.

Ichthyoplankton sampling also was deleted from the monitoring program in May 1982. The most common larval fishes found over the years of study have been herrings and anchovies, which are primarily forage species abundant in the St. Lucie area. Differences in ichthyoplankton densities among ocean stations were attributed to station locations relative to distance from shore and to natural year-to-year and seasonal variations. The amount of ichthyoplankton entrained was a very small percentage of that occurring near the plant and was not considered to be of significant environmental concern.

MACROINVERTEBRATES

The NPDES program initiated during 1982 was designed, in part, to provide background information on macroinvertebrate communities adjacent to the St. Lucie Plant prior to the activation of Unit 2. Two major habitats each supporting a unique assemblage of macroinvertebrates were identified. Communities inhabiting the sandy sediments of the relatively shallow beach terrace exhibited lower densities, lower species richness, lower biomass and lower diversities than those communities inhabiting the deeper shellhash sediments. Seasonal shifts in the relative abundances of constituent species occurred within the benthic assemblages in both habitats.

During 1982, thermal effluents previously emerging from the Y-port diffuser on the beach terrace were diverted through a new multi-port diffuser extending farther offshore. Communities in both major habitats were potentially affected. Statistical analyses of data indicated that on the beach terrace, there was no detectable plant effect on densities, species richness or diversities. Within the shellhash environment, one of two stations immediately adjacent to the multi-port diffuser displayed significantly lower densities and species richness than a comparable control station. Sediment instability associated with pipe construction and/or discharge turbulence, rather than elevated temperatures, is thought to have been responsible for the observed differences. Plant operations appear to affect only those stations in very close proximity to the discharge pipes when only Unit 1 is operating.

PHYTOPLANKTON

Seasonal variations in phytoplankton densities during the years of biotic monitoring were typical of natural cycles and did not show adverse effects resulting from power plant operation. Data suggested, however, that plant operation altered phytoplankton composition in the discharge canal during certain seasons by decreasing or increasing the densities of some taxa. Phytoplankton densities and chlorophyll-a were higher in the canals than in the ocean. The most probable effect in the ocean of plant operation was phytoplankton enrichment at the ocean discharge. However, phytoplankton standing crop was also higher at the control station than at other ocean stations. The similarity in standing crop at the control and discharge stations suggested that nearshore habitat conditions are as important as plant-related effects in determining phytoplankton standing crop at the ocean discharge station. Phytoplankton monitoring was deleted in May 1982.

ZOOPLANKTON

The zooplankton composition off Hutchinson Island has not changed substantially over the years of study. Zooplankton densities, however, were generally higher at the ocean discharge station than at other ocean stations. The higher density at the discharge station was associated with an increase in phytoplankton standing crop at the same location, so plant operation may have had an indirect effect on the zooplankton at the ocean discharge. Plant entrainment directly affected zooplankton by decreasing the number of zooplankton in the discharge canal as compared to the number in the intake canal. Zooplankton monitoring was deleted in May 1982.

ROPHYTES

Attached macrophytic growth at all stations in the study area was limited primarily by the lack of suitable substrates; thus, the importance of this biotic community as a contributor to primary productivity was minimal. Seasonal trends in algal diversity were noted, but no plant related effects were observed. Macrophyte monitoring was deleted in May 1982.

WATER QUALITY

No statistically significant differences were found among the ocean stations for measurements of selected physical parameters. Concentrations of nutrients in the nearshore environment adjacent to the plant were dispersed homogeneously but varied with the time of the year. There have been some differences in nutrient values observed over the years, but these differences have not been related to plant operation. Water quality monitoring was deleted in May 1982.

TURTLES

There have been considerable year-to-year fluctuations in sea turtle nesting activity on Hutchinson Island since monitoring began in 1971. In the vicinity of the plant, low nesting activity in 1975, 1981 and 1982 was attributed to construction of plant intake and discharge systems. Nesting returned to normal levels following construction in 1975 and is expected to do so again when present construction activities are completed. No relationship between total nesting on the island and power plant operation or intake/discharge construction was indicated.

Forty-four loggerhead turtle nests were relocated from the plant intake construction area in 1982. The mean hatch success for these relocated nests was high (77.3 percent), but lower than that for undisturbed nests.

Since intake canal monitoring began in May 1976, 778 turtles have been removed. from the intake canal. Differences in the numbers of turtles found during different years and different months were attributed to natural variations in the occurrence of turtles in the vicinity of the plant, rather than to any influence of the plant itself.

The majority (90 percent) of the turtles removed from the intake canal were captured alive and released back into the ocean. The cause of death for those turtles found dead in the canal was, for the most part, unknown. Evidence did not suggest that drowning or injury sustained from passage through the intake pipes were significant mortality factors. The poor condition of many turtles found alive in the canal suggested the possibility that some individuals, already in poor condition, may have entered the ocean intakes seeking refuge and died in the intake canal from causes unrelated to plant operations.

Based on size, most of the turtles captured from the intake canal were sub-adults. The majority (81 percent) of the turtles released alive were considered to be in good or excellent physical condition, while 19 percent were found in poor condition. Capture/recapture studies showed that turtles that entered the intake canal were captured and released

within a relatively short time span (average of 10.3 days) and, while in the canal, body weights did not change appreciably.

A. INTRODUCTION

BACKGROUND

This document has been prepared in response to the United States Nuclear Regulatory Commission's Environmental Technical Specifications found in Appendix B to Operating License No. DPR-67, and to the United States Environmental Protection Agency's National Pollutant Discharge Elimination System Permit Number FL0002208.

Florida Power & Light Company (FPL) was issued Permit No. CPPR-74 by the United States Atomic Energy Commission, now the Nuclear Regulatory Commission (NRC), in 1970 that allowed construction of Unit 1 of the St. Lucie Plant, an 850-MW nuclear-powered electric generating station on Hutchinson Island in St. Lucie County, Florida. St. Lucie Plant Unit 1 was placed on-line in March 1976. Unit 1 operation was intermittent during the remainder of 1976 and, except for brief outages, has been in operation from 1977 through the present time. In May 1977, FPL was issued Permit No. CPPR-144 by the NRC for the construction of a second 850-MW nuclear-powered unit, Unit 2. This is being constructed near Unit 1 and is scheduled to be placed in operation in the summer of 1983.

St. Lucie Plant Units 1 and 2 are designed to withdraw condenser cooling water from, and discharge warmed water into, the Atlantic Ocean. The potential environmental effects resulting from this water use have been and are of concern to both FPL and the regulatory agencies. Because of this concern, FPL has sponsored environmental studies at the site since 1971.

The Florida Department of Natural Resources (DNR) Marine Research Laboratory conducted baseline environmental studies of the marine environment adjacent to the St. Lucie Plant from September 1971 to July 1974. From these studies, a series was published by the Florida DNR entitled Nearshore Marine Ecology at Hutchinson Island, Florida: 1971-1974 (Florida DNR, 1977, 1979). These publications describe the marine environment prior to operation of the St. Lucie Plant.

In order to provide Unit 1 operational and Unit 2 preoperational monitoring of the aquatic environment at the St. Lucie Plant, Applied Biology, Inc. (ABI), was contracted by FPL in 1975 to conduct the ecological studies program. The results and interpretation of the ABI monitoring program conducted from 1976 through 1981 were submitted to FPL in six annual reports. Two of these annual reports were entitled Ecological Monitoring at the Florida Power & Light Co. St. Lucie Plant, Annual Report (ABI, 1977, 1978) and four were entitled Florida Power & Light Company St. Lucie Plant Annual Non-Radiological Environmental Monitoring Report, Biotic Monitoring (ABI, 1979, 1980, 1981a, 1982).

In January 1982, National Pollutant Discharge Elimination System (NPDES) Permit Number FL0002208 was issued to FPL by the U.S. Environmental Protection Agency (EPA). The NPDES permit provides the EPA guidelines for St. Lucie Units 1 and 2 biological studies. In May 1982, the NRC biological study requirements were deleted from the NRC Environmental Technical Specifications. With the exception of those studies related to sea turtles, jurisdiction of biological studies at the St. Lucie Plant

was thus passed from the NRC to the EPA. Jurisdiction for sea turtle studies remains with the NRC, considered to be the Lead Federal Agency relative to consultation under the Endangered Species Act. Sea turtle study guidelines will be included in the NRC St. Lucie Plant Environmental Protection Plan (EPP), when issued for Unit 2.

The biological study plan entitled Proposed St. Lucie Plant Preoperational and Operational Biological Monitoring Program - August 1981 (ABI, 1981b) was approved by the EPA. This plan is to be conducted in accordance with Part III.F. of the NPDES permit, which states:

> Permittee shall continue the approved non-radiological aquatic monitoring program (revised continuation of existing program) which serve as St. Lucie 1 operational and St. Lucie 2 pre-operational and operational. The program will continue for at least two years after Unit 2 begins commercial operation. After this period the program will be evaluated by the Permittee and EPA to assess the continued need or possible deletion and/or modification of the program. Reports shall be submitted annually not later than April 30 of the year following the reporting period.

The six ABI annual reports and physical data gathered on winds (Dames & Moore, 1977), currents (Worth and Hollinger, 1977) and the thermal plume (Envirosphere, 1976) showed that the St. Lucie Plant discharge effects are limited to areas near the point of discharge and that intake effects of concern are limited to sea turtles. The approved study plan (ABI, 1981b) was therefore designed to evaluate the conditions of nektonic and benthic communities in the near-field area of potential plume impact and to monitor sea turtles at the plant and elsewhere along Hutchinson Island.

AREA DESCRIPTION

The St. Lucie Plant is located on a 457-ha site on Hutchinson Island on Florida's east coast (Figures A-1 and A-2). The plant is approximately midway between the Ft. Pierce and St. Lucie Inlets. It is bounded on its east side by the Atlantic Ocean and on its west side by the Indian River, a shallow lagoon.

Hutchinson Island is a barrier island that extends 36 km between inlets and obtains its maximum width of 2 km at the plant site. Elevations approach 5 m atop dunes bordering the beach and decrease to sea level in the mangrove swamps that are common on much of the western side. Island vegetation is typical of southeastern Florida coastal areas; dense stands of Australian pine, palmetto, sea grape and Spanish bayonet inhabit the higher elevations and mangroves abound in the lower elevations and swamps. Large stands of black mangroves, including some on the plant site, have been killed by flooding for mosquito control over past decades.

The ocean bottom immediately offshore from the plant site consists entirely of sand and shell sediments with no reef obstructions or rock outcroppings. The unstable substrate limits the establishment of rooted macrophytes or permanent attached benthic communities. Worm reefs occur in some intertidal areas and provide a substrate more suitable for plant and animal habitation. However, worm reefs are limited both in locations found and area covered.

The Florida Current, which flows parallel to the continental shelf margin, begins to diverge from the coastline at West Palm Beach. At Hutchinson Island, the current is approximately 33 km offshore. Oceanic water associated with the western boundary of the current periodically meanders over the inner shelf, especially during summer months.

PLANT DESCRIPTION

The St. Lucie Plant consists of two 850-MW nuclear-fueled electric generating units (one operational and one nearing completion) that use nearshore ocean waters to cool the plant's condensers. Water for the once-through cooling system enters the plant through three submerged intake structures (two operational and one nearing completion) located about 365 m offshore. Each of the intake structures is equipped with a velocity cap to minimize fish entrapment. Horizontal intake velocities are less than 30 cm/sec. From the intake structures, the water passes through submerged pipes under the beach and dunes that lead to a 1500-m long intake canal. This canal transports the water to the plant. After passing through the plant, the heated water is discharged into a 670-m long canal that leads to two buried discharge pipelines. These pass underneath the dunes and beach and along the ocean floor to the submerged discharges, the first of which is approximately 365 m offshore and 730 m north of the intake.

Heated water leaves the first discharge from a Y-shaped nozzle (diffuser) at a design velocity of 396 cm/sec. This high-momentum jet entrains ambient water resulting in rapid heat dissipation. The ocean

depth in the area of the first discharge is about 6 m. Heated water leaves the second discharge through a series of 48 equally spaced high velocity jets along a 323-m manifold (multiport diffuser). This diffuser starts 168 m beyond the first discharge and terminates 856 m from shore. The ocean depth at discharge along this diffuser is from about 10 to 12 m. As with the first diffuser, the purpose of the second diffuser is to entrain ambient water and rapidly dissipate heat. From the points of discharge at both diffusers, the warmer water rises to the surface and forms a surface plume of heated water. Under normal full-load conditions, the maximum increase in water temperature at the surface seldom exceeds 2.8°C above ambient. The plume then spreads out on the surface of the ocean under the influence of wind and currents and the heat dissipates to the atmosphere.

LITERATURE CITED

ABI (Applied Biology, Inc.) 1977. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1976. Volumes I and II. AB-44. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

__________. 1978. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1977. Volumes I and II. AB-101. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

__________. 1979. Florida Power & Light Company St. Lucie Plant annual non-radiological environmental monitoring report 1978. Volumes II and III, Biotic monitoring. AB-177. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

__________. 1980. Florida Power & Light Company, St. Lucie Plant annual nonradiological environmental monitoring report 1979. Volumes II and III, Biotic monitoring. AB-244. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

__________. 1981a. Florida Power & Light Company, St. Lucie Plant annual non-radiological environment monitoring report 1980. Volumes II and III, Biotic monitoring. AB-324. Prepared by Applied Biology, Inc. Florida Power & Light Co., Miami.

__________. 1981b. Proposed St. Lucie plant preoperational and operational biological monitoring program - August 1981. AB-358. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

__________. 1982. Florida Power & Light Company, St. Lucie Plant annual non-radiological environmental monitoring report 1981. Volumes II and III, Biotic monitoring. AB-379. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

Dames & Moore. 1977. Graphical and tabular wind roses. St. Lucie, Hutchinson Island, Florida, 1973. Report to Florida Power & Light Co., Miami.

Envirosphere. 1976. St. Lucie Plant site ocean current analysis. Report to Florida Power & Light Co., Miami.

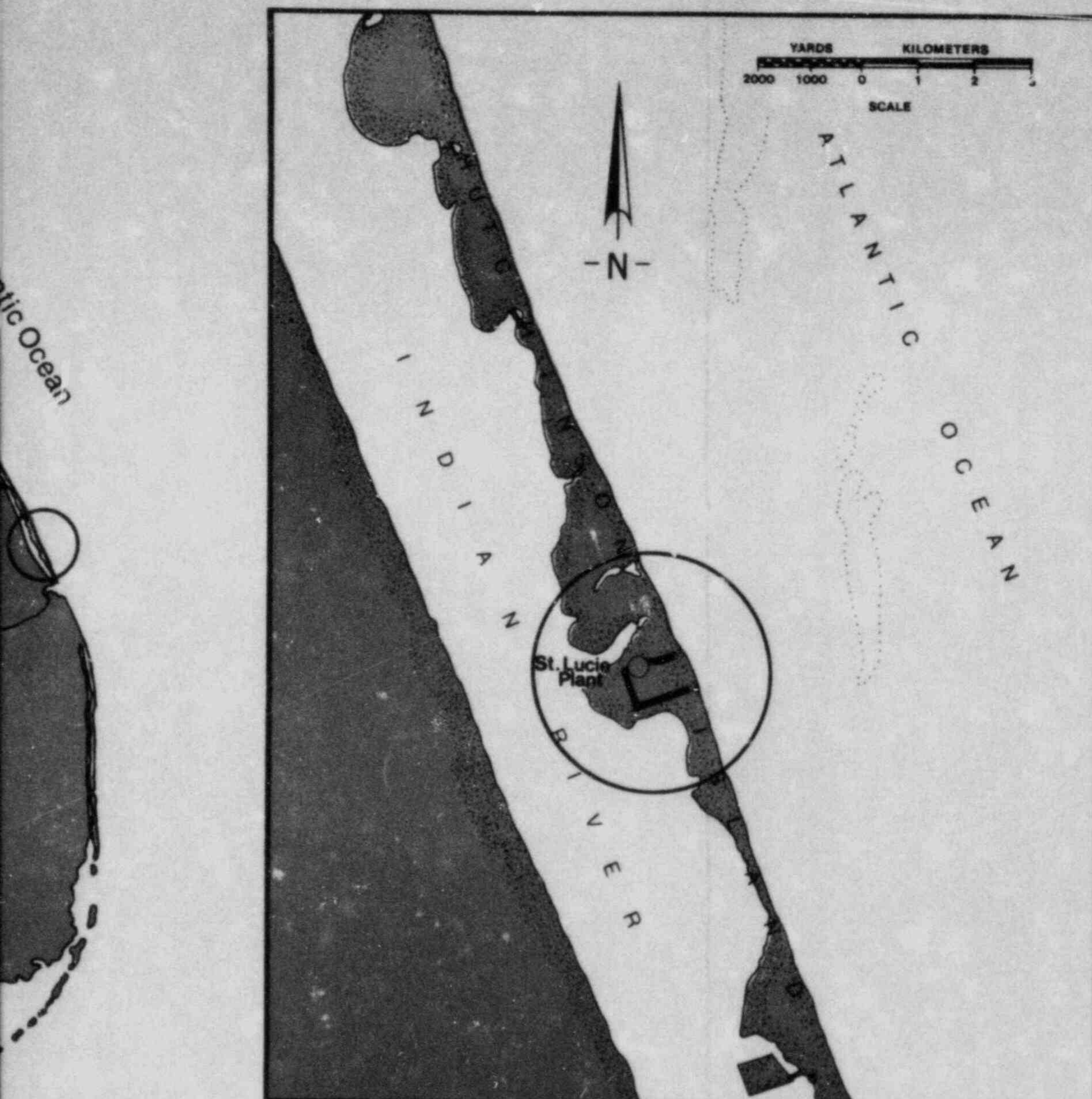
Florida DNR (Department of Natural Resources). 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. Parts I, II and III. Florida Marine Research Publication No. 23; Part IV, Publication No. 24; Part V, Publication No. 25. Florida Department of Natural Resources Marine Research Laboratory.

LITERATURE CITED (continued)

Florida DNR (Department of Natural Resources). 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. Parts VI through X. Florida Marine Research Publication No. 34. Florida Department of Natural Resources Marine Research Laboratory.

Worth, D.F. and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida 1971-1974. III. Physical and chemical environment. Florida Department of Natural Resources Marine Research Laboratory, Florida Marine Research Publication No. 23:25-85.

Figure A-1. Location o



the St. Lucie Plant.

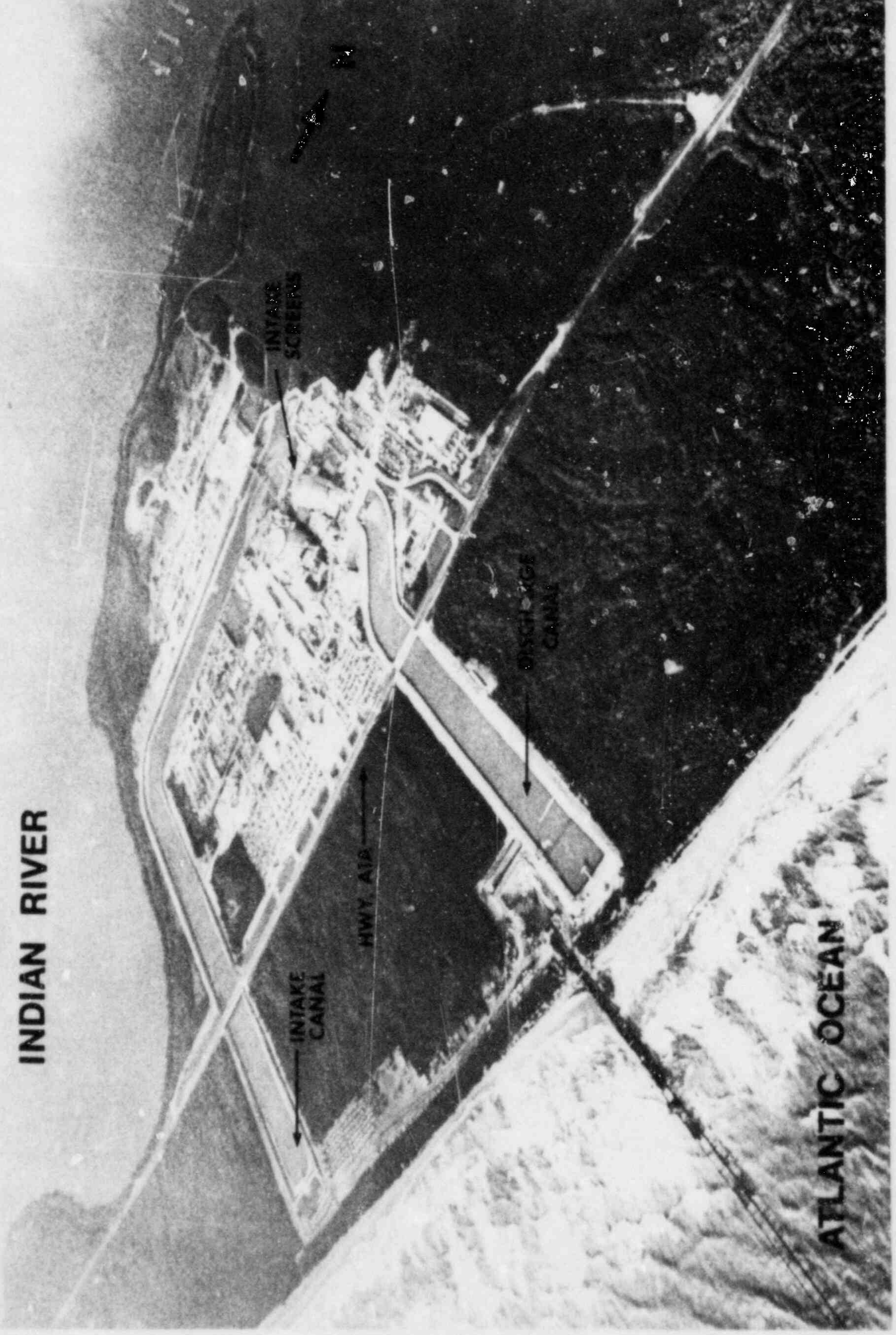


Figure A-2. St. Lucie Plant aerial photograph.

B. NEKTON

NRC Environmental Technical Specifications (Section 3.1.B.c.; deleted May 1982)

> Nektonic Organisms - Samples will be collected monthly by trawling, seining or other suitable method. Types and numbers of organisms present will be determined, including species of migratory fish of commercial and sports fisheries value such as bluefish and mackerel.

NRC Environmental Technical Specification (Section 4.1; deleted May 1982)

> Ichthyoplankton - Samples shall be collected from the intake and discharge canals and a control station at monthly intervals when the unit is in operation to identify the organisms involved, and to attempt to quantify how many of each organism are potentially affected. Biomass measurements, numbers of eggs collected, and numbers and identification of larvae - to the level of major taxonomic groups, if possible - shall be performed. Present "state-of-the-art" information shall be used to attempt to quantify the mortality of the organisms due to entrainment. This program shall determine the seasonal abundance of fish eggs and larvae.

EPA NPDES Permit Required Condition (issued January 1982; as delineated in AB-358 [ABI, 1981a] and approved by the EPA)

> Nektonic Organisms - Samples will be collected by gill netting once per month during April through September and twice per month during October through March. Kind and abundance of organisms present will be determined. Physical measurement will be made at the same time as the nektonic sample collections. Parameters measured will be water temperature, salinity, dissolved oxygen and turbidity.

INTRODUCTION

Fish distribute themselves within the aquatic ecosystem according to their biological limitations and needs. A consequence of this distribution has been the development of fish communities or assemblages that depend on the physical conditions and resources of an area. The aquatic faunal communities off Hutchinson Island are unique because they are transitional between temperate northern faunas and tropical southern faunas. Natural variations in physical conditions, such as seasonal temperature changes or fluctuations in the proximity of the Florida Current to the island's coastline, could cause variations in the composition or abundance of fish in this area. Similarly, although on a much more localized scale, operation of the St. Lucie Plant could affect these fish assemblages.

Applied Biology, Inc. (ABI) began monitoring in December 1975 to examine the composition and abundance of fish near the St. Lucie Plant and to evaluate the habitat, distribution and life history of these fish in terms of plant operation. Monitoring studies were conducted in the intake and discharge canals and in the ocean. Canal samples were taken by gill netting. Samples from the ocean were taken by gill netting, trawling and beach seining. In analyzing canal samples, the emphasis was on the impact on fishes of becoming entrapped in the intake canal. In analyzing ocean samples, the emphasis was on the possible effects of the ocean thermal discharge upon migratory fish of sport and commercial importance. In addition, ichthyoplankton sampling was conducted in the canals to evaluate entrainment effects and in the ocean to evaluate thermal discharge effects.

The data obtained during environmental monitoring were compared among operational study years and between operational study years and preoperational (baseline) study years (ABI, 1977 - 1980, 1981b, 1982). Beginning in 1982, fish monitoring station locations and sampling frequency for ocean gill netting were changed, as delineated in the methods section. These sampling changes enabled a more accurate assessment of fish distribution and abundance in the immediate vicinity of the ocean discharges and intakes. Canal gill netting was retained to monitor fish entrapment in the intake canal. As during other study years, emphasis in 1982 was placed on potential plant effects on the migratory fishes of sport and commercial importance. Trawling, beach seining and ichthyoplankton sampling were deleted from the monitoring program after the May 1982 samples were collected.

MATERIALS AND METHODS

Canal Gill Nets

Monthly gill net collections were taken at two stations in the intake canal to determine if fish were accumulating in the canal because of entrapment. Both stations were located between the Hwy A1A bridge and the plant intake screens (Figure B-1), although exact location varied because of dredging operations in the canal. Sampling was not conducted during 1982 in the discharge canal because the circulating water pumps were not off for any extended period.

The canal gill nets were 61 m long by 3 m deep and were constructed of 76-mm stretch mesh. At each station, a net was set on the bottom and completely spanned the canal. Sampling duration was two consecutive 24-hour periods at each station during each month. After each 24-hour period, fish and shellfish were removed from the nets. Specimens were identified to species, counted, measured to the nearest millimeter and weighed to the nearest gram. Standard length, the distance from the tip of the snout to the base of the tail, was measured for most fish. Total length was measured for sharks and other fishes with indiscernable tail-fin bases. Disk width was measured for rays. Carapace (shell) length was measured for lobsters and carapace width was measured for crabs. The taxonomic nomenclature for fishes is in accordance with Robins et al. (1980).

To facilitate data comparisons, the species data were often summarized by taxon in the text and tables. Taxa are groups of closely related fishes, such as those of the same genus or family.

Ocean Gill Nets

Monthly gill net collections were made from January through May 1982 at each of six ocean stations. Stations 1 through 5 were in the vicinity of the plant and Station 0, the control, was located to the south (Figure B-2). Beginning in February 1982 and continuing through December, gill net collections were taken at Stations F1 and F2 in the vicinity of the ocean intakes, Stations F3 through F7 in the vicinity of the ocean discharges, and at Station C1 further offshore (Figure B-3). These eight

stations were established to enable comparison of fish distribution and abundance 1) in relation to distance from the thermal discharge, 2) between ocean intake and ocean discharge, 3) between ocean intake and intake canal and 4) among years (Stations F3 and C1 were formerly Stations 1 and 2, respectively).

Sampling at Stations F1 through F7 and C1 was conducted once per month during the months of April through September and twice per month during the months of October through March (with the exception of January 1982, which was prior to the start of the new program). The increased sampling frequency in the late fall and winter months coincided with the expected increased abundance of the important migratory fishes in the area.

The ocean gill net was 183 m long by 3.7 m deep and was made up of five 36.6-m panels sewn end-to-end. The mesh sizes of the panels were 64, 74, 84, 97 and 117 mm in stretch lengths. The net was set on the bottom, perpendicular to shore, and fished for 30 minutes at each station. If large numbers of fish were encountered, the net was fished for shorter periods of time and the catch extrapolated to a 30-minute set. Specimens collected by ocean gill netting were analyzed by the same methods described under Canal Gill Nets.

Trawl

Monthly trawl samples were taken at ocean Stations 0 through 5 from January through May 1982 (Figure B-2). One 15-minute tow was made at each station with a 4.9-m semi-balloon bottom trawl of 12.7-mm stretch mesh in the bag and 6.4-mm stretch mesh in the cod end. Towing speed was 2 to 3 knots at each station. To reduce net avoidance by the fish, all trawling was conducted at night. Fish collected by trawling were analyzed by the same methods as described under Canal Gill Nets. Macroinvertebrate samples were obtained concomitant with the fish samples and are discussed in Section C. Macroinvertebrates.

Beach Seine

Beach seining was conducted each month from January through May 1982 at each of three stations: Station 6 north of the discharge, Station 7 between the discharge and intake adjacent to the plant, and Station 8 south of the intake (Figure B-2).

The seine was 30.5 m long by 1.8 m deep with a stretch mesh size of 25 mm. It was heavily weighted along the bottom and had extra flotation along the top to maintain a hanging position under surf conditions. The rolled net was carried out to a depth of approximately 1.2 m, deployed parallel to shore and then pulled onto the beach with the ends perpendicular to shore. Three replicate seine hauls were made at each station during each sampling period. Fish collected by seining were analyzed by the same methods as described under Canal Gill Nets.

Ichthyoplankton

Ichthyoplankton sampling was conducted from January through May 1982 at ocean Stations 0 through 5, Station 11 in the intake canal and Station 12 in the discharge canal (Figure B-2). Ichthyoplankton samples were also collected at an additional ocean station (Station OI), which was established at the ocean intake specifically for ichthyoplankton sampling. Samples were collected twice a month during the daytime using paired 20-cm diameter, 505-μ mesh bongo nets. At each of Stations 0 through 5, nets were towed just below the surface at 3.5 to 4.0 knots for 15 minutes. Mid-depth samples were taken at Station OI in the same manner to sample that parcel of water being drawn into the intake pipe. At Stations 11 and 12, 15-minute step-oblique tows were taken to sample the canal ichthyoplankton population drawn in from ocean waters and circulated through the plant. A digital flowmeter (General Oceanics Model 2030) attached in the mouth of each net enabled calculation of the volume of water filtered.

Ichthyoplankton specimens retained in the cod-end collecting bucket were washed into jars, preserved in 5-percent formalin solution in the field and returned to the laboratory for microscopic analysis. Eggs were counted and their diameters measured. Eggs were not identified to taxon because of the lack of specific egg descriptions in the scientific literature. Larval fishes were identified to the lowest practicable taxon, counted and their total length measured to the nearest tenth of a millimeter. Ichthyoplankton densities were expressed as the number of eggs or fish larvae per cubic meter.

RESULTS AND DISCUSSION

Canal Gill Nets

Intake canal gill netting resulted in the collection of 399 fish during 1982 (Tables B-1 and B-2). Total fish weight recorded was 178 kg; however, this weight included fragments (partially eaten fish) so the undamaged weight would have been somewhat greater. A total of 7 shellfish, weighing 2.5 kg, was also found during intake canal gill netting (Table B-1).

The intake canal gill netting data show that fish were not accumulating there. The average catch rate over the past seven years ranged from 3.5 to 12.5 fish per 30 m of net per day (Figure B-4). Peaks of abundance in 1977 and 1978 (Figure B-4) were primarily caused by influxes of blue runners and crevalle jacks. The average catch rate was highest in 1980 when influxes of spot (a member of the drum family) inflated the average number of fish present. The reasons for relatively high numbers of certain fishes entering the intake on limited occasions are not known. Predation, sampling and other mortality factors have probably prevented any build-up of fishes in the intake canal.

The hardhead catfish, a non-food fish, was the most abundant species found in the intake canal during 1982. It accounted for 23.8 percent of the total number of fishes collected and 17.4 percent of the weight (Table B-1). The porkfish, which was the most abundant species in 1981, was second in abundance in 1982. Based on taxa, catfish were followed in abundance by grunts (that include the porkfish and black margate),

porgies (sheepshead, pinfish and silver porgy), snappers and lesser numbers of other groups (Table B-2). As occurred in previous study years, blue crabs were the predominant shellfish found in 1982 (Table B-1).

Several of the fishes collected in the intake canal were of sport or commercial importance. These included snappers, sheepshead, crevalle jack, drum and mullet. However, the loss to sport or commercial interests was negligible, particularly as compared to the weight of fishes in the commercial landings (Table B-3). The primary commercial fishes in St. Lucie and Martin Counties are Spanish mackerel, king mackerel and bluefish. During the past seven years, only 5 Spanish mackerel, 10 king mackerel and 36 bluefish have been collected in the intake canal. Thus, mackerel and bluefish, which pass Hutchinson Island during seasonal migrations, usually avoid entrapment.

In addition to the wide variations in capture rates over the past seven years (Figure B-4), the taxa represented in the intake canal collections varied considerably (Table B-4). For example, drum were abundant during 1976 and 1980 and less common during the intervening years; jacks were more abundant in 1978 than in either the previous or following years; and catfish accounted for a large proportion of the catch in 1982 for the first time since sampling began. These differences are attributed to natural yearly variations in fish population composition, to the chance occurrence of schooling fishes, and to variations in the total yearly sample sizes from which the percentage compositions

of the taxa are calculated. For all fishes during the seven years combined, grunts accounted for about 20 percent of the gill net catch, followed by snapper, drum, jacks and porgies at 12 to 14 percent, and mullet, catfish and searobin at less than 6 percent (Figure B-5). These fishes are all common offshore Hutchinson Island and were the ones commonly found in the intake canal.

In contrast to the number of fish collected during ocean studies (covered in the next section), the number entrapped in the intake canal was low. This low entrapment is attributed to the velocity caps at the offshore inlets of the intake pipes, which maximize the horizontal flow of water into the intake. Fishes may be entrapped by a downward flow but are more likely to detect and avoid a horizontal flow (Clark and Brownell, 1973).

Ocean Gill Nets

Stations 0 Through 5

A total of 180 fish was collected by gill netting at Stations 0 through 5 during the 5 months these stations were sampled in 1982 (Table B-5). Spanish mackerel composed the largest percentage of the catch, accounting for 43.3 percent of the number of fish and 42.8 percent of the weight.

The largest number of fish at Stations 0 through 5 in 1982 was collected at Station 1 (Table B-6) near the point of discharge. That most fish were found near the discharge was consistent with previous

year's study results. Over the past seven years, 37.2 percent of the fish have been collected at Station 1, 26.1 percent at control Station 0 and 6.4 to 11.5 percent at Stations 2 through 5. Statistically, the catch has been significantly higher at Station 1 than any other station over all years combined and higher at Station 0 than at Stations 2, 3 and 4 ($P \leq 0.05$; ANOVA and Tukey's HSD; 1982 was not included because it was only sampled during 5 months).

Several factors accounted for the observed differences in the number of fish collected among Stations 0 through 5. Some highly motile, often migratory schooling forms were collected by chance as they moved through the area. Other forms, such as forage species and the predators that feed on them, tend to be more abundant near shore. The bottom relief, warmer water and turbulence associated with the ocean discharge pipes probably also attract forage fish and their predators. For these reasons, these fish appeared more frequently at the nearshore stations.

Stations F1 Through F7 and C1

A total of 4152 fish weighing 1529 kg was collected by gill netting at Stations F1 through F7 and C1 during the 11 months these stations were sampled in 1982 (Table B-7). Spanish mackerel composed the largest percentage of the catch, accounting for 25.8 percent of the number of fish and 38.7 percent of the weight. Menhaden, Atlantic bumper and drum (including the spot and Atlantic croaker) followed Spanish mackerel in abundance (Tables B-7 and B-8).

The most fish were collected during December, when the catch averaged 97.6 fish per net set (Figure B-6). Spanish mackerel were particularly abundant in December and composed almost 43 percent of the catch during that month. The fewest fish, average of 2.3 fish per net set, were found during August.

There were no statistically significant differences ($P \leq 0.05$; ANOVA) in the numbers of fish collected among Stations F1 through F7 and C1. Nevertheless, general trends in the distribution and abundance of fish among these stations are apparent. The most fish, 1017 individuals or 24.5 percent of the total, were collected at Station F1, just south of the submerged ocean intake structures (Table B-9; Figure B-7). Station F6, just south of the submerged multi-port diffuser, was second in fish abundance with 714 individuals or 17.2 percent of the total. At both intake structures and multi-port diffuser, more fish were found at the south station than at the north station (F1 compared to F2 and F6 compared to F7; Figure B-7). This trend often occurred on a month-to-month basis (Table B-9), as well as for total fish for the year. The water current along the island is usually unidirectional (to the north) and the majority of the fish were found down-current of the submerged structures. Therefore, the reason for the north-south differences in fish distribution is probably behavioral; that is, based on how fish align with respect to an underwater obstruction in the presence of a current.

Comparison between intake stations (F1 and F2) and discharge stations (F3 through F6) shows that, station for station, more fish occurred

in the area of the intake (Figure B-7). Based on catch-per-unit effort, the average number of fish found per net set was 48 at the two intake stations and 27 at the five discharge stations. Fish are attracted to any structure that stands out from the open bottom or open ocean, as evidenced by the widespread use of artificial reefs to attract and provide habitat for fish and, in turn, concentrate fish for fishermen. At the St. Lucie Plant, it is apparent that fish were attracted to the ocean intake and discharge areas (Figure B-7 and station comparisons among Stations 0 through 5 in previous study years). It is also apparent, however, that large numbers of fish were only in these areas for part of the year (Figure B-6). In other words, fish that were in the area may have been attracted to the intake and discharge structures, but they were not held there and eventually moved on. This has particularly important implications for the migratory species, such as the Spanish mackerel, because it shows that these structures are not important enough as an attractant to offset natural migratory instincts and movements.

The reason for more fish being found in the intake area than the discharge area is probably related to the configurations of the intake and discharge structures. The ocean intakes rise off the bottom to 2.4 m beneath the surface and cover a very limited area (where fish concentrate) relative to the discharge lines and diffusers. The discharge lines run along the bottom and, thus, are low in profile and cover a large area (along which fish disperse) relative to the intake structures.

Stations F3 through F5 were established to enable comparisons of fish abundance at the Y-port diffuser and at two locations potentially influenced by the thermal plume down-current from this diffuser. During most of 1982, however, the Y-port diffuser was not in use (the original Unit 1 discharge line was capped at its point of exit from the discharge canal) and the multi-port diffuser was used instead. Additionally, the heat discharged from the multi-port diffuser dissipated so rapidly that only slight temperature differences were recorded at multi-port diffuser Stations F6 and F7 (Table B-10). No comparisons of fish abundance down-current from the point of discharge could be made for 1982. However, because of the lack of any thermal gradient, it is doubtful if any differences related to thermal conditions existed.

There was an increasing trend in total fishes from Station F3 to F4 to F5 (Figure B-7). However, this trend was inconsistent on a month-to-month basis (Table B-9) and is not considered meaningful.

Water temperature, salinity, dissolved oxygen and turbidity were measured at the same time and location as the ocean gill net samples. With the exception of a few very high turbidity measurements recorded in October and November, little variation was found in these parameters among stations on any given sampling date (Tables B-10 through B-13).

Migratory Fishes

Migratory species of sport and commercial value found during ocean gill netting were Spanish mackerel, king mackerel and bluefish. As previously stated, Spanish mackerel were the most abundant fish collected during 1982. Spanish mackerel migrate north in the spring to spawn during the summer months in the northern part of their range (north of Cape Canaveral on the Atlantic coast) and then migrate south in the fall (Wollam, 1970). Commercial landings of Spanish mackerel in 1977 (the latest data available) in St. Lucie and Martin Counties totaled 4.4 million kg or 89 percent of the entire Florida east coast landings of this species (Table B-3).

During five months of sampling at Stations 0 through 5 in 1982, 57 of the total 78 Spanish mackerel (73 percent) were collected at discharge Station 1 (Table B-6). During the seven years of monitoring at these stations, a total of 1436 Spanish mackerel was collected: 408 at Station 1, 367 at Station 2, 296 at Station 0 and from 77 to 189 at Stations 3-5.

During eleven months of sampling at Stations F1 through F7 and C1 in 1982, a total of 1072 Spanish mackerel was collected. This large number relative to other years is attributed to sampling more stations, sampling more frequently in the winter months, when Spanish mackerel are more abundant, and concentrating sampling effort near shore around the intake and discharge areas. According to commercial fish houses surveyed, the Spanish mackerel landings in 1982 were about average, so the increased

catch during monitoring was not attributed to a strong year among natural yearly fluctuations.

Of the Spanish mackerel collected at Stations F1 through F7 and C1 in 1982, most were found during the winter months (particularly in December) and few were found during the summer (Figure B-6). Based on migration patterns, this seasonal distribution was as expected. Five hundred eighty-two Spanish mackerel (54.3 percent) were found at intake Stations F1 and F2, 253 (23.6 percent) at discharge Stations F3 through F7, and 237 (22.1 percent) at Station C1 located further offshore (Table B-8). Reasons for differences in fish abundance among stations have been previously discussed. In addition, however, with about 22 percent of the Spanish mackerel being found at the furthest offshore station, versus about 7 percent for all other fishes combined, it appears that the intake and discharge areas may be less of an attractant for Spanish mackerel than for other species.

The seasonal migratory habits of king mackerel are similar to those of the Spanish mackerel although king mackerel are usually found further offshore. In addition to its commercial importance (Table B-3), the king mackerel is the most prominent marine fish in the Florida sport fishery (Beaumariage, 1973). Only four king mackerel were found at Stations 0 through 5 during the 5 months sampled in 1982 (Table B-6) and a total of only 75 have been collected during the seven years of monitoring at these stations. During the 11 months Stations F1 through F7 and C1 were sampled in 1982, 34 king mackerel were collected; 22 of these (64.7

percent) were taken at the 2 intake stations (F1 and F2; Table B-8). The majority (76.5 percent) of the king mackerel were found in September and October.

Bluefish occur off the St. Lucie area in the winter and, like Spanish mackerel, are generally found near the shore. They move north during spring and summer (Beaumariage, 1969) and spawn in offshore waters north of Florida in early summer (Deuel et al., 1966). The northward movement of bluefish along the Florida coast is probably part of a spawning migration by that part of the population that extends its winter range into south Florida waters (Moe, 1972). This species is also important in sport and commercial fishing. A total of 396,000 kg was landed commercially in St. Lucie and Martin Counties in 1977 (Table B-3).

Fifteen bluefish were collected in 1982 at Stations 0 through 5; all but one of these fish was found at discharge Station 1 (Table B-6). For all years combined, 60 percent of the total 847 bluefish collected were taken at Station 1. At Stations F1 through F7 and C1, 224 bluefish were collected in 1982. The most bluefish were found in April; none was found in May, June or August (Figure B-6). The relatively high catch in July shown on Figure B-6 was considered unusual because bluefish are uncommon off the island during the summer. As occurred with the other migratory species, the most bluefish (58 percent) were found at the two ocean intake stations (Table B-8).

Other fishes of sport and/or commercial importance, although not considered migratory, also were found during ocean gill netting. They included menhaden, Florida pompano and the drums, such as weakfish, kingfish and spot (Table B-7). As shown by the gill netting results, a high diversity of the larger pelagic fishes occurs offshore Hutchinson Island.

Comparisons Among Study Years

The number of fish collected during ocean gill netting has varied considerably over the past several years. From 1977, the first full year of plant operation, and continuing through 1982, the catch-per-unit-effort has ranged from 15.7 to 54.8 fish per net set at discharge Station 1 (F3) and from 7.9 to 25.3 fish per net set at Station 2 (C1) located further offshore (Figure B-8). Stations 1 (F3) and 2 (C1) were the two locations sampled during all study years. Differences between the two stations are attributed primarily to distance from shore and the probable attractant effect of the Y-port diffuser. Differences among years at either station are attributed primarily to natural annual variations in fish abundance, although heavy clogging of the nets by algae in the summer of 1980 and suspension of operation of the Y-port diffuser during much of 1982 may have been partially the cause of fewer fish being found in those years.

Variations in the taxa of fish making up the catch each year have also been evident (Table B-14). These variations are attributed primarily to the chance occurrence of the highly motile species involved, although natural fluctuations in abundance also would alter the relative

abundance of species. For example, during 1977 the percentage composition for Spanish mackerel (33.3 percent) was higher than that found during any other full study year (Table B-14). Spanish mackerel commercial landings were also higher in 1977 than during the other years. Over 4 million kg were landed in St. Lucie and Martin Counties that year (Table B-3), while only 3.1 million kg were landed in 1976 (NOAA, 1978) and 1.4 million kg in 1975 (NOAA, 1977). This yearly variation in the occurrence of a migratory species could be caused by year-class success, water temperature and current pattern differences, nearshore versus offshore movement of the fish, or other factors. Because of the large size of the study area and the highly motile, often migratory habits of the fishes involved, it is doubtful whether variations in species occurrence or percentage composition in relation to other taxa could be attributed to any plant-related effect.

Trawl

A total of 368 fish weighing 17.6 kg was collected by trawling during the 5 months sampled in 1982 (Table B-15). The leopard searobin, of neither sport nor commercial importance, was the most abundant fish found in 1982. It accounted for 23.9 percent of the total number of fish collected. The pigfish, a member of the grunt family and of some value as a food fish, was the predominant species based on weight (28.2 percent; Table B-15).

The total number of fish per station for the 5 months of 1982 ranged from 47 individuals at Station 3 to 74 at Station 2 (Table B-16). The

number of fish collected by trawling at the different stations has varied considerably over the years of environment l monitoring. However, for the seven years combined, the most fishes (26.0 percent of the total) were collected at Station 1 near the discharge, 19.4 percent were collected at Station 2 and from 12.4 to 15.2 percent were taken at each of the other stations. Over six years of monitoring (1982 was not included because it was only sampled during 5 months), Station 1 had a significantly higher ($P \leq 0.05$; ANOVA and Tukey's HSD) annual mean number of fish collected than Stations 2, 3 or 4. There were no significant differences among other station comparisons.

The percentage composition, or relative abundance, of taxa collected during trawling has varied between the baseline study and subsequent environmental monitoring studies as well as during each operational monitoring study year (Table B-17). [NOTE: The number of fish collected during the baseline study (Table B-17) should not be directly compared to those collected in the operational monitoring studies because stations, sampling frequency and methodology differed.] These differences are attributed to natural yearly variations in fish population composition, to the chance occurrence of schooling fishes and to variations in the total sample sizes from which the percentage compositions of the taxa are calculated. Because no consistent trends are apparent for any particular taxon over the years, it is doubtful that percentage composition differences were related to plant operations.

Beach Seine

A total of 948 fish weighing 7.6 kg was collected by beach seining during the 5 months sampled in 1982 (Table B-18). Sand drum composed 54.2 percent of the total number of fish collected; gulf kingfish composed 62.7 percent of the total weight. The largest number of fish in 1982 was 360 collected at Station 7 adjacent to the plant, followed by 309 at Station 6 north of the plant and 279 at Station 8 south of the intake (Table B-19).

During individual study years, the number of fish collected at each station has varied considerably. For the seven years combined, the most fish (47.0 percent) were found at Station 8, and 25.2 and 27.8 percent were found at Stations 6 and 7, respectively. Exclusive of anchovies, which occurred almost every year but predominated the 1981 catch, the percentages of fish collected at each station over the seven years combined were similar (30.9 to 38.0 percent). Differences among mean numbers of fish collected annually at each station were not statistically significant ($P \leq 0.05$; ANOVA; exclusive of 1982).

Several of the species collected during beach seining are of sport or commercial value, but the only species of major economic value was Florida pompano. During the five months of 1982, 58 pompano were collected; 333 pompano have been found during the seven years of operational monitoring. Of these 333 pompano, 140 were found north of the plant, 109 were adjacent to the plant and 84 were south of the plant. The significance, if any, of this north-south trend is unknown.

Based on the numbers of individuals collected by beach seining, anchovies, herring, sand drum and kingfish have been the predominant taxa collected during baseline and operational studies at the St. Lucie Plant (Table B-20). Most of the differences in relative abundance among years are attributed to the chance occurrences of schooling species in the catch. To illustrate, the herring found at Station 6 in July 1976 accounted for 40 percent of all fishes collected by beach seining in 1976, and the anchovies, which were so abundant during the baseline study, were almost all found on only two occasions during that study. It is unlikely that these occurrences were related to any plant-induced effects. [NOTE: The number of fish collected during the baseline study (Table B-20) should not be directly compared to numbers from subsequent operational monitoring studies because sampling frequency and methodology differed.]

Ichthyoplankton

Ocean Stations

Ichthyoplankton was sampled twice per month for the first 5 months of 1982. Mean density of fish eggs at ocean Stations 0 through 5 during this time ranged from 1.9 to 16.0/m^3 (Table B-21). The lowest mean density of eggs was found at discharge Station 1, while high densities were found at Stations 2 and 3 further offshore. Statistical analysis conducted during previous years showed that differences in egg densities appeared to be related to the location of the stations relative to the shore: stations located further offshore (2 through 5) often had significantly higher egg densities than those stations (0 and 1) located inshore over the beach terrace (ABI, 1982).

Mean density of fish larvae at ocean Stations 0 through 5 during 1982 ranged from 0.5 to 1.5/m^3 (Table B-21). Relatively low mean densities of larvae were found at Stations 2 through 5 and the highest density was found at Station 1. During previous monitoring, larval densities at Station 1 were significantly higher than at the other stations in 1978, but there were no significant differences among stations during any of the other years (ABI, 1982). The most abundant fishes found during 1982 were herrings and anchovies (Table B-22), primarily forage fish and the taxon which was also the most abundant during previous study years.

Fish eggs were found year-round during each study year off the St. Lucie Plant; maximum densities generally occurred during the spring or summer (Figure B-9; ABI, 1982). Most of these eggs were probably herrings and anchovies, based on the relative composition of the fish larvae. Fish larvae were also found throughout the year during each study year. The highest larval densities also generally occurred during the spring and summer (Figure B-9). The majority of the larvae found during operational monitoring was herrings and anchovies. Blennies, gobies, mojarras, drums and jacks also were common in samples collected during each year. Mackerel larvae have been found only occasionally during ichthyoplankton monitoring and no bluefish larvae have been found. In general, the composition of the larval populations in the St. Lucie Plant area has not changed appreciably over the years of environmental monitoring.

Collections specifically for ichthyoplankton were not made during the baseline study in 1971-1973. Therefore, fish eggs and larvae collected in conjunction with baseline and operational zooplankton sampling were compared. Mean (arithmetic) ichthyoplankton density decreased from $39.0/m^3$ during the baseline study to $6.8/m^3$ during the 1976 operational study, increased to $35.4/m^3$ during 1978, and then decreased again to $17.3/m^3$ in 1981 (Table B-23; ABI, 1982). These data are very limited, but suggest cyclic variations in the offshore ichthyoplankton populations.

Entrainment

The mean density of fish eggs during 1982 was $2.3/m^3$ at intake canal Station 11 and $2.8/m^3$ at discharge canal Station 12 (Table B-21). The mean density of larvae was less than $0.1/m^3$ at both the intake and discharge canals ($0.018/m^3$ and $0.013/m^3$, respectively). In general, egg and larval densities were lower in the discharge canal than in the intake canal from 1977 through 1981, reflecting egg and larval mortality from passage through the plant (ABI, 1982).

Mean densities of eggs and larvae in the intake canal were lower than the mean densities found in the ocean during 1977 through 1981 (ABI, 1982). Two factors may explain the lower concentration of eggs and larvae in the intake canal as compared to surface densities found at ocean stations. First, the intake pipe draws cooling water from a lower depth where eggs and larvae are not as abundant as in surface areas and, secondly, mortality may be occurring from mechanical damage or predation during passage through the pipe or in the intake canal.

Statistical analysis showed that ocean intake Station OI (specifically established for ichthyoplankton sampling at the ocean intake) was at a depth relatively depauperate in ichthyoplankton (ABI, 1982). This finding, however, only partially explained the occurrence of low larval densities in the intake canal because the density of larvae at ocean intake Station OI was still considerably higher than the mean density of larvae at intake canal Station 11. It thus appeared that the lower larval densities in the intake canal primarily resulted from loss to mechanical injuries incurred during passage through the intake pipe and/or to predation. Mortalities from mechanical injury are likely because most of the larval fish collected from the intake canal were damaged. Predation is also likely because barnacles that inhabit the inside surface of the intake pipe, and fish that aggregate where the water from the intake pipe first enters the intake canal, probably prey heavily on larvae passing through the pipe and entering the canal.

To put the impact of entrainment into perspective with ichthyoplankton populations in ocean waters, it was necessary to define an offshore boundary for the region from which ichthyoplankton is potentially drawn. Station 3 was selected as this boundary, and fish egg and larval populations beyond this point were assumed to be unaffected by plant operation. The distance between the designated offshore boundary and the shoreline is approximately 3500 m and the average depth is 9.2 m. These dimensions yield a cross-sectional area of 32,200 m^2. The near-surface ichthyoplankton tows sampled populations to a depth of about 3 m. Because stratification of ichthyoplankton could lead to erroneous popula-

tion estimates, an additional calculation was made based on the 3-m depth; this produced a 10,500 m^2 cross-sectional area. The average current velocity in this region, with a prevailing direction to the north, is 0.17 m/sec (Envirosphere, 1977; Worth and Hollinger, 1977). Current velocity multiplied by each of the cross-sectional areas provides the following figures for the volume of water flowing past the plant: 5474 m^3/sec assuming an area of 32,200 m^2 and 1785 m^3/sec assuming an area of 10,500 m^2.

Using these volume figures and the technique developed by Goodyear (1977), it was possible to estimate the percentage of fish eggs and larvae entrained as they drift past the plant. The percentage loss estimates for 1976 through 1981 for fish eggs or larvae were usually less than 1 percent of the egg and larval populations within the ocean boundary, assuming that mean densities of eggs and larvae in the ocean differ from those in the intake canal ($mC_p/C_r \neq 1$; Table B-24). The percentage loss estimates were higher if it was assumed that ocean and intake canal mean egg and larval densities were equal ($mC_p/C_r = 1$). The highest percentage loss (1.81 percent; Table B-24) was calculated using this latter assumption. Because the percentage loss estimates for eggs and larvae were a small portion of the ichthyoplankton occurring near the plant, ichthyoplankton entrainment was not considered to be of significant environmental concern.

SUMMARY

Environmental monitoring at the St. Lucie Plant has been conducted to examine fish composition and abundance and to evaluate the local habitat, distribution and life history of these fish in terms of plant operation. Results of these studies have been presented in a series of six annual environmental monitoring reports. Beginning in February 1982, gill netting was intensified in the immediate vicinity of the plant to enable a more accurate assessment of fish distribution and abundance at the ocean discharges and intakes. Trawl, beach seine and ichthyoplankton study components were deleted from the monitoring program following the May 1982 sampling.

The intake canal gill netting data showed that fish were not accumulating there and that, compared to the number of fish collected at the ocean intake structures, the number entrapped in the intake canal was low. This low entrapment is attributed to the velocity caps at the ocean intakes. These appeared very effective in enabling fish to avoid being drawn into the intake pipes. Several of the fishes collected in the intake canal, such as snappers, sheepshead, drum and mullet, were species of sport and commercial importance. However, the loss of these fishes to sport or commercial interests was negligible considering the low numbers encountered. It is particularly noteworthy that the important migratory fishes usually avoid entrapment (only 15 mackerel and 36 bluefish have been collected in the past seven years).

During the intensified ocean gill netting program, there were no statistically significant differences in the numbers of fish collected among stations in the vicinity of the plant. However, general trends in the distribution and abundance of fish among these stations were apparent. More fish occurred at the intake stations than at the discharge stations, probably resulting from the different configurations of the intake and discharge structures. It was apparent that fish were attracted to both ocean intake and discharge structures. However, concentrations of fish in these areas only occurred during part of the year, which showed that fish were not held there and eventually moved on. This has particularly important implications for the migratory species, such as the Spanish mackerel, because it shows that these structures are not important enough as an attractant to offset natural migratory instincts and movements.

Sampling by gill netting and trawling at ocean Stations 0-5 (deleted in May 1982) generally yielded more fish at the discharge and control locations during the years of biotic monitoring than were obtained at other locations. Differences in the number of fish collected among these stations were attributed primarily to the chance occurrence of highly motile schooling species and to the distance of stations from shore. No detrimental effects of the thermal plume on fish, including the commercially important migratory species, could be discerned from the distribution and number of fish collected. The number of fish collected at each station by beach seining (also deleted in May 1982) varied considerably during each study year. However, excluding anchovies, which dominated

the 1981 catch, the numbers of fish at each station for all years combined were similar. None of the differences in species represented or their relative percentage composition could be attributed to plant operation.

Ichthyoplankton monitoring (deleted in May 1982) showed that fish eggs and larvae were generally abundant during the spring and summer of each year. The most common larval fishes were herrings and anchovies, which are primarily forage species abundant in the St. Lucie area. Mackerel larvae have been found only occasionally during ichthyoplankton sampling and no bluefish larvae have been found. Differences in ichthyoplankton densities among ocean stations were attributed to station locations relative to distance from shore and to natural year-to-year and seasonal variations. The average densities of ichthyoplankton found in the intake canal were lower than those found at the ocean stations, primarily because of mechanical injuries incurred during passage through the intake pipe and to predation in the intake. The amount of ichthyoplankton entrained was a very small portion of the ichthyoplankton population occurring near the St. Lucie Plant and, therefore, not considered of significant environmental concern.

LITERATURE CITED

ABI (Applied Biology, Inc.). 1977. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1976. Volume 1. AB-44. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1978. Ecological monitoring at the Florida Power & Light Company, St. Lucie Plant, annual report 1977. Volume 1. AB-101. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1979. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1978. Volume II, Biotic monitoring. AB-177. Prepared by Applied Biology, Inc. for Florida Power & Light Co. Miami.

____________________. 1980. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1979. Volumes II and III, Biotic monitoring. AB-244. Prepared by Applied Biology, Inc. for Florida Power & Light Co. Miami.

____________________. 1981a. Proposed St. Lucie Plant preoperational and operational biological monitoring program. August 1981. AB-358. Prepared by Applied Biology, Inc. for Florida Power & Light Co. Miami.

____________________. 1981b. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1980. Volume II, Biotic monitoring. AB-324. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1982. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1981. Volume II, Biotic monitoring. AB-379. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

Beaumariage, D.S. 1969. Returns from the 1965 Schlitz tagging program including a cumulative analysis of previous results. Florida Department of Natural Resources Marine Laboratory, Technical Series No. 59. 39 pp. (from Moe, 1972).

______________. 1973. Age, growth, and reproduction of king mackerel *Scomberomorus cavalla*, in Florida. Florida Department of Natural Resources Marine Laboratory, Publication No. 1. 45 pp.

Clark, J. and W. Brownell. 1973. Electric power plants in the coastal zone: environmental issues. American Littoral Society, Special Publication No. 7, Highlands, N.J.

LITERATURE CITED (continued)

Deuel, D.G., J.R. Clark and A.J. Mansueti. 1966. Description of embryonic and early larval stages of bluefish, Pomatomus saltatrix. Transactions American Fisheries Society 95(3):264-271.

Envirosphere. 1977. Predicted thermal plumes for elevated discharge temperatures, St. Lucie Unit 1. Draft report prepared for Florida Power & Light Co., Miami.

Futch, C.R. and S.E. Dwinell. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. IV. Lancelets and fishes. Florida Department of Natural Resources Marine Research Laboratory, Florida Marine Research Publication No. 24. 23 pp.

Goodyear, C.P. 1977. Mathematical methods to evaluate entrainment of aquatic organisms by power plants. FWS/OCS-76/20.3. U.S. Department of the Interior Fish and Wildlife Service. Topical Briefs: Fish and Wildlife Resources and Electric Power Generation, No. 3. 17 pp.

Moe, M.A., Jr. 1972. Movement and migration of south Florida fishes. Florida Department of Natural Resources Marine Research Laboratory, Technical Series No. 69. 25 pp.

NOAA (National Oceanic and Atmospheric Administration). 1977. Florida landings, annual summary 1975. NOAA, National Marine Fishery Service, Current Fisheries Statistics No. 6919. 12 pp.

____________________. 1978. Florida landings, annual summary 1976. NOAA, National Marine Fishery Service, Current Fisheries Statistics No. 7219. 13 pp.

____________________. 1980. Florida landings, annual summary 1977. NOAA, National Marine Fishery Service, Current Fisheries Statistics No. 7517. 14 pp.

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lee and W.B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada, 4th ed. American Fisheries Society, Special Publication No. 12. 174 pp.

Walker, L.M., B.M. Glass and B.S. Roberts. 1979. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. VIII. Zooplankton, 1971-1973. Florida Department of Natural Resources Marine Research Laboratory, Florida Marine Research Publication No. 34: 62-98.

LITERATURE CITED (continued)

Wollam, M.B. 1970. Description and distribution of larvae and early juveniles of king mackerel, *Scomberomorus cavalla* (Cuvier), and Spanish mackerel, *Scomberomorus maculatus* (Mitchill); (Pisces: Scombridae); in the western North Atlantic. Florida Department of Natural Resources Marine Research Laboratory, Technical Series No. 61. 35 pp.

Worth, D.F. and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. Part III. Physical and chemical environment. Florida Department of Natural Resources Marine Research Laboratory, Florida Marine Research Publication No. 23:25-85.

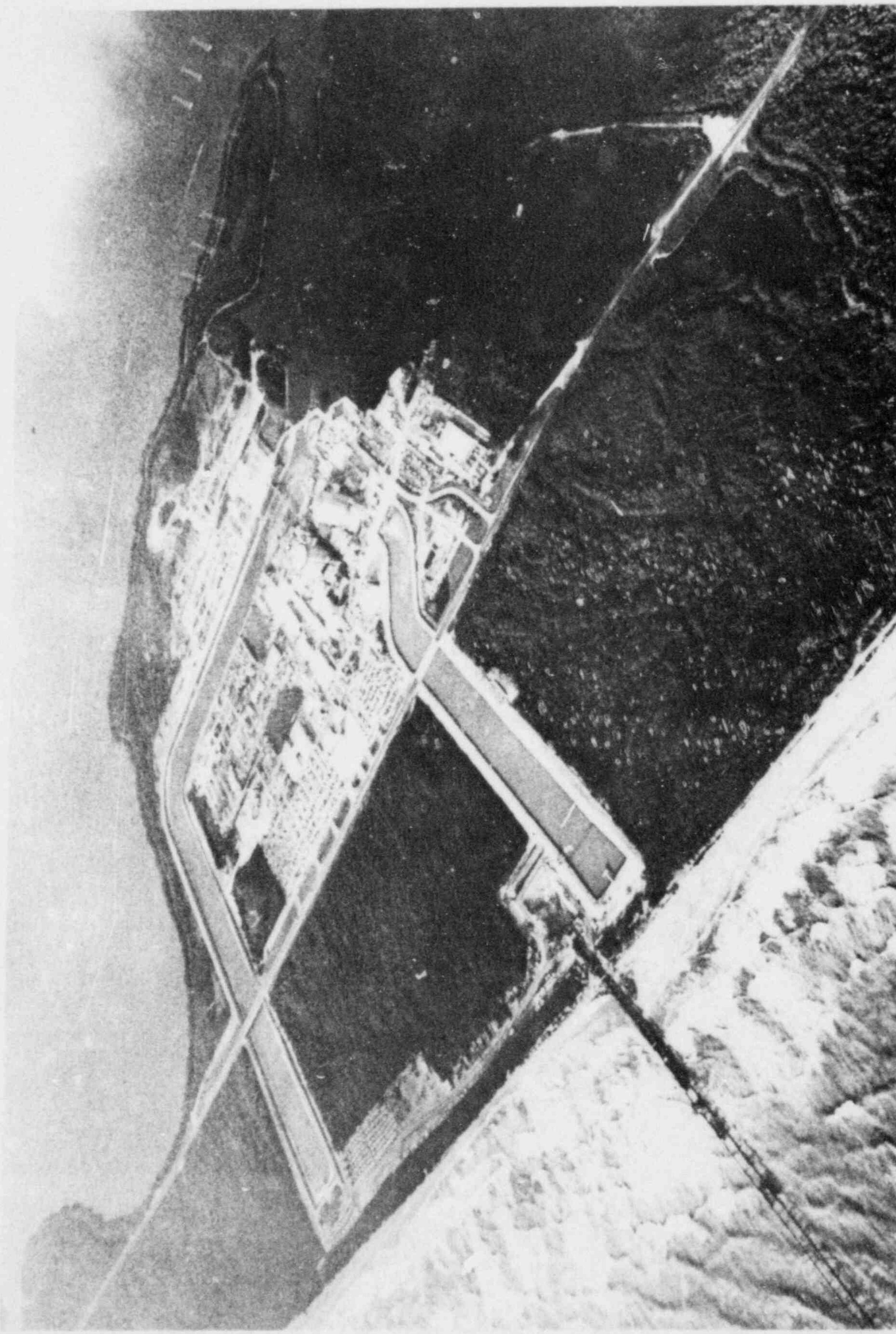


Figure B-1. St. Lucie Plant aerial photograph.

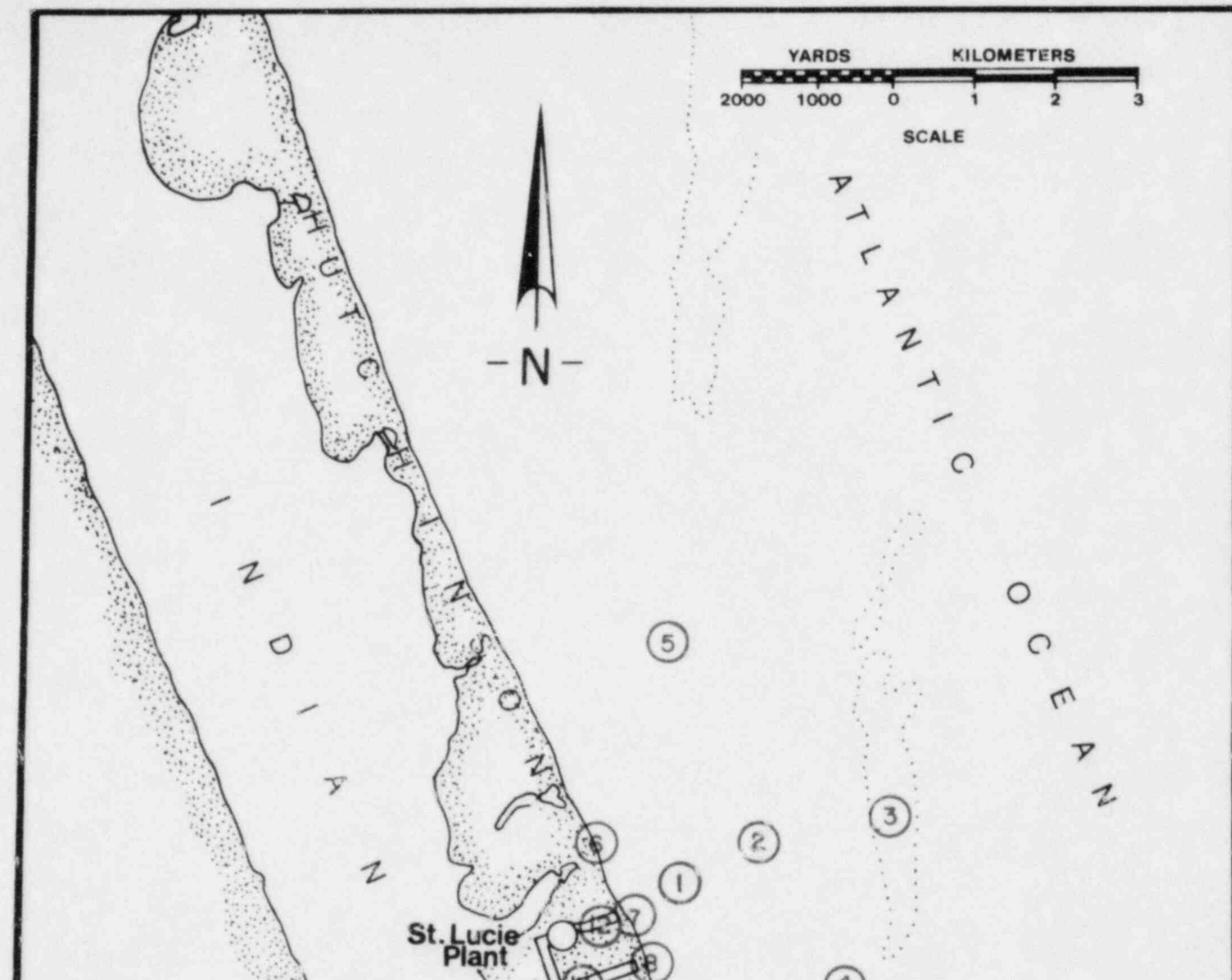


Figure B-2. Fish sampling station designations and locations, St. Lucie Plant non-radiological environmental monitoring, March 1976 - May 1982.

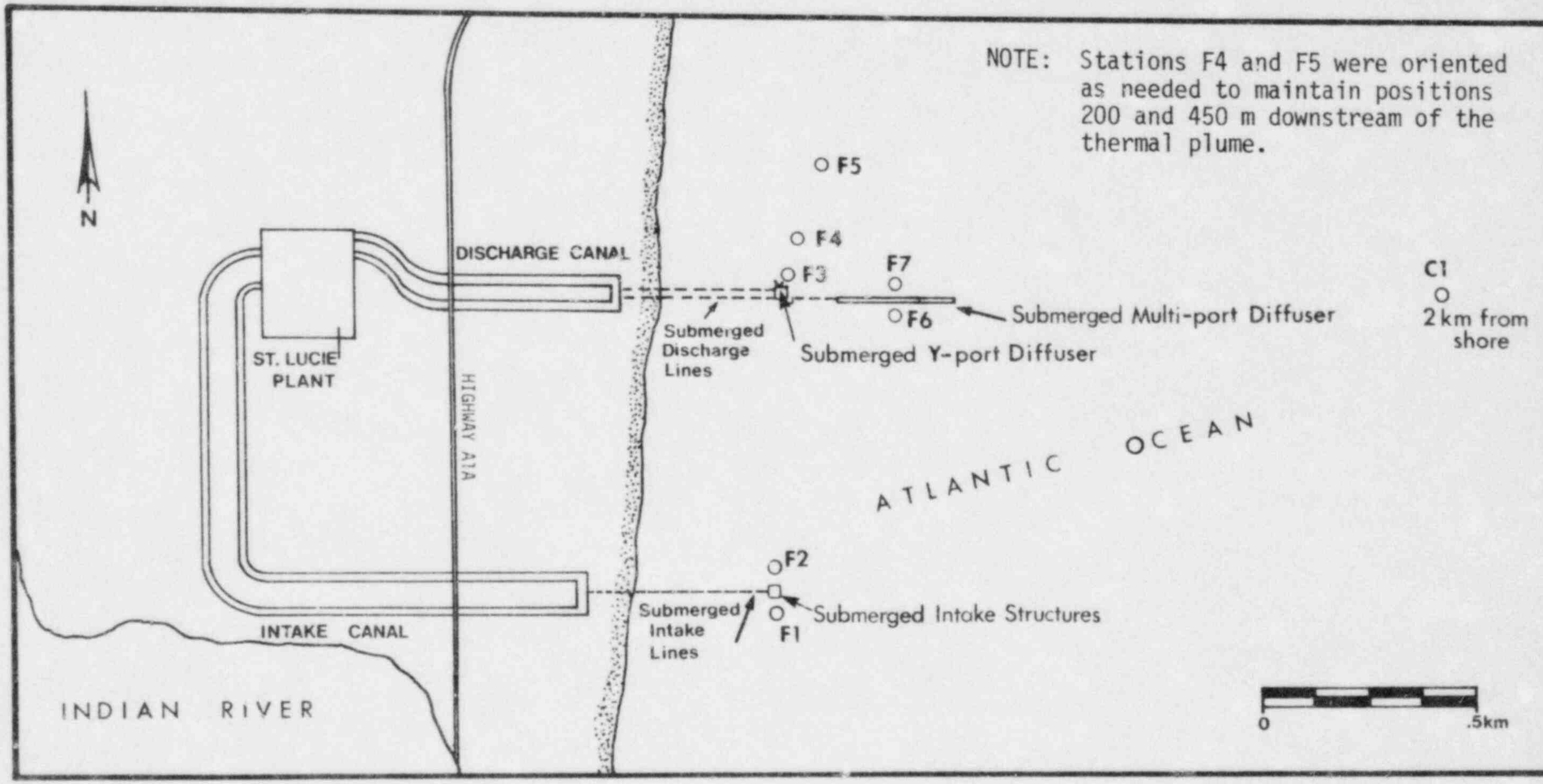


Figure B-3. Fish sampling station designations and locations, St. Lucie Plant non-radiological environmental monitoring, February - December 1982.

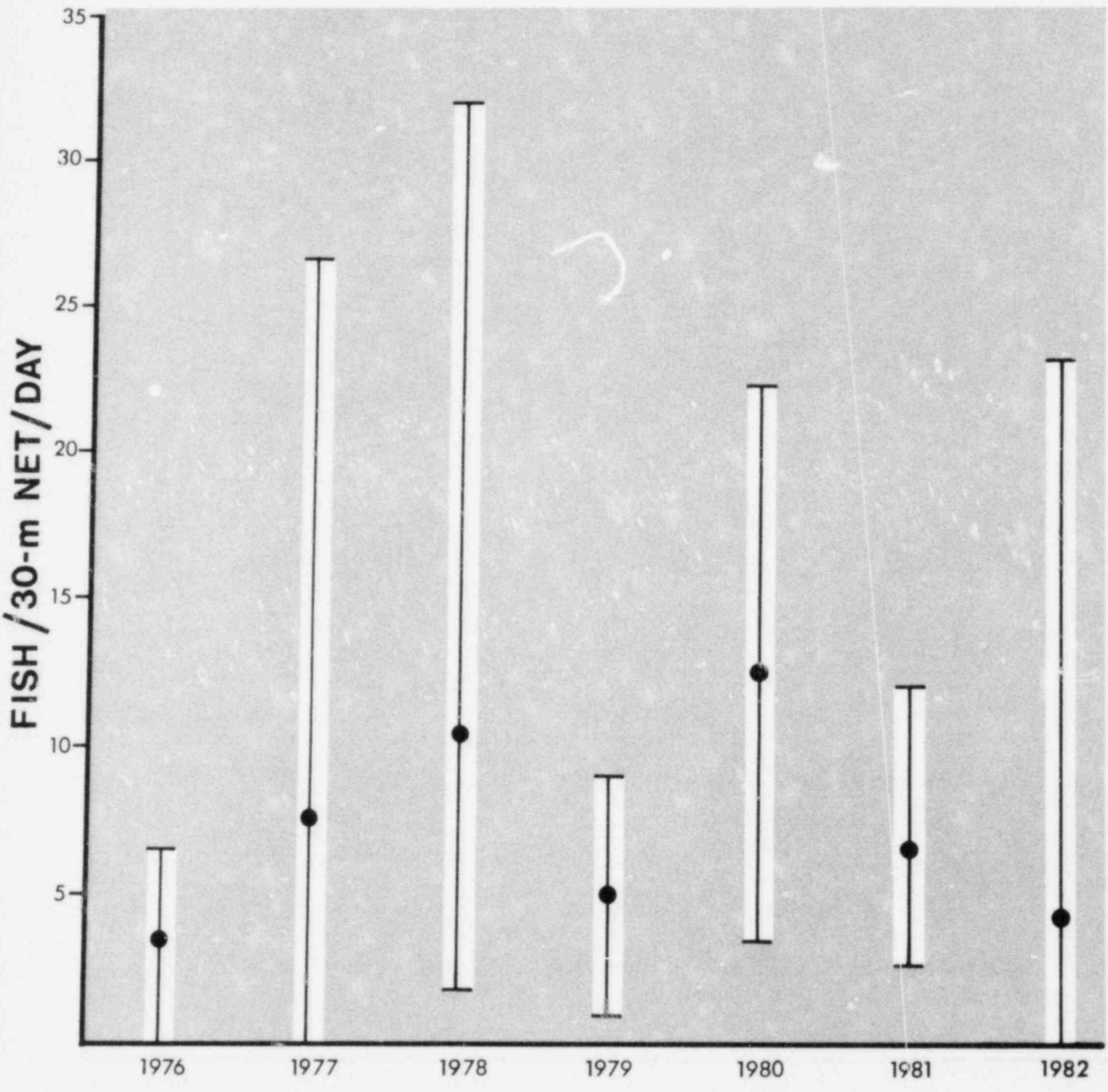


Figure B-4. Range and mean number of fish collected per 30 m of gill net per day in the intake canal, St. Lucie Plant, 1976-1982.

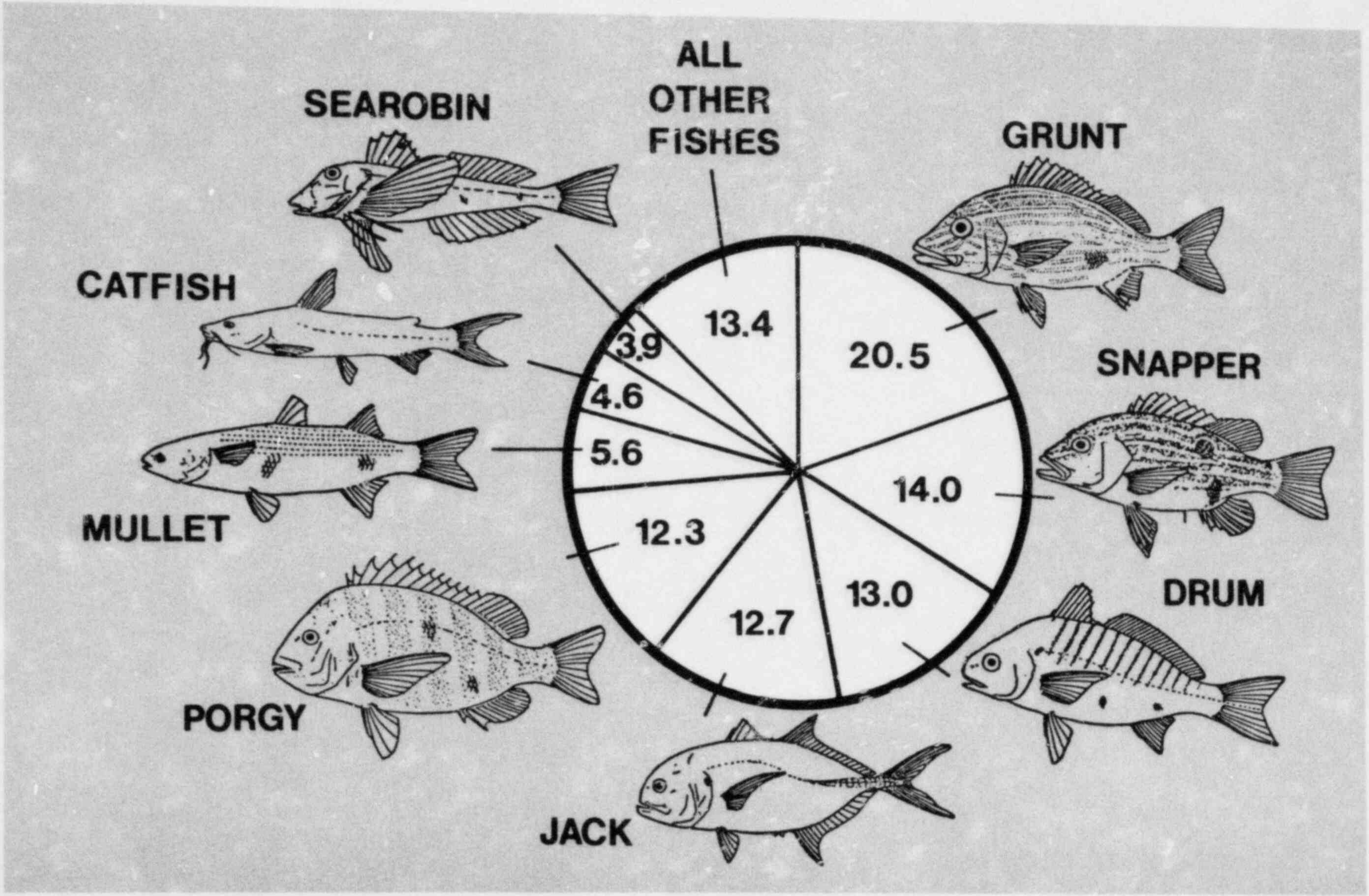


Figure B-5. Percentage composition by number of fishes collected by gill nets in the intake canal, St. Lucie Plant, 1976-1982.

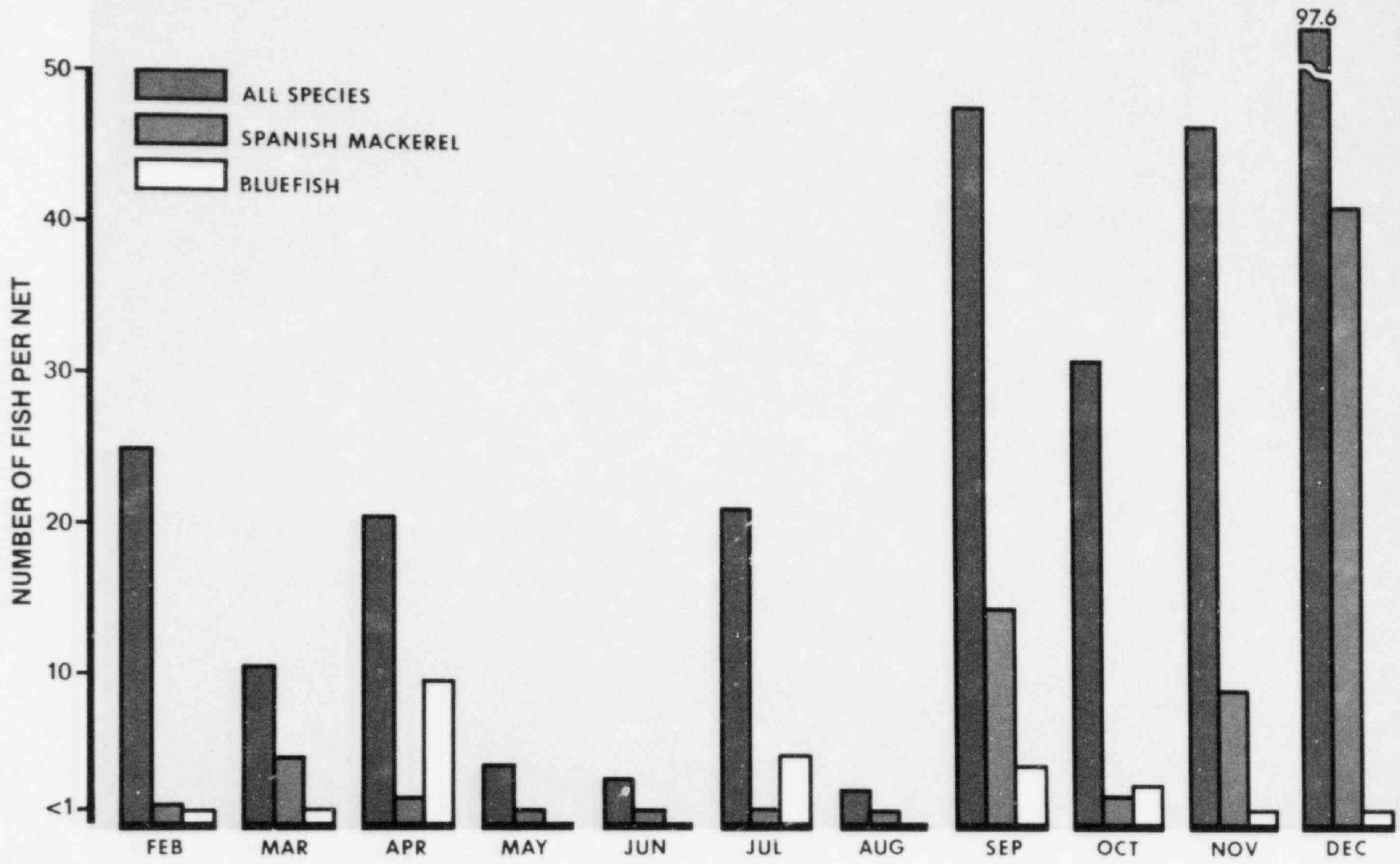


Figure B-6. Mean number of fish collected per net per month by gill netting at ocean Stations F1 through F7 and C1, St. Lucie Plant, February - December 1982.

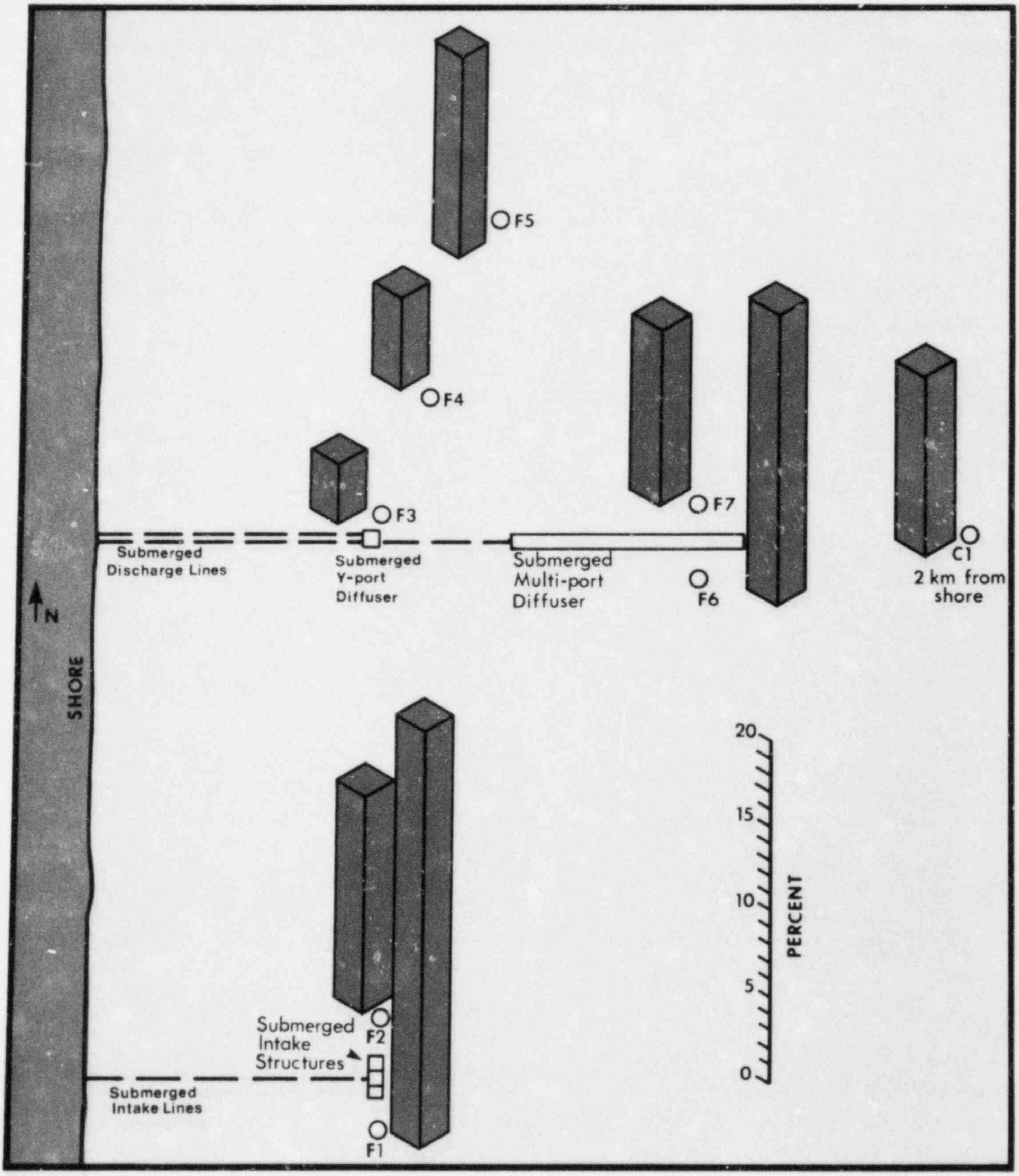


Figure B-7. Percentage by number of fishes collected by gill netting at ocean stations, St. Lucie Plant, February - December 1982.

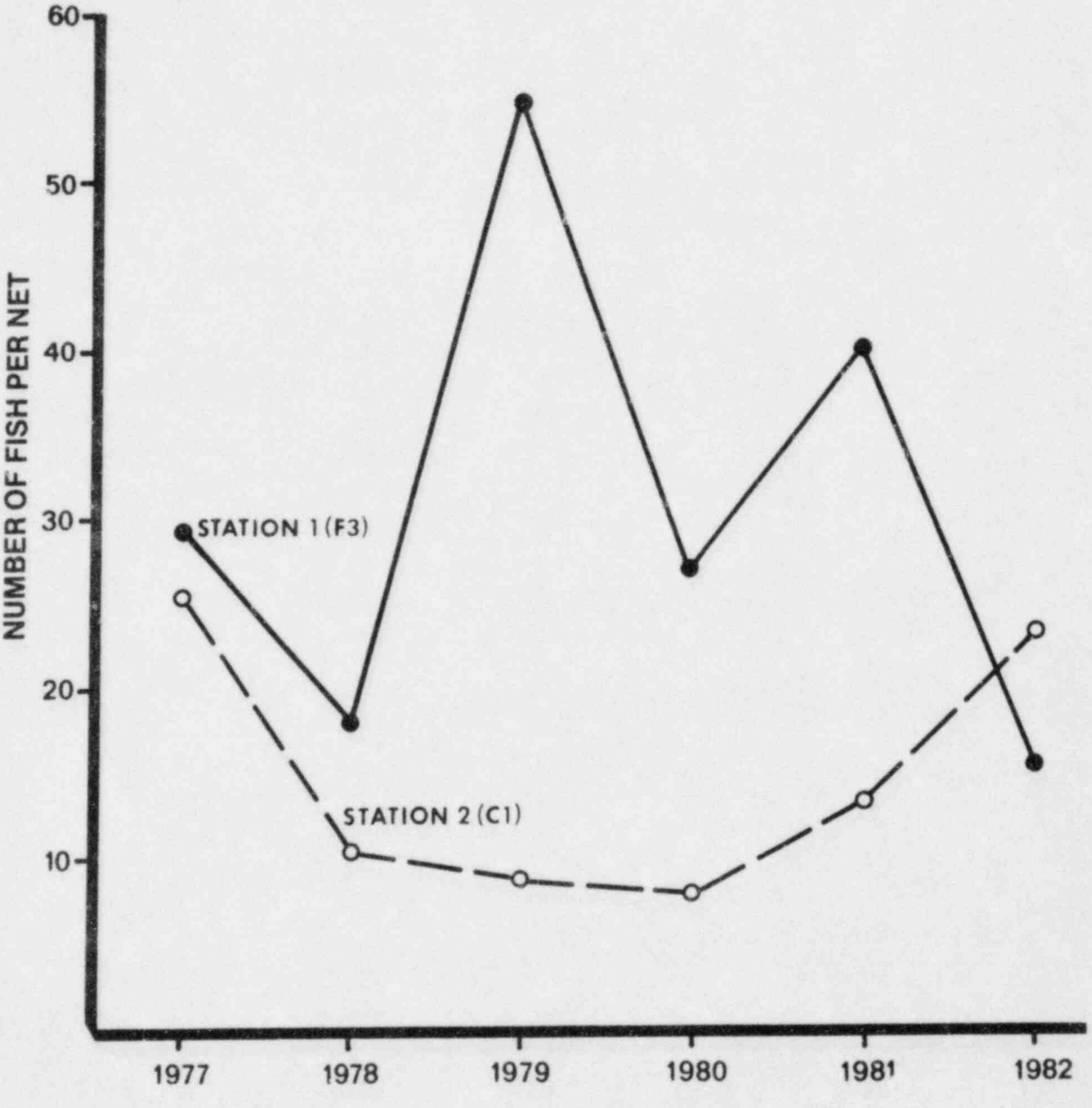


Figure B-8. Mean number of fish collected per net per year at ocean Stations 1 (F3) and 2 (C1), St. Lucie Plant, 1977-1982.

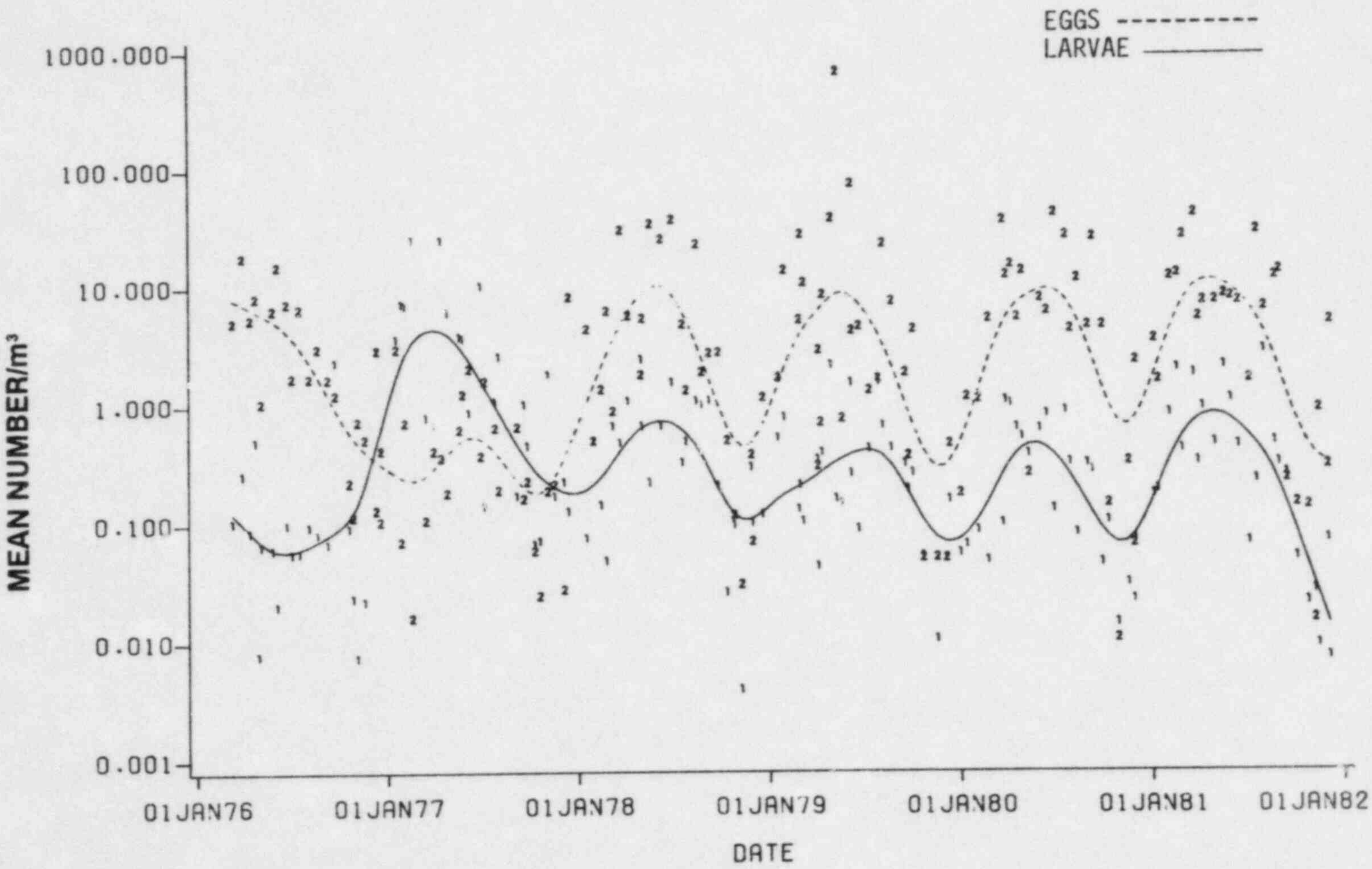


Figure B-9. Smoothed mean densities of fish eggs and larvae at Stations 0 through 5, St. Lucie Plant, March 1976 - December 1981 (ABI, 1982).

TABLE B-1

NUMBER, SIZE AND PERCENTAGE COMPOSITION OF SHELLFISHES AND FISHES
COLLECTED BY GILL NETTING AT INTAKE CANAL STATIONS
ST. LUCIE PLANT
1982

Species	Number of individuals	Range of standard lengths (mm)	Total weight (g)	Percentage composition: Number of individuals	Percentage composition: Total weight
blue crab	4	140-153	644	57.1	25.6
spiny lobster	3	71-100	1872	42.9	74.4
Total	7	-	2516	100.0	100.0
hardhead catfish	95	193-325	31,095[a]	23.8	17.4
porkfish	43	132-244	10,807	10.8	6.1
lane snapper	40	188-277	12,148	10.0	6.8
silver porgy	33	139-256	10,380	8.3	5.8
black margate	32	133-374	13,559[a]	8.0	7.6
spotted scorpionfish	21	149-222	6,657	5.3	3.7
sheepshead	20	180-356	16,533	5.0	9.3
crevalle jack	18	187-320	6,197	4.5	3.5
white mullet	16	260-368	8,497	4.0	4.8
striped mullet	9	295-335	5,604	2.3	3.1
irish pompano	9	140-243	3,369	2.3	1.9
gray snapper	7	210-288	2,803[a]	1.8	1.6
sailor's choice	7	179-243	2,337	1.8	1.3
pinfish	6	237-300	4,204	1.5	2.4
sea bream	6	222-244	2,867	1.5	1.6
white grunt	5	209-287	2,477	1.3	1.4
sand drum	4	234-260	1,099[a]	1.0	0.6
Atlantic spadefish	3	211-229	2,032	0.8	1.1
pigfish	3	240-262	1,330	0.8	0.7
Atlantic croaker	3	231-254	755	0.8	0.4
nurse shark	2	900-1200[b]	17,000[b]	0.5	9.5
southern flounder	2	307-380	1,745	0.5	1.0
blue runner	2	255-357	1,221	0.5	0.7
yellowfin mojarra	2	229-252	892	0.5	0.5
blackwing searobin	2	173-243	391	0.5	0.2
snook	1	720	5,575	0.2	3.2
southern stingray	1	415	3,650	0.2	2.1
great barracuda	1	494	991	0.2	0.6
tarpon snook	1	302	489	0.2	0.3
schoolmaster	1	236	457	0.2	0.3
bluestriped grunt	1	236	406	0.2	0.2
spot	1	247	400	0.2	0.2
sharksucker	1	216	155	0.2	<0.1
silver jenny	1	97	25	0.2	<0.1
Total	399	-	178,247	99.9[c]	100.0

[a] Includes one or more fragments.

[b] Estimated; released alive in ocean.

[c] Fraction lost in rounding.

TABLE B-2

NUMBER OF FISHES COLLECTED PER MONTH BY GILL NETTING[a] AT INTAKE CANAL STATIONS
ST. LUCIE PLANT
1982

Taxon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep[b]	Oct	Nov	Dec	Total by taxon	Percentage composition
catfish	1			11	26	3	3		2	39	3	7	95	23.8
grunt	4	2	2	10	4	2	1		4	46	3	13	91	22.8
porgy		2	2	11	1	1			4	12	9	23	65	16.3
snapper	4	2		7	6	2	2		3	17	3	2	48	12.0
mullet	1	1	2	1	14				1	4		1	25	6.3
scorpionfish, searobin		1								11	5	6	23	5.8
jack		10	2	2						2		4	20	5.0
mojarra		2	1	3	2		1			2		1	12	3.0
drum				2								6	8	2.0
other fish	1			2			2				1	6	12	3.0
Total	11	20	9	49	53	8	9	0[c]	14	133	24	69	399	100.0

[a]Four 24-hour net sets per month.

[b]Two net sets in September.

[c]Nets clogged with algae.

TABLE B-3

COMMERCIAL FISHERY LANDINGS FOR ST. LUCIE COUNTY, MARTIN COUNTY AND THE FLORIDA EAST COAST 1977[a]

Species[b]	St. Lucie County	Martin County	Florida East Coast
	Commercial catch (kg)		
amberjack	15,221	4,140	28,930
bluefish	145,333	250,457	622,791
catfish, sea	0	8,060	22,263
crevalle (jacks)	6,963	13,956	41,710
croaker	1,418	12,526	22,423
dolphin	6,743	145	31,102
drum, black	1,824	12,656	58,034
goatfish	449	33,781	46,875
groupers and scamp	24,375	7,247	364,595
herring, thread	0	22,680	22,680
king mackerel	898,948	26,452	1,775,748
king whiting (kingfish)	8,911	20,231	326,059
menhaden	10,603	28,778	5,794,867
mullet, black (striped)	170,754	134,082	1,265,153
mullet, silver (white)	9,306	3,081	64,228
pompano	32,536	75,478	201,596
sand perch (mojarra)	4,201	36,024	50,239
sea trout, spotted	25,448	3,844	223,986
sheepshead	10,550	45,658	112,334
snapper, mangrove	12,968	3,721	45,810
Spanish mackerel	2,334,137	2,100,765	4,983,786
spot	83,266	34,753	466,760
swordfish	35,932	596	51,454
tilefish	5,846	307	21,655
unclassified, food	24,700	16,072	102,218
unclassified, misc.	7	25,387	55,460
other fish[c]	33,326	24,120	1,325,321
Total	3,903,765	2,944,997	18,128,077

[a]NOAA, 1980. Publication of <u>Florida Landings</u> has since been discontinued.

[b]Species in which over 4536 kg (10,000 lb) were landed in either St. Lucie or Martin Counties.

[c]Species in which less than 4536 kg (10,000 lb) were landed in both St. Lucie and Martin Counties.

TABLE B-4

NUMBER AND PERCENTAGE COMPOSITION OF FISHES COLLECTED
BY GILL NETTING AT INTAKE CANAL STATIONS DURING ENVIRONMENTAL MONITORING
ST. LUCIE PLANT
1976 - 1982

Taxon	1976		1977		1978		1979	
	Number of fishes	Percentage composition	Number of fishes	Percentage composition	Number of fishes	Percentage composition	Number of fishes	Percentage composition
drum	111	25.0	23	5.7	33	2.3	27	4.1
mullet	90	20.3	28	7.0	103	7.1	6	0.9
grunt	63	14.2	41	10.2	309	21.2	96	14.5
snapper	62	14.0	49	12.2	244	16.7	151	22.9
jack	37	8.3	56	14.0	336	23.1	70	10.6
scorpionfish, searobin	16	3.6	8	2.0	92	6.3	23	3.5
porgy	11	2.5	47	11.7	103	7.1	172	26.0
mojarra	10	2.3	3	0.8	18	1.2	28	4.2
spadefish	2	0.4	84	21.0	57	3.9	6	0.9
shark, ray	2	0.4	34	8.5	23	1.6	14	2.1
catfish	0	0.0	1	0.2	64	4.4	20	3.0
other fish	40	9.0	27	6.7	73	5.1	48	7.3
Total	444	100.0	401	100.0	1455	100.0	661	100.0
Meters of net fished	5670	-	3292	-	4267	-	4389	-

TABLE CONTINUED

TABLE B-4
(continued)
NUMBER AND PERCENTAGE COMPOSITION OF FISHES COLLECTED
BY GILL NETTING AT INTAKE CANAL STATIONS DURING ENVIRONMENTAL MONITORING
ST. LUCIE PLANT
1976 - 1982

Taxon	1980		1981		1982		Total	
	Number of fishes	Percentage composition	Number of fishes	Percentage composition	Number of fishes	Percentage composition	Number of fishes	Percentage composition
drum	485	32.3	59	6.5	8	2.0	746	13.0
mullet	19	1.3	52	5.8	25	6.3	323	5.6
grunt	283	18.8	299	33.1	91	22.8	1182	20.5
snapper	136	9.1	118	13.1	48	12.0	808	14.0
jack	106	7.1	109	12.1	20	5.0	734	12.7
scorpionfish, searobin	50	3.3	13	1.4	23	5.8	225	3.9
porgy	197	13.1	114	12.6	65	16.3	709	12.3
mojarra	38	2.5	34	3.8	12	3.0	143	2.5
spadefish	17	1.1	22	2.4	3	0.8	191	3.3
shark, ray	66	4.4	3	0.3	3	0.7	145	2.5
catfish	40	2.7	46	5.1	95	23.8	266	4.6
other fish	64	4.3	34	3.8	6	1.5	292	5.1
Total	1501	100.0	903	100.0	399	100.0	5764	100.0
Meters of net fished	4389	-	4145	-	2760	-	28912	-

TABLE B-5

NUMBER, SIZE AND PERCENTAGE COMPOSITION OF FISHES
COLLECTED BY GILL NETTING AT OCEAN STATIONS 0-5
ST. LUCIE PLANT
JANUARY - MAY 1982

Species	Number of individuals	Range of standard lengths (mm)	Total weight (g)	Percentage composition	
				Number of individuals	Total weight
Spanish mackeral	78	355-610	41,438	43.3	42.8
hardhead catfish	18	217-288	5,241	10.0	5.4
bluefish	15	278-419	12,542	8.3	13.0
blue runner	15	228-311	5,985	8.3	6.2
banded rudderfish	7	320-352	5,462	3.9	5.6
sharksucker	4	449-774	5,905	2.2	6.1
king mackerel	4	439-675	5,018	2.2	5.2
Atlantic sharpnose shark	4	500-600	3,078	2.2	3.2
spot	4	183-192	609	2.2	0.6
gafftopsail catfish	3	285-390	1,950	1.7	2.0
yellowfin menhaden	3	280-289	1,552	1.7	1.6
pigfish	3	195-214	643	1.7	0.7
Atlantic bumper	3	183-207	352	1.7	0.4
weakfish	2	309-314	943	1.1	1.0
knobbed porgy	2	171-192	489	1.1	0.5
sand drum	2	184-210	370	1.1	0.4
banded drum	2	169-191	314	1.1	0.3
Atlantic thread herring	2	145-154	118	1.1	0.1
Atlantic manta	1	~3000	-[a]	0.6	-
cobia	1	510	1,800	0.6	1.9
ladyfish	1	423	766	0.6	0.8
sheepshead	1	277	760	0.6	0.8
Florida pompano	1	270	620	0.6	0.6
pinfish	1	239	405	0.6	0.4
Atlantic spadefish	1	160	241	0.6	0.2
silver jenny	1	156	128	0.6	0.1
butterfish	1	126	65	0.6	0.1
Total	180	-	96,794	100.3[b]	100.0

[a] Released in the water, not weighed.

[b] Fraction gained in rounding.

TABLE B-6

NUMBER OF FISHES COLLECTED BY GILL NETTING AT OCEAN STATIONS 0-5[a]
ST. LUCIE PLANT
JANUARY - MAY 1982

Taxon	Total by station 0	1	2	3	4	5	Total by taxon	Percentage composition
Spanish mackerel	7	57	8	1	-	5	78	43.3
catfish	5	9	2	-	5	-	21	11.7
bluefish	1	14	-	-	-	-	15	8.3
blue runner	6	4	-	-	2	3	15	8.3
drum	-	10	-	-	-	-	10	5.6
king mackerel	-	1	-	2	-	1	4	2.2
shark	-	-	1	-	1	2	4	2.2
Atlantic bumper	-	3	-	-	-	-	3	1.7
menhaden	3	-	-	-	-	-	3	1.7
other fish	5	14	1	1	3	3	27	15.0
Total	27	112	12	4	11	14	180	100.0

[a]One 30-minute set per station per month.

TABLE B-7

NUMBER, SIZE AND PERCENTAGE COMPOSITION OF FISHES COLLECTED
BY GILL NETTING AT OCEAN STATIONS F1 THROUGH F7 AND C1
ST. LUCIE PLANT
FEBRUARY - DECEMBER 1982

Species	Number of individuals	Range of standard lengths (mm)	Total weight (g)	Percentage composition: Number of individuals	Percentage composition: Total weight
Spanish mackerel	1072	251-601	592,542	25.8	38.7
yellowfin menhaden	651	183-292	196,411	15.7	12.8
Atlantic bumper	474	107-236	37,726	11.4	2.5
spot	388	148-224	61,108	9.3	4.0
blue runner	241	192-337	96,284	5.8	6.3
bluefish	224	233-413	130,479	5.4	8.5
crevalle jack	212	133-553	83,405	5.1	5.5
Atlantic croaker	191	162-245	32,438	4.6	2.1
Atlantic menhaden	122	198-292	39,193	2.9	2.6
banded drum	65	153-207	11,258	1.6	0.7
Atlantic cutlassfish	59	615-994	24,681	1.4	1.6
ladyfish	55	227-523	39,216	1.3	2.6
southern kingfish	46	228-389	16,298	1.1	1.1
weakfish	40	242-386	14,674	1.0	1.0
king mackerel	34	323-530	15,812	0.8	1.0
silver seatrout	31	239-436	11,913	0.7	0.8
gafftopsail catfish	25	187-332	8,091	0.6	0.5
Atlantic thread herring	22	142-193	2,310	0.5	0.2
Florida pompano	20	127-313	5,933	0.5	0.4
hardhead catfish	19	188-275	4,664	0.5	0.3
sand drum	18	164-360	4,216	0.4	0.3
scalloped hammerhead	17	670-822	35,758	0.4	2.3
bonnethead	16	374-1010	22,063	0.4	1.4
leatherjacket	15	220-256	2,267	0.4	0.1
Atlantic moonfish	13	139-212	1,783	0.3	0.1
pigfish	10	161-204	1,939	0.2	0.1
Atlantic sharpnose shark	9	498-814	8,664	0.2	0.6
porkfish	7	134-204	1,354	0.2	<0.1
bigeye scad	6	194-215	1,074	0.1	<0.1
Irish pompano	6	157-172	843	0.1	<0.1
scaled sardine	5	144-156	392	0.1	<0.1
gulf kingfish	4	235-278	1,129	<0.1	<0.1
horse-eye jack	4	151-177	484	<0.1	<0.1
finetooth shark	3	727-924	9,902	<0.1	0.6
cobia	3	347-536	3,044	<0.1	0.2
lookdown	3	131-137	262	<0.1	<0.1
permit	2	328-368	3,025	<0.1	0.2
guaguanche	2	435-436	1,348	<0.1	<0.1
striped croaker	2	181-182	334	<0.1	<0.1
sharksucker	1	514	685	<0.1	<0.1
bullnose ray	1	385	680	<0.1	<0.1
banded rudderfish	1	321	641	<0.1	<0.1
gray snapper	1	278	620	<0.1	<0.1
sheepshead	1	223	442	<0.1	<0.1
northern kingfish	1	290	437	<0.1	<0.1
African pompano	1	204	259	<0.1	<0.1
unicorn filefish	1	234	239	<0.1	<0.1
scrawled cowfish	1	267	205	<0.1	<0.1
spotted scorpionfish	1	148	137	<0.1	<0.1
pinfish	1	161	123	<0.1	<0.1
dusky flounder	1	191	117	<0.1	<0.1
butterfish	1	151	95	<0.1	<0.1
redear sardine	1	152	81	<0.1	<0.1
silver perch	1	141	55	<0.1	<0.1
blackwing searobin	1	136	51	<0.1	<0.1
Total	4152	-	1,529,404	100.0	100.0

TABLE B-8

NUMBER OF FISHES COLLECTED BY GILL NETTING AT
OCEAN STATIONS F1 THROUGH F7 AND C1
ST. LUCIE PLANT
FEBRUARY - DECEMBER 1982

Taxon	Total by station								Total by taxon	Percentage composition
	F1	F2	F3	F4	F5	F6	F7	C1		
Spanish mackerel	403	179	36	45	49	72	51	237	1072	25.8
drum[a]	126	119	11	76	69	236	110	40	787	19.0
menhaden	156	59	28	34	216	165	60	55	773	18.6
Atlantic bumper	51	32	65	66	40	118	74	28	474	11.4
blue runner	43	27	24	17	30	27	25	48	241	5.8
bluefish	103	27	21	25	29	4	9	6	224	5.4
crevalle jack	41	30	5	15	18	22	75	6	212	5.1
jack[b]	33	4	4	4	14	3	2	1	65	1.6
Atlantic cutlassfish	9	6	-	2	-	42	-	-	59	1.4
ladyfish	15	14	7	6	4	1	6	2	55	1.3
shark	7	2	-	12	3	5	7	9	45	1.1
catfish	7	6	7	4	1	11	1	7	44	1.1
king mackerel	13	9	2	3	5	-	-	2	34	0.8
other fish[c]	10	7	7	6	13	8	7	9	67	1.6
Total	1017	521	217	315	491	714	427	450	4152	100.0

[a]Spot, Atlantic croaker and 9 other species.

[b]Nine species other than Atlantic bumper, blue runner and crevalle jack.

[c]Nineteen species.

TABLE B-9

NUMBER OF FISHES COLLECTED DURING EACH SAMPLING PERIOD
BY GILL NETTING AT OCEAN STATIONS F1 THROUGH F7 AND C1[a]
ST. LUCIE PLANT
FEBRUARY-DECEMBER 1982

	Station								
Date	F1	F2	F3	F4	F5	F6	F7	F8	Total
12 Feb	14	8	10	70	63	14	117	3	299
19 Feb	2	5	6	3	1	2	55	-[b]	74
3 Mar	6	0	9	14	19	30	3	7	88
15 Mar	2	5	8	35	19	4	3	4	80
22 Apr	43	9	9	55	43	0	4	0	164
25 May	0	1	4	6	8	6	6	0	31
25 Jun	4	0	4	2	1	0	5	9	25
16 Jul	121	17	12	6	6	2	1	3	168
5 Aug	4	4	1	0	5	0	3	1	18
13 Sep	114	121	51	15	49	10	13	14	387
5 Oct	35	38	22	36	14	12	8	6	171
15 Oct	131	74	11	10	12	6	61	23	328
4 Nov	18	7	20	0	0	8	32	5	90
19 Nov	179	62	0	10	82	238	18	78	667
16 Dec	45	60	50	52	105	244	63	116	735
22 Dec	299	110	0	0	64	138	35	181	827
TOTAL	1017	521	217	315	491	714	427	450	4152

[a]One 30-minute net set per station per date.

[b]No sample; the net was destroyed.

TABLE B-10

PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, WATER TEMPERATURE (°C)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station								Current direction to
		F1	F2	F3	F4	F5	F6	F7	C1	
12 February	S	23.0	22.4	23.1	23.0	23.2	23.0	23.4	23.0	N
	M	22.3	22.2	22.1	22.2	22.3	22.3	23.4	22.5	
	B	22.2	22.1	22.1	22.0	22.0	22.2	22.1	22.0	
19 February	S	23.0	23.0	22.3	22.9	22.9	23.0	22.7	-	S
	M	23.0	23.0	22.3	22.9	22.8	23.0	22.4	-	
	B	23.0	23.0	22.4	22.9	22.9	23.0	22.4	-	
3 March	S	20.5	20.4	21.3	21.2	21.4	20.7	21.2	21.2	N
	M	20.3	20.0	20.1	20.3	20.3	20.2	20.6	20.2	
	B	19.5	20.0	20.1	20.3	20.3	20.0	20.2	20.2	
15 March	S	22.7	22.9	23.2	23.3	23.2	23.0	23.5	23.0	N
	M	22.1	22.2	22.7	22.6	22.7	22.4	23.2	22.5	
	B	22.0	22.2	22.4	22.4	22.4	22.4	22.5	22.3	
22 April	S	24.7	24.8	25.1	25.1	25.2	25.0	25.2	25.1	N
	M	24.2	24.2	24.7	24.8	25.1	24.2	25.0	24.5	
	B	24.2	24.2	24.5	24.5	24.8	24.2	24.3	24.5	
25 May	S	25.7	26.0	26.5	26.2	26.0	26.0	27.0	26.7	N
	M	25.5	25.8	25.9	26.0	25.6	25.8	26.5	26.0	
	B	25.5	25.8	25.9	25.9	25.2	25.8	26.0	25.3	
25 June	S	24.2	25.1	24.1	24.2	24.3	24.9	24.4	25.3	None
	M	23.7	24.0	23.9	23.0	23.3	23.4	24.2	24.6	
	B	22.9	24.0	23.0	23.0	22.8	22.8	23.0	22.7	

TABLE B-10
(continued)
PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, WATER TEMPERATURE (°C)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station								Current direction to
		F1	F2	F3	F4	F5	F6	F7	C1	
16 July	S	27.6	27.8	27.5	27.2	27.3	27.4	28.0	27.5	N
	M	27.4	27.3	26.0	27.2	27.4	27.4	27.5	27.3	
	B	24.7	24.7	24.8	25.5	25.5	25.7	25.8	27.0	
5 August	S	27.1	27.2	27.4	27.2	27.3	27.2	27.5	27.7	N
	M	27.0	27.0	27.0	27.0	26.9	27.0	26.8	27.0	
	B	26.3	25.3	25.5	26.3	25.2	26.9	25.0	25.0	
13 September	S	28.4	28.8	29.0	29.2	29.0	29.0	29.5	29.2	N
	M	28.4	28.5	28.8	29.0	29.0	28.7	29.0	29.0	
	B	28.0	28.0	28.0	28.0	28.0	27.9	28.0	27.8	
5 October	S	28.0	28.0	28.0	28.1	28.1	28.3	28.2	28.2	N
	M	27.6	27.8	27.8	27.9	27.8	28.0	27.8	27.5	
	B	27.3	27.8	27.8	27.8	27.8	27.5	27.5	27.5	
15 October	S	26.1	26.2	26.8	26.8	26.9	27.1	26.2	26.8	S
	M	26.1	26.2	26.8	26.8	26.9	26.8	26.3	26.2	
	B	26.0	26.2	26.8	26.9	26.9	26.3	26.2	26.1	
4 November	S	26.1	26.2	26.3	26.2	26.2	26.4	26.9	26.3	N
	M	26.1	26.2	26.2	26.2	26.0	26.2	26.8	26.0	
	B	26.1	26.0	26.0	26.0	26.0	26.2	26.5	25.9	
19 November	S	24.0	24.1	24.8	24.8	24.2	24.9	23.8	24.1	S
	M	24.0	24.1	24.6	24.8	24.2	24.2	24.6	24.2	
	B	24.8	24.0	24.6	24.7	24.1	24.0	24.2	24.8	

TABLE B-10
(continued)
PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, WATER TEMPERATURE (°C)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station								Current direction to
		F1	F2	F3	F4	F5	F6	F7	C1	
16 December	S	22.3	22.4	22.2	23.0	23.1	22.3	23.0	22.3	N
	M	22.2	22.3	22.2	22.9	23.0	22.5	22.9	23.3	
	B	22.2	22.3	22.0	22.9	23.0	22.6	22.9	23.3	
22 December	S	18.9	18.9	19.2	19.1	19.7	19.1	19.8	18.8	N
	M	18.8	18.9	18.9	18.8	19.0	19.0	19.8	18.8	
	B	18.7	18.8	18.8	18.8	18.8	18.8	19.6	18.8	

[a]S = surface, M = mid-depth, B = bottom.

TABLE B-11

PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, SALINITY (ppt)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station F1	F2	F3	F4	F5	F6	F7	C1	Current direction to
12 February	S	35.5	35.0	35.5	35.0	35.0	35.0	35.0	35.5	N
	M	35.5	35.0	35.0	35.0	35.0	35.0	35.0	35.5	
	B	35.5	35.0	35.0	35.0	35.0	35.0	35.0	35.5	
19 February	S	35.5	35.5	35.0	35.0	35.0	35.0	34.5	-	S
	M	35.5	35.5	35.0	35.0	35.0	35.0	35.0	-	
	B	35.5	35.5	35.0	35.0	35.0	35.0	35.0	-	
3 March	S	36.1	35.5	35.5	35.5	35.5	35.5	35.5	35.5	N
	M	36.1	36.1	35.5	35.5	35.5	35.5	35.5	35.5	
	B	36.1	35.5	35.5	35.5	35.5	35.5	35.5	35.5	
15 March	S	36.1	36.1	36.1	35.5	35.5	35.5	35.5	35.5	N
	M	36.1	36.1	36.1	35.5	35.5	35.5	35.5	35.5	
	B	36.1	36.1	36.1	35.5	35.5	35.5	35.5	35.5	
22 April	S	36.1	35.5	35.5	35.5	35.5	35.5	35.5	35.5	N
	M	36.1	36.1	35.5	35.5	35.5	35.5	35.5	35.5	
	B	36.1	36.1	35.5	35.5	35.5	35.5	35.5	35.5	
25 May	S	36.1	36.1	36.1	36.1	36.1	35.5	35.5	36.1	N
	M	36.1	36.1	36.1	36.1	35.5	35.5	35.5	36.6	
	B	36.1	36.1	36.1	36.1	35.5	35.5	35.5	36.6	
25 June	S	36.1	36.1	36.1	35.5	35.5	35.5	35.5	36.1	None
	M	36.1	36.1	36.1	35.5	35.5	35.5	35.5	36.1	
	B	36.1	36.1	36.1	35.5	35.5	35.5	35.5	36.1	

TABLE B-11
(continued)
PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, SALINITY (ppt)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station F1	F2	F3	F4	F5	F6	F7	C1	Current direction to
16 July	S	31.2	35.0	30.7	35.0	34.5	35.0	35.0	33.4	N
	M	33.9	36.1	30.7	35.0	36.1	34.5	35.0	33.9	
	B	30.7	35.0	35.0	34.5	35.0	32.3	35.0	35.0	
5 August	S	34.5	34.5	35.0	34.5	35.0	35.0	33.4	33.4	N
	M	35.0	35.0	33.9	35.0	35.5	33.4	33.9	35.0	
	B	35.5	33.4	35.0	33.9	35.5	35.0	35.0	35.0	
13 September	S	35.5	35.5	33.9	33.4	33.4	34.5	32.9	34.5	N
	M	-	35.5	35.0	33.9	33.4	33.9	32.9	35.0	
	B	33.4	34.5	35.0	33.9	33.9	32.9	30.7	33.9	
5 October	S	35.0	35.0	35.0	35.0	35.0	34.5	35.0	32.9	N
	M	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	
	B	35.0	35.0	35.0	34.5	34.5	35.0	35.0	35.5	
15 October	S	36.1	35.5	35.5	35.0	35.5	35.5	35.5	35.0	S
	M	35.0	35.5	35.5	35.5	35.5	35.0	35.0	33.4	
	B	35.5	35.5	35.5	36.1	35.5	35.0	35.0	35.0	
4 November	S	35.0	35.5	35.0	35.5	35.0	35.0	35.0	35.5	N
	M	35.0	35.5	35.0	35.0	35.0	35.0	35.5	35.0	
	B	35.0	35.5	35.0	35.5	35.0	35.5	35.0	35.0	
19 November	S	34.5	34.5	34.5	33.9	34.5	34.5	33.9	34.5	S
	M	34.5	34.5	34.5	32.3	34.5	34.5	34.5	35.0	
	B	35.0	35.0	33.9	34.5	34.5	34.5	34.5	35.0	

TABLE B-11
(continued)
PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, SALINITY (ppt)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station								Current direction to
		F1	F2	F3	F4	F5	F6	F7	C1	
16 December	S	35.0	35.0	35.0	35.0	34.5	35.0	35.0	35.5	N
	M	35.0	35.0	34.5	35.5	35.0	35.0	35.0	35.5	
	B	35.0	34.5	35.0	35.0	35.0	35.5	35.5	35.5	
22 December	S	35.5	35.5	35.5	35.0	35.0	35.5	35.0	35.0	N
	M	33.9	35.5	35.5	35.0	35.5	35.0	35.0	35.5	
	B	35.0	35.5	35.5	35.0	35.5	35.0	35.0	35.0	

[a]S = surface; M = mid-depth; B = bottom.

TABLE B-12

PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, DISSOLVED OXYGEN (ppm)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station F1	F2	F3	F4	F5	F6	F7	C1	Current direction to
12 February	S	8.0	7.9	7.8	7.8	8.0	8.4	8.0	8.5	N
	M	7.9	7.8	7.8	7.7	7.8	7.8	7.8	8.3	
	B	7.8	7.7	7.7	7.4	7.6	7.7	7.6	8.1	
19 February	S	7.0	7.9	7.8	7.9	7.9	8.1	8.0	-	S
	M	8.0	8.0	7.9	8.1	8.1	8.2	7.8	-	
	B	7.9	8.1	7.8	8.0	8.0	7.9	7.9	-	
3 March	S	7.3	7.4	7.8	7.9	7.7	7.6	7.4	7.6	N
	M	7.3	7.4	8.0	8.0	7.8	7.7	7.5	7.8	
	B	7.4	7.8	7.6	7.0	7.6	7.7	7.6	7.8	
15 March	S	7.4	7.5	7.8	7.8	7.7	7.8	7.7	7.9	N
	M	7.5	7.6	7.8	7.9	7.8	8.0	7.7	7.9	
	B	7.5	7.5	7.8	8.1	7.9	8.0	7.5	7.8	
22 April	S	7.8	7.7	7.8	7.7	7.9	7.7	7.9	7.8	N
	M	7.7	7.6	7.9	7.8	8.0	7.9	7.8	7.9	
	B	7.8	7.5	7.8	7.9	8.1	7.6	7.8	7.9	
25 May	S	7.1	7.2	7.3	7.3	7.2	7.3	7.2	7.2	N
	M	7.1	7.3	7.4	7.4	7.3	7.3	7.3	7.2	
	B	7.2	7.4	7.4	7.4	7.1	7.9	7.5	7.4	
25 June	S	8.2	7.9	8.0	8.0	8.0	8.0	8.2	8.0	None
	M	8.1	8.0	8.0	8.0	8.1	8.2	8.2	8.2	
	B	8.2	8.4	8.2	8.1	8.3	8.5	8.3	8.7	

TABLE B-12
(continued)
PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, DISSOLVED OXYGEN (ppm)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station								Current direction to
		F1	F2	F3	F4	F5	F6	F7	C1	
16 July	S	7.5	7.6	7.5	7.4	7.4	7.8	7.8	7.5	N
	M	6.8	7.6	7.5	7.7	7.5	7.7	7.7	7.5	
	B	7.2	7.5	7.8	7.8	7.8	7.8	7.8	7.5	
5 August	S	7.0	6.9	6.9	7.0	7.0	6.9	6.7	7.1	N
	M	7.0	6.9	6.9	7.1	7.1	6.9	6.6	7.1	
	B	7.1	7.0	6.8	7.3	7.2	7.0	6.5	6.8	
13 September	S	6.6	6.8	6.7	7.0	7.2	6.7	6.3	6.7	N
	M	6.6	6.6	6.9	7.0	7.1	6.9	6.2	6.9	
	B	5.9	4.8	6.2	6.8	6.0	6.0	6.5	6.5	
5 October	S	5.5	5.7	5.5	5.6	5.7	5.5	5.6	5.7	N
	M	5.6	5.7	5.3	5.6	5.6	5.6	5.7	5.7	
	B	5.5	5.7	5.4	5.5	5.6	5.6	5.6	5.7	
15 October	S	5.1	5.1	5.3	5.2	5.2	5.0	5.3	5.7	S
	M	5.1	5.1	5.2	5.2	5.1	5.0	5.2	5.4	
	B	5.1	5.2	5.1	5.3	5.1	4.8	5.2	4.9	
4 November	S	6.0	6.1	6.2	6.2	6.2	6.1	6.0	6.1	N
	M	6.2	6.1	6.2	6.2	6.0	6.1	6.0	6.1	
	B	6.4	5.9	6.1	6.3	6.0	6.1	6.1	6.2	
19 November	S	6.4	6.4	7.0	6.9	6.7	6.3	6.8	6.5	S
	M	6.3	6.2	7.0	6.8	6.7	6.3	6.7	6.4	
	B	6.2	5.8	6.7	6.7	6.3	6.2	6.8	6.3	

TABLE B-12
(continued)
PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, DISSOLVED OXYGEN (ppm)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station F1	F2	F3	F4	F5	F6	F7	C1	Current direction to
16 December	S	7.3	7.3	7.4	7.4	7.5	7.2	7.6	7.1	N
	M	7.1	7.2	7.3	7.2	7.2	7.2	7.3	7.2	
	B	7.0	7.2	7.4	7.2	7.2	7.2	7.3	7.4	
22 December	S	7.5	7.5	7.6	7.7	7.7	7.5	7.3	7.4	N
	M	7.5	7.5	7.6	7.7	7.7	7.5	7.4	7.4	
	B	7.7	7.7	7.9	7.8	7.8	7.5	7.5	7.4	

[a]S = surface; M = mid-depth; B = bottom

TABLE B-13

PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, TURBIDITY (FTU)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station F1	F2	F3	F4	F5	F6	F7	C1	Current direction to
12 February	S	1.1	1.1	1.1	1.5	1.1	1.1	1.1	0.3	N
	M	0.9	0.9	1.9	1.1	1.1	1.5	0.7	0.9	
	B	1.7	0.9	5.2	6.0	1.5	1.1	1.7	0.7	
19 February	S	1.5	1.3	1.5	1.5	1.5	2.5	2.1	-	S
	M	2.1	1.5	1.7	1.5	1.7	2.1	2.1	-	
	B	1.3	1.5	2.5	1.5	2.1	1.9	3.2	-	
3 March	S	1.1	2.3	1.7	1.9	1.9	1.5	1.7	1.1	N
	M	1.1	1.5	1.7	1.9	1.9	1.5	1.7	0.9	
	B	1.1	1.5	2.3	1.9	1.1	1.1	1.5	1.3	
15 March	S	1.3	1.3	0.9	0.7	0.7	1.1	0.5	0.2	N
	M	1.1	1.5	1.5	0.9	1.1	0.9	0.5	0.2	
	B	1.1	0.9	0.7	0.9	0.7	0.5	0.7	0.1	
22 April	S	0.1	0.2	0.3	0.0	0.0	0.0	0.0	0.0	N
	M	0.1	0.2	0.3	0.0	0.0	0.0	0.1	0.0	
	B	0.3	0.3	0.1	0.1	0.3	0.0	0.0	0.0	
25 May	S	0.5	0.7	0.9	0.7	1.1	1.5	1.1	0.2	N
	M	0.5	0.7	0.2	1.1	0.9	1.1	1.3	0.2	
	B	0.7	0.9	0.7	1.1	1.1	0.7	1.1	0.3	
25 June	S	0.7	0.3	0.5	0.2	0.2	0.3	0.1	0.2	None
	M	0.3	0.5	0.5	0.7	0.2	0.2	0.2	0.3	
	B	0.7	1.1	0.2	1.1	0.3	0.1	0.2	0.5	

TABLE B-13
(continued)
PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, TURBIDITY (FTU)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station F1	F2	F3	F4	F5	F6	F7	C1	Current direction to
16 July	S	0.9	0.7	0.9	0.9	0.5	1.9	1.1	1.1	N
	M	3.0	1.9	0.7	0.5	0.3	1.5	0.9	0.9	
	B	2.5	1.1	1.1	0.5	0.3	1.5	1.5	1.3	
5 August	S	0.1	0.5	0.3	0.8	1.1	0.7	1.0	0.9	N
	M	0.2	0.3	0.9	1.5	1.1	0.9	1.7	0.3	
	B	1.3	0.9	1.9	1.3	1.7	0.7	1.1	0.2	
13 September	S	1.3	0.7	1.5	1.5	1.7	2.1	1.9	2.5	N
	M	1.3	1.3	1.3	1.7	1.3	1.9	1.7	1.7	
	B	2.1	8.3	1.3	0.9	0.9	1.1	2.1	2.1	
5 October	S	0.7	1.9	0.7	1.9	1.7	1.3	1.7	1.7	N
	M	2.3	7.0	1.5	2.8	1.5	1.1	2.1	0.2	
	B	3.2	10.2	3.7	6.5	3.9	2.1	5.2	2.3	
15 October	S	3.7	3.0	9.2	12.8	11.5	7.2	7.7	6.5	S
	M	4.7	3.7	10.2	13.2	21.6[b]	9.2	7.7	5.4	
	B	6.0	11.8	9.2	12.5	21.6[b]	10.5	8.0	35.6[b]	
4 November	S	8.3	2.8	3.4	1.5	2.8	1.9	1.5	2.8	N
	M	2.1	3.9	2.5	3.0	1.3	0.9	1.3	2.8	
	B	1.9	3.4	3.0	0.9	1.1	0.3	1.1	5.4	
19 November	S	1.7	1.1	5.7	4.9	3.4	3.2	4.9	5.4	S
	M	2.8	2.8	5.7	5.4	4.9	3.2	4.7	3.4	
	B	28.8[b]	4.9	7.2	7.7	54.0[b]	6.5	8.9	6.5	

TABLE B-13
(continued)
PHYSICAL MEASUREMENTS RECORDED DURING
OCEAN GILL NET COLLECTIONS, TURBIDITY (FTU)
ST. LUCIE PLANT
1982

Date	Depth[a]	Station								Current direction to
		F1	F2	F3	F4	F5	F6	F7	C1	
16 December	S	4.3	2.4	5.9	6.2	5.9	5.9	5.9	6.2	N
	M	8.3	5.6	5.1	5.4	6.5	10.3	12.8	7.1	
	B	10.6	9.6	7.7	8.9	10.3	9.6	6.5	11.6	
22 December	S	5.4	5.9	4.6	4.9	4.3	4.3	5.4	4.3	N
	M	4.9	7.4	4.6	7.7	4.9	5.6	5.9	4.3	
	B	8.9	4.9	4.6	9.6	6.8	14.6	5.9	3.3	

[a] S = surface, M = mid-depth, B = Bottom.

[b] Very turbid; dilution and extrapolation required to obtain value.

TABLE B-14

NUMBER AND PERCENTAGE COMPOSITION OF FISHES COLLECTED BY OCEAN GILL NETTING DURING ENVIRONMENTAL MONITORING[a]
ST. LUCIE PLANT
1976 - 1982

Taxon	1976		1977		1978		1979	
	Number of fishes	Percentage composition	Number of fishes	Percentage composition	Number of fishes	Percentage composition	Number of fishes	Percentage composition
Atlantic bumper	557	32.1	211	17.2	482	55.1	247	15.3
crevalle jack	327	18.9	5	0.4	46	5.3	222	13.8
blue runner	273	15.7	71	5.8	91	10.4	77	4.8
other jacks	26	1.5	48	3.9	7	0.8	33	2.1
Spanish mackerel	179	10.3	407	33.3	61	7.0	238	14.8
king mackerel	3	0.2	29	2.4	1	0.1	12	0.8
bluefish	91	5.3	331	27.1	12	1.4	221	13.7
menhaden	85	4.9	12	1.0	12	1.4	81	5.0
drum	42	2.4	35	2.9	12	1.4	240	14.9
shark	9	0.5	20	1.6	31	3.5	169	10.5
other fish	142	8.2	54	4.4	119	13.6	70	4.3
Total	1734	100.0	1223	100.0	874	100.0	1610	100.0
Number of net sets	60	-	72	-	72	-	72	-

TABLE CONTINUED

[a]Ocean gill netting was not conducted during the baseline study.

TABLE B-14
(continued)
NUMBER AND PERCENTAGE COMPOSITION OF FISHES COLLECTED BY OCEAN GILL NETTING DURING ENVIRONMENTAL MONITORING[a]
ST. LUCIE PLANT
1976 - 1982

	1980		1981		1982(Stations 0-5)[b]		1982(Stations F1-F7,C1)[c]	
Taxon	Number of fishes	Percentage composition	Number of fishes	Percentage composition	Number of fishes	Percentage composition	Number of fishes	Percentage composition
Atlantic bumper	95	10.0	235	17.2	3	1.7	474	11.4
crevalle jack	13	1.4	31	2.3	0	0.0	212	5.1
blue runner	107	11.3	64	4.7	15	8.3	241	5.8
other jacks	20	2.1	13	0.9	1	0.6	65	1.6
Spanish mackerel	218	23.0	153	11.2	78	43.3	1072	25.8
king mackerel	21	2.2	5	0.4	4	2.2	34	0.8
bluefish	74	7.8	103	7.5	15	8.3	224	5.4
menhaden	123	13.0	409	30.0	3	1.7	773	18.6
drum	136	14.4	196	14.4	10	5.6	787	19.0
shark	97	10.3	84	6.1	4	2.2	45	1.1
other fish	42	4.5	72	5.3	47	26.1	225	5.4
Total	946	100.0	1365	100.0	180	100.0	4152	100.0
Number of net sets	72	-	72	-	30	-	127	-

[a]Ocean gill netting was not conducted during the baseline study.

[b]January-May.

[c]February-December.

TABLE B-15

NUMBER, SIZE AND PERCENTAGE COMPOSITION OF FISHES
COLLECTED BY TRAWLING
ST. LUCIE PLANT
JANUARY - MAY 1982

Species	Number of individuals	Range of standard lengths (mm)	Total weight (g)	Percentage composition	
				Number of individuals	Total weight
leopard searobin	88	39-182	3696	23.9	21.0
Cuban anchovy	39	42-61	43	10.6	0.2
pigfish	33	153-219	4974	9.0	28.2
spotted whiff	18	54-153	589	4.9	3.3
searobin	16	9-29	8	4.3	<0.1
twospot flounder	15	21-116	220	4.1	1.2
hardhead catfish	14	159-251	1683	3.8	9.6
flatfish	12	14-27	9	3.3	<0.1
inshore lizardfish	11	41-298	779	3.0	4.4
dusky flounder	11	56-222	719	3.0	4.1
bank cusk-eel	10	139-253	542	2.7	3.1
herring	9	17-22	1	2.5	<0.1
sand drum	8	33-177	156	2.2	0.9
blotched cusk-eel	8	32-217	137	2.2	0.8
snakefish	6	33-171	258	1.6	1.5
bighead searobin	5	101-243	559	1.4	3.2
blackcheek tonguefish	4	36-151	69	1.1	0.4
planehead filefish	4	41-59	21	1.1	0.1
bigeye stargazer	4	36-60	6	1.1	<0.1
gulf flounder	3	220-254	701	0.8	4.0
sand perch	3	19-136	123	0.8	0.7
blackwing searobin	3	62-147	76	0.8	0.4
barbfish	3	66-105	63	0.8	0.4
offshore tonguefish	3	103-128	43	0.8	0.2
rock sea bass	3	41-111	40	0.8	0.2
banded drum	2	162-178	299	0.5	1.7
lane snapper	2	157-158	214	0.5	1.2
ocellated flounder	2	133-134	101	0.5	0.6
black sea bass	2	50-68	15	0.5	0.1
mooneye cusk-eel	2	83-99	5	0.5	<0.1
cusk-eel	2	66-81	3	0.5	<0.1
sand stargazer	2	32-43	2	0.5	<0.1
drum	2	13-16	2	0.5	<0.1
twospot cardinalfish	2	18-20	2	0.5	<0.1
blackfin cardinalfish	2	17-23	2	0.5	<0.1
eyed flounder	2	28-30	1	0.5	<0.1
lesser electric ray	1	351	724	0.3	4.1
silver seatrout	1	235	227	0.3	1.3
pinfish	1	138	167	0.3	0.9
tomtate	1	180	144	0.3	0.8
silver jenny	1	127	71	0.3	0.4
spottedfin tonguefish	1	88	57	0.3	0.3
fringed flounder	1	95	15	0.3	0.1
lined seahorse	1	121	15	0.3	0.1
spotfin mojarra	1	84	15	0.3	0.1
stargazer	1	85	7	0.3	<0.1
smoothhead scorpionfish	1	46	5	0.3	<0.1
Seminole goby	1	25	1	0.3	<0.1
Atlantic croaker	1	21	1	0.3	<0.1
Total	368	-	17,610	100.0	100.0

TABLE B-16

NUMBER OF FISHES COLLECTED BY TRAWLING[a]
ST. LUCIE PLANT
JANUARY - MAY 1982

Taxon	Total by station						Total by taxon	Percentage composition
	0	1	2	3	4	5		
searobin, scorpionfish	25	14	22	5	17	33	116	31.5
flatfish[b]	15	14	12	11	17	3	72	19.6
anchovy	4	16	13	1	-	5	39	10.6
grunt	-	5	9	4	2	14	34	9.2
cusk-eel	3	5	4	5	4	1	22	6.0
lizardfish	-	-	8	5	4	-	17	4.6
catfish	1	2	2	9	-	-	14	3.8
drum	9	2	-	2	-	1	14	3.8
other fish	2	14	4	5	7	8	40	10.9
Total	59	72	74	47	51	65	368	100.0

[a]One 15-minute tow per station per month.

[b]Flounder, sole, tonguefish.

TABLE B-17

NUMBER AND PERCENTAGE COMPOSITION OF FISHES COLLECTED
BY TRAWLING DURING THE BASELINE STUDY AND ENVIRONMENTAL MONITORING
ST. LUCIE PLANT
1971-1974 AND 1976-1982

Taxon	1971-1974[a]		1976		1977		1978	
	Number of fishes	Percentage composition	Number of fishes	Percentage composition	Number of fishes	Percentage composition	Number of fishes	Percentage composition
jack	38	13.9	0	0.0	1	0.0	3	0.1
flatfish[c]	35	12.8	129	19.7	220	10.7	302	12.0
drum[d]	35	12.8	13	2.0	250	12.2	114	4.5
searobin, scorpion-fish	34	12.4	129	19.7	170	8.3	293	11.7
anchovy	28	10.3	18	2.7	22	1.1	459	18.3
porgy	14	5.1	2	0.3	0	0.0	4	0.2
lizardfish	13	4.8	9	1.4	45	2.2	47	1.9
cusk-eel	12	4.4	72	11.0	47	2.3	202	8.0
grunt	11	4.0	61	9.3	178	8.7	263	10.5
catfish	10	3.7	18	2.7	10	0.5	69	2.7
mojarra	6	2.2	26	4.0	139	6.8	83	3.3
sand perch	4	1.5	86	13.1	141	6.9	61	2.4
seatrout	2	0.7	0	0.0	606	29.6	176	7.0
other fish	31	11.4	93	14.1	219	10.7	437	17.4
Total	273	100.0	656	100.0	2048	100.0	2513	100.0
Number of trawl tows	132	-	60	-	72	-	72	-

TABLE CONTINUED

TABLE B-17
(continued)
NUMBER AND PERCENTAGE COMPOSITION OF FISHES COLLECTED
BY TRAWLING DURING THE BASELINE STUDY AND ENVIRONMENTAL MONITORING
ST. LUCIE PLANT
1971-1974 AND 1976-1982

Taxon	1979		1980		1981		1982	
	Number of fishes	Percentage composition	Number of fishes	Percentage composition[b]	Number of fishes	Percentage composition	Number of fishes	Percentage composition
jack	47	1.5	24	0.5 (3.1)	55	1.4	0	0.0
flatfish[c]	189	5.8	104	2.1 (13.5)	220	5.7	72	19.6
drum[d]	129	4.0	73	1.5 (9.5)	766	19.8	13	3.5
searobin, scorpionfish	391	12.0	226	4.5 (29.2)	524	13.5	116	31.5
anchovy	1353	41.6	4257	84.6 (0.0)	1511	39.1	39	10.6
porgy	10	0.3	1	<0.1 (0.1)	1	<0.1	1	0.3
lizardfish	37	1.1	11	0.2 (1.4)	42	1.1	17	4.6
cusk-eel	165	5.1	51	1.0 (6.6)	97	2.5	22	6.0
grunt	178	5.5	81	1.6 (10.5)	53	1.4	34	9.2
catfish	33	1.0	27	0.5 (3.5)	12	0.3	14	3.8
mojarra	39	1.2	11	0.2 (1.4)	8	0.2	2	0.6
sand perch	52	1.6	16	0.3 (2.1)	7	0.2	3	0.8
seatrout	313	9.6	4	<0.1 (0.5)	360	9.3	1	0.3
other fish	315	9.7	144	2.9 (18.6)	213	5.5	34	9.2
Total	3251	100.0	5030	100.0 (100.0)	3869	100.0	368	100.0
Number of trawl tows	72	72	72	-	72	-	30	-

[a] Baseline study data from Futch and Dwinell (1977).

[b] Percentage in parenthesis is composition exclusive of anchovy.

[c] Flounder, sole, tonguefish.

[d] Other than seatrout.

TABLE B-18

NUMBER, SIZE AND PERCENTAGE COMPOSITION OF FISHES
COLLECTED BY BEACH SEINING
ST. LUCIE PLANT
JANUARY - MAY 1982

Species	Number of individuals	Range of standard lengths (mm)	Total weight (g)	Percentage composition	
				Number of individuals	Total weight
sand drum	514	24-176	1365	54.2	17.9
gulf kingfish	330	27-214	4774	34.8	62.7
Florida pompano	58	22-109	544	6.1	7.1
longnose anchovy	17	29-33	6	1.8	<0.1
broad flounder	6	43-94	58	0.6	0.8
drum	5	26-33	5	0.5	<0.1
southern kingfish	4	61-88	25	0.4	0.3
white mullet	3	181-238	558	0.3	7.3
spot	3	119-128	139	0.3	1.8
bluefish	3	39-69	13	0.3	0.2
palometa	1	143	87	0.1	1.1
redear sardine	1	119	34	0.1	0.4
anchovy	1	29	1	0.1	<0.1
Cuban anchovy	1	39	1	0.1	<0.1
jack	1	36	1	0.1	<0.1
Total	948	-	7611	99.8[a]	100.0

[a]Fraction lost in rounding.

TABLE B-19

NUMBER OF FISHES COLLECTED PER STATION BY BEACH SEINING[a]
ST. LUCIE PLANT
JANUARY - MAY 1982

Species	Total by station 6	7	8	Total by taxon	Percentage composition
sand drum	198	171	145	514	54.2
kingfish	83	166	85	334	35.2
Florida pompano	19	13	26	58	6.1
anchovy	1	3	15	19	2.0
other fish	8	7	8	23	2.5
Total	309	360	279	948	100.0

[a]Three seine hauls per station per month.

TABLE B-20

NUMBER AND PERCENTAGE COMPOSITION OF FISHES COLLECTED
BY BEACH SEINING DURING THE BASELINE STUDY AND ENVIRONMENTAL MONITORING
ST. LUCIE PLANT
1971-1973 AND 1976-1982

	1971 - 1973[a]		1976		1977		1978	
Taxon	Number of fishes	Percentage composition[b]	Number of fishes	Percentage composition	Number of fishes	Percentage composition	Number of fishes	Percentage composition
anchovy	11540	89.5 (0.0)	159	13.1	60	7.3	0	0.0
herring	580	4.5 (42.8)	510	42.1	171	20.9	340	28.3
sand drum	360	2.8 (26.5)	105	8.7	173	21.1	194	16.1
kingfish	121	0.9 (8.9)	108	8.9	172	21.0	172	14.3
jack[c]	96	0.7 (7.1)	73	6.0	42	5.1	23	1.9
spot	59	0.5 (4.4)	101	8.3	0	0.0	147	12.2
Florida pompano	59	0.5 (4.4)	43	3.6	22	2.7	27	2.2
Atlantic bumper	43	0.3 (3.2)	28	2.3	44	5.4	1	0.1
mojarra	6	0.1 (0.4)	8	0.7	81	9.9	280	23.3
other fish	31	0.2 (2.3)	76	6.3	54	6.6	19	1.6
Total	12894	100.0 (100.0)	1211	100.0	819	100.0	1203	100.0
Number of beach seine hauls	108	-	90	-	108	-	108	-

TABLE CONTINUED

TABLE B-20
(continued)
NUMBER AND PERCENTAGE COMPOSITION OF FISHES COLLECTED
BY BEACH SEINING DURING THE BASELINE STUDY AND ENVIRONMENTAL MONITORING
ST. LUCIE PLANT
1971-1973 AND 1976-1982

Taxon	1979 Number of fishes	1979 Percentage composition	1980 Number of fishes	1980 Percentage composition	1981 Number of fishes	1981 Percentage composition[b]	1982 Number of fishes	1982 Percentage composition
anchovy	1	0.2	279	32.8	4099	64.0 (-)	19	2.0
herring	234	37.2	104	12.2	628	9.8 (37.2)	1	0.1
sand drum	168	26.7	202	23.7	542	8.5 (23.5)	514	54.2
kingfish	55	8.7	122	14.3	941	14.7 (40.8)	334	35.2
jack[c]	53	8.4	36	4.2	49	0.8 (2.1)	2	0.2
spot	15	2.4	10	1.2	2	<0.1 (0.1)	3	0.3
Florida pompano	47	7.5	55	6.5	87	1.4 (3.7)	58	6.1
Atlantic bumper	30	4.8	20	2.4	2	<0.1 (0.1)	0	0.0
mojarra	12	1.9	1	0.1	5	0.1 (0.2)	0	0.0
other fish	14	2.2	22	2.6	52	0.8 (2.3)	17	1.9
Total	629	100.0	851	100.0	6407	100.0 (100.0)	948	100.0
Number of beach seine hauls	108	-	108	-	108	-	45	-

[a]Baseline study data from Futch and Dwinell (1977).

[b]Percentage in parentheses is composition exclusive of anchovy.

[c]Other than Florida pompano and Atlantic bumper.

TABLE B-21

NUMBER OF FISH LARVAE AND FISH EGGS, MEAN DENSITY OF FISH LARVAE AND FISH EGGS AND WATER VOLUME FILTERED AT OCEAN STATIONS 0 THROUGH 5 AND OI, INTAKE CANAL STATION 11 AND DISCHARGE CANAL STATION 12
ST. LUCIE PLANT
JANUARY - MAY 1982

	Station									Mean density at Ocean Stations 0-5
	0	1	2	3	4	5	OI	11	12	
19 January										
Number of fish larvae	219	4[illegible]0	66	21	124	10	439	2	1	-
Fish larvae/m^3	2.147	4.528	0.623	0.221	1.204	0.093	3.991	0.02[illegible]	0.011	1.484
Number of fish eggs	70	66	101	344	135	1309	142	13	9	-
Fish eggs/m^3	0.686	0.623	0.953	3.621	1.311	12.1[illegible]	1.291	0.144	0.097	3.266
Volume filtered (m^3)	102	106	106	95	103	108	110	90	93	-
28 January										
Number of fish larvae	6	294	112	115	48	22	27	2	0	-
Fish larvae/m^3	0.064	2.911	1.143	1.106	0.500	0.242	0.276	0.021	0.000	1.022
Number of fish eggs	6218	562	11680	3392	4644	2454	2222	340	182	-
Fish eggs/m^3	66.149	5.564	119.184	32.615	48.375	26.967	22.673	3.579	1.596	49.572
Volume filtered (m^3)	94	101	98	104	96	91	98	95	114	-
18 February										
Number of fish larvae	16	33	9	6	14	12	31	0	1	-
Fish larvae/m^3	0.150	0.317	0.080	0.053	0.135	0.105	0.279	0.000	0.011	0.137
Number of fish eggs	92	112	316	218	426	368	86	28	60	-
Fish eggs/m^3	0.860	1.077	2.796	1.929	4.096	3.228	0.775	0.346	0.652	2.339
Volume filtered (m^3)	107	104	113	113	104	114	111	81	92	-
25 February										
Number of fish larvae	[illegible]8	327	48	37	67	229	55	4	4	-
Fish larvae/m^3	0.907	3.206	0.480	0.349	0.626	2.245	0.500	0.040	0.042	1.290
Number of fish eggs	1144	546	711	519	736	318	637	280	236	-
Fish eggs/m^3	10.593	5.353	7.110	4.896	6.879	3.118	5.791	2.800	2.484	6.358
Volume filtered (m^3)	108	102	100	106	107	102	110	100	95	-
12 March										
Number of fish larvae	133	17	83	56	38	86	27	2	1	-
Fish larvae/m^3	1.267	0.1[illegible]	0.856	0.538	0.396	0.827	0.229	0.020	0.011	0.676
Number of fish eggs	621	59	603	5912	196	742	91	523	66	-
Fish eggs/m^3	5.914	0.562	6.216	56.846	2.042	7.135	0.771	5.178	0.702	13.311
Volume filtered (m^3)	105	105	97	104	96	104	118	101	94	-
16 March										
Number of fish larvae	167	[illegible]54	122	113	12	32	241	2	0	-
Fish larvae/m^3	1.452	3.437	1.184	1.009	0.112	0.317	2.171	0.025	0.000	1.248
Number of fish eggs	169	217	152	55	102	278	130	31	78	-
Fish eggs/m^3	1.470	2.107	1.476	0.491	0.953	2.752	1.171	0.383	0.876	1.518
Volume filtered (m^3)	115	103	103	112	107	101	111	81	89	-
15 April										
Number of fish larvae	40	6	90	154	209	126	116	2	3	-
Fish larvae/m^3	0.400	0.056	0.874	1.510	1.917	1.273	1.172	0.024	0.038	1.006
Number of fish eggs	24	21	27	29	87	110	24	65	113	-
Fish eggs/m^3	0.240	0.194	0.262	0.284	0.798	1.111	0.242	0.783	1.430	0.480
Volume filtered (m^3)	100	108	103	102	109	99	99	83	79	-
20 April										
Number of fish larvae	165	47	10	21	25	20	19	1	0	-
Fish larvae/m^3	1.571	0.435	0.098	0.208	0.240	0.202	0.186	0.010	0.000	0.465
Number of fish eggs	242	86	1763	2556	916	236	91	16	8	-
Fish eggs/m^3	2.305	0.796	17.284	25.307	8.808	2.384	0.892	0.167	0.113	9.368
Volume filtered (m^3)	105	108	102	101	104	99	102	96	71	-
12 May										
Number of fish larvae	12	22	12	9	9	8	104	1	2	-
Fish larvae/m^3	0.114	0.232	0.119	0.090	0.095	0.083	1.010	0.013	0.022	0.122
Number of fish eggs	32	1	12	21	19	3	8	398	1588	-
Fish eggs/m^3	0.305	0.011	0.119	0.210	0.200	0.031	0.078	4.975	17.260	0.149
Volume filtered (m^3)	105	95	101	100	95	96	103	80	92	-
21 May										
Number of fish larvae	6	2	8	5	19	3	0	0	0	-
Fish larvae/m^3	0.057	0.020	0.085	0.051	0.194	0.029	0.000	0.000	0.000	0.072
Number of fish eggs	800	341	880	344	2548	3334	151	314	145	-
Fish eggs/m^3	7.619	3.376	9.362	3.510	26.000	31.752	1.641	3.694	1.813	13.722
Volume filtered (m^3)	105	101	94	98	98	105	92	85	80	-
Mean Density (January-May)										
Fish larvae/m^3	0.824	1.531	0.551	0.519	0.554	0.538	1.005	0.018	0.013	0.754
Fish eggs/m^3	8.998	1.947	15.973	12.937	9.626	8.981	3.398	2.251	2.764	9.729

TABLE B-22

PERCENTAGE COMPOSITION OF LARVAL FISHES COLLECTED
AT OCEAN STATIONS 0 THROUGH 5
ST. LUCIE PLANT
JANUARY - MAY 1982

	Station							
Taxon	0	1	2	3	4	5	Mean	Number of larvae
Herrings and anchovies	61.7	70.2	51.2	65.7	41.4	60.0	61.2	2846
Drums	24.5	8.5	24.9	13.6	21.8	16.6	16.6	773
Gobies	1.8	11.3	1.1	2.2	1.8	3.8	5.2	242
Stargazers	3.7	1.5	4.5	5.4	11.8	4.2	4.3	200
Blennies	0.9	0.8	6.8	3.3	10.1	0.9	3.0	139
Mojarras	1.7	0.4	1.2	2.0	0.7	0.7	1.0	47
Jacks	0.5	1.7	0.5	0.4	0.2	0.6	0.8	39
Flatfishes	0.8	0.8	0.5	0.2	0.5	0.4	0.6	29
Puffers	0.6	0.1	0.9	0.6	1.6	0.7	0.6	28
Sea basses	0.2	0.3	0.5	0.0	0.9	0.7	0.4	19
Clingfishes	0.2	0.0	0.5	0.4	0.3	0.4	0.2	11
Searobins	0.0	0.3	0.4	0.4	0.2	0.0	0.2	9
All others	3.4	4.1	7.0	5.8	8.7	11.0	5.9	273
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	-
Number of larvae	862	1582	561	537	565	548	-	4655

TABLE B-23

MEAN DENSITY OF ICHTHYOPLANKTON[a]
FOR BASELINE AND OPERATIONAL MONITORING STUDY YEARS
ST. LUCIE PLANT
1971-1973 and 1976-1981[b]

Study year	Mean density (number/m^3)	95 percent confidence limits	
		Lower limit	Upper limit
Baseline 1971-73	39.0[c]	-	-
Operational 1976	6.8	3.0	10.6
Operational 1977	15.3	10.3	20.3
Operational 1978	35.4	0.0	75.9
Operational 1979	34.6	20.3	48.9
Operational 1980	22.3	14.1	30.5
Operational 1981	17.3	12.4	21.6

[a]Arithmetic means are based on ichthyoplankton collected during zooplankton sampling.

[b]ABI (1982)

[c]Walker et al. (1979).

TABLE B-24

PERCENTAGE LOSS ESTIMATES OF ICHTHYOPLANKTON ENTRAINMENT
ST. LUCIE PLANT
1976-1981[a]

Year	Category	Variables[b] C_r	C_p	Q_r	Q_p	m	Percentage loss (mean depth=9.2 m) $\frac{mC_p}{C_r} \neq 1$	$\frac{mC_p}{C_r} = 1$	Percentage loss (mean depth=3.0 m) $\frac{mC_p}{C_r} \neq 1$	$\frac{mC_p}{C_r} = 1$
1976	eggs	3.848	1.259	5474(1785)	32.36	1.0	0.19	0.59	0.59	1.81
	larvae	0.205	0.041	5474(1785)	32.36	1.0	0.12	0.59	0.36	1.81
1977	eggs	0.429	0.366	5474(1785)	32.36	1.0	0.50	0.59	1.55	1.81
	larvae	1.345	0.028	5474(1785)	32.36	1.0	0.01	0.59	0.04	1.81
1978	eggs	2.709	1.503	5474(1785)	32.36	1.0	0.33	0.59	1.01	1.81
	larvae	0.421	0.087	5474(1785)	32.36	1.0	0.12	0.59	0.37	1.81
1979	eggs	3.744	0.831	5474(1785)	32.36	1.0	0.13	0.59	0.40	1.81
	larvae	0.304	0.030	5474(1785)	32.36	1.0	0.06	0.59	0.18	1.81
1980	eggs	3.325	0.889	5474(1785)	32.36	1.0	0.16	0.59	0.48	1.81
	larvae	0.257	0.080	5474(1785)	32.36	1.0	0.18	0.59	0.56	1.81
1981	eggs	3.862	0.846	5474(1785)	32.36	1.0	0.13	0.59	0.40	1.81
	larvae	0.444	0.017	5474(1785)	32.36	1.0	0.02	0.59	0.07	1.81

[a]ABI (1982).

[b]C_r = geometric mean concentration of organisms per cubic meter in offshore areas (Stations 0 through 5).

C_p = geometric mean concentration of organisms per cubic meter in the intake canal (Station 11).

Q_r = flow in cubic meters per second past the plant, based on a cross-sectional area of 32,200 m^2; numbers in parentheses are based on a cross-sectional area of 10,500 m^2.

Q_p = water flow in cubic meters per second through the plant intake, based on maximum recorded daily value.

m = mortality rate of entrained organisms (assumed to be 100%, making m = 1.0).

C. MACROINVERTEBRATES

NRC Environmental Technical Specification (Section 3.1.B.a; deleted May 1982).

> Benthic Organisms - Benthic organisms will be collected quarterly and inventoried as to type and abundance of major taxonomic groups present.

EPA NPDES Permit Required Condition (issued January 1982; as delineated in AB-358 [ABI, 1981a] and approved by the EPA).

> Benthic Organisms - Benthic organisms will be collected quarterly and inventoried as to kind and abundance. Physical measurements will be made at the same time as the benthic sample collections. Parameters measured will be water temperature, salinity, dissolved oxygen and turbidity.

INTRODUCTION

Benthic macroinvertebrates compose the majority of larger organisms living in or on submerged substrates. They exhibit a diversity of form and function and, as a result, occupy a wide variety of habitats and virtually all trophic levels. Although most benthic macroinvertebrates are of no direct economic importance, they are important members of marine food webs and constitute a major food source for many economically important fish and shellfish. Consequently, the vitality of commercial fisheries depends on the well-being of the benthic invertebrate fauna.

Different benthic macroinvertebrate species which have similar preferences for particular environmental conditions may form species assemblages which are characteristic for that particular set of environmental conditions. Relative to nektonic forms, macroinvertebrate species are limited in motility and, once established in an area, are largely unable to avoid or escape subsequent environmental changes. They must either acclimate or regulate or they will perish. Thus, fluctuations in community structure often indicate changing environmental conditions. Consequently, benthic communities have been very useful in assessing the local impact of environmental perturbations (Holland et al., 1973; Reish et al., 1980). Benthic macroinvertebrate communities have been particularly helpful in assessing the effects of elevated water temperatures associated with power plant discharges. In general, increased temperatures have impacted these assemblages through shifts in faunal density, biomass, species richness, diversity or species composition (Warinner and Brehmer, 1966; Virnstein, 1972; Logan and Maurer, 1975; Blake et al., 1976).

Because of their ecological importance and usefulness as indicators of localized environmental perturbation, benthic communities adjacent to the St. Lucie Plant have been used to study the potential impact of thermal effluents. Throughout the period 1976 to 1981, three distinct faunal assemblages were described, each associated with unique substrate characteristics (ABI, 1978, 1979, 1980a, 1981b, 1982). Although seasonal and annual variations in community parameters were observed, both were found to be natural phenomena unrelated to power plant operations. Within-

habitat comparisons among benthic communities potentially affected by thermal effluents and those temporally or spatially removed from the discharge plume similarly revealed no adverse plant effects. Statistical tests applied to comparable operational and baseline data showed no significant reductions in the abundance or species richness of the major macroinvertebrate groups following the activation of Unit 1 (ABI, 1982).

Beginning in May 1982, when regulatory jurisdiction of biological studies at the St. Lucie Plant was transferred from the NRC to the EPA (Section A. INTRODUCTION), a new benthic NPDES monitoring program was initiated. The intent of this benthic program is: 1) to provide continued operational monitoring of Unit 1 and ensure detection of any long-term changes in benthic community structure associated with plant operations; and 2) to provide both preoperational and operational information on Unit 2, including potential effects of a new discharge system and a larger discharge dispersal area. Unit 2 is scheduled for activation in the summer of 1983.

Seven stations (four of which had been sampled under the ETS program) were established for the new study, and sampling commenced in March 1982. However, ETS monitoring requirements mandated by the NRC were not officially deleted until the end of May 1982. Therefore, this report includes summarized ETS monitoring data for January through May, as well as data generated by NPDES sampling over the entire year. As in previous reports, the emphasis of the 1982 study was placed on characterizing the macroinvertebrate communities within the study area, com-

paring potentially affected communities with those spatially distant from the influence of thermal discharges, and examining temporal changes in community structure associated with continued operation of Unit 1. This information will form an integrated data base from which to assess the potential effects of combined operations of Units 1 and 2 on the benthos during subsequent years.

MATERIALS AND METHODS

ETS Monitoring

Six permanent ocean stations (Figure C-1) were sampled under the ETS monitoring program conducted from January through May. Stations 1 through 5 corresponded to locations sampled during baseline studies conducted from 1971 to 1974 (Gallagher and Hollinger, 1977). Station 0, 4.3-km south of the plant discharge, has served as a control since operational monitoring began in 1976.

Smaller less motile infaunal and epifaunal macroinvertebrates were collected at each station with a Shipek sediment sampler (Holmes and McIntyre, 1971). This grab device was used during baseline studies at the St. Lucie Plant and has been successfully used in similar habitats elsewhere (Maurer et al., 1976). Because of the Shipek's ability to shear obstructing materials caught in its rotating jaws, this sampler tends to operate more effectively than other grabs in the shelly substrata found within the study area (EPA, 1973).

ETS grab sampling was conducted only during March in 1982. Four replicates, each representing 0.04-m^2 of bottom surface area, were taken at each of the six stations. Three of the four replicates were used for examining community structure, while the fourth was used for substrate particle-size analysis. Sediment temperature was measured at each station by inserting a mercury-in-glass thermometer into the undisturbed sediment of one of the replicates.

All samples were preserved in a 10-percent buffered formalin-seawater solution, stained with rose bengal dye and transported to the laboratory. A No. 25 (0.710-mm) sieve was used to remove fine sediments and particulate matter from the samples. Material retained on the sieve was hand sorted under low magnification and the organisms removed, counted and identified to the lowest practicable taxon. Identified organisms from all three replicates at each station were combined by major group for dry weight biomass determination.

The substratum material of the fourth replicate was dried, disaggregated and placed in a graduated nest of nine sieves (mesh widths of 16, 8, 4, 2, 1, 0.5, 0.25, 0.125 and 0.063-mm, respectively). The nest of sieves was then shaken for 15 minutes on a Tyler Ro-Tap sieve shaker to separate the sample into size-class fractions. Particle size class distribution, mean particle diameter and sorting coefficient were subsequently calculated according to the procedures of Folk (1966).

Larger, more motile, epibenthic macroinvertebrates were sampled monthly in conjunction with the fish sampling program (Section B. FISH AND SHELLFISH). Using a 4.9-m semi-balloon otter trawl, one 15 minute tow was made at each of the six stations. Tows were made at night to reduce net avoidance. The samples were preserved in a 10-percent buffered formalin-seawater solution, labeled and transported to the laboratory for sorting and identification to the lowest practicable taxon.

Surface, mid-depth and bottom water temperatures were recorded at the time of each grab and trawl sampling and averaged with data from concurrent sampling programs to provide monthly means. The data were then used to correlate annual ocean temperature cycles with seasonal and spatial variations in community characteristics.

NPDES Monitoring

Commencing in March, the NPDES benthic sampling program was initiated. Seven stations were established under this program (Figure C-1). Station B1 (previously Station 1) adjacent to the Y-port diffuser of the Unit 1 discharge pipe (Section A. INTRODUCTION), and Station B2 just north of the Y-port diffuser were located in areas with similar sediment characteristics and represented a gradient of thermal influence. Stations B4 and B5, located south and north, respectively, of the new multi-port discharge diffuser provided background information relative to the potential impact of thermal effluents from the combined operation of Units 1 and 2. Station BC (previously Station 0) was maintained as a control for stations nearest to shore, while Station C1 (previously

Station 2) was used to integrate data from previous study years and serve as a control for stations farther from shore. Because thermal effluents from the combined operation of Units 1 and 2 may be more intense and cover a larger portion of the study area, Station B3 (previously Station 5) was used to document the potential impact of the discharge plume at this more distant location.

Shipek grab sampling was conducted at each station in March, June, September and late November using the methodologies described for ETS grab monitoring. These procedures were used to make baseline, ETS and NPDES benthic data comparable. Trawl sampling was eliminated under the NPDES monitoring program.

Data Analysis

A variety of statistical methods were used to evaluate the data collected at the St. Lucie Plant during ETS and NPDES monitoring in 1982. These tests and their applications are listed in Table C-1 with detailed descriptions of each provided in Appendix Table C-1. All tests were performed at the $P \leq 0.05$ level of significance. For most statistical comparisons, individual replicate values were used instead of station totals to provide additional degrees of freedom, thereby increasing the sensitivity of the test.

RESULTS AND DISCUSSION

Physical Environment

Substratum

Among the more important environmental parameters affecting the composition and distribution of marine benthic communities is substratum type. Sharp distinctions in community structure may occur between areas with hard substrates and those with soft substrates even when exposure to consistent patterns of water temperature, salinity and ocean currents would potentially allow colonization by similar faunal elements.

Hard substrates, such as coral reefs, rock outcroppings, wrecks and pilings support a distinct and varied community of encrusting, boring and epifaunal species. In the nearshore sediments adjacent to the St. Lucie Plant, this substratum is represented by biogenically-derived shellhash sediments. Large shell particles (>2.0 mm), a major component of the shellhash, impart heterogeneity, with resultant high porosity, to these sediments. The shellhash substratum usually supports a very diverse benthic community composed of both infaunal and hard substrate elements. Soft substrates, exemplified by the homogeneous quartz sands on the beach terrace adjacent to the St. Lucie Plant, generally support a somewhat lower infaunal biomass and species diversity (Abele, 1974).

Based on substrate characteristics (Table C-2), the study area may be divided into two distinct zones: 1) the beach terrace; and 2) the adjacent continental shelf. Beach terrace substrates were composed of fine to very fine, moderately sorted, gray, non-biogenic (quartz) sands.

These occurred at Stations BC, B1 and B2 on the seaward edge of the terrace. The larger substrate fractions at these stations consisted of mollusc shell fragments.

The adjacent continental shelf substrates were composed almost entirely of mollusc shells, barnacle plates and sand dollar tests in various stages of decomposition and fragmentation. This pebbly to very coarse, poorly sorted substrate was found at Stations B3, B4, B5 and C1.

The Kolmogorov-Smirnov Test (Sokal and Rohlf, 1981) was used to determine if significant differences ($p \leq 0.05$) in sediment texture, as evidenced by differences in grain size distributions, existed between stations. This test was also used to evaluate quarterly variations in substrates at each station. As expected, substrate composition at Stations BC, B1 and B2 was significantly different from that at Stations B3, B4, B5 and C1 (Figure C-2).

Along the beach terrace, grain size distribution did not differ significantly between Stations BC and B2 (Figure C-2). Substrate composition for these stations remained relatively constant throughout 1982 except during Quarter 4 when the percentage of very fine particles increased appreciably. Similar shifts in the relative abundance of fine and very fine sands at beach terrace stations have been noted during the winters of other years (Gallagher, 1977; ABI, 1982). This phenomenon probably results from the selective transport of certain grain sizes over the beach terrace during fall northeast storms.

Station B1 exhibited a somewhat coarser substrate than the other two beach terrace stations (Table C-2). It differed significantly from both during all sampling periods except June (Figure C-2). Because ocean turbulence is reduced during summer months, offshore transport of sediments may be reduced. This consequently enhances substrate stability and creates a more uniform substrate regime along the entire beach terrace. Substrates at Station B1 were also characterized by significant variations between quarters. Turbulence created as a result of plant discharges may be partially responsible for substrate instability at Station B1.

Stations B4 and B5, located near the seaward edge of the new discharge pipe, are located in water depths somewhat intermediate to those of the beach terrace stations and those further offshore (Stations B3 and C1; Figure C-1). As might be predicted from their proximity to the beach terrace, the sediments at Stations B4 and B5 had larger percentages by weight of fine to very fine sand particles than sediments at Stations B3 and C1 (Table C-2). Stations B4 and B5 were generally not significantly different from each other (Figure C-2), although Station B4 exhibited greater variation in grain size distribution. Stations B4 and B5 have both been exposed to disturbances associated with construction of the new discharge pipe during 1981 and may still be affected by their proximity to the pipe and turbulence associated with thermal discharges. The greater sediment instability at Station B4 suggests that this station may be more chronically impacted by plant operation or has simply taken longer to stabilize than Station B5. The latter would seem most likely

if the majority of the sediments excavated during dragline operations had been dumped south of the new discharge pipe.

Sediment characteristics of Station C1 were most similar to those of Station B3, although there were significant differences in September and December when Station C1 sediments were coarser (Figure C-2; Table C-2). A significantly larger percentage of finer particles was found at Station B3 in December than in other quarters.

Stations BC, B1, B3 and C1 correspond to Stations 0, 1, 5 and 2, respectively, from the ETS monitoring program conducted from March 1976 to March 1982. Substrates at these four stations remained relatively unchanged throughout operational years with the exception of two periods (1976 and 1981) when unusually coarse grain size were found at Station 1 (B1; ABI, 1977 and 1982). Dragline operations associated with placement of the discharge pipes were probably responsible for these sediment distribution anomalies. Little change in substrate has been observed at Stations 3 and 4 throughout the ETS program.

<u>ETS Monitoring - Benthic Grab Samples</u>

<u>Community Characteristics</u>

Appendix B, ETS monitoring for benthic macroinvertebrates was terminated after Quarter 1 sampling in 1982. Therefore, detailed comparisons with previous years' data are not possible. With few exceptions, however, March 1982 values for density, species richness, biomass and diversity were consistently within the range of values

obtained in March during other operational years (Table C-3). These data provide no evidence to suggest that the structure of benthic macroinvertebrate communities within the study area has deviated from natural long-term trends previously reported (ABI, 1982).

In general, benthic community structure has shown extensive seasonal and annual variability throughout Unit 1 ETS operational monitoring. This variability reflects the natural responses of a rich and diverse fauna to a dynamic physical environment. The imprecision of sequential peaks in macroinvertebrate abundance over the years is a phenomenon common to coastal benthic assemblages and does not necessarily indicate community instability (Frankenberg, 1971; Livingston, 1976; Frankenberg and Leiper, 1977; Maurer et al., 1979; Dugan and Livingston, 1982). In fact, assemblages such as those described during St. Lucie ETS monitoring are probably quite stable over time, faunal composition remaining relatively constant while constituent species experience continual fluctuations in population sizes.

Power Plant Impact

Over the course of ETS monitoring, there has been no evidence to suggest that thermal effluents from continued operation of Unit 1 have adversely affected the structure of benthic assemblages near the discharge (ABI, 1982). Diversity values at Station 1, directly exposed to thermal effluents have remained above minimum levels proposed by the EPA (1973) to be indicative of healthy, unstressed environments. Comparisons of abundance and species richness data between the discharge and

control stations have similarly shown no adverse plant effects. During March 1982, measured community parameters at Stations 1 and 0 were again very similar to each other (Table C-4). The lack of evidence to suoport the hypothesis of disrupted community organization through direct thermal influences is obvious considering that measured bottom water temperatures at Station 1 have never exceeded 30°C. This temperature is well below the level demonstrated to be detrimental to benthic communities elsewhere in Florida (Bader and Roessler, 1972; Virnstein, 1972; Blake et al., 1976).

Macroinvertebrate communities throughout the remainder of the study area appear likewise unaffected by plant operations. Statistical comparisons of community parameters among pre-, intermittent- and full-operational years have detected no significant differences (ABI, 1982).

ETS Monitoring-Trawl Samples

Community Characteristics

During the five months prior to the termination of ETS monitoring in May of 1982, a total of 3805 individuals of 77 taxa was collected by otter trawls at the six ocean stations. The greatest numbers of individuals (1121 and 1013) were found at beach terrace Stations 0 and 1, respectively, while the fewest (103) occurred at Station 3 on Pierce Shoal (Figure C-3). Despite considerable variation in monthly abundances at at discharge and control stations (Stations 1 and 0, respectively; Figure C-4) no significant difference was found when comparable data for all years were combined and compared statistically (Wilcoxon Paired Sample Test, $P \leq 0.05$).

The highest number of macroinvertebrate taxa collected during 1982 (36) occurred at Station 5, while the lowest number (11) was found at Station 3 (Figure C-3). The numbers of taxa found during 1982 generally fell within the ranges observed for corresponding months of previous years (Figure C-5). Throughout the ETS study a seasonal pattern of lower numbers of taxa during the winter and higher numbers during the summer was observed.

Comparison of 1982 species richness data (Figure C-5) showed no significant differences (Mann-Whitney U-Test, $P \leq 0.05$) between the discharge and control stations. The same results were obtained when the combined data for all years were tested. Additionally, when the total number of taxa collected annually at Station 1 was compared, no significant differences were found among years (Mann-Whitney U-Test, $P \leq 0.05$). Finally, no correlation (Spearman Rank, $P \leq 0.05$) was observed between mean bottom water temperature and species richness at either Station 0 or Station 1 throughout the entire ETS study period.

Because of the termination of trawl sampling in May, insufficient data were available to permit the construction of meaningful dominance-diversity curves for 1982. Such curves from previous years (ABI, 1982) indicate that there has been little change in dominance-diversity values since the plant began full operations in 1977. In addition, variation at Station 1 (discharge) between 1977 and 1981 fell within the range of variation observed at Station 0 (control) during that same period.

As was the case for diversity, similarity analyses based on the first five months of 1982 were considered inappropriate. In past studies (ABI, 1982), Morisita's (1959) index of community similarity consistently showed a high degree of similarity between Stations 0 and 1, particularly if Acetes americanus, a relatively small species which may not be effectively sampled by the trawl, was omitted from the calculations.

During 1982, shrimp of the genus Trachypenaeus were among the top five dominant taxa (McCloskey's Biological Index Value) at all trawl stations (Table C-5), being ranked first at every station except Station 5. This represents a continuation of the trend observed throughout operational monitoring studies (1976-1981). Comparison of the dominant taxa at Stations 0 and 1 during 1982 showed that four of the five top ranked species were shared between the two stations. In addition, 11 of the 13 dominant taxa at Station 0 from 1977-1981 were also ranked as dominants at Station 1 during that period.

Because Trachypenaeus constrictus has been so predominant in trawl samples throughout the ETS monitoring program, this non-commercial species was chosen for analysis as a potential indicator of environmental stress. During 1982, the greatest abundance of T. constrictus (229) was recorded at Station 0, while the lowest (34) occurred at Station 3 (Figure C-3). Although 1982 data represent only five months of sampling, a decline in the extremely high numbers recorded at Station 1 during 1981 is indicated (Figure C-6). This information supports the suggestion made previously (ABI, 1982) that such high numbers may have reflected

increased food availability resulting from 1981 dragline-dredging activities near Station 1. No such dredging operations were carried out near the discharge in 1982. Even though abundances of T. constrictus at the discharge and control stations were highly variable throughout the ETS study period (Figure C-6), comparisons between the two stations revealed no significant differences (Wilcoxon Paired Sample Test, $P \leq 0.05$).

Six taxa of commercially important shellfish were collected by trawling during 1982 (Table C-6). These included the brown shrimp (Penaeus aztecus), the pink shrimp (Penaeus duorarum), juvenile penaeid shrimp (Penaeus sp.), the rock shrimp (Sicyonia brevirostris), the blue crab (Callinectes sapidus) and the calico scallop (Argopecten gibbus). In general, the commercially important crustaceans were collected at most stations, including the discharge, but were present in such small numbers that no trends were evident. A. gibbus, on the other hand, was found in relatively large numbers at offshore Stations 2, 4 and 5, but it was never collected at Station 0 and only one individual was found at Station 1. The very low abundance pattern of A. gibbus on the beach terrace has been maintained throughout the six-year ETS study period. A. gibbus occurrence at trough stations has been quite variable in past years, ranging from absent to very abundant.

Baseline Comparisons

From September 1973 through August 1974, prior to plant operation, monthly otter trawl samples were collected at sites corresponding to Stations 1, 2 and 3 of the present ETS program (Camp et al., 1977). Although that program differed somewhat from the operational study (1976-1982), it provides baseline information concerning the larger epibenthic crustaceans and echinoderms near the discharge (Table C-7).

Comparisons of baseline and operational crustacean abundance and species richness data for Station 1 show values for both parameters to have increased following plant activation. This may have resulted from a combination of factors such as the presence of new habitat types provided by the discharge structure, more effective trawling techniques implemented during operational years, and natural population fluctuations. All but one of the crustacean species collected at Station 1 prior to plant operation were also encountered after plant start-up. Therefore, it appears that few, if any, of the larger epibenthic crustaceans sampled by the trawls have been eliminated from the vicinity of the discharge since plant operations began in 1976.

In general, the numbers of echinoderms collected in both preoperational and operational years have been low and somewhat variable (Table C-7). None were collected in 1982. Thus, echinoderms appear to have constituted only a minor portion of the epibenthic invertebrate fauna near the discharge both before and after plant start-up.

Power Plant Impact

The results of analyses of trawl data collected since 1976 indicate that no statistically significant differences exist between abundance and species richness of epibenthic macroinvertebrates living at the discharge (Station 1) and those inhabiting the control (Station 0). A high degree of similarity was also observed between these two stations in terms of 1) general community composition and structure; 2) dominant taxa; 3) abundance and composition of commercial species present; and 4) abundance of *Trachypenaeus constrictus*, a species dominant in trawl collections. In addition, species richness at Station 1 has not varied significantly throughout the years of operational monitoring (1976-1982). Comparison of operational with baseline trawl data was limited because of differing methodologies; however, a high degree of similarity was indicated in those aspects of the programs which could be compared.

Throughout the course of ETS monitoring, there has been no evidence to suggest thermal impact upon the epibenthic macroinvertebrate community near the St. Lucie Unit 1 discharge. Both direct and indirect thermal effluent effects appear unlikely because of the high degree of similarity between discharge and control stations.

NPDES Monitoring-Benthic Macroinvertebrate Community Structure

Density

Over 21,000 macroinvertebrates were collected and identified during 1982 NPDES benthic monitoring. Beach terrace Stations BC, B1 and B2 supported the fewest number of individuals and adjacent shelf stations,

B3, B5 and C1, the greatest (Table C-4). Station B4 was an exception to the latter group having densities intermediate to those found on the beach terrace and adjacent shelf. The highest station density recorded during the study (16,600 individuals/m^2) occurred at Station B3 (September), while the lowest (217 individuals/m^2) was observed at Station B1 (late November). When individuals from all stations were combined, highest densities occurred in September, lowest densities in late November. However, seasonal shifts in macroinvertebrate abundance varied considerably among stations with no consistent trends apparent (Figures C-7 and C-8; Table C-4).

Species Richness

During 1982 NPDES monitoring, 472 macroinvertebrate taxa were identified from benthic collections (Appendix Table C-2). As with densities, beach terrace stations supported the fewest number of species, while adjacent shelf stations supported the greatest number (Table C-4). Again, Station B4 exhibited an intermediate species richness relative to beach terrace and adjacent shelf stations. The largest number of taxa collected during any sampling period (156) was at Station B3 (June), while the lowest number (15) occurred at Station BC (late November). When collections from all stations were combined, highest seasonal species richness (287) occurred in June, the lowest (204) in late November. Similar to abundance data, seasonal trends in species richness varied considerably among stations except in late November when appreciable declines in the number of taxa collected occurred at all stations.

When data for all stations were combined, species richness was found to be positively correlated (Pearson Product-Moment $P \leq 0.05$) with faunal abundance (Table C-8). This positive correlation persisted when the two major station groupings (beach terrace, adjacent shelf) were examined separately. Thus, both within and between habitats, communities having the greatest number of individuals also had the largest number of species.

Biomass

As expected, mean annual biomass was lowest at beach terrace stations where faunal abundances were low and highest at adjacent shelf stations where abundances were high (Table C-4). Station C1 had the highest seasonal biomass value of any station (33.192 g/m^2) due, primarily, to the presence of a relatively large starfish in the June sample. The lowest biomass value (0.556 g/m^2) was recorded at Station B2 in September. When all stations were combined, highest mean biomass occurred in June, lowest mean biomass in late November. As with other community parameters, no consistent seasonal trends in biomass were apparent when stations were examined individually.

Biomass is a poor indicator of community structure because of bias introduced by the chance acquisition of relatively large, sparsely distributed organisms and bias resulting from differences through time and space in the relative abundances of heavier-bodied organisms such as arthropods and echinoderms. Because the number of taxa collected increases with the number of individuals collected, the chances of

collecting a large variety of organisms, including heavier-bodied forms, increases also. Consequently, significant correlations were found between biomass and both faunal abundance and species richness when data from all stations and quarters were combined (Table C-8). However, this same relationship did not persist when beach terrace stations were examined separately, and only biomass and species richness were significantly correlated when adjacent shelf stations were tested. As a result, much of the correlation between biomass and abundance appears related to differences in community structure between, rather than within, major stations groupings.

Diversity

Diversity (H') based on the Shannon-Weaver information function (Pielou, 1966) is a more complex measure of faunal diversity than species richness. Diversity considers not only the number of species present, but also the number of individuals and the distribution of those individuals among the constituent species. Communities in healthy non-stressed environments should theoretically have higher diversities than communities in similar systems experiencing various forms of physical stress (EPA, 1973).

Beach terrace communities generally had lower diversities than adjacent shelf stations even though there were a few exceptions (Table C-4). At most stations, diversity values were relatively stable throughout the first three quarters of sampling. However, during late November, noticeable declines accompanied reductions in species richness at all stations

(Figures C-7 and C-8). A similar decline in diversity occurred at Station B2 in June, but probably resulted from reduced sample size (An unrepresentative data set was deleted so that two, rather than three, replicates were used for analysis during that quarter. The reduced sample size affected the number of species accumulated).

The highest diversity calculated during the study (5.491) was at Station B3 (June), and the lowest (2.180) was at Station BC (late November). In general, diversity values were representative of communities in a non-stressed environment. Declines in diversity at all stations in late November indicated natural community responses to seasonally fluctuating environmental factors.

Evenness values (J') numerically describe the distribution of individuals among the taxa present in a collection. In environments experiencing physical stress, certain organisms may gain a competitive advantage and become numerically dominant. As dominance increases, evenness declines.

Contrary to other trends in community parameters, evenness values were generally higher at beach terrace than at adjacent shelf stations (Table C-4). Station BC had the highest mean evenness value for the year (0.793) and Station B5 the lowest (0.475). Highest and lowest values, respectively, for individual stations occurred at Station BC in March (0.829) and Station B2 in June (0.416). As with diversity, the low value at Station B2 during Quarter 2 is probably reflective of reduced replica-

tion. No consistent seasonal trends in evenness were apparent from the data. Stations B4 and B5 exhibited the most seasonally stable evenness values.

Rarefaction is another method for examining the relationship between species richness and faunal abundance. This method produces a set of station curves depicting the expected number of taxa in a community at various faunal densities. It thus allows for comparison of data from different sample sizes (i.e., abundances). Curves with sharp slopes represent communities having a relatively large number of taxa per unit number of individuals, and gentle slopes indicate fewer taxa for that same number of individuals. The absolute height of the curve represents species richness and the end point total faunal abundance.

Rarefaction curves generated using total annual abundance were similar for all stations (Figure C-9 and C-10); the two station groupings were plotted on different scales because of the large disparity between abundances at beach terrace and adjacent shelf stations. The smallest total annual abundance for any one station during 1982 was 250 individuals (Station 2). At that abundance level, expected number of taxa predicted from rarefaction curves ranged from 54 to 84 (Figures C-9 and C-10), with beach terrace stations generally accruing species at a lower rate than adjacent shelf stations (range 54-67 and 62-84, respectively). Within the beach terrace station group, Stations B1 and B2 exhibited higher rarefaction diversity than did Station BC. Within the adjacent shelf station group, Stations C1 and B4 exhibited the highest rarefaction

diversities and Station B5 the lowest. All stations lacked plateaus at highest faunal densities indicating that more species would have been collected with increased replication. Earlier saturation studies showed that those species which are being missed are rare forms represented by very few individuals (ABI, 1978).

Community Composition

During 1982 NPDES monitoring, annelids numerically predominated the collections at all stations (Figure C-11). Annelids contributed between 45 percent (Station BC) and 57 percent (Station B2) of total faunal abundance at beach terrace stations and between 67 percent (Station B3) and 71 percent (Station C1) at adjacent shelf stations. Various combinations of molluscs, arthropods and miscellaneous minor phyla composed the majority of remaining individuals at beach terrace stations, while sipunculids were the second major contributors at adjacent shelf stations. Station B4 was an exception to the latter group as arthropoda and miscellaneous minor phyla replaced sipunculans as important contributors to community density. Echinoderms and cephalochordates (lancelets) contributed little to total faunal abundance at any station.

As mentioned earlier, biomass is affected by both the number and absolute size of individuals contained in collections. Although annelids predominated abundances at all stations, they accounted for only 11 percent (Station C1) to 31 percent (Station B5) of community biomass (Figure C-11). At beach terrace Stations BC and B2, miscellaneous minor phyla, primarily nemerteans, contributed over 50 percent of total biomass, while

at Station B1, biomass contributions were more equitably distributed among all major groups. A noticeable disparity between relative abundances and biomass of major groups occurred at adjacent shelf stations where cephalochardates and echinoderms collectively accounted for between 22 (Station B4) and 69 percent (Station C1) of total biomass, while contributing less than 2 percent of total abundances. The extremely large contribution of echinoderms to biomass at Station C1 was primarily because of the presence of one relatively large starfish during June. No general conclusion can be drawn regarding contributions by major groups to biomass at shelf stations.

Dominance

Dominance relates to the disproportionate contribution of some taxa to total community abundance. Communities experiencing various forms of physical stress often display high levels of dominance as certain species may gain a competitive advantage over others under adverse conditions. However, dominance by certain taxa also occurs naturally as certain forms are better adapted to the existing physical environment. In this situation, changes in dominant taxa over time may reflect changing environmental conditions.

The criteria used for selecting dominant taxa was determined *a priori*. All taxa at each station were ranked from most to least abundant. Those taxa, whose cumulative abundances approached but did not exceed 50 percent of all organisms present, were designated as dominants. Using this criteria, 30 taxa were listed as dominants at one or more sta-

tions during 1982 (Table C-9). Seventeen annelids, five molluscs, five arthropods and unidentified individuals of three minor phyla (Platyhelminthes, Nemertina and Sipuncula) were included in this group.

The highest number of dominant taxa occurring in any quarter (7) was at Station B3 during both March and June. Dominance by a single taxa occurred at three stations, Stations B2 (June), B3 (late November) and B5 (late November). When data for all quarters were combined, two major components were evident. The polychaete Armandia agilis and unidentified nemerteans were dominant forms at all beach terrace stations, while the tube worm Filogranula sp. A and unidentified sipunculans were dominants at adjacent shelf stations. Again, Station B4 was an exception to the latter group as Nemertina was the only principal dominant taxa shared in common with either station grouping. Station B4 also had the largest number of taxa (7) classified as dominants for the entire year. This suggests that community stability may be lower there than at other stations and that turnover among dominant taxa is high. Station B5 had the fewest dominant taxa for all quarters combined (2) suggesting that it may be the most stable.

When quarterly data were examined separately, there were considerable shifts in dominance at each station over time. Again, Station B5 appeared to be the most seasonally stable community with regards to dominant organisms.

Station Similarities

Morisita's (1959) index of faunal similarity (Cλ) compares the number of species shared between two collections and their relative abundances. Collections having the largest number of numerically abundant species in common will have the highest cλ values.

As expected from previous discussions of community parameters, two major station groupings were apparent from similarity matrices. Beach terrace stations exhibited high to very high similarities to one another during most quarters while adjacent shelf stations, excluding Station B4, were highly to very highly similar to one another (Figure C-12). When data for all quarters were combined, the similarities within station groupings were all very high, except for Station B4 which displayed low to very low similarities with both groups. Similarity coefficients determined for dominant taxa at each station portrayed the same relationship among stations (Figure C-13).

Similarity indices for individual stations indicated that adjacent shelf stations, again excluding Station B4, tended to be more similar over time (i.e., more stable) than beach terrace stations. The community at Station B4 exhibited low similarity from one quarter to the next providing additional evidence that it was in a state of transition during 1982.

General Responses to Physical Variables

Both temperature and substrate are known to be important in shaping benthic community structure (Sanders, 1958; Boesch, 1972). In most environments, temperature is an obvious causative agent of benthic community dynamics, as it is known to affect seasonal reproductive patterns in marine invertebrates (Giese and Pierce, 1974; Sastry, 1975). Consequently, periods of juvenile recruitment are often linked to seasonal ocean temperature cycles.

During 1982, mean bottom water temperatures ranged from 20.2°C in January to 28.5°C in September (Figure C-14). Minimum and maximum temperatures recorded during those months were 18.0 and 29.5°C, respectively. Bottom and surface water temperatures at the deeper offshore stations usually differed by less than 1°C and rarely differed by more than 2°C. At the shallower beach terrace stations, thermal gradients were even less noticeable.

The existing ambient thermal regime at the St. Lucie site may be modified by intrusions of colder offshore bottom or by thermal discharge from the plant. During June, for example, offshore winds created an upwelling effect which allowed offshore bottom water to enter the area and depressed bottom water temperatures to below 20°C. Surface water temperatures exceeded bottom water temperatures by more than 3°C during this period which created distinct thermal stratifications. Thermal discharges from the St. Lucie Plant are rapidly dispersed and dissipated because of the ocean's great capacity to absorb heat and natural tur-

bulence from currents and waves. During 1982, discharge stations on the beach terrace (Stations B1 and B2) generally experienced bottom temperatures less than 1°C higher than those observed at Control Station BC. However, greater differences were sometimes recorded during the summer with a maximum observed ΔT of 2°C occurring in June. Discharge stations located farther from shore (Stations B3, B4 and B5) never experienced bottom temperatures greater than 1°C above ambient conditions (Control Station C1). Temperatures at Station B3 consistently approximated those of Control Station C1 indicating that Station B3 is beyond the range of thermal influence when only Unit 1 is operating. Because St. Lucie Power Plant effluents are directed upward through the water column, differences between surface and bottom water temperatures at stations adjacent to the discharge diffuser pipes (Stations B1, B3, B4 and B5) were typically more pronounced than at stations more distant from the pipes (Stations BC, B3 and C1).

Community data for all stations combined and for both beach terrace and adjacent shelf station groupings separately showed no significant correlation with bottom water temperature during 1982 NPDES monitoring (Table C-8). However, a general trend of increasing densities with increasing water temperatures was apparent (Figure C-14). The lack of a significant correlation, as was found during ETS monitoring (ABI, 1982) may have been, in part, because of the presence of a cold-water intrusion during the June 1982 sampling period. This anomalous situation depressed bottom water temperatures considerably below normal seasonal averages. When data for all years were considered, a positive relationship between

faunal abundance and water temperature was apparent. Because of the significant positive correlation between density and species richness, it can be assumed that within the study area, the greatest number of individuals and species will occur in the summer and the fewest in the winter.

During ETS monitoring, community structure was shown to be strongly influenced by substratum (ABI, 1978). This same relationship was evident during 1982 NPDES monitoring. Sediments of beach terrace stations were similar to each other (Table C-2; Figure C-2), and communities at these stations showed very high degrees of community similarity. Adjacent shelf stations were also similar to one another in both community and sediment characteristics. Within the latter grouping, Station B4 exhibited the most seasonally unstable sediment regime and the greatest fluctuations in community characteristics. For that reason it occupied an intermediate position to beach terrace and adjacent shelf stations in relation to general community structure.

When all stations and quarters were combined, a significant negative correlation existed between all community parameters and mean sediment grain size (Table C-8). However, when major station groupings were examined separately, there was no relationship. Therefore, major differences in sediment texture between beach terrace and adjacent shelf stations probably accounted for observed differences in community structure between these two habitats. Within-habitat differences in community structure appeared to be more closely associated with sediment stability over

time than with minor differences in sediment grain size distributions occurring between stations.

Shipek Grab Reliability

Gallagher (1977) previously addressed the inherent problems associated with the operation of the Shipek sediment sampler. Its principal deficiencies are that it does not operate with the same effectiveness in different types of substrata and that within a substrata, it does not consistently remove the same volume of sediments. Thus, differences in sampling efficiencies may invalidate inferences made regarding spatial and temporal fluctuations of community parameters.

In order to determine if sampling efficiency, measured as the amount of material excavated during sampling, affected the number of organisms collected, a set of tests were applied to St. Lucie grab data. Within each major sediment regime (i.e., beach terrace and adjacent shelf), the total number of organisms collected in each replicate was correlated (Pearson product-moment correlation; $P \leq 0.05$; Zar, 1974) with sediment depth (mm) in the sample bucket. Data for all quarters combined showed no significant correlation within either sediment type. When individual quarters were treated separately, only the adjacent shelf stations exhibited a significant correlation, and that occurred only during one sampling period (Quarter III). Thus, within each sediment type, spatial and temporal differences in faunal abundance were seldom related to changes in sampling efficiency.

To partition out possible confounding effects resulting from the heterogeneous distribution of organisms over time and space, least squares linear regression analyses (Sokal and Rohlf, 1981) were performed on a series of samples taken at two stations (one in each sediment type) during one point in time. In March 1977, 10 replicates were taken at Station B1 and 7 at Station B3 (ABI, 1978). Numbers of individuals plotted against grab penetration depth produced regression lines at both stations whose slopes did not differ significantly ($P \leq 0.05$) from zero (B1: slope = 0.109, R^2 = 0.081 and $t_{(df=8)}$ = 0.855; B3: slope = 0.035, R^2 = 0.337 and $t_{(df=6)}$ = 1.421). Thus, factors other than grab sampling efficiency were affecting observed differences in faunal abundances between replicates.

It is realized that given an evenly dispersed fauna, both vertically and horizontally, larger grab samples will contain greater numbers of individuals than smaller samples. However, the data presented above suggest that both within habitat and within station differences in faunal abundance (as well as associated community parameters) are structured to a greater degree by factors other than grab sampling efficiency. Thus, it is assumed that within a sediment type, minor sampling inconsistencies will not appreciably affect the outcome of data analyses, and inferences drawn from the statistical tests will be valid.

NPDES Monitoring-Power Plant Impact

The primary function of any applied environmental study is to answer questions regarding a possible source of impact through the use of known biological and ecological relationships supported by inferential statistics. This task first requires a series of logical statements as to what types of biological changes will be accepted as indicative of the existence of impact. Next, a series of null hypotheses are formulated concerning these logical statements before the data are collected. The following discussion addresses the biological and statistical logic employed in this study to assess the existence and extent of power plant discharge effects.

The most complete and unambiguous answers to environmental problems are obtained when spatial control stations and control (baseline) years can be compared with treatment stations and operational years. The NPDES sampling program assumes that Station C1 (ETS Station 2) has never been affected by the thermal plume because of prevailing currents and plume dispersion characteristics. Hence, it may be considered a control station. Station B3 (ETS Station 5), exhibiting a similar grain-size distribution to Station C1, is potentially affected by the discharge plume during most of the year. Therefore, it can be used as a treatment station. Both stations were sampled during baseline years and thus can be compared in an optimal experimental design.

Only baseline data on echinoderms, arthropods, and lancelets are currently available (Camp et al., 1977; Futch and Dwinell, 1977; Martin, in prep). Lancelet densities were very sporadic, often very low and generally unsuitable for parametric analysis of variance (ANOVA). For this reason, only echinoderm and arthropod total densities were analyzed.

The optimal statistical design was a 2 x 2 (stations x time) two-way ANOVA. Because baseline sampling was conducted bimonthly, while operational sampling was quarterly, it was necessary to mold the data into similar scales. This was accomplished by choosing four months during each baseline year that best approximated the months sampled during operational years. This procedure then produced eight quarters of baseline data to be compared with 24 quarters of operational data. Since two-way ANOVA is severely affected by an unbalanced design, it was necessary to select eight quarters from the 24 occurring during operational years. Selection was accomplished through a stratified random method, providing two first quarters, two second quarters, two third quarters and two fourth quarters. For every two-way ANOVA, three randomizations were separately analyzed (Appendix Tables C-3 through C-8).

In these analyses, the existence of plant impact was indicated by a significant stations x time interaction term. Regardless of significance or non-significance of any main effects (space or time), if a significant interaction term resulted, then the plant was assumed to have had an impact on the benthic associations at that site.

The important null hypothesis was then:

HO: There is no significant interaction effects of differences in space and time on the selected criteria variable (i.e., arthropod and echinoderm densities).

For arthropod and echinoderm total densities, two-way ANOVA revealed no significant interaction term for any randomization. Therefore, at Station B3 (5), the null hypothesis was not rejected. Such an outcome is not unexpected since this treatment station is relatively distant from the discharge pipes. Unfortunately, the spatial control station (Station BC) on the beach terrace was not sampled during baseline years, and so stations closer to the discharge could not be tested in this manner.

For most community characteristics, such as total faunal density, species richness, diversity (H') and relative abundance, it was not possible to apply the optimal analysis described previously because the baseline data was incomplete relative to operational data. Thus, inferences concerning plant effects on these parameters must be derived from comparisons between treatment stations (stations potentially impacted by plant operation) and the proper control station:

Null hypothesis and variables

HO: If there is no significant change in a criteria variable at a treatment station relative to the control at a specified time, then there has been no plant effect.

Using one-way ANOVA (Appendix Tables C-9 through C-30) faunal densities at adjacent shelf Stations B3, B4 and B5 were compared with their

control site, Station C1. When data for all quarters were combined, a significant difference was found. Newman-Keuls Multiple Range test revealed that the densities at Station B4 were significantly lower than all the other stations, while densities at Stations C1, B3 and B5 were not significantly different from one another. Except for Quarter I, these differences persisted when adjacent shelf stations were compared on a quarter by quarter basis. Identical comparisons made for species richness showed that, for all quarters combined and for each quarter separately, Station B4 had significantly fewer species than other adjacent shelf stations.

When beach terrace Stations B1 and B2 were compared with their control, Station BC, in the same manner described above, no significant differences were found for either densities or species richness.

Differences in diversity were tested for significance using the t-test method described by Poole (1974). For Quarters 1, 3 and 4 there were no significant differences in diversity between Station C1 and adjacent shelf Stations B3, B4 and B5 (Table C-11). However, during Quarter 2, Station B5 had a significantly lower diversity than Station C1. No differences existed between Stations BC (control) and B1 and B2 (treatments) during any quarter.

Between station differences in the relative abundance regimes (frequency distributions of individuals among species) were tested in pair-wise fashion using the Kolmogorov-Smirnov test. When data for all

quarters were combined, adjacent shelf Stations B3, B4 and B5 were all different from their control, Station C1 (Table C-12). Analysis by quarter revealed that Station C1 was always statistically different from Stations B3 and B5, and was different from Station B4 during Quarters 1 and 3. For each of these stations, there was significant within-station variation between quarters for all temporally adjacent comparisons (Table C-13). By the nature of statistical design, the null hypothesis must be rejected for every quarter for Stations B3 and B5. However, since Station C1 was also changing every quarter, as were the treatments, it is likely that a relatively large portion of the change in relative abundance regimes statistically attributed to the plant may, in fact, be a result of natural multi-directional succession.

Relative abundance at Station BC did not vary statistically from quarter to quarter (Table C-13) and, therefore, the difficulties in interpretation seen for Station C1 and its treatments do not exist here. During Quarters 1 and 4, Stations B1 and B2 were not different from Station BC; however, both stations were different from Station BC during Quarters 2 and 3. These changes were paralleled by increases in the number of dominant species at Stations B1 and B2 during these quarters (Table C-9). The plant discharge appears to have the effect of changing relative abundance distributions on the beach terrace during warmer months specifically by increasing the number of dominant species (decreasing numerical dominance by fewer species).

For the variables employed in statistical inference testing, treatment Stations B1 and B2 seldom showed differences from their control, Station BC. Since Stations B1 and B2 are 168 m inshore from the discharge ports of the new pipe and very near the pipe not currently in use, it seems likely that 1) there is little biologically significant leakage from the capped old discharge pipe and 2) the plume from the new discharge system does not extend inshore as far as these stations.

The null hypothesis of no plant effect was rejected for faunal abundance and species richness at Station B4 and for diversity during one quarter at Station B5. Station B4 was often different from the other stations in this grouping. This station also underwent significant changes in sediment grain-size composition over the course of the year (Table C-2). Since density and species richness were shown to be significantly correlated with sediment characteristics (Table C-8), the changes noted for the biological variables at this station may largely derive from this relationship. Possibly increased water velocity from the new discharge may have resulted in the observed changes in sediment characteristics. It is unlikely that thermal effects were the causative agent since the correlations between water temperature and various biological variables were low.

Although statistically significant, community disturbances at Station B4 appear to have been moderate, as density values consistently remained above 1000 individuals and diversity values remained similar to those at the control station. Similarly, the relatively low diversity

value at Station B5 during Quarter 2 (4.229) was still much higher than values commonly reported for polluted marine areas (Gray, 1981). Hence, even though the null hypothesis of no plant effect was rejected for certain community parameters at the two stations located immediately adjacent to the new discharge, effects appear to be limited in both magnitude and areal extent.

Clearly, because there were no effects at Stations B1, B2 and B3 that were not mirrored by their respective controls (except the somewhat ambiguous relative abundance variable), discharge effects were confined to absolute maximum distances from the new discharge of 2.7 km north (the distance to Station B3), 168 m west (inshore, distance to Stations B1 and B2) and 94 m east (seaward, the distance to Station C1) This is the best level of resolution possible from station placements. However, judging from biological and temperature data, the impact of heated effluent is probably restricted to areas very much closer to the discharge pipe.

SUMMARY

During 1982, ETS sampling was terminated and the NPDES program was initiated. The NPDES program was designed to provide continued operational monitoring of Unit 1 and to provide both preoperational and operational monitoring of Unit 2. Seven stations were sampled quarterly and collected organisms identified and enumerated.

Two major habitats were evident from sediment data, the beach terrace and the adjacent shelf. Beach terrace sediments were composed of fine to very fine, moderately-sorted, non-biogenic sands, while adjacent shelf sediments consisted of pebbly to very coarse, poorly-sorted, biogenic materials referred to as shell hash. Each substratum supported a unique assemblage of macroinvertebrates, shell hash communities exhibiting higher densities, higher species richness, higher biomass and higher diversities than beach terrace communities. Within both habitats, annelids were numerically predominant.

Prior to 1982, thermal effluents were discharged through a Y-port diffuser on the beach terrace. However, during 1982, effluents were diverted through a new multiport diffuser extending farther offshore. Thermal discharges were thus dispersed over a larger area and potentially affected benthic communities in both major habitats. Experimental (discharge) and control stations were established within both habitats to assess the effects of power plant operation.

Within the benthic macroinvertebrate communities throughout the study area appreciable shifts in the relative abundances of constituent species occurred over time and seasonal changes in dominant organisms occurred. In the shell hash habitat, these fluctuations occurred at both control and discharge stations, and thus probably reflected natural community responses to a dynamic physical environment. On the beach terrace, shifts in species-abundance patterns at discharge stations, relative to the control, suggest that during the summer, plant operations may have affected community composition within this habitat.

Statistical tests were used to compare selected community parameters between control and discharge stations within each habitat. On the beach terrace, no statistically significant plant effect on densities, species richness or diversities was detected. However, within the shell hash substrata, the community south of the new discharge pipe (Station B4) exhibited significantly lower densities and lower species richness than at the control station. Sediment instability from construction activities during placement of the new pipe and/or turbulence from discharged water may have accounted for the observed differences. Temperature appears to have had little effect on community structure.

Comparison of control and treatment stations between baseline and operational years, using an optimal experimental disign, indicated that seven years of power plant operation (Unit 1) has not significantly affected either arthropod or echinoderm densities at the most distant sampling location (2.7 km north of the plant). The lack of an appropriate control on the beach terrace during baseline years precludes an evaluation for stations closer to the plant site. However, operational data suggest that plant effects are limited in both magnitude and areal extent.

LITERATURE CITED

Abele, L.G. 1974. Species diversity of decapod crustaceans in marine habitats. Ecology 55:156-161

ABI (Applied Biology, Inc.). 1977. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1976. Vol. 1. AB-44. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________________. 1978. Ecological monitoring at the Florida Power & Light Co., St. Lucie Plant, annual report 1977. Vol. 1. AB-101. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________________. 1979. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1978. Vol. II, Biotic monitoring. AB-177. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________________. 1980a. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1979. Vol. II, Biotic monitoring. AB-261. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________________. 1980b. Florida Power & Light Company St. Lucie Plant. Effects of increased water temperature on the marine biota of the St. Lucie Plant area. AB-261. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________________. 1981a. Proposed St. Lucie Plant preoperational and operational biological monitoring program. August 1981. AB-358. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________________. 1981b. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1979. Vol. II, Biotic monitoring. AB-324. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________________. 1982. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1979. Vol. II. Biotic monitoring. AB-379. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

Bader, R.G. and M.A. Roessler, eds. 1972. An ecological study of south Biscayne Bay and Card Sound. Progress report to U.S. Atomic Energy Commission (AT (40-1) - 3801-4).

Blake, N.J., L.J. Doyle and T.E. Pyle. 1976. The macrobenthic community of a thermally altered area of Tampa Bay, Florida. Pages

LITERATURE CITED (continued)

296-301 in G.W. Esch and R.W. McFarlane, eds. Thermal ecology II. NTIS No. CONF-750425. Technical Information Center, Energy Research and Development Administration.

Boesch, D.F. 1972. Species diversity of marine macrobenthos in the Virginia area. Chesapeake Science 13:206-211.

Camp, D.K., N.H. Whiting and R.E. Martin. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. V. Arthropods. Florida Department of Natural Resources Marine Research Laboratory, Marine Research Publication No. 25. 63 pp.

Dugan, P.J. and R.J. Livingston. 1982. Long-term variation of macroinvertebrate assemblages in Apalachee Bay, Florida. Estuarine, Coastal and Shelf Science 14:391-403.

EPA. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA 670/4-73-01. C.I. Weber, ed. Environmental Protection Agency, National Environmental Research Center, Cincinnati.

Elliot, J.M. 1971. Some methods for the statistical analysis of samples of benthic invertebrates. Freshwater Biological Association. Scientific Publication No. 25. 144 pp.

Folk, R.L. 1966. A review of grain-size parameters. Sedimentoloty 6: 73-93.

Frankenberg, D. 1971. The dynamics of benthic communities of Georgia, U.S.A. Thalassia Jugoslavica 7:49-55.

Frankenberg, D. and A.S. Leiper. 1977. Seasonal cycles in benthic communities of the Georgia continental shelf. Pages 383-397 in B.C. Coull, ed. Ecology of marine benthos. University of South Carolina Press, Columbia.

Futch, C.R. and S.E. Dwinell. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. IV. Lancelets and fishes. Florida Department of Natural Resources Marine Research Laboratory, Marine Research Publication No. 24. 23 pp.

Gallagher, R.M. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. II. Sediments. Florida Department of Natural Resources Marine Research Laboratory, Marine Research Publication No. 23: 6-25.

Gallagher, R.M. and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. I. Introduction and rationale. Florida Department of Natural Resources Marine Research Laboratory, Marine Research Publication No. 23: 1-5.

LITERATURE CITED (continued)

Giese, A.C. and J.S. Pearse. 1974. Introduction: General principles. Pages 1-49 in A.C. Giese and J.S. Pearse, eds. Reproduction of marine invertebrates. Vol. I. Academic Press, New York.

Gray, J.S. 1981. The ecology of marine sediments. Cambridge University Press, New York. 185 pp.

Green, R.H. 1979. Sampling design and statistical methods for environmental biologists. John Wiley and Sons, New York, N.Y. 257 pp.

Holland, J.S., N.J. Maciolek and C.H. Oppenheimer. 1973. Galveston Bay benthic community structure as an indicator of water quality. Contributions to Marine Science 17:169-188.

Livingston, R.J. 1976. Diurnal and seasonal fluctuations of organisms in a north Florida estuary. Estuarine and Coastal Marine Science 4:373-400.

Lloyd, M.J., J.H. Zar and J.R. Karr. 1968. On the calculation of information-theoretical measures of diversity. American Midland Naturalist 79:257-272.

Logan, D.T. and D. Maurer. 1975. Diversity of marine invertebrates in a thermal effluents. Journal of the Water Pollution Control Federation 47:515-523.

Martin, R.E. In preparation. Nearshore marine ecology at Hutchinson Island, Florida. 1971-1974. VI. Echinoderms. Florida Department ofNatural Resources Marine Research Laboratory, Marine Research Publication.

Maurer, D., P. Kinner, W. Leathem and L. Watling. 1976. Benthic faunal assemblages off the Delmarva Peninsula. Estuarine and Coastal Marine Science 4:163-177.

Maurer, D., W. Leathem, P. Kinner and T. Tinsman. 1979. Seasonal fluctuations in coastal benthic invertebrate assemblages. Estuarine and Coastal Marine Science 2:181-194.

McCloskey, L.R. 1970. The dynamics of the community associated with a marine scleractinian coral. Int. Revue Ges Hydrobiol. 55:1381.

Morisita, M. 1959. Measuring of interspecific association and similarity between communities. Mem. Fac. Sci. Kyusu University, Ser. E (Biology). 3:65-80.

Pielou, E.C. 1966. The measurement of diversity in different types of biological collections. Journal of Theoretical Biology 13:131-144.

LITERATURE CITED (continued)

Poole, R.W. 1974. An introduction to quantitative ecology. McGraw-Hill, Inc., New York, N.Y. 532 pp.

Reish, D ., D.F. Soule and J.D. Soule. 1980. The benthic biological ...itions of Los Angeles-Long Beach Harbors: Results of 28 years of investigations and monitoring. Helgolander Meeresunters 34:193-205.

Sanders, H.L. 1958. Benthic studies in Buzzards Bay. I. Animal-sediment relationships. Limnology and Oceanography 3:245-258.

____________. 1968. Marine benthic diversity: A comparative study. American Naturalist 102:243-282.

Sastry, A.N. 1975. Physiology and ecology of reproduction in marine invertebrates. Pages 279-299 in F.J. Vernberg, ed. Physiological ecology of estuarine organisms. University of South Carolina Press, Columbia.

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill, Inc., New York. 311 pp.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry. W.H. Freeman and Co. San Francisco. 859 pp.

Virnstein, R.W. 1972. Effects of heated effluent on density and diversity of benthic infauna at Big Bend, Tampa Bay, Florida. M.A. Thesis, University of South Florida, Tampa. 60 pp.

Warinner, J.E. and M.L. Brehmer. 1966. The effects of thermal effluents on marine organisms. Air α Water Pollution Institute Journal 10:277-289.

Whittaker, R.H. 1965. Dominance and diversity in land plant communities. Science 147:250-259.

Worth, D.F. and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. III. Physical and chemical environment. Florida Department of Natural Resources Marine Research Laboratory, Marine Research Publication No. 23. 25-85.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall, Inc. Englewood Cliffs, N.J. 620 pp.

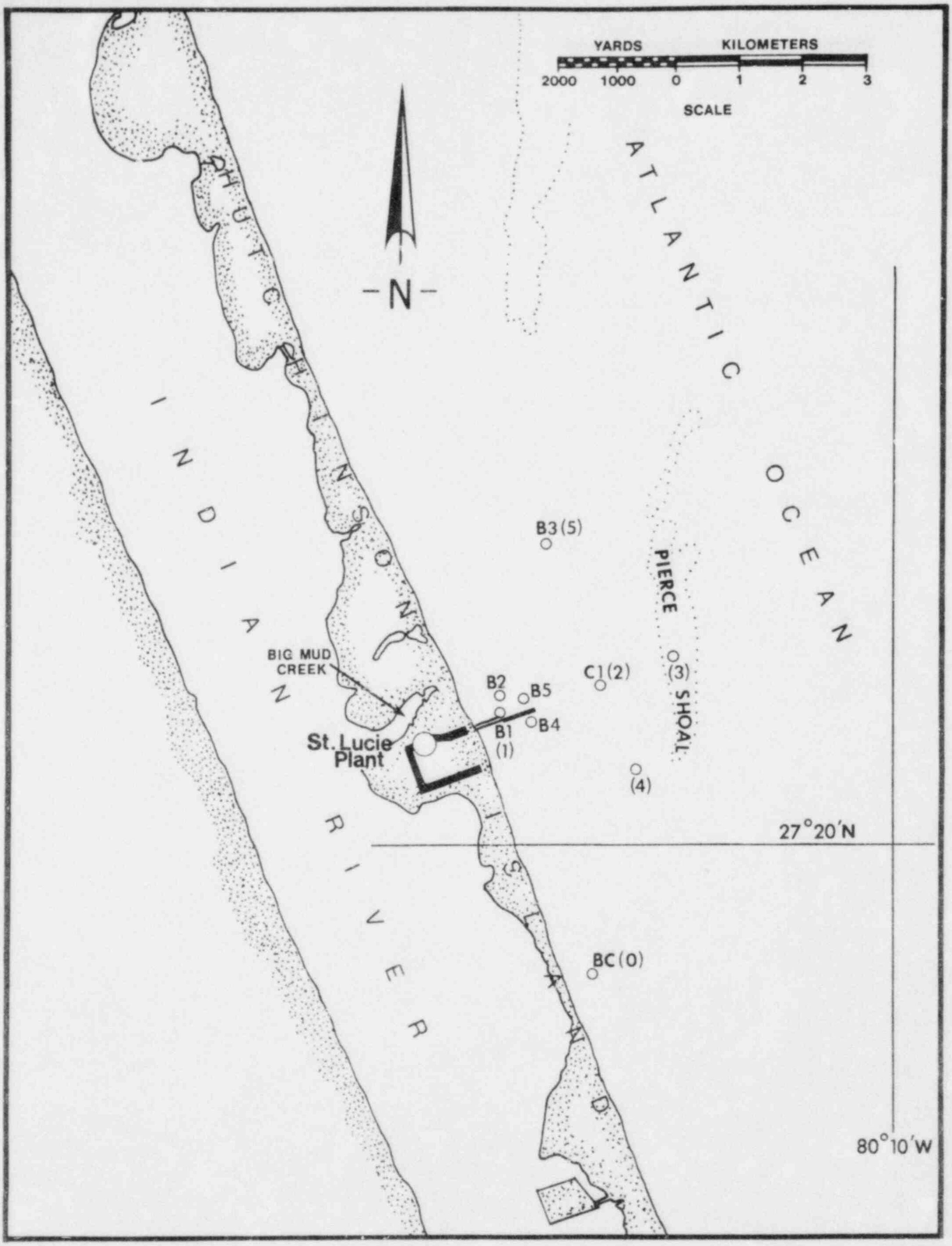


Figure C-1. Benthic sampling station designations and locations, St. Lucie Plant NPDES non-radiological aquatic monitoring, 1982. Numbers in parentheses represent station designations under the ETS non-radiological environmental monitoring program terminated in May.

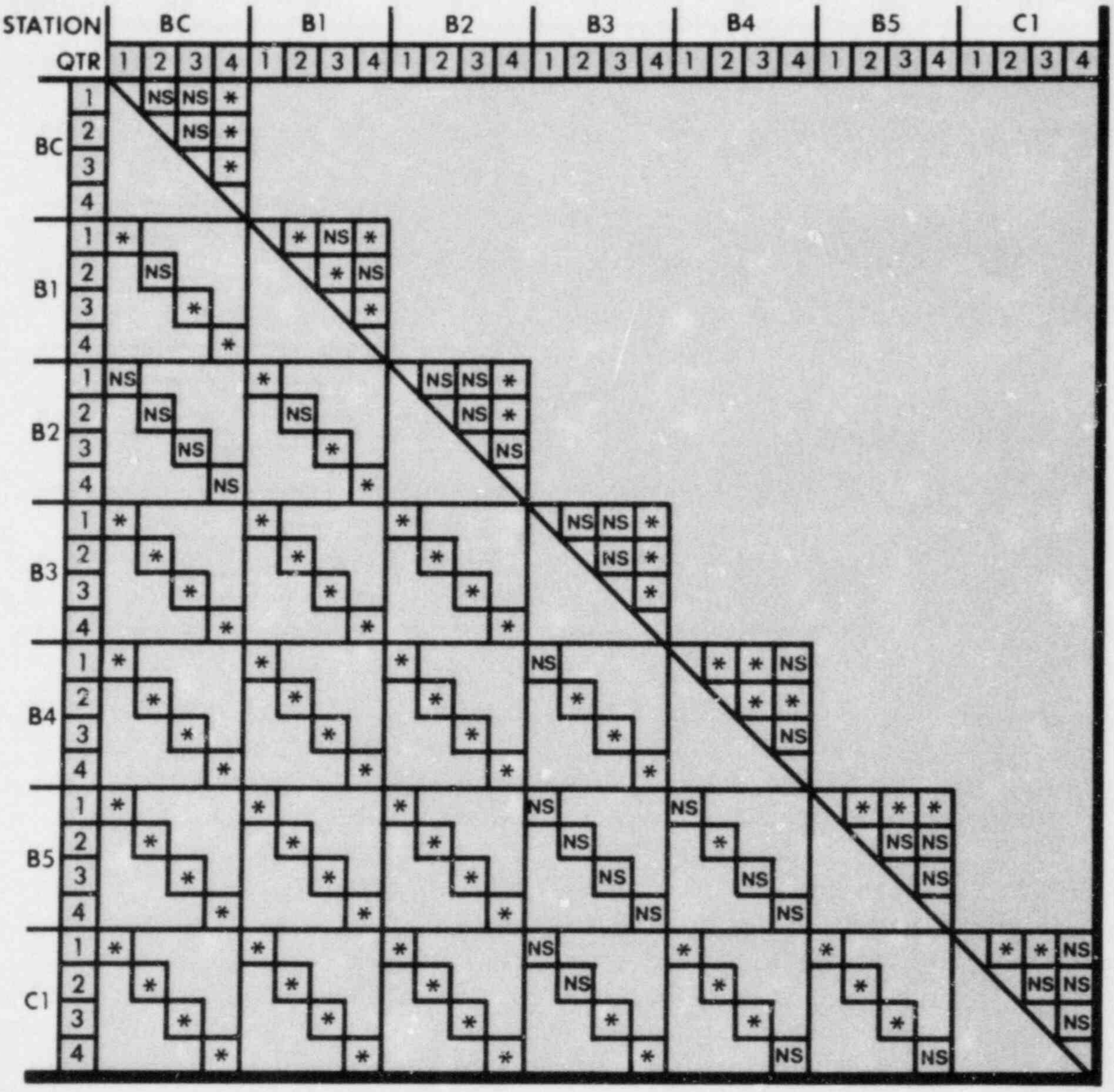


Figure C-2. Comparisons of grain size distributions between stations and quarters, St. Lucie Plant, 1982. A Kolmogorov-Smirnov goodness of fit test was used to detect significant differences (*at P≤ 0.05). NS indicates no significant difference.

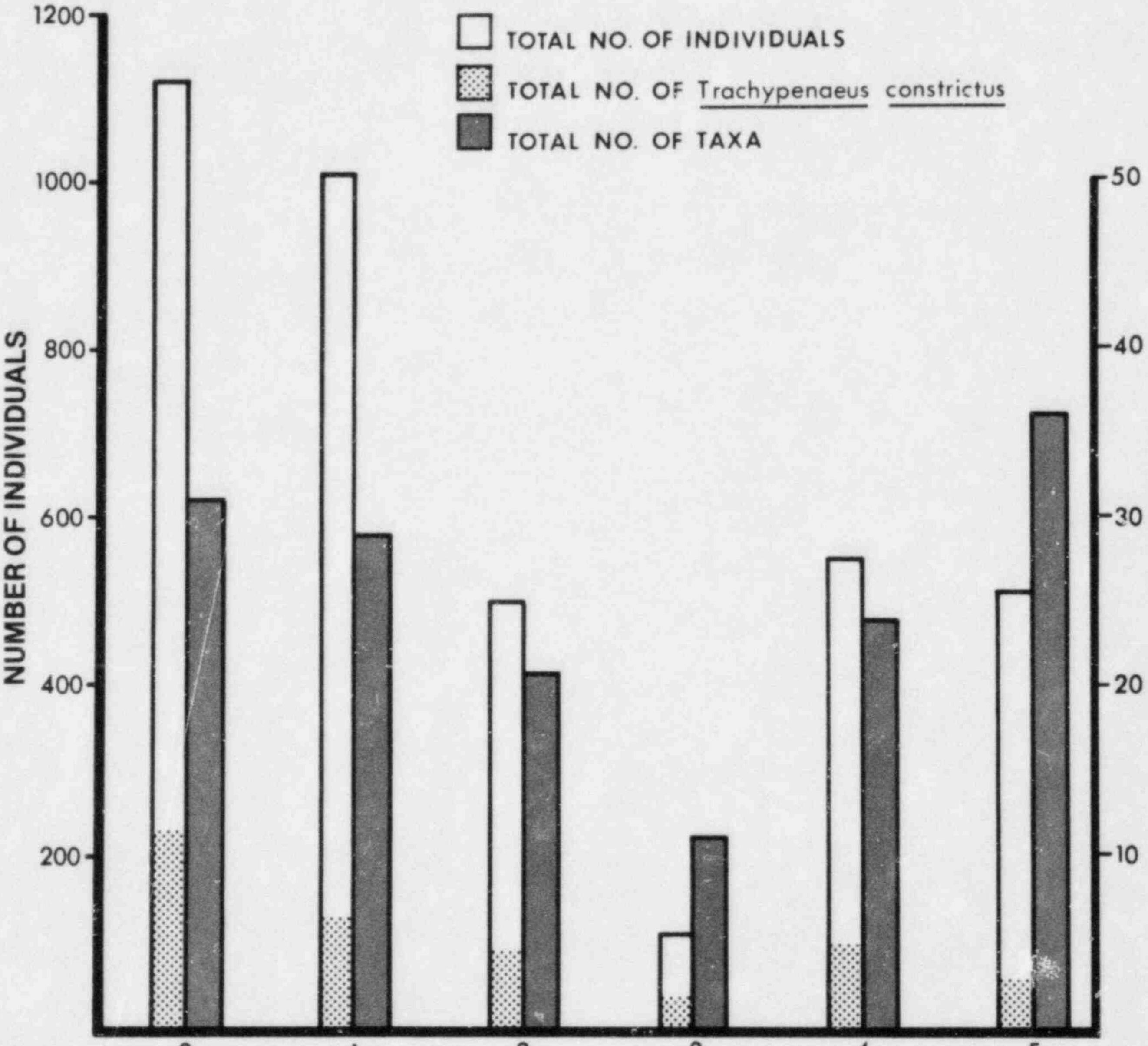


Figure C-3. Total number of all individuals and of Trachypenaeus constrictus and total number of taxa collected by monthly otter trawls at each ocean station, St. Lucie Plant, January-May 1982.

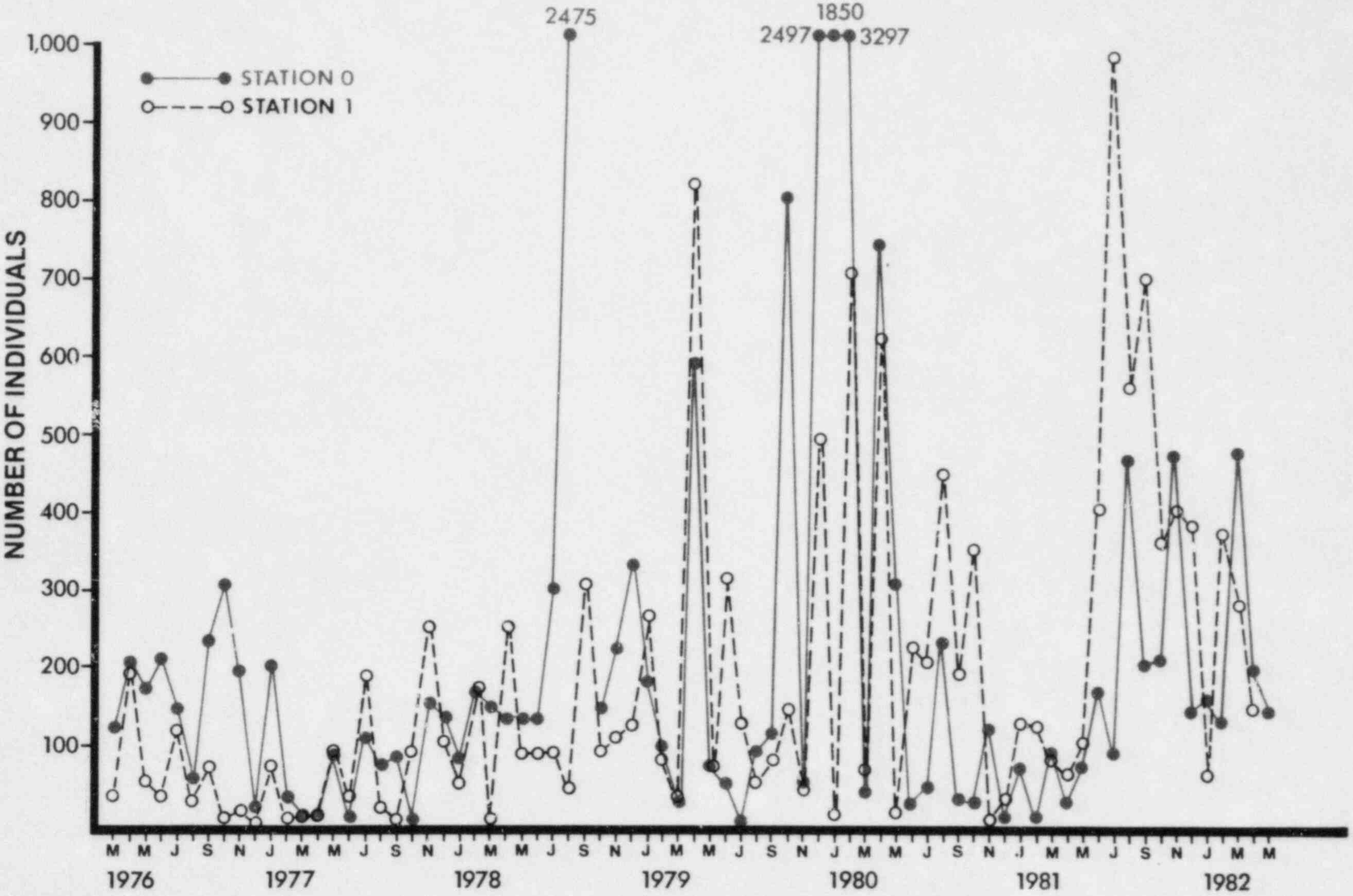


Figure C-4. Total number of macroinvertebrates collected by monthly otter trawls at Stations 0 (Control) and 1 (Discharge), St. Lucie Plant, March 1976 - May 1982.
*No data available for September 1978 at Station 0.

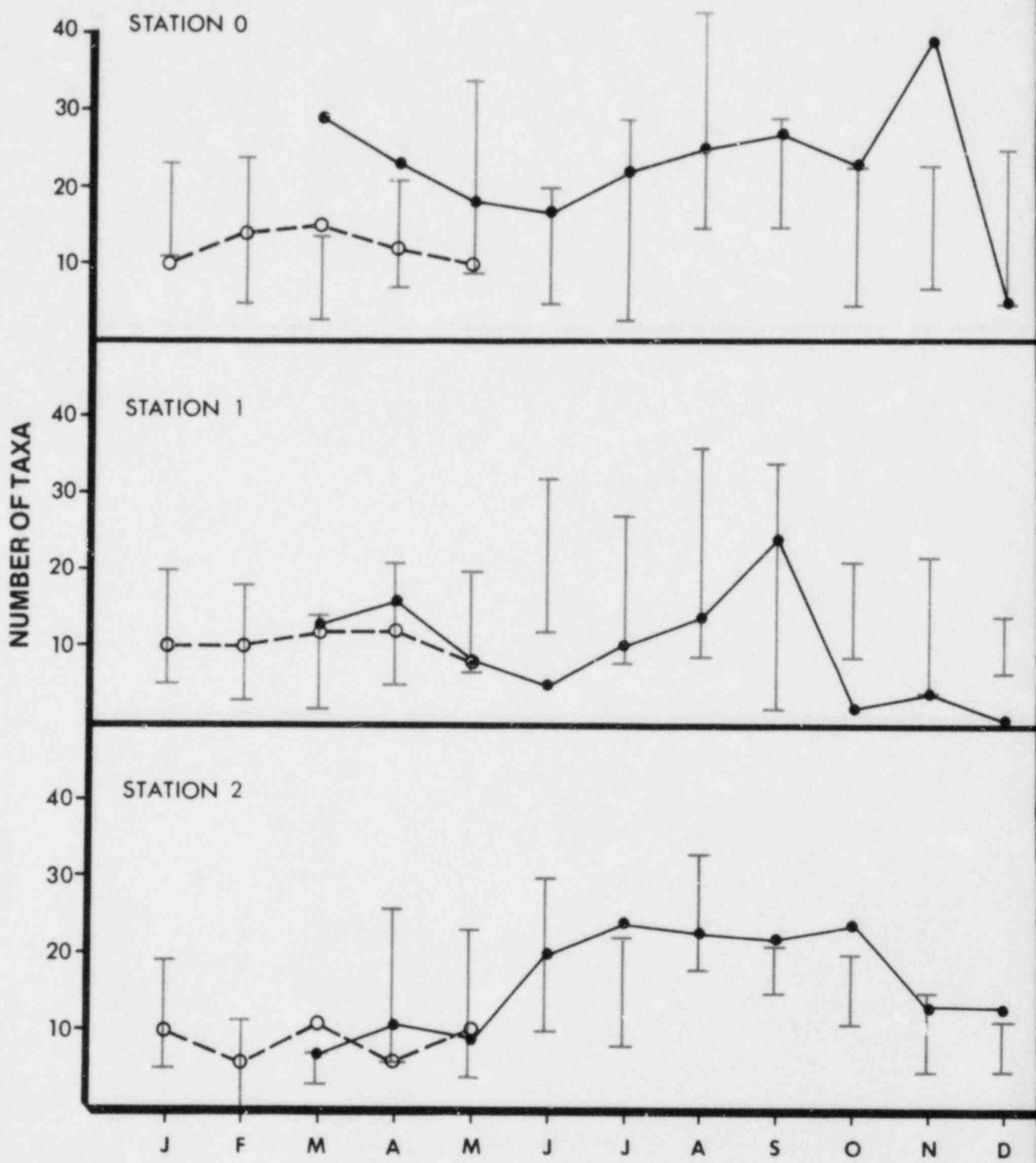
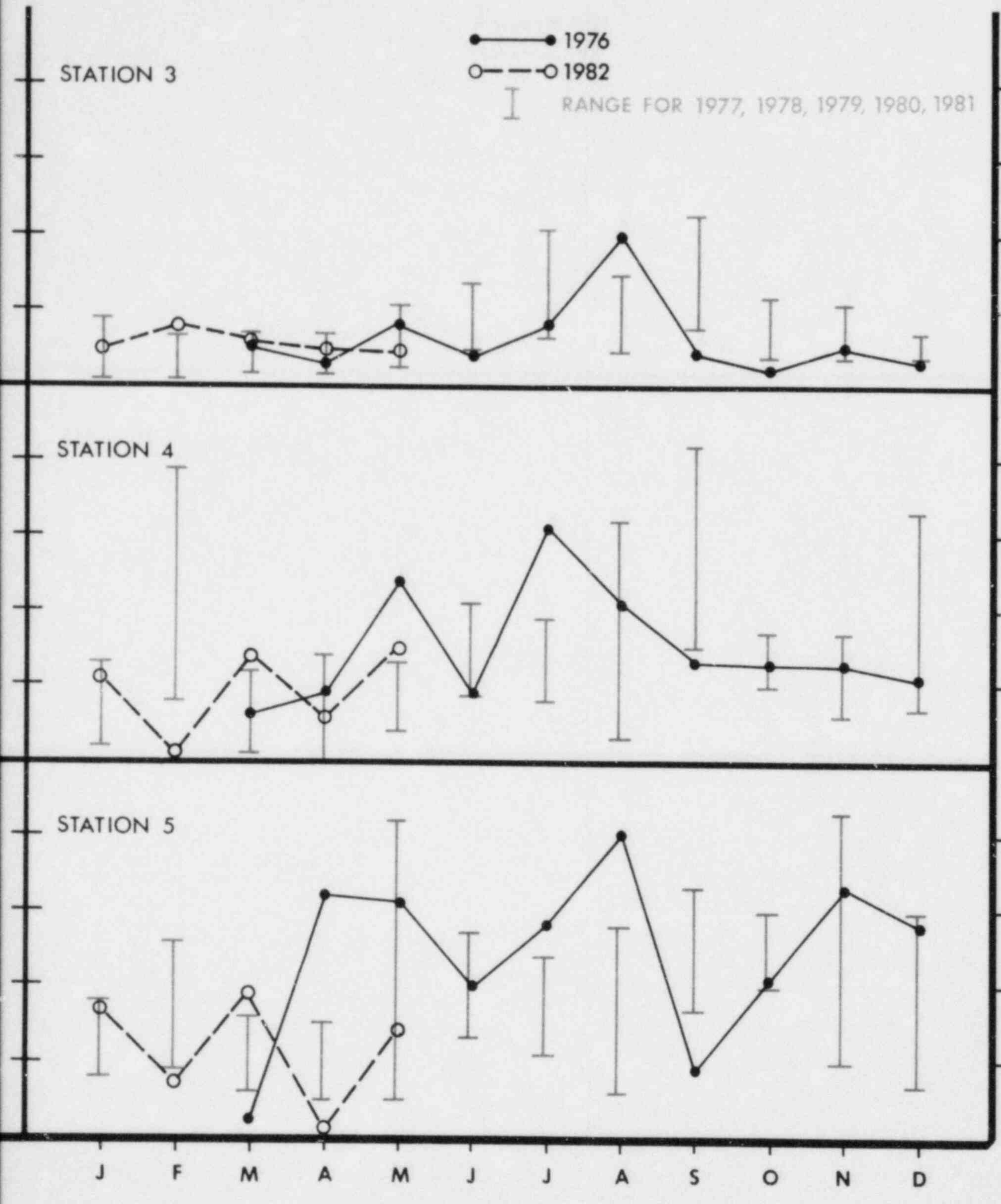


Figure C-5. Total number of macroinvertebrate ta
St. Lucie Plant, March, 1976 - May,



a collected by monthly otter trawls at each ocean station,
982. Points connected for visual continuity only.

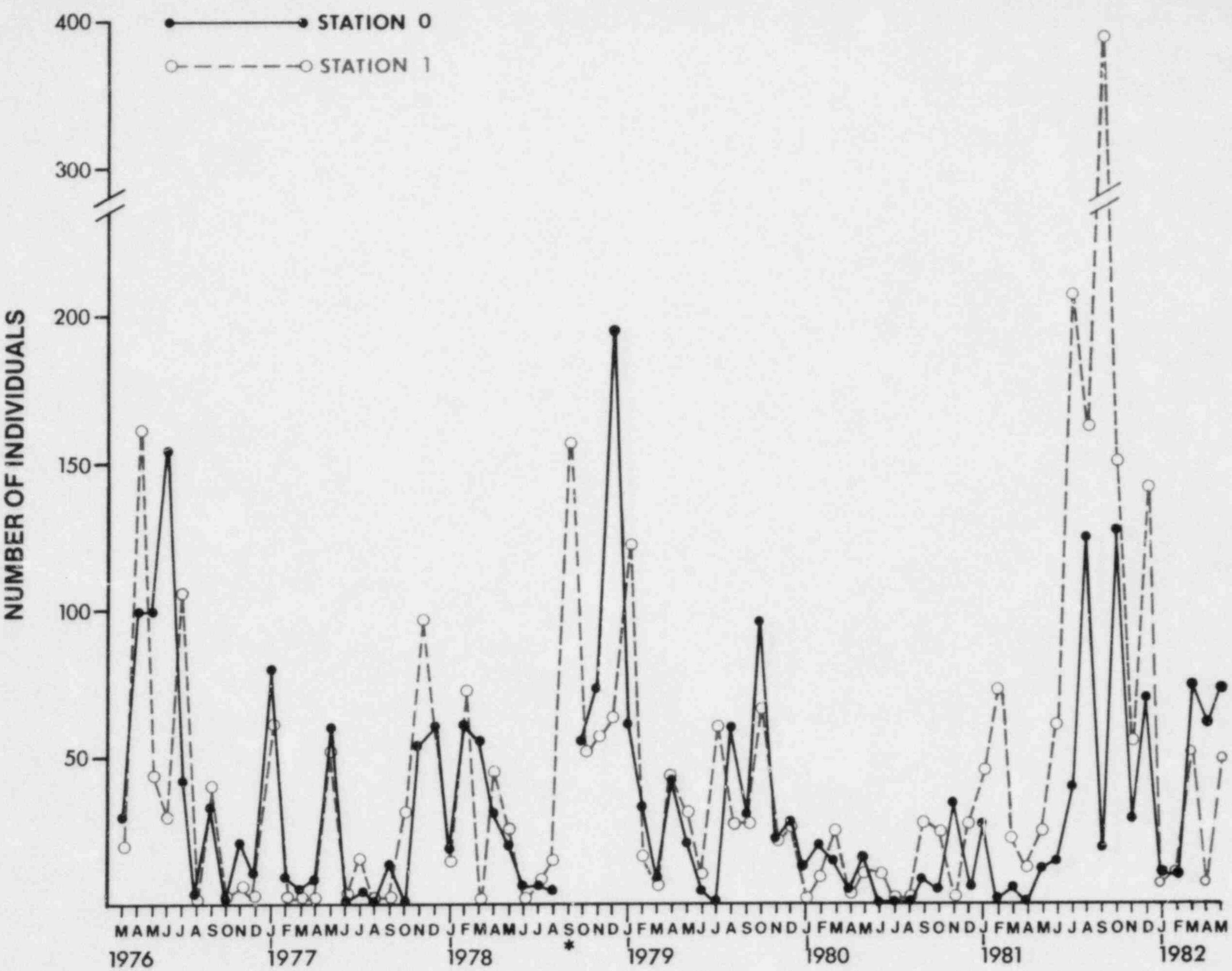


Figure C-6. Monthly abundance of _Trachypenaeus constrictus_ in trawl collections at Stations 0 and 1, St. Lucie Plant, March 1976 - May 1982.
*No data available for September, 1978 at Station 0.

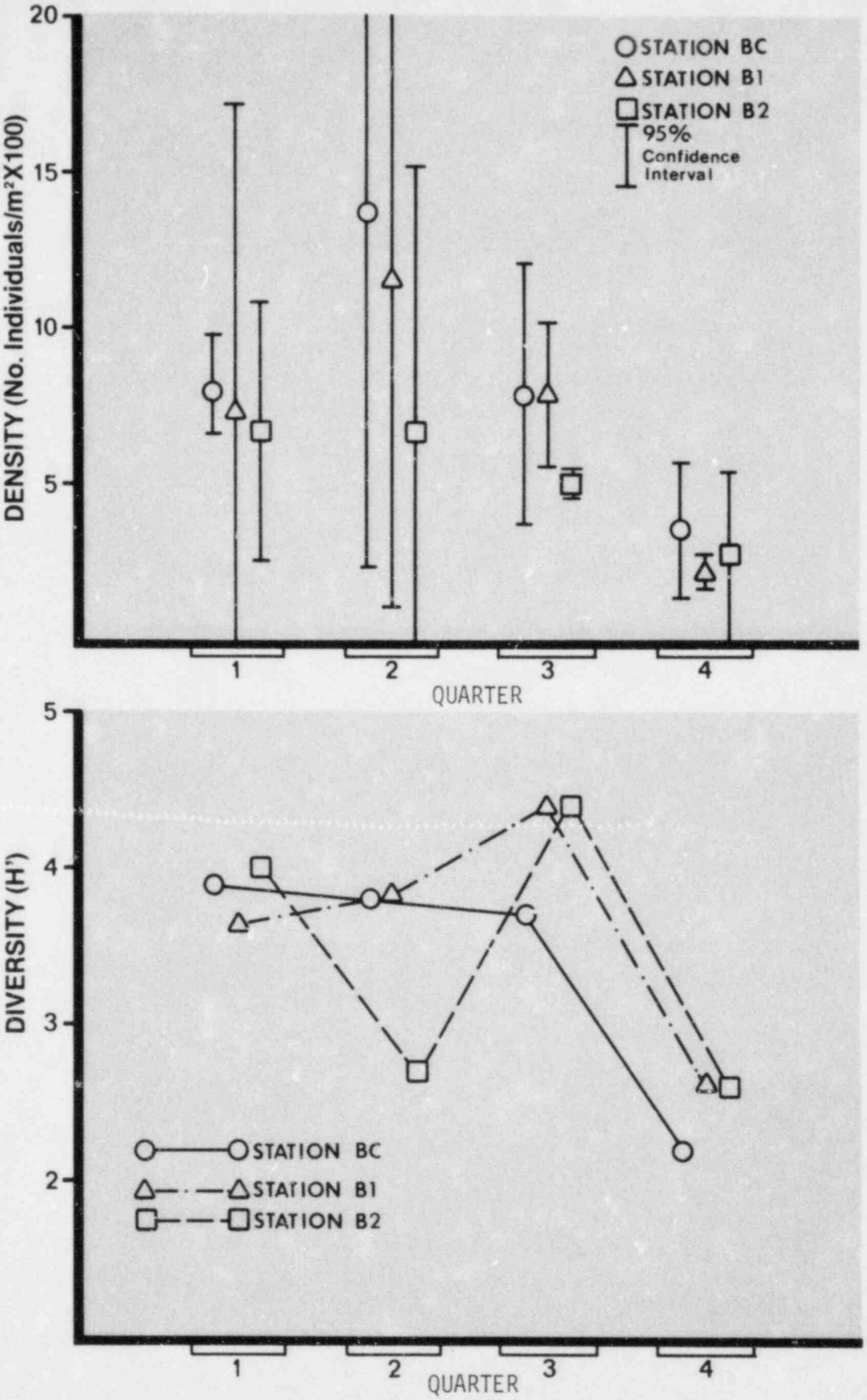


Figure C-7. Density and diversity of benthic macroinvertebrates collected each quarter by grab at Stations BC, B1, and B2, St. Lucie Plant, 1982.

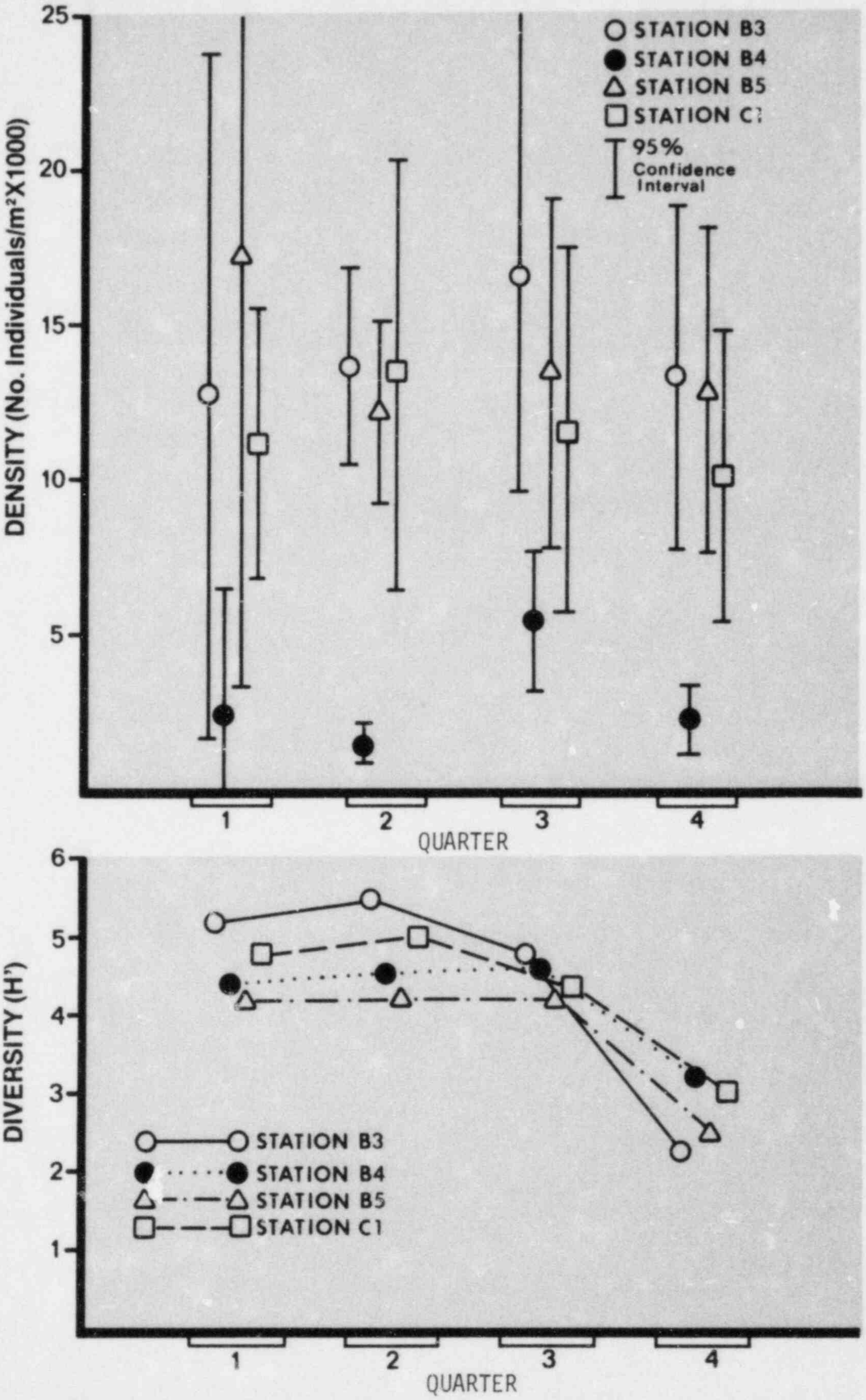


Figure C-8. Density and diversity of benthic macroinvertebrates collected each quarter by grab at Stations B3, B4, B5 and C1, St. Lucie Plant, 1982.

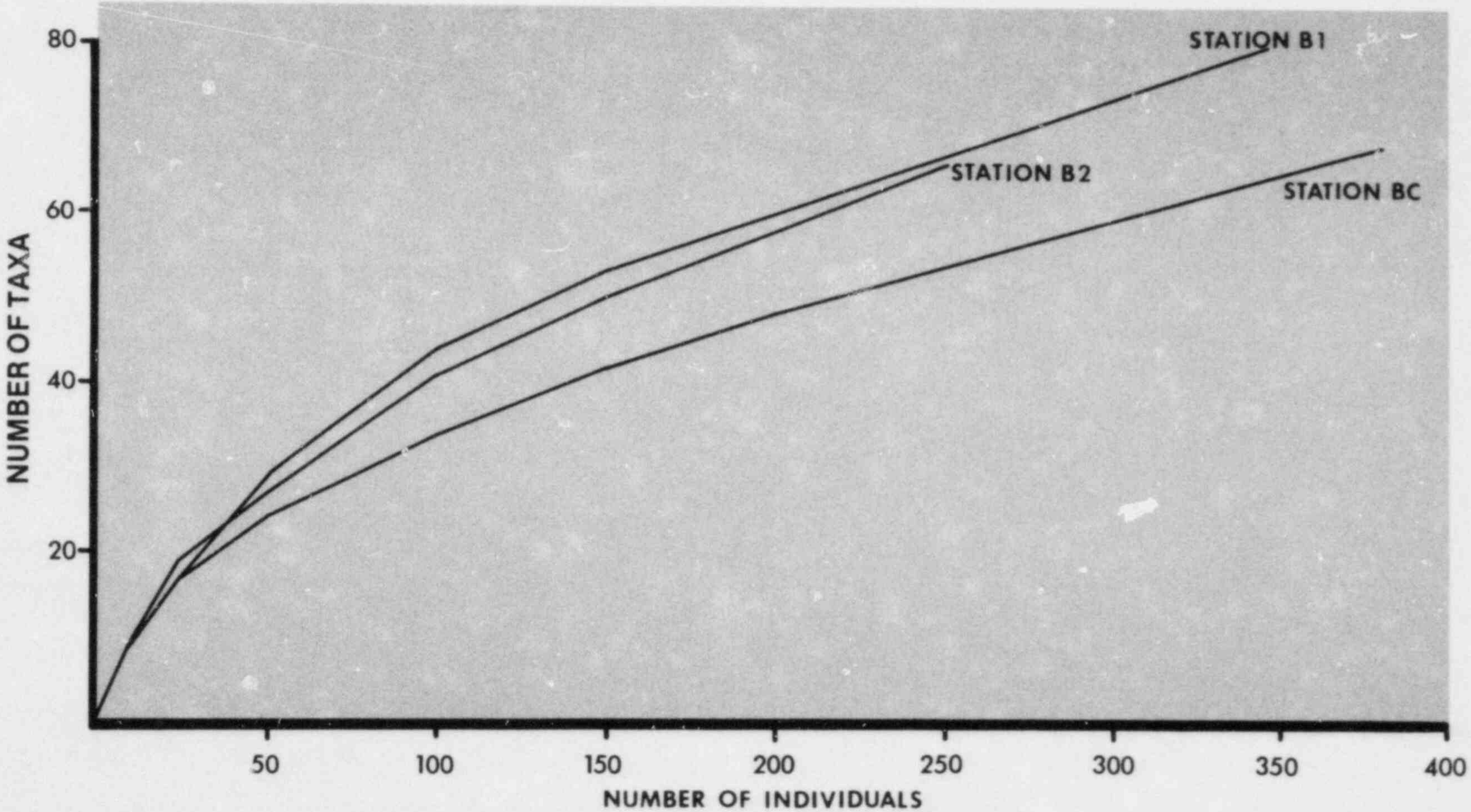


Figure C-9. Rarefaction diversity curves for Stations BC, B1 and B2 showing expected number of taxa for varying population levels of benthic macroinvertebrates, St. Lucie Plant, 1982.

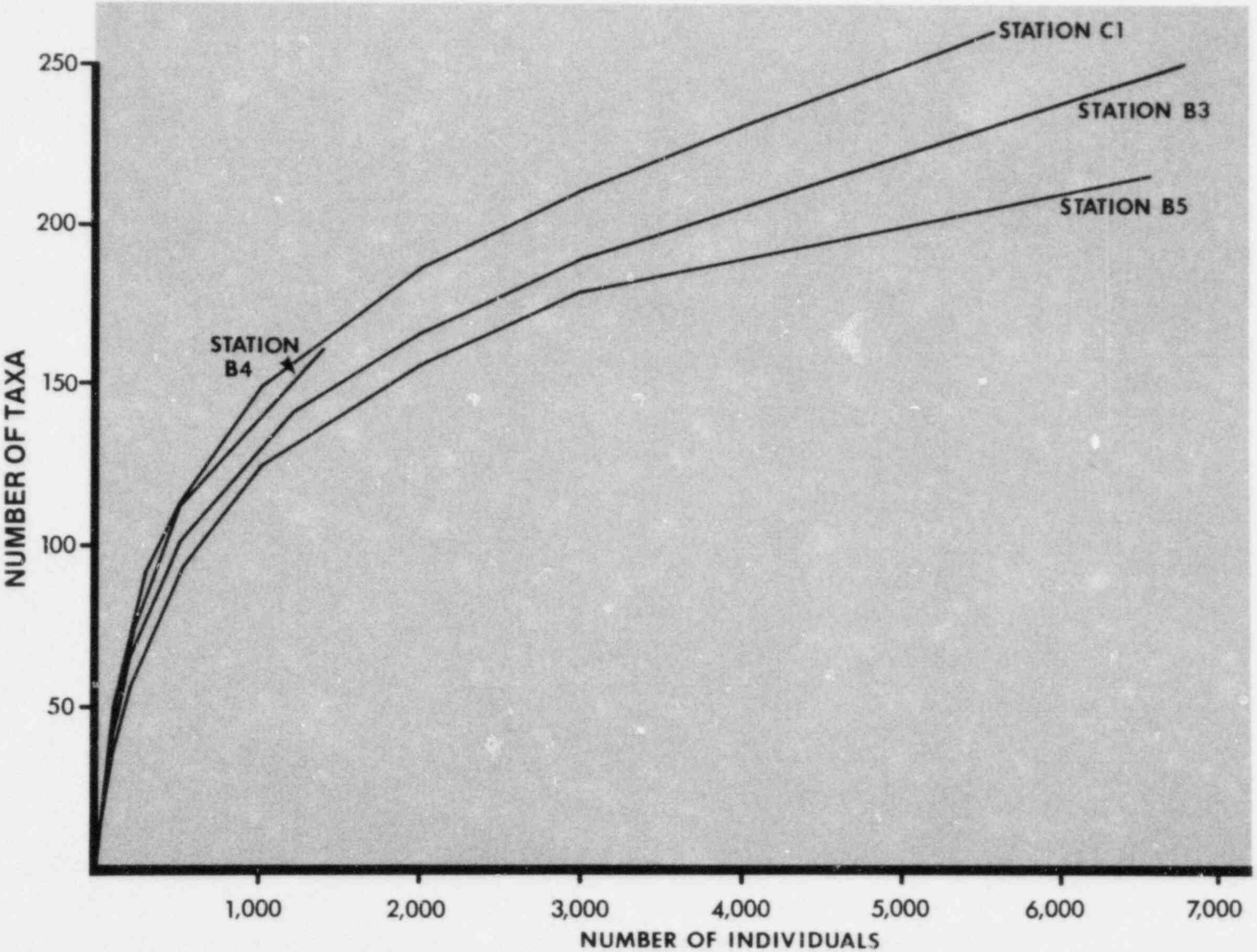


Figure C-10. Rarefaction diversity curves for Stations B3, B4, B5 and C1 showing expected number of taxa for varying population levels of benthic macroinvertebrates, St. Lucie Plant, 1982.

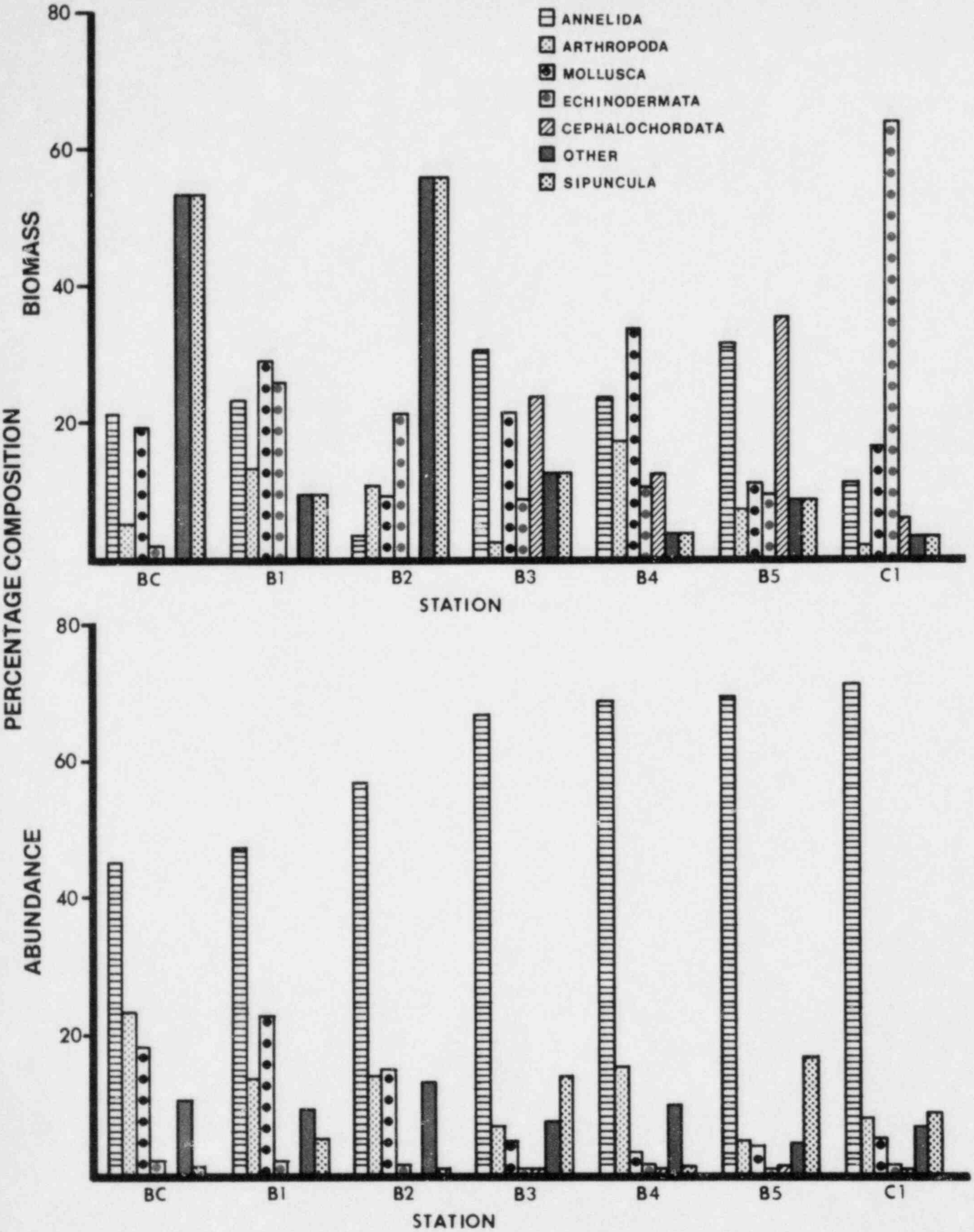


Figure C-11. Percentage contribution by major macroinvertebrate group to total community abundance and biomass at each ocean station, St. Lucie Plant, 1982. Sipuncula and miscellaneous minor phyla were combined for biomass determinations.

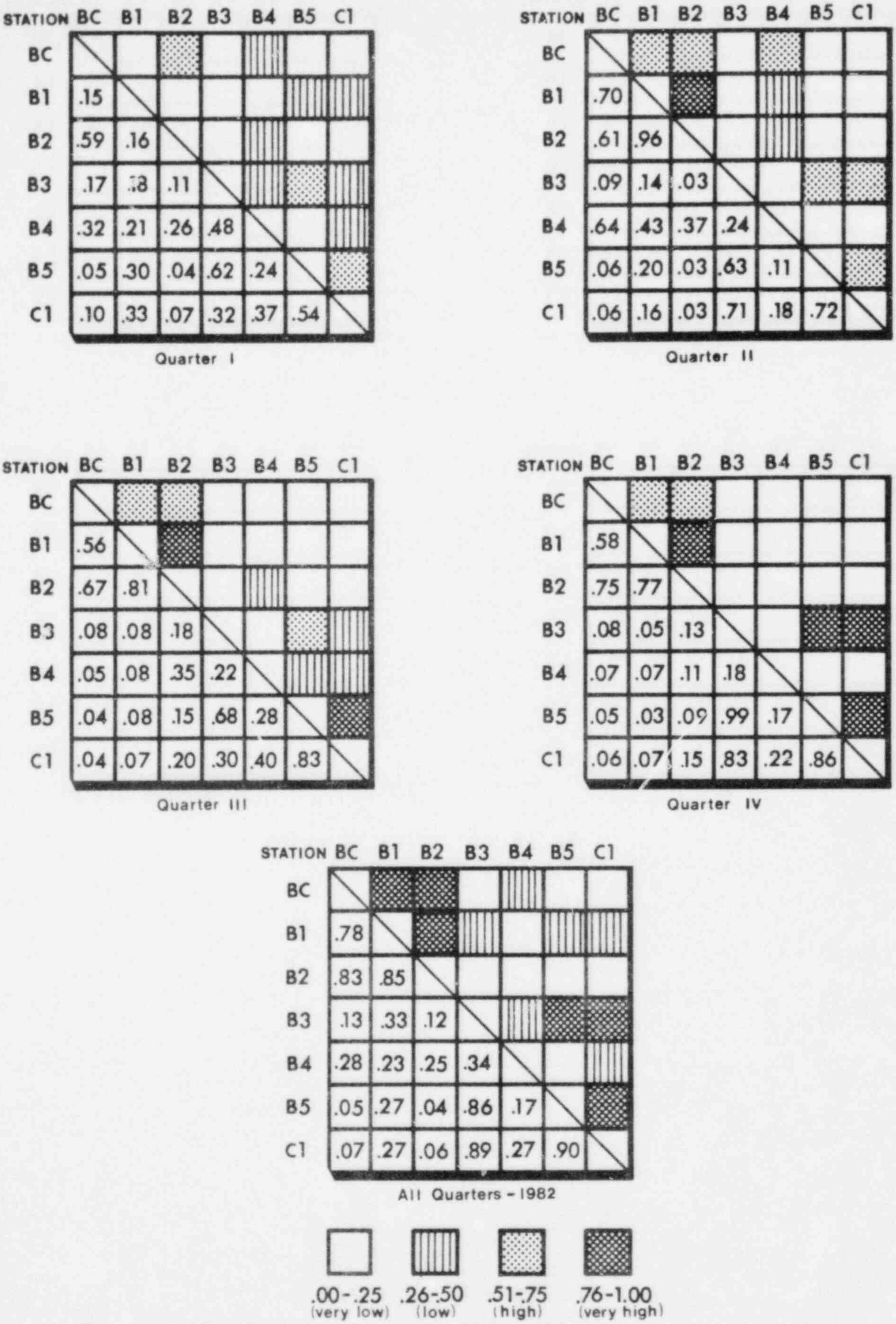


Figure C-12. Morisita indices of faunal similarity between ocean stations based on Shipek grap data for each quarter and for all quarters combined, St. Lucie Plant, 1982.

STATION	BC	B1	B2	B3	B4	B5	C1
BC							
B1	.00						
B2	.49	.00					
B3	.09	.00	.09				
B4	.00	.00	.18	.22			
B5	.00	.14	.00	.51	.00		
C1	.00	.27	.07	.13	.17	.44	

Quarter I

STATION	BC	B1	B2	B3	B4	B5	C1
BC							
B1	.67						
B2	.65	.97					
B3	.00	.00	.00				
B4	.18	.34	.22	.19			
B5	.00	.00	.00	.56	.00		
C1	.00	.00	.00	.67	.15	.74	

Quarter II

STATION	BC	B1	B2	B3	B4	B5	C1
BC							
B1	.28						
B2	.51	.66					
B3	.10	.08	.14				
B4	.00	.00	.20	.00			
B5	.00	.00	.00	.55	.00		
C1	.00	.00	.14	.21	.34	.78	

Quarter III

STATION	BC	B1	B2	B3	B4	B5	C1
BC							
B1	.33						
B2	.52	.67					
B3	.00	.00	.00				
B4	.00	.00	.00	.15			
B5	.00	.00	.00	.15	.15		
C1	.00	.00	.04	1.00	.16	.96	

Quarter IV

STATION	BC	B1	B2	B3	B4	B5	C1
BC							
B1	.75						
B2	.81	.83					
B3	.09	.35	.11				
B4	.11	.13	.13	.14			
B5	.00	.27	.00	.88	.00		
C1	.00	.25	.00	.83	.11	.91	

All Quarters - 1982

.00-.25 (very low) .26-.50 (low) .51-.75 (high) .76-1.00 (very high)

Figure C-13. Morisita indices of community similarity applied to dominant taxa at ocean stations, St. Lucie Plant, 1982.

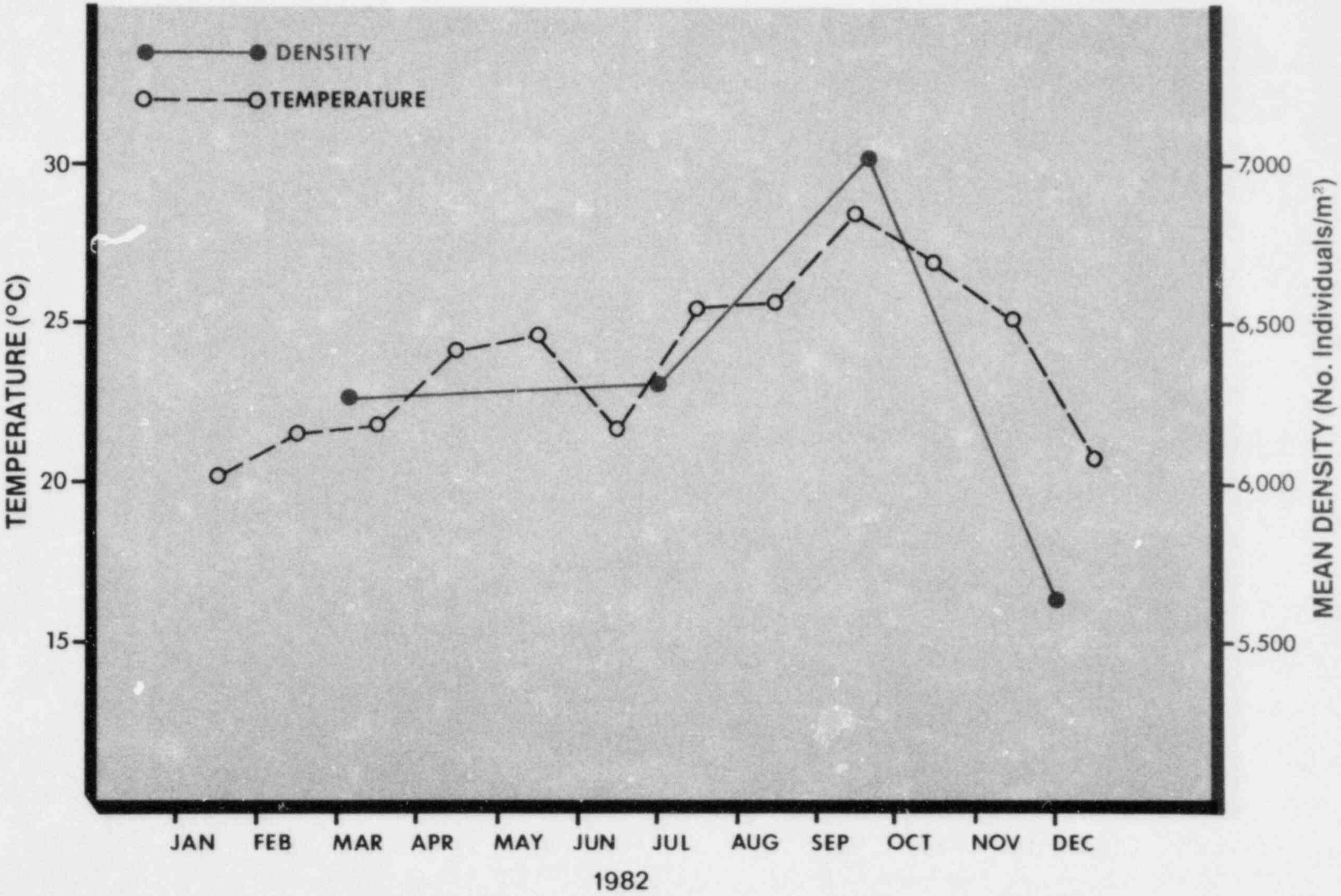


Figure C-14. Mean bottom water temperature and mean density of benthic macroinvertebrates collected by grab at all stations, St. Lucie Plant, 1982.

TABLE C-1

SUMMARY OF NUMERICAL METHODS USED FOR ANALYZING COMMUNITY STRUCTURE, ST. LUCIE PLANT, 1982

Test	Description	Use
Mann-Whitney U-Test (Elliot, 1971)	Nonparametric test for comparing means derived from two samples of different size.	Used to determine if trawl data from Stations BC(0) and B1(1) were significantly different.
Wilcoxon-Paired Sample Test (Zar, 1974)	Nonparametric test for comparing means derived from two samples of equal size.	Used to determine if trawl data from Stations BC(0) and B1(1) were significantly different.
One-way ANOVA (Sokal and Rohlf, 1981)	Parametric test for comparing several sample means.	Used in sub-optimal experimental design to determine if mean faunal abundance and mean species richness differed significantly between control and treatment stations.
Two-way ANOVA (Sokal and Rohlf, 1981)	Parametric test for comparing several sample means over time and space.	Used in optimal experimental design to determine if a significant interaction existed between baseline vs. operational years and control vs. treatment stations relative to arthropod and echinoderm densities.
Newman-Keuls Mulitple Range Test (Zar, 1974)	Parametric test for determining which of several sample means are significantly different.	Used in association with one-way ANOVA for determining which station means within each major station grouping were significantly different.
Spearman-Rank Correlation (Siegal, 1956)	Nonparametric test to correlate two variables.	Used to examine relationship between water temperature and species richness at Stations BC(0) and B1(1).

TABLE C-1
(continued)
SUMMARY OF NUMERICAL METHODS USED FOR ANALYZING
COMMUNITY STRUCTURE, ST. LUCIE PLANT, 1982

Test	Description	Use
Pearson Product-Moment Correlation Coefficient (Sokal and Rohlf, 1981)	Parametric test to correlate two variables.	Used to examine interrelationships among density, species richness, diversity, biomass, water temperature and sediment mean grain size within major station groupings.
McClosky's (1970) Index of Faunal Dominance	Assigns biological index values (BIV's) to species based on their numerical abundance in each of a series of samples.	Used to compare dominant taxa among stations and to look for changes in dominant taxa over time.
Quantitative Dominance	Using cumulative abundance data determines which species numerically account for 50 percent of total faunal abundance.	Used to compare dominant taxa among stations and to look for changes in dominant taxa over time.
Dominance-Diversity Curves (Whittaker, 1965)	Graphically displays faunal diversity using species-abundance data.	Used to compare faunal diversity among stations.
Rarefaction Diversity (Sanders, 1968)	Graphically displays faunal diversity using cumulative frequency distributions of component species.	Used to compare species accumulation rates among stations having different faunal densities.
Kolmogorov-Smirnov Test (Sokal and Rohlf, 1981)	Nonparametric test for comparing cumulative frequency distributions of elements within two samples.	Used to determine if grain-size distributions and species-abundance patterns differed among stations within each major station grouping.

TABLE C-1
(continued)
SUMMARY OF NUMERICAL METHODS USED FOR ANALYZING
COMMUNITY STRUCTURE, ST. LUCIE PLANT, 1982

Test	Description	Use
Shannon-Weaver Index of Diversity and Evenness Component (Lloyd et al., 1968; Pielou, 1966)	Calculates mean diversity of a sample based on the number of species present and the way in which individuals are distributed among those species. The observed diversity is then compared to a hypothetical maximum diversity based on the number of species in the sample.	Used for measuring the quality of the environment and the effect of induced stress on community structure.
Morisita's (1959) Index of Community Similarity	Compares abundances of shared species, total faunal abundance and diversities between two samples.	Used to construct trellis diagrams depicting faunal similarities among stations.

TABLE C-2

SEDIMENT GRAIN SIZE ANALYSIS (PERCENTAGE BY WEIGHT) AT BENTHIC STATIONS
ST. LUCIE PLANT
1982

Station	Month	Pebble (>32mm)	(32-16mm)	(16-8mm)	(8-4mm)	Granule 4-2	Very Coarse sand 2-1	coarse sand 1-0.50	Medium sand 0.500-0.250	Fine sand 0.250-0.125	Very fine sand 0.125-0.063	Silt and clay <0.063	Mean diameter ø	Sorting coefficient ø
BC (0)	March	0.0	0.0	0.0	0.0	1.38	1.42	1.16	1.51	29.19	64.87	0.47	3.03	0.91
	June	0.0	0.0	0.0	0.0	0.28	0.64	1.38	1.75	20.07	75.05	0.83	3.20	0.72
	Sept	0.0	0.0	0.0	0.0	0.10	0.20	0.29	0.95	25.48	72.61	0.38	3.21	0.56
	Nov	0.0	0.0	0.0	0.0	0.21	0.10	0.41	0.10	2.57	95.17	1.44	3.48	0.47
B1 (1)	March	0.0	0.0	0.0	0.0	1.40	2.32	3.89	16.12	45.26	30.84	0.17	2.45	1.04
	June	0.0	0.0	0.0	0.0	0.19	0.76	0.94	2.74	22.10	72.90	0.38	3.17	0.70
	Sept	0.0	0.0	0.0	0.39	0.88	1.17	2.24	14.24	36.59	44.20	0.29	2.68	1.01
	Nov	0.0	0.0	0.0	0.0	0.09	0.45	1.26	7.50	26.02	63.32	1.36	3.06	0.81
B2	March	0.0	0.0	0.0	0.0	0.41	1.24	3.80	14.89	18.55	60.01	1.10	2.86	1.04
	June	0.0	0.0	0.0	0.0	0.54	1.26	1.35	3.05	22.06	70.94	0.81	3.12	0.84
	Sept	0.0	0.0	0.0	0.0	0.68	0.58	0.49	2.82	21.67	72.98	0.78	3.17	0.76
	Nov	0.0	0.0	0.0	0.0	0.18	0.44	0.27	0.27	7.47	87.38	4.00	3.49	0.69
B3 (5)	March	0.0	0.0	0.0	0.0	28.00	24.39	34.88	11.84	0.48	0.30	0.11	-0.16	1.06
	June	0.0	0.0	3.50	8.96	9.43	22.92	34.81	16.60	1.60	2.08	0.09	-0.06	1.45
	Sept	0.0	0.0	4.91	5.10	8.64	26.01	37.49	16.49	0.39	0.88	0.10	-0.08	1.34
	Nov	0.0	0.0	3.58	3.34	3.26	12.98	44.35	32.17	0.16	0.08	0.08	0.39	1.22
B4	March	0.0	0.0	0.0	0.0	32.91	30.70	12.23	17.38	4.74	1.77	0.27	-0.13	1.35
	June	0.0	0.0	0.46	2.86	2.86	9.12	16.13	34.65	23.50	10.32	0.09	1.38	1.42
	Sept	0.0	0.0	4.41	9.81	12.87	15.84	13.41	17.10	16.56	9.90	0.09	0.42	2.00
	Nov	0.0	0.0	6.06	10.38	11.66	20.11	19.93	17.54	8.82	4.96	0.55	0.04	1.87
B5	March	0.0	0.0	0.0	0.0	42.19	28.82	18.58	7.43	2.01	0.80	0.17	-0.48	1.13
	June	0.0	0.0	6.53	6.82	9.94	21.12	18.84	17.14	9.09	10.32	0.19	0.30	1.94
	Sept	0.0	0.0	3.98	5.17	9.15	23.56	22.63	21.95	8.56	4.92	0.08	0.31	1.64
	Nov	0.0	0.0	3.70	3.79	5.41	22.63	28.22	25.25	8.75	2.16	0.09	0.04	1.52
C1 (2)	March	0.0	0.0	0.0	0.0	15.61	21.03	41.84	20.50	0.25	0.60	0.18	0.22	1.04
	June	0.0	0.0	2.38	9.60	20.53	30.32	24.14	11.03	1.24	0.67	0.10	-0.44	1.32
	Sept	0.0	7.90	8.14	12.16	10.66	20.54	27.25	11.14	0.79	1.34	0.08	-0.83	1.88
	Nov	0.0	0.0	5.19	6.37	11.17	24.49	34.57	15.08	1.47	1.57	0.10	-0.13	1.43
3	March	0.0	0.0	0.0	0.0	0.26	0.48	7.40	55.14	36.40	0.30	0.04	1.78	0.65
4	March	0.0	0.0	0.0	0.0	14.06	23.52	38.98	22.27	0.66	0.39	0.12	0.24	1.02

TABLE C-3

QUARTER 1 1982 ETS BENTHIC MACROINVERTEBRATE COMMUNITY PARAMETERS
COMPARED WITH MINIMUM, MAXIMUM AND MEAN VALUES
OBTAINED FOR QUARTER 1 1976-1981
ST. LUCIE PLANT

Station	Parameter	Minimum value	Year	Maximum value	Year	Mean 1976-1981	1982
0	Density*	333	1981	4,483	1977	1,245	808
	No. taxa	13	1981	56	1977	30	26
	Biomass	0.142	1981	5.100	1977	1.562	0.112**
	Diversity (H')	2.953	1981	4.044	1980	3.699	3.896
1	Density	225	1976	1,933	1977	832	733
	No. taxa	8	1976	32	1980	27	23
	Biomass	0.400	1981	2.860	1978	1.521	0.489
	Diversity (H')	1.533	1976	4.808	1977	3.655	3.648
2	Density	10,462	1980	23,917	1977	14,449	11,221
	No. taxa	94	1976	152	1977	113	118
	Biomass	3.833	1981	25.363	1976	12.420	11.002
	Diversity (H')	4.215	1979	5.523	1977	4.723	4.762
3	Density	817	1976	2,407	1980	1,372	1,516
	No. taxa	14	1976	45	1981	32	52**
	Biomass	0.617	1981	33.240	1978	7.086	1.109
	Diversity (H')	3.025	1976	4.377	1981	3.880	4.630**
4	Density	3,817	1977	29,940	1981	11,396	18,301
	No. taxa	91	1976,77	146	1981	105	119
	Biomass	0.795	1977	317.142	1980	57.922	3.876
	Diversity (H')	3.931	1981	5.464	1977	4.614	4.519
5	Density	8,275	1976	19,425	1977	12,453	12,820
	No. taxa	102	1979	152	1977	122	113
	Biomass	2.508	1981	17.695	1977	7.068	5.235
	Diversity (H')	4.314	1979	5.537	1978	4.957	5.178

* Number of individuals/m^2.

** Outside the range reported for 1976-1981.

TABLE C-4

BENTHIC MACROINVERTEBRATE COMMUNITY PARAMETERS MEASURED AT OFFSHORE STATIONS
DURING ETS AND NPDES MONITORING
ST. LUCIE PLANT
1982

Parameter	Quarter	Station										
		BC(0)	B1(1)	B2	B3(5)	B4	B5	C1(2)	(3)	(4)	Totals[a]	Mean[a]
No. of taxa	1	26	23	29	113	55	110	118	52	119	229[c]	67.7
	2	33	39	15[b]	156	48	112	148			287	72.7
	3	27	34	30	142	87	110	110			261	77.1
	4	15	16	19	92	65	98	92			204	56.7
	Total[c]	68	80	66	252	162	215	262			472	-
	Mean	25.3	28.0	23.3	125.8	63.8	107.5	117.0			-	70.1
Density (individuals/m^2)	1	808	733	667	12833	2317	15241	11225	1517	18308	43824	6261
	2	1375	1158	662[b]	13699	1525	12250	13516			44185	6312
	3	783	783	492	16608	5483	13475	11608			49232	7033
	4	350	217	267	13333	2325	12858	10141			39491	5642
	Total	3316	2891	2088	56473	11650	53824	46490			176732	-
	Mean	829	723	522	14118	2913	13456	11623			44183	6312
Biomass (g/m^2)	1	0.112	0.489	0.167	5.235	0.474	4.488	11.002	1.1087	3.8759	21.9662	3.1380
	2	0.242	0.684	-[d]	3.518	1.319	6.482	33.192			45.4377	7.572
	3	0.253	0.337	0.556	3.524	1.992	3.809	3.075			13.5469	1.9353
	4	0.766	0.068	2.123	2.025	2.469	2.967	2.900			13.3146	1.9021
	Total	1.373	1.578	2.846	14.302	6.254	17.746	50.169			94.265[illegible]	-
	Mean	0.343	0.394	0.949	3.575	1.563	4.437	12.542			23.566	3.367
Diversity (H')	1	3.896	3.648	4.047	5.178	4.444	4.184	4.762	4.630	4.519		4.308
	2	3.815	3.847	2.681[b]	5.491	4.553	4.229	5.048				4.238
	3	3.716	4.427	4.410	4.863	4.630	4.230	4.360				4.377
	4	2.180	2.598	2.557	2.263	3.210	2.486	3.002				2.614
	Mean	3.402	3.630	3.424	4.449	4.209	3.782	4.293				
Variance (of $\overline{d}$)	1	0.157	0.336	0.581	0.482	0.343	0.639	0.107	0.127	0.212		
	2	0.958	0.242	0.811[b]	0.453	0.525	0.780	0.176				
	3	0.156	0.364	0.905	0.403	0.158	0.778	0.107				
	4	0.130	0.471	0.605	0.172	0.143	0.320	0.502				
Evenness (J')	1	0.829	0.650	0.644	0.683	0.560	0.494	0.536	0.812	0.609		0.628
	2	0.756	0.624	0.416[b]	0.693	0.556	0.489	0.700				0.605
	3	0.781	0.746	0.678	0.618	0.556	0.483	0.480				0.620
	4	0.805	0.757	0.654	0.456	0.602	0.435	0.502				0.602
	Mean	0.793	0.694	0.598	0.613	0.569	0.475	0.555				

[a]Excluding Stations (3) and (4)

[b]Based on two replicates.

[c]Number of distinct taxa for quarter or year.

[d]Excluded because of unrepresentative sample.

TABLE C-5

FIVE TOP-RANKED[a] DOMINANT TAXA OF BENTHIC INVERTEBRATES
FROM TRAWL SAMPLES AT SIX OFFSHORE STATIONS
ST. LUCIE PLANT
1976-1982[c]

Station	Species	1976	1977	1978	1979	1980	1981	1982
0	Trachypenaeus constrictus	1	1	1	2	2	2	2
	Crepidula fornicata	2	-	-	-	-	-	-
	Mellita quinquiesperforata	3	2	-	-	-	-	-
	Anomia simplex	3	-	-	-	-	-	-
	Portunus spinimanus	4	-	-	-	-	5	-
	Trachypenaeus sp.[b]	-	3	2	1	1	1	1
	Turbo castanea	-	4	-	-	-	-	-
	Loligo plei	-	5	-	-	-	-	-
	Leptochela serratorbita	-	-	5	5	5	-	-
	Periclimenes longicaudatus	-	-	3	-	-	-	-
	Processa hemphilli	-	-	4	4	3	4	-
	Acetes americanus	-	-	-	3	4	-	-
	Portunus gibbesii	-	-	-	-	-	3	3
	Arenaeus cribrarius	-	-	-	-	-	-	4
	Hepatus epheliticus	-	-	-	-	-	-	5
1	Trachypenaeus constrictus	1	1	1	2	2	2	2
	Sicyonia dorsalis	2	-	-	-	-	-	-
	Leptochela serratorbita	3	4	4	5	-	-	3
	Mellita quinquiesperforata	4	-	-	-	-	-	-
	Squilla neglecta	5	-	-	-	-	-	-
	Periclimenes longicaudatus	-	2	3	-	-	-	-
	Loligo plei	-	3	-	-	-	-	-
	Trachypenaeus sp.[b]	-	5	2	1	1	1	1
	Portunus spinimanus	-	-	5	-	-	-	-
	Processa hemphilli	-	-	-	3	5	4	-
	Acetes americanus	-	-	-	4	3	5	-
	Latreutes fucorum	-	-	-	-	4	-	-
	Portunus gibbesii	-	-	-	-	-	3	-
	Arenaeus cribrarius	-	-	-	-	-	-	4
	Hepatus epheliticus	-	-	-	-	-	-	5
2	Crepidula fornicata	1	3	-	-	-	-	-
	Trachypenaeus constrictus	2	2	1	1	1	1	2
	Anomia simplex	3	-	-	-	-	-	-
	Portunus spinimanus	4	5	3	4	-	-	-
	Processa hemphilli	5	-	5	-	4	-	-
	Periclimenes longicaudatus	-	1	2	4	2	4	-
	Loligo plei	-	4	-	-	-	-	-
	Trachypenaeus sp.[b]	-	-	4	2	3	3	1
	Portunus gibbesii	-	-	-	3	-	2	2
	Leptochela serratorbita	-	-	-	-	5	-	-
	Argopecten gibbus	-	-	-	-	-	5	4
	Diplothyra smithii	-	-	-	-	-	-	3

TABLE C-5
(continued)
FIVE TOP-RANKED[a] DOMINANT TAXA OF BENTHIC INVERTEBRATES
FROM TRAWL SAMPLES AT SIX OFFSHORE STATIONS
ST. LUCIE PLANT
1976-1982[c]

Station	Species	1976	1977	1978	1979	1980	1981	1982
3	Trachypenaeus constrictus	1	1	1	1	1	1	1
	Trachypeneopsis mobilispinis	2	2	3	3	-	-	-
	Portunus anceps	3	-	-	-	-	-	-
	Leptochela serratorbita	4	4	-	-	5	-	-
	Encope michelini	5	-	-	-	-	-	-
	Periclimenes longicaudatus	-	3	5	4	4	-	-
	Processa sp. A	-	5	2	5	-	5	-
	Mellita quinquiesperforata	-	-	4	-	2	-	-
	Trachypenaeus sp.[b]	-	-	-	2	3	2	2
	Portunus gibbesii	-	-	-	-	-	3	5
	Portunus spinimanus	-	-	-	-	-	4	4
	Arenaeus cribrarius	-	-	-	-	-	-	3
4	Mellita quinquiesperforata	1	1	1	-	4	-	-
	Trachypenaeus constrictus	2	5	3	1	2	1	1
	Chaetopleura apiculata	3	-	-	-	-	-	-
	Portunus spinimanus	4	-	5	-	-	-	5
	Anomia simplex	5	-	-	-	-	-	-
	Periclimenes longicaudatus	-	2	2	4	1	-	-
	Turbo castanea	-	3	-	-	-	-	-
	Loligo plei	-	4	-	-	-	-	-
	Processa hemphilli	-	-	5	-	5	5	-
	Metapenaeopsis goodei	-	-	4	-	-	-	-
	Trachypenaeus sp.[b]	-	-	-	2	3	4	2
	Acetes americanus	-	-	-	3	-	-	-
	Portunus gibbesii	-	-	-	5	-	2	3
	Argopecten gibbus	-	-	-	-	-	3	5
	Crepidula fornicata	-	-	-	-	-	-	5
	Diplothyra smithii	-	-	-	-	-	-	4
5	Crepidula fornicata	1	-	-	-	-	-	-
	Trachypenaeus constrictus	2	-	1	1	2	1	4
	Turbo castanea	3	2	-	-	-	-	-
	Anomia simplex	4	-	-	-	-	-	-
	Portunus spinimanus	5	-	3	-	-	-	1
	Lytechinus variegatus	-	1	2	3	-	-	-
	Chaetopleura apiculata	-	3	-	-	-	-	-
	Arbacia punctulata	-	4	-	-	-	-	-
	Chione grus	-	5	-	-	-	-	-
	Periclimenes longicaudatus	-	-	4	4	3	5	-
	Metapenaeopsis goodei	-	-	5	-	-	-	-
	Trachypenaeus sp.[b]	-	-	-	2	1	2	3
	Processa hemphilli	-	-	-	5	4	4	-

TABLE C-5
(continued)
FIVE TOP-RANKED[a] DOMINANT TAXA OF BENTHIC INVERTEBRATES
FROM TRAWL SAMPLES AT SIX OFFSHORE STATIONS
ST. LUCIE PLANT
1976-1982[c]

Station	Species	1976	1977	1978	1979	1980	1981	1982
5	Acetes americanus	-	-	-	-	5	-	-
(cont'd)	Portunus gibbesii	-	-	-	-	-	3	2
	Diplothyra smithii	-	-	-	-	-	-	5

[a]Ranked according to McCloskey (1970) biological index values.

[b]Trachypenaeus sp. are probably juvenile specimens of Trachypenaeus constrictus but positive identification to species was not possible.

[c]Mar-Dec, 1976-1981; Jan-May, 1982.

TABLE C-6

COMMERCIALLY IMPORTANT SPECIES OF MACROINVERTEBRATES
COLLECTED BY TRAWLS
ST. LUCIE PLANT
1976 - 1982[a]

Species	Year	Number collected	Station
Argopecten gibbus	1976	26	0,2,4,5
	1977	3	2,5
	1978	8	5
	1979	0	-
	1980	14	2,5
	1981	1756	all
	1982	143	1,2,4,5
Callinectes sapidus	1976	2	0,1
	1977	2	1
	1978	1	1
	1979	8	0,1,2
	1980	7	0,1,4
	1981	8	0,1,3,4
	1982	4	0,1
Menippe mercenaria	1976	1	0
	1977	0	-
	1978	0	-
	1979	0	-
	1980	0	-
	1981	0	-
	1982	0	-
Penaeus aztecus	1976	0	-
	1977	12	0,1,5
	1978	2	1
	1979	25	0,1,2,4,5
	1980	29	0,1,2,3,4
	1981	30	0,1,2,3,4
	1982	2	0,5
Penaeus brasiliensis	1976	3	0,5
	1977	2	0,2
	1978	2	1,5
	1979	3	1,2,5
	1980	7	2,5
	1981	0	-
	1982	0	-

TABLE C-6
(continued)
COMMERCIALLY IMPORTANT SPECIES OF MACROINVERTEBRATES
COLLECTED BY TRAWLS
ST. LUCIE PLANT
1976 - 1982[a]

Species	Year	Number collected	Station
Penaeus duorarum	1976	43	0,4,5
	1977	57	all
	1978	97	0,1,2,4,5
	1979	38	0,1,2,4,5
	1980	24	0,1,2,4,5
	1981	34	0,1,4,5
	1982	11	0,1,2,5
Penaeus sp.	1976	11	0,1
	1977	15	0,1
	1978	11	1,2,5
	1979	13	1,2,5
	1980	2	1
	1981	35	0,1,2,5
	1982	2	0,2
Sicyonia brevirostris	1976	21	0,2,3,5
	1977	35	0,2,3,4,5
	1978	67	all
	1979	5	2,5
	1980	32	1,2,4,5
	1981	34	2,3,4,5
	1982	3	2,5

[a]Mar-Dec, 1976; Jan-May, 1982; Jan-Dec all other years.

TABLE C-7

COMPARISON OF CRUSTACEANS AND ECHINODERMS COLLECTED BY OTTER TRAWLS DURING BASELINE[a] (1973-1974) AND FOLLOW-UP STUDIES (1976-1982[b])
STATION 1
ST. LUCIE PLANT

Macroinvertebrate group	Baseline 1973-74	1976	1977	1978	1979	1980	1981	1982
Crustaceans								
Total number of individuals	201	509	763	1377	2374	2611	3990	1003
Total number of taxa	26	32	41	54	36	52	46	23
Taxa identified to species	17	26	34	42	24	40	36	19
Taxa shared with baseline	-	8	13	12	12	13	13	9
Echinoderms								
Total number of individuals	3	21	7	20	1	3	20	0
Total number of taxa	1	5	5	8	1	1	5	0
Taxa identified to species	1	5	5	7	1	1	5	0
Taxa shared with baseline	-	1	0	1	0	0	1	0

[a]Camp et al., 1977; Martin, in press.

[b]March-December 1976
January-May 1982
January-December all other years

TABLE C-8

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS (r) FOR MEASURED COMMUNITY PARAMETERS
AND SELECTED PHYSICAL VARIABLES AT OFFSHORE BENTHIC STATIONS
ST. LUCIE PLANT
1982

	Abundance vs.					Species richness vs.				Diversity (H') vs.			Biomass vs.	
Station groupings and quarters	Number of taxa	Diversity (H')	Biomass	Bottom water temperature	Mean grain size	Diversity (H')	Biomass	Bottom water temperature	Mean grain size	Biomass	Bottom water temperature	Mean grain size	Bottom water temperature	Mean grain size
All stations combined Quarters[a]														
1	0.9619*	0.6566	0.7698*	0.8783*	-0.7217	0.7939*	0.8667*	0.8743*	-0.8286*	0.6573	0.4539	-0.7955*	0.7828*	-0.6092
2	0.9790*	0.7511*	0.6250	0.1621	-0.9221*	0.8573*	0.6329	0.1645	-0.9367*	0.4532	0.0906	-0.8288*	-0.2033	-0.6476
3	0.9767*	0.4702	0.9726*	-0.0885	-0.7869*	0.5817	0.9634*	-0.2075	-0.8493*	0.4432	-0.3920	-0.3999	0.0314	-0.8640*
4	0.9329*	-0.0841	0.6428	-0.0747	-0.8307*	0.2507	0.7914*	-0.1561	-0.9623*	0.4298	-0.4002	-0.3900	-0.0221	-0.7284
All quarters[b]	0.9465*	0.3535*	0.4759*	-0.0812	-0.8079*	0.5457*	0.5733*	-0.0222	-0.8571*	0.3557*	-0.0580	-0.3646*	-0.2570	-0.4393*
Stations BC, B1 and B2 All quarters[c]	0.8071*	0.6125*	-0.3929	-0.3717	-0.2242	0.8620*	0.3271	0.0434	-0.2656	-0.4931	0.1977	-0.5110	-0.0031	0.4980
Stations B3, B4, B5 and C1 All quarters[d]	0.8475*	0.0774	0.2905	0.1664	-0.2067	0.4437	0.5129*	-0.0009	-0.2317	0.3159	-0.2401	0.1780	-0.3892	-0.2730

*Significant difference at $P \leq 0.05$ for critical r value.

[a]Critical r value (df=5) ≥ 0.755.

[b]Critical r value (df=26) ≥ 0.344.

[c]Critical r value (df=10) ≥ 0.576.

[d]Critical r value (df=14) ≥ 0.497.

TABLE C-9

LIST OF DOMINANT TAXA OF BENTHIC MACROINVERTEBRATES
COLLECTED BY GRAB EACH QUARTER AT OFFSHORE STATIONS
ST. LUCIE PLANT
1982

Dominant taxa[a]	Abundance by quarter and station																																		
	Quarter 1							Quarter 2							Quarter 3							Quarter 4							Entire Year						
	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
PLATYHELMINTHES				71																															
NEMERTINA			6	110	46		109				80	35		84	15	11	12	91				8	4	10					40	29	30	357	104		
ANNELIDA																																			
Arenicolidae spp.			15																												15				
Armandia agilis	16		16					33	53	26		12					3												67	59	45				
Exogene arenosa											52																								
Filogranula sp. A				215		559					160		322	337				139		475	408				685	14	623	450		14		1199		1979	1230
Goniada littorea																16							2	2							12				
Hemipodus roseus					41																					11							107		
Mediomastus californiensis											70			78					97					3				65					102		192
Notomastus latericeus																			79														80		
Owenia fusiformis																5	3																		203
Phallodrilus sabulosus																												54							
Podarke obscura																										25							43		
Prionospio cristata	10			68							133		299	111			4	74	120		236												138		392
Pseudoeurythoe sp.							84				175							318								81						577	138		
Scolelepis texana									11			25																							
Sphaerosyllis sp.				103			67																												
Spiophanes bombyx								35																					44						
Tubificoides wasselli				82																															
MOLLUSCA																																			
Cylichnella canaliculata															20																				
Kurtziella atrostyla																							3												
Montacuta sp. B		29																												29					
Olivella adelae																							4												
Parvilucina multilineata																10	5					13							24						
ARTHROPODA																																			
Cyclaspis varians												12																							
Janiridae sp. A				118																															
Maera sp. A														187				51																	203
Platyischnopidae sp. A																5																			
Xenanthura brevitelson	15																																		
SIPUNCULA		9				299	408				83							437		235										17		947		1083	474

TABLE C-10

SUMMARY OF PLANT EFFECTS REVEALED BY USE OF
SUBOPTIMAL EXPERIMENTAL DESIGN
ST. LUCIE PLANT
1982

	Control Station = BC Treatment Stations = B1 and B2	Control Station = C1 Treatment stations = B3, B4 and B5
Density	1. No effects	1. B4 < C1 (quarters combined) B3 = B5 = C1 2. No effects (quarters separated)
Species richness	1. No effects	1. No effects
Diversity	1. No effects	1. Quarter 2: B5 < C1 2. Otherwise, no effects
Relative abundance	1. Quarters 1 and 4 no effects 2. Quarters 2 and 3 B1 and B2 not = BC	1. B3 and B5 different from C1 at all quarters 2. B4 different at Quarters 1 and 3

TABLE C-11

RESULTS OF T-TESTS (Poole, 1974) USED TO DETECT SIGNIFICANT DIFFERENCES (P<0.05) IN DIVERSITY (H') BETWEEN CONTROL STATIONS (C1 AND BC) AND THEIR CORRESPONDING TREATMENT STATIONS (B3, B4 AND B5 AND B1 AND B2, RESPECTIVELY)
ST. LUCIE PLANT
1982

Quarter	Control stations (H' value)	Treatment stations B1	B2	B3	B4	B5
1	C1(4.762)	-	-	NS	NS	NS
	BC(3.896)	NS	NS	-	-	-
2	C1(5.047)	-	-	NS	NS	*(4.229)
	BC(3.815)	NS	NS	-	-	-
3	C1(4.360)	-	-	NS	NS	NS
	BC(3.716)	NS	NS	-	-	-
4	C1(3.002)	-	-	NS	NS	NS
	BC(2.180)	NS	NS	-	-	-

NS = No significant difference.

* = Significant difference.

TABLE C-12

RESULTS OF KOLMOGOROV-SMIRNOV GOODNESS OF FIT TESTS
(SOKAL AND ROHLF, 1982) USED TO DETECT SIGNIFICANT DIFFERENCES ($P<0.05$)
IN RELATIVE ABUNDANCE PATTERNS OF BENTHIC MACROINVERTEBRATES
BETWEEN CONTROL STATIONS (C1 AND BC) AND THEIR
CORRESPONDING TREATMENT STATIONS
ST. LUCIE PLANT
1982

Quarter	Control Stations	Treatment stations B1	B2	B3	B4	B5
1	C1	-	-	*	*	*
	BC	NS	NS	-	-	-
2	C1	-	-	*	NS	*
	BC	*	*	-	-	-
3	C1	-	-	*	*	*
	BC	*	*	-	-	-
4	C1	-	-	*	NS	*
	BC	NS	NS	-	-	-

NS = No significant difference.

* = Significant difference.

TABLE C-13

RESULTS OF KOLMOGOROV-SMIRNOV GOODNESS OF FIT TESTS (SOKAL AND ROHLF, 1982) USED TO DETECT SIGNIFICANT DIFFERENCES ($P \leq 0.05$) IN RELATIVE ABUNDANCE PATTERNS OF BENTHIC MACROINVERTEBRATES AT EACH STATION OVER TIME
ST. LUCIE PLANT
1982

	Stations						
Quarterly comparisons	BC	B1	B2	B3	B4	B5	C1
Quarter 1 vs. Quarter 2	NS	NS	*	*	*	*	*
Quarter 2 vs. Quarter 3	NS	*	*	*	*	*	*
Quarter 3 vs. Quarter 4	NS	NS	NS	*	*	*	*

NS = indicates no significant difference.

* = indicates significant difference.

APPENDIX TABLE C-1

EXPLANATION OF NUMERICAL METHODS USED IN THE
ANALYSIS OF BENTHIC COMMUNITY DATA
ST. LUCIE PLANT
1982

Both parametric and non-parametric statistics, as well as various biological indices, were used during the analysis of 1982 ETS and NPDES community data. Where appropriate, parametric tests were selected over non-parametrics because of their increased sensitivity to detection of differences between variables being compared. However, semi-quantitative data, such as that obtained during trawling studies, often do not meet assumptions implicit in such tests, and thus, alternative non-parametric statistics must sometimes be employed.

KOLMOGOROV-SMIRNOV TEST (Sokal and Rohlf, 1981)

This non-parametric technique tests for differences between two cumulative frequency distributions using pair-wise comparisons. Elements of the two distributions to be compared are ranked from most to least abundant, and the cumulative frequencies of elements within each distribution are calculated.

For each pair of cumulative frequencies the quantity

$$di = \left| F_1 - F_2 \right| \quad \text{is calculated}$$

where F_1 and F_2 represent the cumulative frequencies of element i in samples 1 and 2, respectively. The maximum di value is divided by the number of elements (n) to give the quantity D:

APPENDIX TABLE C-1
(continued)

$$D = di_{(max)} \Big/ n$$

The calculated D value is then compared with a critical tabulated value to determine significance ($a_{0.05}$ with n degrees of freedom).

THE SPEARMAN RANK CORRELATIONS (Siegel, 1956)

In this test "N" individuals are ranked for each of two variables. If the ranking of the independent variables is denoted as X_1, X_2, X_3, ..., X_n and the ranking of the dependent variables is represented by Y_1, Y_2, Y_3, ..., Y_n, a measure of rank correlation may be used to determine the relationship between the X's and the Y's.

$$d_i = X_i - Y_i$$

indicates the disparity between the two sets of rankings.

$$r_s = 1 - \frac{6 \sum_{i=1}^{N} d_i^2}{N^3 - N}$$

is used if no tied rankings are present. When a considerable number of ties are present, the following formula is used:

$$rs = \frac{\Sigma x^2 + \Sigma y^2 - \Sigma d^2}{2 \sqrt{\Sigma x^2 y^2}}$$

where: $$\Sigma x^2 = \frac{N^3 - N}{12} - \Sigma T_x$$

$$\Sigma y^2 = \frac{N^3 - N}{12} - \Sigma T_y$$

and $$T = \frac{t^3 - t}{12}$$

where t = the number of observations tied at a given rank. Critical values of significance (P=0.05) have been determined for various N's.

THE MANN-WHITNEY U-TEST (Elliott, 1971)

This is a nonparametric alternative to the t-test for comparing differences between two sample means. The null hypothesis is that there is no difference between sample means from two independent random samples drawn from populations having the same parent distribution.

The test statistics are calculated as follows:

$$U_1 = n_1 n_2 + \frac{n_2 (n_2 + 1)}{2} - R_2$$

$$U_2 = n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - R_1$$

where n_1 = number of elements in sample 1 and n_2 = number of elements in sample 2. Data are pooled and ranked by order of magnitude, so that the lowest ranking element receives a value of 1. If any ranks are equal, they are given the average of the tied ranks. R_1 and R_2 are the sum of ranks in samples 1 and 2, respectively. The smaller of the two U values is compared to the appropriate value of U in a table of U-statistic values at the desired level of significance.

APPENDIX TABLE C-1
(continued)

THE WILCOXON PAIRED SAMPLE TEST (Zar, 1974)

This is a nonparametric test that is applicable to instances where the paired t-test is applicable. The null hypothesis is that there is no difference between matched data.

The test statistic is calculated as follows:

$$T' = m(n + 1) - T$$

Each set of data are ranked and the difference between the matched ranks, regardless of the sign, are determined. T is the sum of the ranks with the less frequent sign, and m is the number of ranks with the less frequent sign. If T or T' is less than or equal to the selected critical value, the null hypothesis is rejected.

INDICES OF FAUNAL DOMINANCE

McCloskey's (1970) Index ranks each species taken in a series of samples to determine the most dominant species. Use of this index disregards sample size. The species in each sample are ranked for dominance by their biological index value (BIV), which is obtained by giving 10 points to the species which numerically dominates that sample, 9 for each second dominant species, and so on. The "scores" of each species in the series of samples are then added to determine the total biological index value. The species having the highest total BIV is then the species of primary dominance.

Another technique for determining dominance relies on the absolute abundances of species rather than ranking values. Relative abundance

distribution curves generated from benthic macroinvertebrate data generally conform to a logarithmic series model as shown in Figure A. . The region of the curve where the function is changing axes along which it asympototes reflects the boundary between species that are increasingly abundant and those that are increasingly rare. The increasingly abundant species may be taken as those that numerically dominate the community. This, of course, says nothing about their function in the community and indeed a very rare species may be dominant in that it controls the abundance of many other species. However, the type of ecological data required to accurately describe the interrelationships of constituent species within a community is generally not available. Thus, numerical dominance must be taken as a first good approximation.

For the "typical" data set stylized above, the breakpoint between rare and abundant species (indicated by the line y=x) divides the logrithmic series curve into two halves. Those species accounting for the shaded portion of total abundance may be thought of mathematically as dominating the curve. During NPDES monitoring, an "a priori" criterion of dominance was established: those species accounting for 50 percent of the total faunal abundance at each station were designated as dominants.

DOMINANCE-DIVERSITY CURVES (Whittaker, 1965)

In order to examine the relative abundances of the taxa at each station, all taxa were ranked by abundance and the ranks were then plotted against the log of the number of individuals represented by each rank. A steeply sloping curve indicates a high degree of dominance by a few spe-

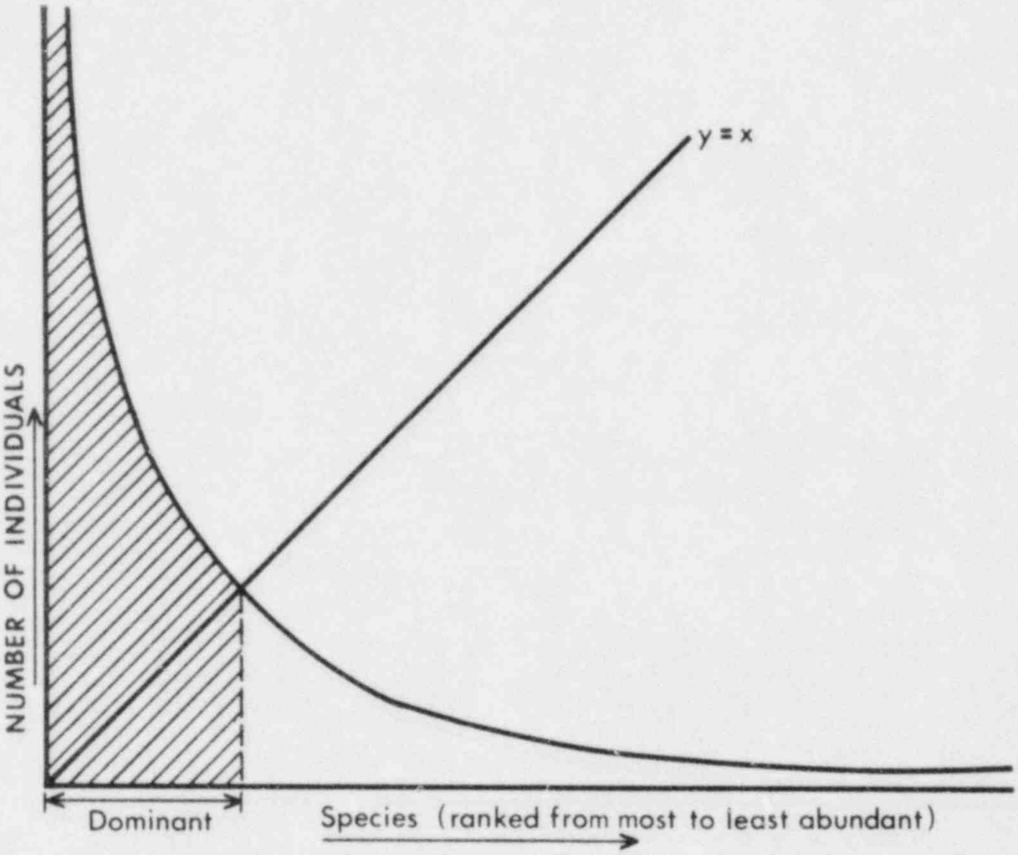


Figure A. Logarithmic series model.

cies, while a gently sloping curve indicates a more equitable distribution of abundances among taxa.

RAREFACTION DIVERSITY (Sanders, 1968)

The rarefaction method of graphically calculating species diversity was formulated to directly compare samples of different sizes. The usual difficulty inherent in such a comparison is that, as the sample size increases, individuals are added at a constant arithmetic rate but species accumulate at a decreasing logarithmic rate. The rarefaction method is dependent on the shape of the species abundance curve rather than on the absolute number of specimens per sample. The procedure is to keep the percentage composition of the component species constant with that of a hypothetical sample of 1000 individuals while reducing the sample size, i.e., to artificially create the results that would have been obtained had smaller samples with identical faunal composition been taken. With this technique, the expected number of species in any size sample can be determined.

MORISITA'S (1959) INDEX OF COMMUNITY SIMILARITY: $C\lambda$

This index is used with semi-quantitative data such as trawl samples. It compares two samples by taking into account the abundances of common species, total abundances in each sample, and their respective diversities.

Morisita's index is based on Simpson's index of diversity (λ):

$$\lambda = \frac{\Sigma n_i(n_i-1)}{N(N-1)}$$

where: N = total number of individuals, and

n_i = importance value (abundance, biomass, etc.) of the i^{th} species.

Using subscripts 1 and 2, the λ values of two samples may be differentiated:

$$\lambda_1 = \frac{\Sigma n_i^1(n_i^1-1)}{N_1(N_1-1)} \quad \text{and} \quad \lambda_2 = \frac{\Sigma n_i^2(n_i^2-1)}{N_2(N_2-1)}$$

Morisita's index of similarity between communities may then be calculated by the following formula:

$$C\lambda = \frac{2\Sigma n_{i1} n_{i2}}{(\lambda_1+\lambda_2)N_1 N_2}$$

This index is almost uninfluenced by the sizes of N_1 and N_2. The value of $C\lambda$ will approach unity when samples demonstrate similarity in species abundance and diversity. Conversely, as $C\lambda$ approaches zero, the samples will have fewer species in common, which suggests that the samples have been drawn from dissimilar habitats.

DIVERSITY AND EVENNESS

Diversity indices are very useful for measuring the quality of the environment and the effect of induced stress on the structure of a biological community. Their use is based on the generally observed phenomenon that undisturbed environments support communities having large numbers of

species with no individual species represented in overwhelming abundance (EPA, 1973). Many forms of stress tend to reduce diversity by making the environment unsuitable for some species or by giving other species a competitive advantage.

The most widely used measure of species diversity is the information diversity index. This index considers two aspects of community species-numbers relationships: species richness (the number of species in relation to the number of individuals) and species evenness (the distribution of individuals among species). A decrease in either component of information means a decline in diversity.

The Shannon-Weaver information function (H') calculates mean diversity (i.e., the degree of uncertainty attached to the specific identity of any randomly selected individual; Pielou, 1966):

$$H' = -\sum_{i=1}^{s} p_i \log p_i$$

where: s = total number of species in the sample, and

p_i = proportion of the total sample represented by the ith species.

However, as Lloyd et al. (1968) argued, if p_i's are to be estimated (i.e., the actual community composition is unknown) as $p_i \simeq n_i/N$, then the formula for H' can be computed directly in terms of the observed n's, and the necessity for calculating proportions and their attendant rounding errors can be avoided. In an attempt to standardize the calculation of diversity, the EPA (1973) recommended the machine formula presented by Lloyd et al. (1968) using base 2 log:

APPENDIX TABLE C-1
(continued)

$$H' = \frac{C}{N}(N \log_{10} N - \Sigma n_i \log_{10} n_i)$$

where: C = 3.321928 (converts base 10 log to base 2),

N = total number of individuals, and

n_i = total number of individuals of the ith species.

In order to test for significant differences between two diversity values (H'), diversity variance must first be determined (Poole, 1974). The variance of the diversity function (before converting to base two) is:

$$Var(H') = \frac{\sum_{i=1}^{i=s}\left[\frac{n_i}{N}\left(\log_{10}\frac{n_i}{N}\right)^2\right] - \sum_{i=1}^{i=s}\left[\left(\frac{n_i}{N}\log_{10}\frac{n_i}{N}\right)^2\right]}{N} + \frac{S-1}{2N^2} + \text{(Series of additional forms)}$$

For most ecological samples, the first two terms of this equation are adequate to determine the variance.

Then, given the diversity and variance values for two samples (symbolized below by subscripts 1 and 2) a t-value may be calculated as follows:

$$t = \frac{H'_1 - H'_2}{\sqrt{var(h')_1 + var(h')_2}}$$

This t is compared with a tabulated critical t with the following degrees of freedom

$$df = \frac{(var(H'_1) + var(H'_2))^2}{\frac{var(H'_1)^2}{N_1} + \frac{var(H'_2)^2}{N_2}}$$

To evaluate the component of diversity due to the distribution of individuals among the species (evenness), the calculated H' is compared with the maximum diversity possible for the same number of species (Pielou, 1966):

$$J' = H'/H'_{max}$$

where: $H'_{max} = \log_2 S$ (for H'computed with base 2 log).

Evenness values may range from zero to one.

ANALYSIS OF VARIANCE (ANOVA) (Sokal and Rohlf, 1981)

Environmental biologists must always be concerned with meeting the assumptions of various statistical tests before relying upon those tests for drawing inferences. For parametric tests such as one- and two-way ANOVA, important assumptions include: 1) variances of all cells are equal and 2) the overall distributions approach normality.

Because most environmental data generally violate one or both assumptions, many environmental biologists have increasingly turned to the use of non-parametric statistics (Green, 1979). While this eliminates distribution and variance problems, the power of the test to discern differences is diminished. Green (1979) suggests using parametric statistics (with the proper data transformation) if the ratio of the maximum cell's variance to the minimum cell's variance is less than 20. During 1982 NPDES monitoring, this ratio was below 20 for both density and species richness when stations within the two major groups to be analyzed were compared (i.e., Station BC versus Stations B1 and B2; and Station C1 versus Stations B3, B4 and B5).

One-way ANOVA can be employed to test whether or not two or more sample means come from the same parametric population mean. This technique tests the variance between groups of samples and within groups of samples (error term) against an expected value derived from the F-distribution. The model used is:

$$Y_{ij} = u + a_i + E_{ij}$$

Where: i - ranges from 1 to a groups (samples)

j - ranges from 1 to n replicates

u - is the grand mean of all samples

a_i - is the variance of group i from the grand mean

E_{ij} - is a measure of the random deviation of individual replicate j from its expected value $(u + a_i)$

The two-way ANOVA allows testing of two main factors (time, with baseline and operational years as classes; and space, with control and experimental stations as classes) and the interaction term (time X space). Green (1979) states that in an "optimally" designed environmental study with both baseline and operational years and a spatial control station, the existence of a significant ecological impact is shown by a significant time X space interaction term. In non-mathematical terminology, a significant interaction term means that the effect of one main variable is dependent on the level of the other main variable.

The equation describing a two-way ANOVA is:

APPENDIX TABLE C-1
(continued)

$$Y_{ijk} = U + a_i + B_j + (aB)_{ij} + E_{ijk}$$

Where: U = parametric mean

a_i = fixed treatment effect of level i of the first main treatment (e.g., time),

B_j = fixed treatment effect of level j of the second main treatment (e.g., space),

$(aB)_{ij}$ = interaction effect in the sub-partition representing level i of the first treatment and level j of the second treatment, and

E_{ijk} = error term of item k in the subgroup ij.

Procedures for conducting this analysis may be found in Sokal and Rohlf (1982) or any other general biometry text.

A plot of density means versus their variances showed a strong positive association between the two (i.e., as the mean increased, the variance increased). This positive relationship indicated that the proper data transformation was $\log_{10}(X + 1)$. This transformation was used in all ANOVA tests.

THE NEWMAN-KEULS MULTIPLE RANGE TEST (Zar, 1974)

After a significant difference has been found in ANOVA, a multiple range test may be used to ascertain which sample means are different. In this test, the sample means are ranked from largest to smallest. The difference between the largest and the smallest mean is then calculated. This difference is divided by the following term:

$$\sqrt{\text{(error mean square/number of replicates)}}$$

This produces a quantity called q. The quantity q is then tested against a tabulated q (0.05 level of significance and numerator degrees of freedom = p, and denominator degrees of freedom = error degrees of freedom minus one). The value of p is the range of all sample means encompassed by testing these two sample means. For example, if there were five groups, and the largest mean was tested against the smallest, the test would cover five means. If the calculated q is greater than the tabulated q, then there is a significant difference between the means.

After this first pair, the largest mean is tested against the second smallest, and so on.

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENT (Zar, 1974)

This parametric test measures the association between two sets of independent variables. It does not imply influence of one on the other but determines the degree to which one varies with the other. The correlation coefficient (r) ranges from 0, no association, to +1 or -1 for variables displaying a very high degree of association. A positive correlation implies that one variable increases in value as the other increases, while a negative correlation indicates that one variable increases as the other decreases.

Correlation coefficients are calculated as follows:

$$r = \frac{\Sigma xy}{\sqrt{\Sigma x^2 \Sigma y^2}}$$

where x and y are paired independent variables. The value of r can subsequently be tested for significance by comparing it with a tabulated r having n degrees of freedom.

APPENDIX TABLE C-2

NUMBERS OF BENTHIC MACROINVERTEBRATES COLLECTED BY SHIPEK GRAB
ST. LUCIE PLANT
1982

	Quarter and station																											
	Quarter 1							Quarter 2							Quarter 3							Quarter 4						
Species	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
CNIDARIA																												
Renilla sp.																						1	1	1				
unidentified Anthozoa				5	1	8	2				4	1	1	3	1			1		1	1				1	1	1	5
PLATYHELMINTHES				71	5	42	31				28		4	7			1	20	15	15	5				13	9	18	16
NEMERTINA	7	7	6	110	46	62	109	10	7	2	80	35	26	84	15	11	12	91	14	50	36	8	4	10	76	9	33	52
ANNELIDA																												
Polychaeta																												
Polynoidae																												
Harmothoe extenuata																									1			
Malmgrenia lunulata														1														
Polynoidae sp. A											1																	
Unidentified Polynoidae																				1								
Polyodontidae																												
Polyodontes lupinus																									1			
Sigalionidae																												
Psammolyce arenosa				3																								
Sigalion arenicola				4	5	6	25											1										
Sthenelais limicola		2	1					2						1									1					
Sthenelais sp.												1																
Thalenessa lewisii														1													1	
Pisionidae																												
Pisione remota				3		1	12				5			1				4			1				3			
Chrysopetalidae																												
Paleonotus heteroseta														2				4			2							15
Amphinomidae																												
Pseudeurythoe sp.				64	30	4	84				175		3					318	27	127					20	81	5	2
Phyllodocidae																												
Eteone heteropoda																				1	2							1
Eulalia bilineata							1				1			2				4			7				1		2	
Eumida sanguinea				1		1							1					4		3	13				1			3
Hesionura laubieri ?							6																					
Nereiphylla fragilis				3		5	3				3			6							4							3
Paranaites polynoides				1																								
Paranaites speciosa											1																	
Phyllodoce arenae								1			1	1		2				2	1	2	1							
Protomystides sp. A							2											1										
Pterocirrus macrocerus				1							1							4			5							
Unidentified Phyllodocidae				2																								
Hesionidae																												
Gyptis brevipalpa																1				2					1		1	1
Hesionidae sp. A				6			16				4			28				10	2		3				12	3	6	2
Heteropodarke sp. A							1				1																	
Microphthalmus hartmanae				21	1	6	4				4		2	2				8		7					1	2	2	5
Podarke obscura				14	10	136	10				12		13	10			1	19	8	4	11				1	25	20	29
Pilargidae																												
Ancistrosyllis carolinensis				2		1					1		1	1				5		2	2							1
Ancistrosyllis hartmanae				6	1		1				1	1	1	4				37	1	2	6				18	1	4	6
Ancistrosyllis jonesi																		2			1						2	1
Sigambra bassi												1					1					1		1				
Sigambra tentaculata			1																									
Synelmis albini							2											1							2			

APPENDIX TABLE C-2
(continued)
NUMBERS OF BENTHIC MACROINVERTEBRATES COLLECTED BY SHIPEK GRAB
ST. LUCIE PLANT
1982

	Quarter and station																											
	Quarter 1							Quarter 2							Quarter 3							Quarter 4						
Species	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
Syllidae																												
Autolytus sp.				2			2																					
Brania gallagheri							2																					
Brania swedmarki				7	4	8	7							1				4							8	2		
Brania sp. A																												2
Dentatisyllis carolinae				9		1	12				14		11	18				27	2	16	4				8	1	6	18
Dioplosyllis octodentata				1		2	1							1				3										
Exogene arenosa				24	1	8	7				52		4	9				3[illegible]	2	7	19				12	3	8	34
Exogone atlantica																					1							1
Langerhansia cornuta				1		2																						
Odontosyllis sp.				2		5	13				1							3		1								1
Parapionosyllis longicirrata				35	5	34	22				14	1	10	13				38		17	23				13	6	18	45
Pionosyllis gesae							5											1								1		
Pionosyllis uraga											1			3					2							2		2
Plakosyllis quadrioculata				15		10	21				2			2				19		1	1				2		1	6
Sphaerosyllis aciculata													1	1						1					1			
Sphaerosyllis labyrinthophila											7														7	1	1	4
Sphaerosyllis piriferopsis											15		1	2				22		3	10				18		3	41
Sphaerosyllis riseri																									1			
Sphaerosyllis taylori											3		2	2				3		1	1					3	1	6
Sphaerosyllis sp.			1	103	4	44	67							2				28							1			
Streptosyllis pettiboneae						1	3																		2			
Syllides bansei				3		1	4				2			2				3	1		2						1	3
Syllides floridanus				10	2	2	12				5			2				5		1					3	2	1	
Syllis amica				2			1				8			4				13		17	3				9		7	8
Syllis gracilis				1							6			1				2			1							1
Typosyllis hyalina											1							3										
Trypanosyllis coeliaca				3									2					3										2
Trypanosyllis inglei							1				4														1			
Trypanosyllis parvidentata																		[illegible]										
Trypanosyllis savagei						1					1		1					2										
Trypanosyllis sp.													1	1														
Unidentified Syllidae						1	1																					
Nereidae																												
Ceratonereis irritabilis																					2					1		2
Ceratonereis longicirrata				3	1	1					8		4	16				2	14	22	56				1	7		3
Nereis falsa																		1	1									
Nereis riisei				1										1							6							1
Nephtyidae																												
Nephyts simoni							1						7	3		2		2	2	2					2		1	
Nephtys squamosa							2											1									1	
Unidentified Nephtyidae												3																
Glyceridae																												
Glycera americana					1														5	4	1				1	1	3	1
Glycera capitata			1																									
Glycera dibranchiata		1						1		2																		
Glycera sp.									1						1								2					
Hemipodus roseus				58	41	92	22				21	7	35	17				22	48	43	7				7	11	12	18

APPENDIX TABLE C-2
(continued)
NUMBERS OF BENTHIC MACROINVERTEBRATES COLLECTED BY SHIPEK GRAB
ST. LUCIE PLANT
1982

	Quarter and station																											
	Quarter 1							Quarter 2							Quarter 3							Quarter 4						
Species	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
Goniadidae																												
Goniada littorea	2	4	5					1	1	3					1	16	2					6	2	2				
Goniadides carolinae				28	2	7	28				48		2	66				29		2	19				8		34	27
Eunicidae																												
Eunice vittata							1							2				7		1	1							6
Nematonereis hebes						1					1							2		1							1	
Unidentified Eunidicae																					1							
Onuphidae																												
Diopatra cuprea																			1		1							
Onuphis eremita oculata								4																			1	
Onuphis sp. A				1	1	13	10				6		7					1	1								2	
Onuphis sp.									1				1															
Unidentified Onuphidae				1		1	2				8	6		1		2	1	1									10	1
Lumbrineridae																												
Lumbrinerides jonesi				1			2				5			3							2							
Lumbrineris cf. *latreilli*				8							3			7				2		5	9				2	1	2	18
Lumbrineris verrilli														1														
Lumbrineris sp. A			1													1								1				
Arabellidae																												
Arabella mutans																									1		1	
Arabella sp.														1														
Driloneris sp.																		1										
Dorvilleidae																												
Dorvillea sociabilis					1																4							
Protodorvillea sp.				23	10	8	23				4		3					12		12					3	4	11	1
Schistomeringos pectinata						1					1			3				1								2	2	
Schistomeringos rudolphi				8			4				18			12				26		3	1				4		4	2
Orbiniidae																												
Haploscoloplos foliosus																1												
Haploscoloplos fragilis									5							3	1							1				
Haploscoloplos sp.			2			1		2	1			1			1	2	2											
Scoloplos cf. *acmeceps*									1																			
Scoloplos rubra					1	5								1				1										
Scoloplos sp. A																					1							
Paraonidae																												
Aricidea lopezi																									1			
Aricidea sp. A											1										2				1	1		7
Aricidea sp. B											1																	
Cirrophorus sp. A					1																1						1	
Paraonides sp. A											1			3				2										
Paraonides sp. B				18		1															7				2			4
Arenicolidae																												
Unidentified Arenicolidae			15	1		14			1				5					1	1	1							4	
Spionidae																												
Aonides sp. A				2							1			1							3							4
Laonice cirrata											2																1	
Paraprionospio pinnata									1		1	4																
Polydora anoculata											1															1		1
Polydora socialis						4	1				6		11	6							1							

APPENDIX TABLE C-2
(continued)
NUMBERS OF BENTHIC MACROINVERTEBRATES COLLECTED BY SHIPEK GRAB
ST. LUCIE PLANT
1982

Species	Quarter and station																											
	Quarter 1							Quarter 2							Quarter 3							Quarter 4						
	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
Spionidae (cont'd)																												
Polydora websteri													1					1										
Prionospio cristata	10			68	8	19	2	2	5	1	133	3	299	111			4	74	120	136	236	1			21	7		43
Prionospio dayi										1																		
Prionospiro (Minuspio) sp. A				2							1		2	1			2	1	22	2					3	1	6	2
Pseudopolydora pulchra											1		1	3					3									
Rhynsocpio glutaeus							1																					
Scolelepis texana	5	1						13	11	9		25				2												
Spio pettiboneae														1														
Spiophanes bombyx	4	1		4	5	4	6	35	3		19	10	10	9	5		1	4	10	5								
Unidentified Spionidae												5																
Magelonidae																												
Magelona cf. obockensis					1																							
Magelona sp. A															1										1			
Magelona sp. C															1							1						
Magelona sp.		1							1			1																
Poecilochaetidae																												
Poecilochaetus johnsoni		1					1	2		1			1					3	3							1	1	
Acrocirridae																												
Macrochaeta sp.				10	2	21	1				2		7	2				3	1	8						5	5	15
Chaetopteridae																												
Chaetopterus varieapeclatus														1														
Spiochaetopterus costarum oculatus								3	1			6	3															
Cirratulidae																												
Caulleriella alata				1		1													1	2							1	
Caulleriella cf. killariensis							1																					1
Cirriformia filigera						2	2				5																	
Cirriformia grandis											1																	
Tharyx marioni	1			2	1	10	5				2		1	9					2	2	1					2		
Opheliidae																												
Armandia agilis	16	2	16					33	53	26		12	1		15	4	3					3						
Armandia maculata	1				1	1					30	4	46	43				2	1	7	9							5
Ophelia denticulata				1		6	5						4							1						1	2	1
Capitellidae																												
Mastobranchus ? sp. A				6							35		44	21				2	1	16	8				1		16	6
Mediomastus californiensis				18	3	2				1	70		5	78		1	2	7	97	36	49			3	8	2	23	65
Notomastus latericeus				5			12						3			1			79	6						1	3	
Unidentified Capitellidae				7		11																						
Maldanidae																												
Axiothella mucosa				1		1					43		1	62				10	1	12	26				2	2	5	11
Euclymene sp. A											1									1							1	
Macrolymene zonalis				56	6	42	1				22		28	20				1	2	4							1	
Petaloproctus socialis				3		3					16							8							5		2	1
Unidentified Maldanidae							1					4						1										
Oweniidae																												
Owenia fusiformis				1			2				1				5	5	3	1	4									
Bogueidae																												
Bogues enigmatica											18		2								2						6	2

APPENDIX TABLE C-2
(continued)
NUMBERS OF BENTHIC MACROINVERTEBRATES COLLECTED BY SHIPEK GRAB
ST. LUCIE PLANT
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	Quarter and station																											
	Quarter 1							Quarter 2							Quarter 3							Quarter 4						
Species	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
Sabellariidae																												
Sabellaria vulgaris			1			1	1				13		2					5	1	1	8				2	1	2	
Ampharetidae																												
Ampharete americana											28		4	9				20	2	1	6						1	
Isolda pulchella						1					6		2					2		3	5				2	1	1	
Terebellidae																												
Loimia medusa				1		2					2			2														
Pista cristata											1																	
Polycirrus eximius							1				6			2				3	1	2	7				2			8
Polycirrus sp. A																			9							2		
Polycirrus sp.																										3		
Unidentified Terebellidae							1												4	1								
Sabellidae																												
Amphiglena mediterranea				2																								
Chone sp.											4			2				2	2	6	5							2
Notaulax nudicollis											1																	
Megalomma bioculatum									2																			
Megalomma sp. A											1										1							
Potamilla sp. A																					2							
Sabella microphthalmus																					1							
Unidentified Sabellidae											1																	
Serpulidae																												
Filogranula sp. A		5		215	1	559	35		8		160		322	337		1		139	5	475	408				685	14	623	450
Hydroides bispinosa				1		1					2							4										1
Hydroides dianthus											1		1															
Hydroides floridana											1		1	1				2			6							3
Hydroides microtus											1							2	2		9							
Hydroides sp.																				1								
Pseudovermilia sp. A				1		1	13				2		1	3				12		4					3		2	
Serpula sp.																		1	1	1	1						1	
Vermiliopsis sp. A		3		4	3	80	33		2		41		25	19				70		49	3				50	2	71	9
Spirorbidae																												
Unidentified Spirorbidae						1	1						6														22	
Polygordiidae																												
Polygordius sp.				15		6	1				5		3	3				1		31	7				2	1	7	8
Saccocirridae																												
Saccocirrus sp.				5		3					1		1	3						10							1	1
Protodrilidae																					2							
Protodrilus sp.				13	3	6	27						1	2				2								1	4	
Oligochaeta																												
Adelodrilus acochlearis							4											2							3		1	
Grania macrochaeta				6		1	13				21		1	18				3			1						4	2
Heterodrilus arenicolus				20		13	7				5	1	42	11			1	6		40	10				17		45	20
Heterodrilus sp. A							2				1		2					2									6	
Peosidrilus biprostatus						1	8											11							1		3	
Phallodrilus leukodermatus				3							1			8				3							2		1	
Phallodrilus sabulosus				10	1		31				1			4				10	1		114				17		18	54
Tubificoides wasselli				82		2	2				46	3		24				37		2	5				20		20	11
Tubificoides sp. A																									1			

APPENDIX TABLE C-2
(continued)
NUMBERS OF BENTHIC MACROINVERTEBRATES COLLECTED BY SHIPEK GRAB
ST. LUCIE PLANT
1982

	Quarter and station																											
	Quarter 1							Quarter 2							Quarter 3							Quarter 4						
Species	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
MOLLUSCA																												
Gastropoda																												
Aeolidiacea sp. A							2																		1			
Aesopus stearnsii																		2										
Arene tricarinata			1	1			9				1							1		1					8		1	
Armina ? wattla																1												
Astyris lunata																									1			
Boonea seminuda																			1									
Brochina vestitum																				1								
Caecidae sp.										1																		
Caecum pulchellum						1	1			2				1					1									
Caecum sp. A							1																					
Calyptraea centralis						2	2				12		2	10				12	1	1	6				6		1	2
Cingula ? floridana			1																									
Crepidula fornicata											3		1	3						1								
Crepidula plana											2									2								
Crepidula sp.														1														1
Crucibulum sp.											1																	
Cyclichnella bidentata															1	1	1		1									
Cyclichnella canaliculata							1								20	2			1		1	1						
Cyclichnella candei													1						1	2					2			
Elephantulum cooperi				7		7			1				3	1				6		1	1				2		1	
Elephantulum cooperi ?						1																						
Elephantulum floridanum														1														
Elephantulum imbricatum													1	1														
Elephantulum plicatum						4							1															
Epitonium (Asperiscala) sp. A																							1					
Eulimidae sp. F							1																					
Fartulum strigosum				3		17	9				1		8	26				14	1	4					1	3	5	1
Finella adamsi													1	2			1	1		1								
Haminoea sp.																								1				
Kurtziella atrostyla											2				1							1	3					
Kurtziella limonitella								1																				
Macromphalina palmilitoris											2			1														
Nassarius consensus													1	1						1								
Natica pusilla				1					1																			
Oceanida inglei							1																					
Oliva sayana							1		1			1				1	1						1			1		
Olivella adelae	1		2													1				2			4				1	
Olivella mutica ?								2																				
Olivella sp.																	1											
Parvanachis obesa														1	1										2			
Pdygyreulima sp. A											2			1				1										
Seila adamsi																		4										
Suturoglypta iontha																		1							1			
Turbonilla (Strioturbinilla) sp. E														1														
Uromitra wandoense														2														
Unidentified Gastropoda									1		3	1		2														

APPENDIX TABLE C-2
(continued)
NUMBERS OF BENTHIC MACROINVERTEBRATES COLLECTED BY SHIPEK GRAB
ST. LUCIE PLANT
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	Quarter and station																											
	Quarter 1							Quarter 2							Quarter 3							Quarter 4						
Species	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
Polyplacophora																												
Chaetopleura _apiculata_											7									1	2							1
Ischnochiton _hartmeyeri_											2							3	1	1						1	1	1
Ischnochiton _hartmeyeri_ ?							5																					
Ischnochiton _striolatus_											6			1				6			2				1			4
Ischnochiton sp. A																		1										
Stenoplax _boogii_ ?														1														
Scaphopoda																												
Dentalium _calamus_							2																					
Bivalvia																												
Americardia _guppyi_								1			1										1							
Anadora _transversa_																					2							
Anomia _simplex_											6			2				2			11							
Arcopsis _adamsi_											1																	
Chama _congregata_							1																					
Chama _sinuosa_				1																								
Chione _cancellata_																				1								
Chione _grus_						2					1			3				2			6							
Chione _intapurpurea_				3			5				28		3	1				8	2	12					12	4	5	2
Chlamys sp. A											1										1							
Corbula _contracta_				1		1	1							2														
Corbula _swiftiana_					1						1							1	1	1	1						1	
Crassinella _dupliniana_		4		4		29	2		1		1		43	9				3		10	3				19	1	22	1
Crassinella _lunulata_				19	1	9					6		5	25				2	1	1	47				1	2	4	15
Crenella _divaricata_											1							1										
Dinocardium _robustum_																				1								
Dinocardium _robustum_ _robustum_															1													
Dinocardium _robustum_ _vanhyningi_			1																									
Diplodonta ? sp. A											1																	
Dosinia sp. A																										1		
Ervilia _nitens_	1																											
Glycymeris _spectralis_				1		1	6							1											6		2	
Glycymeris sp.																		1										
Lithophaga _bisulcata_														1				4									1	
Macoma _brevifrons_											3		3					7	7	2								
Macoma sp.				1		1																						
Mactra _fragilis_											2													1				
Mactridae sp.																2												
Montacuta sp. A											1																	
Montacuta sp. B		29						2					2	1														
Mulinia _lateralis_																						1						
Nucula _proxima_				1																								
Ostreidae sp.																1												
Parvilucina _multilineata_								1				1		5	10	10	5					13	1	2		1		
Pitar _fulminata_														1														
Pleuromeris _tridentata_													1	1											1			

APPENDIX TABLE C-2
(continued)
NUMBERS OF BENTHIC MACROINVERTEBRATES COLLECTED BY SHIPEK GRAB
ST. LUCIE PLANT
1982

	Quarter and station																											
	Quarter 1							Quarter 2							Quarter 3							Quarter 4						
Species	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
Bivalvia (cont'd)																												
Plicatula gibbosa						1												1										
Pododesmus rudis																				1					2		2	
Pteromeris perplana																											1	
Semele bellastriata						1					1			1						1								
Sphenia antillensis											1																1	
Spisula solidissima similis						1																						
Tellina consobrina	4		3					3	2	1		1			1				1									
Tellina iris	1		1						1	1							3						1	1				
Tellina sybaritica												4			1	4	1			2		2	1	1				
Tellina (Eurytellina) sp.																				1								
Tellina (Scissula) sp.	1																											
Tellina sp.	1		1															1	1				1					
Trachycardium muricatum											3																	
Veneridae sp. A														1														
Unidentified Bivalvia														2	1					1								
ARTHROPODA																												
Ostracoda																												
Cycloberis biminiensis							2																					
Cycloberis sp. A					1	1																						
Ostracoda sp. A						1																						
Ostracoda sp. B						1								1						1								
Ostracoda sp. C						3																						1
Ostracoda sp. Q	1																											
Ostracoda sp. S	1		2			1																						
Ostracoda sp. T									1																			
Ostracoda sp. U		1						1				1												1				
Ostracoda sp.				4		1																						
Philomedes paucichelata						2	4						1					1										
Cirripedia																												
Balanus trigonus																			15	2	2							
Balanus venustus																		4	10	34	13				1			
Balanus sp.													1	3				8	2	6	4					1		
Mysidacea																												
Bowmaniella brasiliensis																											4	
Bowmaniella portoricensis														1														
Bowmaniella sp.					1																							
Mysidopsis sp. A	1																											
Mysidopsis sp.			1																									
Promysis atlantica			2						1		1																	
Cumacea																												
Cyclaspis pustula			2	1		1							2						1									
Cyclaspis varians			1	4	1	9	2	20	3		2	12	3	2	2										2			
Diastylis sp. A											1																	
Oxyurostylis smithi	1		2	4	1	2		3				2	1	1	1	1	1							1				
Unidentified Cumacea												1																

APPENDIX TABLE C-2
(continued)
NUMBERS OF BENTHIC MACROINVERTEBRATES COLLECTED BY SHIPEK GRAB
ST. LUCIE PLANT
1982

	Quarter and station																											
	Quarter 1							Quarter 2							Quarter 3							Quarter 4						
Species	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
Tanaidacea																												
Apseudes sp. A				1							7							3		1	1							
Heterotanais sp. A											2			2				1			3							1
Tanaidacea sp. A							10						1					1										
Isopoda																												
Chiridotea arenicola																						1		1				
Eurydice littoralis					4	5	1				1		2					1		1					1	1	5	
Horoloanthura irpex							1													1								
Janiridae sp. A				118		1	6				4			2				50		1	2				1			5
Panathura formosa				3							1							2			1				1			
Xenanthura brevitelson	15																1							1				
Amphipoda																												
Acanthohaustorius sp. A							2																					
Acanthohaustorius sp. B							3																					
Acanthohaustorius sp.							2					1																
Aoridae sp.														1														
Batea catharinensis											1				1													6
Corophiidae sp.																			1									
Elasmopus sp.				1																	1					2		
Elasmopus ? sp. A																					1					1		
Erichthonius sp.				1																								
Hyale sp.												1																
Jassa falcata							1																					
Lembos smithi											5			1														
Lembos sp.														5														
Liljeborgia sp. A				2		8	5						1	10				3		2					1			
Liljeborgia sp.					1	1																						
Listriella barnardi			1	1										1							1							
Luconacia incerta														1														
Maera sp. A				12		1					51		17	187				44	19	4	16					6		
Maera sp.											2			1														
Megaluropus sp. A							3	1			2		3	2														
Megaluropus sp.				1	1		1											1										
Melitidae sp. A													2						3	3						1	2	
Melitidae sp.											2		1	24				8	7		1				1			1
Metharpinia floridana		1		2	1							1	6															
Microprotopus sp.	1																											
Monoculodes nyei																2							1					
Neomegamphopus sp. A											6			7					1		1							
Paracaprella pusilla																											1	
Photidae sp.																												
Photis sp. B														2														
Photis sp.						1					2			5														

APPENDIX TABLE C-2
(continued)
NUMBERS OF BENTHIC MACROINVERTEBRATES COLLECTED BY SHIPEK GRAB
ST. LUCIE PLANT
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Species	Quarter and station																											
	Quarter 1							Quarter 2							Quarter 3							Quarter 4						
	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
Amphipoda (cont'd)																												
Phoxocephalidae sp.								1	1			2	2						1									
Platyischnopidae sp. A	1	2	1					10	3			4				5												
Podocerus brasiliensis							1																					
Protohadzia schoenerae				12		5					6		1	6				3	1	16	6				1	9	2	16
Rildardanus laminosa						1							2						13	2	9							
Synchelidium americanum	10		1						1			1	1				1							1				
Tiron triocellatus							1									1		1										
Tiron tropakis					1						2			5					3	1								
Tiron sp.												2	3	1														
Trichophoxus sp. B								3																				
Unidentified Amphipoda														3							4							
Decapoda																												
Crab megalopa				2	2																							
Decapod mysis											1	1																
Penaidea																												
Lucifer faxoni				1																								
Sicyonia laevigata																												1
Sicyonia typica													1															
Sicyonia sp.																												1
Trachypenaeus constrictus					1																							
Trachypenaeus sp.													1			2	1		3		1		1					
Caridea																												
Alpheus sp.				1																	1							
Caridean postlarvae														1														
Latreutes parvulus													1															1
Leptochela serratorbita						1	1		1			1	1												1		1	
Ogyrides alphaerostris								1	1	1		1			1	1			2									
Processa bermudensis													1															
Processa hemphilli			1	6	2	3	3						6							1								
Processa sp.								1				1		1	1													
Processidae sp.													1															
Synalpheus fritzmuelleri											1																	
Unidentified Caridea														1														
Thalassinidea																												
Axiidae sp.	1																											
Callianassa sp.	1							1														1						
Upogebia sp.											1																	
Anomura																												
Albuncea paretti									1							1	1											
Albunea ? sp.																	1											
Euceramus praelongus		1																										
Munida sp.													1	1														
Paguristes hummi																		1	1		1							
Paguroid megalopa														2														
Paguroidea sp.		2				1	1		1		1		57							1								
Pagurus annulipes-bonairensis													5						5							3		

APPENDIX TABLE C-2
(continued)
NUMBERS OF BENTHIC MACROINVERTEBRATES COLLECTED BY SHIPEK GRAB
ST. LUCIE PLANT
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	Quarter and station																											
	Quarter 1							Quarter 2							Quarter 3							Quarter 4						
Species	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1	BC	B1	B2	B3	B4	B5	C1
Anomura (cont'd)																												
Pagurus sp.					1																							
Brachyura																												
Brachyuran postlarvae	8	4	6	21	33	7	3				1						1	1	1		1							
Calappa sp.												1																
Cronius sp.																				1								
Euryplax nitida													1								1							
Heterocrypta granulata																												1
Libinia sp.												1																
Panopeus sp.																			1									
Parthenopidae sp.																			1									
Persephona mediterranea									1																			
Pinnixa cristata										1																		
Pinnixa floridana		2		1		1												1	7									
Pinnixa sp.		4		2	1		1	1			1		3		1				3	1	2						1	
Portunus sp.													1															
Xanthidae sp.				1	1	1													1									
Pycnogonida																												
Anoplodactylus sp.									1																			
Insecta																												
Collembola sp.																		1								3	1	2
S'PUNCULA	1	9		30	8	299	408	1	8		83	1	214	44				437	3	235	8	1		1	397	3	335	14
ECHIURA									2									1	1	2	2						1	
PHORONIDA											2			1				1			4						1	3
ECHINODERMATA																												
Stelleroidea																												
Asteroidea																												
Astropecten duplicatus														1														
Unidentified Asteroidea											1																	
Ophiuroidea																												
Amphiodia pulchella											1		1	1					1		1					1		
Amphiuridae sp.				7	3	11	8	1			3		1	4												4	2	2
Hemipholis elongata															3									1				
Ophiolepis elegans				1							1		1	2							1							
Ophiolepis sp.																									1			
Opholphragmus wurdemani																3												
Ophiophragmus sp.																1												
Unidentified Ophiuroidea						3	1				1		1	3	1	1	2	6		2					2			
Echinoidea																												
Clypeasterioda sp.							11	1											1									
Echinoidea sp. (exocyclic)												3																
Mellitidae sp.							1															1			1			
Holothuroidea																												
Epitomapta roseola																		1	5									
Phyllophorus occidentalis		1					1											1										
Unidentified Holothuroidea						2								1												1		
HEMICHORDATA																												
Enteropneusta																												
Unidentified Enteropneusta												1																
CHORDATA																												
Cephalochordata																												
Brachiostoma caribaeum				6	3	33	7				2		13					4	1	3					4	1		1

APPENDIX TABLE C-3

TWO-WAY ANOVA OF TOTAL ARTHROPOD DENSITY FOR BASELINE VERSUS OPERATIONAL YEARS AT CONTROL STATION C1 AND TREATMENT STATION B3. THIS IS RANDOMIZATION ONE OF THREE RANDOMIZATIONS PERFORMED ON OPERATIONAL DATA.

Source	Sum of squares	Degrees of freedom	Mean square
Total	129.86	31	
Stations	11.39	1	11.39
Years	59.88	1	59.88
Interaction	10.41	1	10.41
Error	48.18	28	1.72

CRITICAL F(0.05,2,1,28) = 5.64

F stations = 6.62 significant

F years = 34.79 significant

F interaction = 5.54 not significant

APPENDIX TABLE C-4

TWO-WAY ANOVA OF TOTAL ARTHROPOD DENSITY FOR BASELINE VERSUS OPERATIONAL YEARS AT CONTROL STATION C1 AND TREATMENT STATION B3. THIS IS RANDOMIZATION TWO OF THREE RANDOMIZATIONS PERFORMED ON OPERATIONAL DATA.

Source	Sum of squares	Degrees of freedom	Mean square
Total	110.70	31	
Stations	6.48	1	6.48
Years	48.48	1	48.48
Interaction	12.44	1	12.44
Error	78.34	28	2.80

CRITICAL F(0.05,2,1,28) = 5.64

F stations = 2.31 not significant

F years = 17.31 significant

F interaction = 4.44 not significant

APPENDIX TABLE C-5

TWO-WAY ANOVA OF TOTAL ARTHROPOD DENSITY FOR BASELINE VERSUS OPERATIONAL YEARS AT CONTROL STATION C1 AND TREATMENT STATION B3. THIS IS RANDOMIZATION THREE OF THREE RANDOMIZATIONS PERFORMED ON OPERATIONAL DATA.

Source	Sum of squares	Degrees of freedom	Mean square
Total	115.32	31	
Stations	9.90	1	9.90
Years	33.74	1	33.74
Interaction	10.21	1	10.21
Error	57.17	28	2.04

CRITICAL F(0.05,2,1,28) = 5.64

F stations = 4.85 not significant

F years = 16.54 significant

F interaction = 5.01 not significant

APPENDIX TABLE C-6

TWO-WAY ANOVA OF TOTAL ECHINODERM DENSITY FOR BASELINE VERSUS OPERATIONAL YEARS AT CONTROL STATION C1 AND TREATMENT STATION B3. THIS IS RANDOMIZATION ONE OF THREE RANDOMIZATIONS PERFORMED ON OPERATIONAL DATA.

Source	Sum of squares	Degrees of freedom	Mean square
Total	46.92	31	
Stations	0.99	1	0.99
Years	14.26	1	14.26
Interaction	0.23	1	0.23
Error	31.42	28	1.12

CRITICAL F(0.05,2,1,28) = 5.64

F stations = 0.88 not significant

F years = 12.71 significant

F interaction = 0.20 not significant

APPENDIX TABLE C-7

TWO-WAY ANOVA OF TOTAL ECHINODERM DENSITY FOR BASELINE VERSUS OPERATIONAL YEARS AT CONTROL STATION C1 AND TREATMENT STATION B3. THIS IS RANDOMIZATION TWO OF THREE RANDOMIZATIONS PERFORMED ON OPERATIONAL DATA.

Source	Sum of squares	Degrees of freedom	Mean square
Total	55.19	31	
Stations	1.95	1	1.95
Years	20.84	1	20.84
Interaction	2.32	1	2.32
Error	49.01	28	1.75

CRITICAL F(0.05,2,1,28) = 5.64

F stations = 1.11 not significant

F years = 11.91 significant

F interaction = 1.33 not significant

APPENDIX TABLE C-8

TWO-WAY ANOVA OF TOTAL ECHINODERM DENSITY FOR BASELINE VERSUS OPERATIONAL YEARS AT CONTROL STATION C1 AND TREATMENT STATION B3. THIS IS RANDOMIZATION THREE OF THREE RANDOMIZATIONS PERFORMED ON OPERATIONAL DATA.

Source	Sum of squares	Degrees of freedom	Mean square
Total	38.17	31	
Stations	0.83	1	0.83
Years	13.94	1	13.94
Interaction	2.33	1	2.33
Error	25.28	28	0.902

CRITICAL F(0.05,2,1,28) = 5.64

F stations = 0.92 not significant

F years = 14.96 significant

F interaction = 2.58 not significant

APPENDIX TABLE C-9

ONE-WAY ANOVA FOR TOTAL FAUNAL DENSITY AT STATIONS C1 (CONTROL) AND B3, B4 AND B5 (TREATMENTS), ALL QUARTERS COMBINED, 1982. NEWMAN-KEULS MULTIPLE RANGE TEST INDICATES SIGNIFICANT DIFFERENCES BETWEEN MEANS. DATA WERE TRANSFORMED USING COMMON LOG (X+1)

Source	Sum of squares	Degrees of freedom	Mean square
Total	6.268	47	
Groups	4.782	3	1.594
Error	1.485	44	0.034

CRITICAL F(0.05,2,3,40) = 3.460

F = 47.217 significant difference

NEWMAN-KEULS MULTIPLE RANGE TEST

	Difference	q	p	Critical q	
B3 vs B4	0.758	14.296	4	3.791	Significant difference
B5 vs B4	0.740	13.957	3	3.442	Significant difference
C1 vs B4	0.679	12.796	2	2.858	Significant difference
B3 vs B5	0.080	1.500	3	3.442	
B5 vs C1	0.062	1.161	2	2.858	
B3 vs C1	0.018	0.339	3	3.442	

APPENDIX TABLE C-10

ONE-WAY ANOVA FOR TOTAL FAUNAL DENSITY AT STATIONS C1 (CONTROL) AND B3, B4 AND B5 (TREATMENTS), QUARTER I, 1982.

Source	Sum of squares	Degrees of freedom	Mean square
Total	740802.0	11	
Groups	457842.0	3	152614.0
Error	282960.0	8	35370.0

CRITICAL F(0.05,2,3,8) = 5.420

F = 4.315 not significant

APPENDIX TABLE C-11

ONE-WAY ANOVA FOR TOTAL FAUNAL DENSITY AT STATIONS C1 (CONTROL) AND B3, B4 AND B5 (TREATMENTS), QUARTER II, 1982. DATA WERE TRANSFORMED USING COMMON LOG (x+1).

Source	Sum of squares	Degrees of freedom	Mean square
Total	2.001	11	
Groups	1.946	3	0.649
Error	0.005	8	0.007

CRITICAL F(0.05,2,3,8) = 5.420

F = 94.841 significant difference

NEWMAN-KEULS MULTIPLE RANGE TEST

	Difference	q	p	critical q	
B4 vs B3	0.950	19.898	4	4.681	significant difference
B4 vs B5	0.936	19.594	3	4.165	significant difference
B4 vs C1	0.902	18.885	2	3.344	significant difference
B3 vs B5	0.048	1.014	3	4.165	
B5 vs C1	0.034	0.709	2	3.344	
B3 vs C1	0.015	0.304	2	3.344	

APPENDIX TABLE C-12

ONE-WAY ANOVA FOR TOTAL FAUNAL DENSITY AT STATIONS C1 (CONTROL) AND B3, B4 AND B5 (TREATMENTS), QUARTER III, 1982. DATA WERE TRANSFORMED USING COMMON LOG (x+1).

Source	Sum of squares	Degrees of freedom	Mean square
Total	0.495	11	
Groups	0.379	3	0.127
Error	0.115	8	0.014

CRITICAL F(0.05,2,3,8) = 5.420

F = 8.796 significant difference

NEWMAN-KEULS MULTIPLE RANGE TEST

	Difference	q	p	critical q	
B4 vs B3	0.469	6.768	4	4.681	significant difference
B4 vs B5	0.389	5.613	3	4.165	significant difference
B4 vs C1	0.319	4.612	2	3.344	significant difference
B3 vs B5	0.149	2.155	3	4.165	
B3 vs C1	0.080	1.155	2	3.344	
B5 vs C1	0.069	1.000	2	3.344	

APPENDIX TABLE C-13

ONE-WAY ANOVA FOR TOTAL FAUNAL DENSITY AT STATIONS C1 (CONTROL) AND B3, B4 AND B5 (TREATMENTS), QUARTER IV, 1982,. DATA WERE TRANSFORMED USING COMMON LOG (x+1).

Source	Sum of squares	Degrees of freedom	Mean square
Total	1.261	11	
Groups	1.166	3	0.388
Error	0.095	8	0.012

CRITICAL F(0.05,2,3,8) = 5.420

F = 32.905 significant difference

NEWMAN-KEULS MULTIPLE RANGE TEST

	Difference	q	p	critical q	
B4 vs B3	0.758	12.076	4	4.681	significant difference
B4 vs B5	0.742	11.819	3	4.165	significant difference
B4 vs C1	0.636	10.132	2	3.344	significant difference
B3 vs C1	0.122	1.943	3	4.165	
B5 vs C1	0.106	1.686	2	3.344	
B3 vs B5	0.016	0.257	2	3.344	

APPENDIX TABLE C-14

ONE-WAY ANOVA FOR TOTAL FAUNAL DENSITY AT STATIONS BC (CONTROL) AND B1 AND B2 (TREATMENTS), ALL QUARTERS COMBINED, 1982.

Source	Sum of squares	Degrees of freedom	Mean square
Total	11298.7	35	
Groups	1333.5	2	666.7
Error	9965.3	33	302.0

CRITICAL F(0.05,2,2,33) = 4.180

F = 2.208 not significant

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APPENDIX TABLE C-15

ONE-WAY ANOVA FOR TOTAL FAUNAL DENSITY AT STATIONS BC (CONTROL) AND B1 AND B2 (TREATMENTS), QUARTER 1, 1982. DATA WERE TRANSFORMED USING COMMON LOG (x+1).

Source	Sum of squares	Degrees of freedom	Mean square
Total	0.218	8	
Groups	0.020	2	0.010
Error	0.198	6	0.033

CRITICAL F(0.05,2,2,6) = 7.260

F = 0.303 not significant

APPENDIX TABLE C-16

ONE-WAY ANOVA FOR TOTAL FAUNAL DENSITY AT STATIONS BC (CONTROL) AND B1 AND B2 (TREATMENTS), QUARTER II, 1982.

Source	Sum of squares	Degrees of freedom	Mean square
Total	5736.0	8	
Groups	2290.7	2	1145.3
Error	3445.3	6	574.2

CRITICAL F(0.05,2,2,6) = 7.260

F = 1.995 not significant

APPENDIX TABLE C-17

ONE-WAY ANOVA FOR TOTAL FAUNAL DENSITY AT STATIONS BC (CONTROL) AND B1 AND B2 (TREATMENTS), QUARTER III, 1982.

Source	Sum of squares	Degrees of freedom	Mean square
Total	488.2	8	
Groups	272.2	2	136.1
Error	216.0	6	36.0

CRITICAL F(0.05,2,2,6) = 7.260

F = 3.781 not significant

APPENDIX TABLE C-18

ONE-WAY ANOVA FOR TOTAL FAUNAL DENSITY AT STATIONS BC (CONTROL) AND B1 AND B2 (TREATMENTS), QUARTER IV, 1982. DATA WERE TRANSFORMED USING COMMON LOG (x+1).

Source	Sum of squares	Degrees of freedom	Mean square
Total	0.246	8	
Groups	0.055	2	0.027
Error	0.191	6	0.032

CRITICAL F(0.05,2,2,6) = 7.260

F = 0.858 not significant

APPENDIX TABLE C-19

ONE-WAY ANOVA FOR SPECIES RICHNESS AT STATIONS C1 (CONTROL) AND B3, B4 AND B5 (TREATMENTS), ALL QUARTERS COMBINED, 1982. DATA WERE TRANSFORMED USING COMMON LOG (x+1).

Source	Sum of squares	Degrees of freedom	Mean square
Total	1.593	47	
Groups	1.003	3	0.334
Error	0.590	44	0.013

CRITICAL F(0.05,2,3,40) = 3.460

F = 24.940 significant difference

NEWMAN-KEULS MULTIPLE RANGE TEST

	Difference	q	p	Critical q	
B4 vs B3	0.353	10.570	4	3.791	significant difference
B4 vs B5	0.341	10.195	3	3.442	significant difference
B4 vs C1	0.297	8.882	2	2.858	significant difference
B3 vs B5	0.056	1.689	3	3.442	
B5 vs C1	0.044	1.314	2	2.858	
B3 vs C1	0.013	0.375	2	2.858	

APPENDIX TABLE C-20

ONE-WAY ANOVA FOR SPECIES RICHNESS AT STATIONS C1 (CONTROL) AND B3, B4 AND B5 (TREATMENTS), QUARTER I, 1982.

Source	Sum of squares	Degrees of freedom	Mean square
Total	5082.0	11	
Groups	4038.0	3	1346.0
Error	1044.0	8	130.5

CRITICAL F(0.05,2,3,8) = 5.420

F = 10.314 not significant

NEWMAN-KEULS MULTIPLE RANGE TEST

	Difference	q	p	critical q	
B4 vs C1	46.000	6.975	4	4.681	significant difference
B4 vs B3	43.000	6.520	3	4.165	significant difference
B4 vs B5	35.000	5.307	2	3.344	
B5 vs C1	11.000	1.668	2	3.344	
B3 vs B5	8.000	1.213	3	4.165	
B3 vs C1	3.000	0.455	3	4.165	

APPENDIX TABLE C-21

ONE-WAY ANOVA FOR SPECIES RICHNESS AT STATIONS C1 (CONTROL)
AND B3, B4 AND B5 (TREATMENTS), QUARTER II, 1982.
DATA WERE TRANSFORMED USING COMMON LOG (x+1).

Source	Sum of squares	Degrees of freedom	Mean square
Total	0.656	11	
Groups	0.638	3	0.213
Error	0.018	8	0.002

CRITICAL F(0.05,2,3,8) = 5.420

F = 95.587 significant difference

NEWMAN-KEULS MULTIPLE RANGE TEST

	Difference	q	p	critical q	
B4 vs B3	0.572	21.018	4	4.681	significant difference
B4 vs C1	0.552	20.277	3	4.165	significant difference
B4 vs B5	0.422	15.508	2	3.344	significant difference
B3 vs B5	0.150	5.510	3	4.165	significant difference
B5 vs C1	0.130	4.769	2	3.344	significant difference
B3 vs C1	0.020	0.741	2	3.344	

APPENDIX TABLE C-22

ONE-WAY ANOVA FOR SPECIES RICHNESS AT STATIONS C1 (CONTROL) AND B3, B4 AND B5 (TREATMENTS), QUARTER III, 1982. DATA WERE TRANSFORMED USING COMMON LOG (x+1).

Source	Sum of squares	Degrees of freedom	Mean square
Total	0.975	11	
Groups	0.937	3	0.312
Error	0.039	8	0.005

CRITICAL F(0.05,2,3,8) = 5.420

F = 64.827 significant difference

NEWMAN-KEULS MULTIPLE RANGE TEST

	Difference	q	p	critical q	
B3 vs C1	0.681	17.000	4	4.681	significant difference
B3 vs B5	0.678	16.918	3	4.165	significant difference
B3 vs B4	0.530	13.217	2	3.344	significant difference
B4 vs C1	0.152	3.783	3	4.165	
B4 vs B5	0.148	3.702	2	3.344	significant difference
B5 vs C1	0.003	0.082	2	3.344	

APPENDIX TABLE C-23

ONE-WAY ANOVA FOR SPECIES RICHNESS AT STATIONS C1 (CONTROL) AND B3, B4 AND B5 (TREATMENTS), QUARTER IV, 1982.

Source	Sum of squares	Degrees of freedom	Mean square
Total	1268.3	11	
Groups	946.9	3	315.6
Error	321.3	8	40.2

CRITICAL F(0.05,2,3,8) = 5.420

F = 7.858 significant difference

NEWMAN-KEULS MULTIPLE RANGE TEST

	Difference	q	p	critical q	
B4 vs B5	23.333	6.377	4	4.681	significant difference
B4 vs C1	19.667	5.375	3	4.165	significant difference
B4 vs B3	13.333	3.644	2	3.344	significant difference
B3 vs B5	10.000	2.733	3	4.165	
B3 vs C1	6.333	1.731	2	3.344	
B5 vs C1	3.667	1.002	2	3.344	

APPENDIX TABLE C-24

ONE-WAY ANOVA FOR SPECIES RICHNESS AT STATIONS BC (CONTROL) AND B1 AND B2 (TREATMENTS), ALL QUARTERS COMBINED, 1982.

Source	Sum of squares	Degrees of freedom	Mean square
Total	821.0	35	
Groups	78.0	2	39.0
Error	743.0	33	22.5

CRITICAL F(0.05,2,2,33) = 4.180

F = 1.732 not significant

APPENDIX TABLE C-25

ONE-WAY ANOVA FOR SPECIES RICHNESS AT STATIONS BC (CONTROL) AND B1 AND B2 (TREATMENTS), QUARTER I, 1982.

Source	Sum of squares	Degrees of freedom	Mean square
Total	22.222	8	
Groups	3.555	2	1.778
Error	18.667	6	3.111

CRITICAL F(0.05,2,2,6) = 7.260

F = 0.571 not significant

APPENDIX TABLE C-26

ONE-WAY ANOVA FOR SPECIES RICHNESS AT STATIONS BC (CONTROL) AND B1 AND B2 (TREATMENTS), QUARTER II, 1982.

Source	Sum of squares	Degrees of freedom	Mean square
Total	392.0	8	
Groups	252.7	2	126.3
Error	139.3	6	23.2

CRITICAL F(0.05,2,2,6) = 7.260

F = 5.440 not significant

APPENDIX TABLE C-27

ONE-WAY ANOVA FOR SPECIES RICHNESS AT STATIONS BC (CONTROL) AND B1 AND B2 (TREATMENTS), QUARTER III, 1982.

Source	Sum of squares	Degrees of freedom	Mean square
Total	78.0	8	
Groups	14.0	2	7.0
Error	64.0	6	10.7

CRITICAL F(0.05,2,2,6) = 7.260

F = 0.656 not significant

APPENDIX TABLE C-28

ONE-WAY ANOVA FOR SPECIES RICHNESS AT STATIONS BC (CONTROL) AND B1 AND B2 (TREATMENTS), QUARTER IV, 1982.

Source	Sum of squares	Degrees of freedom	Mean square
Total	31.556	8	
Groups	0.222	2	0.111
Error	31.333	6	5.222

CRITICAL F(0.05,2,2,6) = 7.260

F = 0.021 not significant

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ST. LUCIE PLANT

ANNUAL NON-RADIOLOGICAL AQUATIC MONITORING REPORT

1982

VOLUME II

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MARCH 1983

AQUATIC MONITORING REPORT

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D. PHYTOPLANKTON

Environmental Technical Specification (3.1.B.b; deleted May 1982)

> Plankton - Plankton samples will be collected monthly. Both zooplankton and phytoplankton species will be identified as to kind and abundance. Chlorophyll "a" analysis will be performed as a measure of primary productivity.

INTRODUCTION

This phytoplankton study is a continuation of studies begun at the St. Lucie Plant in 1976 to monitor changes in phytoplankton density, relative abundance, pigment levels and productivity, and to examine the relationships between these variables and power plant operation.

Phytoplankton is comprised of chlorophyll-bearing algae which have limited means of locomotion or passively drift in aquatic environments. These primary producers use solar energy to convert inorganic nutrients into protoplasm by means of photosynthesis. Phytoplankters form the basis of the aquatic food chain, along with macrophytes, which are important primary producers when present in shallow water (Reid, 1961). Phytoplankters are consumed by zooplankters and other filter feeders that, in turn, provide food for larger carnivores. Therefore, phytoplankton abundance and composition affect many primary and higher level consumers such as zooplankton and ichthyoplankton.

Physical and chemical factors that influence phytoplankton standing crop and productivity include water temperature, light, nutrient availability, salinity and current. Major groups of algae vary both in temperature tolerance ranges and in temperature ranges for optimum growth (Patrick, 1969), so thermal additions from power plants may affect the composition and density of phytoplankton. Alterations of phytoplankton species composition, diversity and population succession have been attributed to power plant thermal addition in several studies (Carpenter, 1973; Patrick, 1974; Briand, 1975). Because phytoplankton groups differ in their relative food value, extensive changes in phytoplankton composition may disrupt food chain relationships and affect the diversity and condition of consumer forms.

Investigators have found that increased water temperature in conjunction with other adverse environmental factors may create a greater impact on the phytoplankton community than the impact from any single parameter (Grayum, 1971; Fisher and Wurster, 1973; Griffiths, 1973; Thomas and Dodson, 1974; Fox and Moyer, 1975; Flemer and Sherk, 1977; Roberts, 1977). Even when water temperatures are not high enough to cause death, synergistic effects may profoundly disturb phytoplankton productivity, species composition and physiology; this may directly or indirectly lead to impact at higher trophic levels.

Several studies have addressed the synergistic effects of thermal addition and biocide application on phytoplankton standing crop and productivity. Studies of phytoplankton cultures from the intake and

discharge canals of a coastal power plant showed that there was substantial recovery after entrainment (Goldman and Quinby, 1979). In another coastal power plant study, however, phytoplankton enzyme activity was depressed as a result of entrainment and showed no sign of recovery after 24 hours (Peck and Warren, 1978). One hundred percent mortality of entrained phytoplankton was observed when total residual biocide concentrations were greater than 1.0 part per million in a power plant study in Connecticut (Gentile et al., 1976). These studies show that power plant effects are difficult to generalize and must be assessed on the basis of individual plant location and operational characteristics. Factors commonly associated with coastal power plants, such as the proportionately small percentage of available water entrained, complete dissipation of biocides in seawater and rapid return of cooling water to ambient temperature, minimize the impact of entrainment on phytoplankton (Goldman and Quinby, 1979).

The NPDES required studies deleted phytoplankton as a study component and collections at the St. Lucie Plant were terminated in May 1982.

MATERIALS AND METHODS

Phytoplankton Analysis

From January through May 1982, monthly phytoplankton samples were collected from surface and bottom levels of the water column at six ocean stations (Stations 0 through 5) and in the intake canal (Station 11; Figure D-1). After November 1976, only surface water was sampled in the

discharge canal (Station 12). Replicate 1-liter whole-water samples were collected at each station with a pump designed to minimize damage to the phytoplankters (Figure D-2). Each 1-liter water sample was preserved in the field with 5-percent buffered formalin and returned to the laboratory. The preserved samples were allowed to settle for a minimum period of 4 hours per centimeter of sample container height before concentration (EPA, 1973). Whole-water samples were used in conjunction with the sedimentation technique for qualitative analyses and quantitative estimates of standing crop.

Microscopic analysis was performed by the Utermohl (1958) technique using inverted compound microscopes equipped with calibrated ocular micrometers. Identifications and counts were made after the sample concentrates had settled in counting chambers for a minimum of 4 hours. Through the use of random field counts (Littleford et al., 1940; EPA, 1973; APHA, 1980), phytoplankton species were enumerated in two identically prepared counting chambers per replicate sample. A minimum of one-half of the entire counting chamber was examined to enumerate large and relatively scarce phytoplankters. Statistical analyses (hierarchical design analysis of variance) were used to determine the examined volume of sample concentrate necessary to ensure 90-percent accuracy in counts at the 95-percent confidence interval.

All phytoplankters, except some green and blue-green algae, were counted individually. Filamentous green and blue-green algae were measured in 100-μ standard lengths, with each length representing one

counting unit. Colonial forms exclusive of diatoms were counted as colonies, with each colony representing one counting unit. An average number of individuals per colony was specified where possible. Cells per liter (N) were calculated by:

$$N = \frac{\frac{V_s}{V_c} C}{V_i}$$

where: V_s = Volume of sample concentrate, in milliliters;

V_c = Counted concentrate volume; determined by multiplying the aliquot volume, in milliliters, by the proportion of the counting chamber that was examined;

C = Units counted;

V_i = Initial sample volume, in liters.

As part of the ABI quality assurance program, a minimum of two individuals verified both qualitative analyses and counts for each group of monthly samples. Analysis of variance was used to determine significant differences between counts. If discrepancies were greater than 10 percent or if significant differences existed between operators at the 95-percent confidence level, counts were repeated. Qualitative verifications of new species were performed on each sample as new species were encountered.

Samples for water chemistry were collected, and physical measurements and weather observations were made concurrently with phytoplankton collections at each station. These data, which are presented in Section G. Water Quality of this report, were examined as potential factors influencing phytoplankton populations.

Pigment Analysis

Replicate water samples for pigment determinations were collected monthly concurrently with phytoplankton samples. Samples were pumped from specified surface and bottom depths at each station, stored in 25-liter polyethylene containers, and transported to the on-site laboratory as quickly as possible to minimize chlorophyll degradation.

Samples were processed according to the method of Strickland and Parsons (1972) and the recommendations of UNESCO (1966). Samples were filtered through Whatman GFC filters on the day of collection; these were folded in half with the filtered particulates on the inside, immediately frozen under darkened conditions, and shipped frozen in light-proof containers to the Atlanta laboratory for extraction and analysis.

Filters from replicate samples were extracted by grinding in a 90-percent aqueous acetone solution. The volume of the extract was measured and extinction values were read with a spectrophotometer at a slit width of 1.0 nanometer (nm), using 1-cm cuvettes.

Chlorophyll-a, -b, and -c concentrations were determined from readings at 665, 645 and 630 nm, respectively. Carotenoid concentration was determined from extinction at 480 nm. The amount of nonactive chlorophyll-a, in terms of the quantity of phaeopigments present, was estimated from extinction at 665 nm 1 minute after acidification with 50-percent HCl. All extinctions were corrected by subtracting the turbidity reading at 750 nm. Excessive turbidity readings were reduced by

additional centrifugation. Results were obtained from the equations of Strickland and Parsons (1972), and chlorophyll and phaeopigment values were expressed in milligrams per cubic meter. Carotenoid values were expressed in millispecified pigment units per cubic meter (m-SPU/m^3).

Data Analysis

The phytoplankton study at the St. Lucie plant was not part of the NPDES required studies, therefore, collections were terminated in May 1982. This precluded meaningful statistical comparisons of the annual data from previous years (12-month periods) with the partial data available from 1982 (5-month period). The 1982 data were qualitatively compared to prior data from comparable operational phase monitoring periods.

RESULTS AND DISCUSSION

Total phytoplankton densities at ocean stations ranged from 177 x 10^3 to 5,861 x 10^3 cells per liter over the January through May 1982 sampling period (Tables D-1 through D-5). The lowest density occurred at the bottom at Station 3 in January, while the highest density was observed in April at the bottom at Station 1. Average density was slightly higher at bottom depths than at the surface (Figure D-3). Total phytoplankton densities in the canals ranged from 392 x 10^3 cells per liter in March to 10,636 x 10^3 cells per liter in April. Average phytoplankton densities in the canals were characteristically higher than those at ocean stations. The ranges in phytoplankton density were similar to previously reported ranges (ABI, 1977-1982).

Seasonal and Interstation Distribution of Ocean Phytoplankton Density

As in previous studies, phytoplankton densities at ocean Stations 0 and 1 were higher than at any other ocean station. Consistently higher phytoplankon densities at nearshore ocean stations in previous studies indicated that natural environmental factors such as depth, light, water temperature and currents were predominant influences on phytoplankton standing crop. This trend continued in 1982.

Seasonal variation in phytoplankton density at ocean stations has typically reflected a bimodal distribution with peak densities in the spring and fall (Figure D-3). Average phytoplankton density at ocean stations was highest in February and May. Density at the surface was highest in May and, at the bottom, highest in February. Phytoplankton productivity increases in spring in response to changing water temperature and light availability. Nutrients, which are recycled and accrue over the winter, generally decrease in concentration as productivity increases. Changing nutrient concentrations can, in turn, affect species abundance because different species exhibit maximum productivity at different nutrient concentrations. Water temperature and light transmittance were slightly lower in February than in January or March. Silicates, a nutrient necessary for diatom growth, were highest in February and decreased through May. The nitrogenous nutrients generally decreased throughout the sampling period. In February, Leptocylindrus danicus was the dominant diatom at the surface and codominant with Skeletonema costatum and Nitzschia closterium at bottom depths; S. costatum, N. closterium and Asterionella japonica were codominant at both depths in May.

Phytoplankton Community Composition

As in previous studies, the phytoplankton community was composed primarily of diatoms (Bacillariophyta) and unidentified phytoflagellates (Figures D-4 through D-8). Cryptophytes and dinoflagellates (Pyrrhophyta) occurred infrequently as major groups. Cryptophytes were more abundant than dinoflagellates, which typically exhibit greatest densities in the warmer summer months when nutrient concentrations are lower. Phytoplankton composition during the sampling period was typical of nearshore marine flora observed in other studies (Smayda, 1957; Patten et al., 1963; Carpenter, 1971; Mulford and Norcross, 1971; Marshall 1976).

Diatoms were the most abundant phytoplankton group over the sampling period and the major diatom species included:

Asterionella japonica	Nitzschia closterium
Bellerochea horologicalis	Nitzschia delicatissima
Campylosira cymbelliformis	Skeletonema costatum
Leptocylindrus danicus	

All of these species, except B. horologicalis, were major species in various seasons over previous operational monitoring at the St. Lucie Plant (Table D-6). The predominant diatoms were A. japonica, L. danicus, N. closterium, N. delicatissima and S. costatum. These five diatoms consistently have been major species in winter and/or spring collections since 1976. The two latter species were also the most abundant diatoms observed in 1981. Consistent long-term patterns of major species occurrence suggest that changes in community composition result from natural succession and are not influenced by ocean discharge. S. costa-

tum, commonly abundant along the east coast, has typically been one of the most abundant and widely distributed diatoms at St. Lucie. Throughout the 1982 sampling period, excluding April, this species was a major diatom at all stations and depths. Similar composition and distribution of major species among stations indicate a predominantly seasonal influence on changes in the ocean phytoplankton community.

Interstation Comparisons of Ocean Phytoplankton Data

As typically observed in previous studies, average phytoplankton density was highest at ocean Station 1, nearest the point of ocean discharge, and lowest at Station 3, located over Pierce Shoal (Figure D-1). Phytoplankton density was also high at control Station 0, south of the plant site. Over the 1976-1981 monitoring period, phytoplankton densities at both surface and bottom depths at Stations 0 and 1 were significantly higher than at other ocean stations (ABI, 1982). This long-term difference among stations probably reflects natural enhancement of phytoplankton growth near shore because both stations are located at similar distances from shore. Higher phytoplankton densities at Stations 0 and 1 and similar community composition among all ocean stations indicate no adverse influence from St. Lucie plant operation.

Entrainment and Temperature Relationships

From January through May 1982, average phytoplankton densities in the intake canal (Station 11) ranged from 399 x 10^3 to 9,478 x 10^3 cells per liter and in the discharge canal (Station 12) densities ranged from 548 x 10^3 to 7,772 cells per liter (Table D-7). Values of ΔT (change in

water temperature between the intake and discharge canals) ranged from 0.2°C to 12.8°C.

Between 1976 and 1982, total phytoplankton densities have decreased from the intake to discharge canal on 68 percent of all sampling dates (ABI, 1982). However, with each succeeding year, the decrease in densities between the intake and discharge canals has occurred less frequently. During the five-month sampling period in 1982, phytoplankton densities decreased between the intake and discharge canals on two occasions and increased on two of the four occasions when the plant was generating (Table D-7). There has been no apparent correlation of phytoplankton density changes (between the intake and discharge canals) with ΔT. Pressure changes, acceleration, shear, abrasion and biocide application have been well documented as factors other than water temperature that can contribute to power plant impact from entrainment (Marcy et al., 1978; Morgan and Carpenter, 1978). All or any combination of these factors may act independently or interact with temperature in determining net entrainment effects. Environmental differences between the canals, when the plant is down or in limited operational mode, may also influence differential phytoplankton growth during periods of reduced water circulation, as occurred in May 1982.

Consistent seasonal entrainment effects on certain major phytoplankton taxa have been observed during operational monitoring (ABI, 1982). These seasonal trends in density changes between the intake and discharge canals and between the discharge canal and ocean discharge Station 1

reflect variable plant effect on phytoplankton composition and abundance in response to seasonal factors such as changing ambient water temperatures and natural species succession. However, changes in the densities of certain taxa at ocean Station 1, relative to densities in the discharge canal, have not resulted in anomalous phytoplankton composition or abundance at Station 1 in comparison to Station 0 and other ocean stations.

Distribution of Chlorophyll-a at Ocean Stations

Chlorophyll-a is widely used as an index of phytoplankton standing crop because it is the primary photosynthetic pigment in all phytoplankton species. Historically, chlorophyll-a concentration has shown a significant positive correlation with phytoplankton density at the St. Lucie Plant site.

Over the January to May 1982 sampling period, chlorophyll-a values at ocean stations ranged from 0.24 to 3.20 mg/m^3 at the surface and from 0.19 to 3.28 mg/m^3 at the bottom (Table D-8). As in all previous monitoring, average chlorophyll-a at the surface was slightly lower than at bottom depths (ABI, 1977-1982; Worth and Hollinger, 1977; Figure D-9). The distribution of monthly chlorophyll-a over the sampling period reflected that observed for phytoplankton density with highest concentrations in February and May. Maximum concentrations at ocean stations generally occurred in February. Chlorophyll-a has typically been highest in spring and late summer (March and August) and lowest in summer (June and July). As in 1981, chlorophyll-a concentration was lowest at

ocean Stations 3 and 4. Chlorophyll-a concentration at these two stations in 1982 also resembled 1981 data in that the trend in chlorophyll-a concentration at these stations differed from that observed at the other ocean stations.

Interstation Comparisons of Ocean Chlorophyll-a Levels

Average chlorophyll-a concentration at ocean Station 1 (2.01 mg/m^3) was intermediate between average concentrations in the intake and discharge canals, 2.46 and 1.84 mg/m^3, respectively. As in previous study years average chlorophyll-a concentration was consistently higher at ocean Stations 0 and 1 than at other ocean stations.

On the average, water high in chlorophyll-a, relative to average concentrations in the ocean, has been discharged at ocean Station 1 throughout operational monitoring at the St. Lucie Plant. This may, in part, account for the higher phytoplankton standing crop observed at Station 1. It also appears that phytoplankton productivity is enhanced in the vicinity of the ocean discharge during periods when standing crop not only exceeds that at other ocean stations but also is higher than that in the discharge canal.

Seasonal and Interstation Distribution of Chlorophyll-a in the Canals

High concentrations of chlorophyll-a in the canals occurred in February and April. Average chlorophyll-a concentration ranges in the intake and discharge canals were 0.62 to 6.97 mg/m^3 and 0.58 to 3.53 mg/m^3, respectively (Table D-8). As generally observed during previous

studies, chlorophyll-a concentration was higher in the intake canal than in the discharge canal, except in May 1982 when there was no appreciable water temperature change ΔT between the canals (Figure D-10).

Phaeopigment Levels at Ocean Stations and in the Canals

The distribution of average phaeopigment concentrations among the sampling stations generally reflected the distribution observed for chlorophyll-a; stations with higher chlorophyll-a concentrations generally had higher phaeopigment concentrations.

Generalized annual trends from previous monitoring studies show slightly higher phaeopigment levels at the bottom as compared to the surface at ocean stations (Figure D-11) and higher concentrations in the discharge canal than in the intake canal (Figure D-10). Over the five-month sampling period in 1982, phaeopigment concentration at surface and bottom depths at ocean stations was generally similar. Phaeopigment concentration in the discharge was lower than in the intake canal. However, the ratio of phaeopigment to chlorophyll-a in the canals indicated a slightly greater proportion of phaeopigment in the discharge canal.

Comparison Between Baseline and Operational Monitoring Data

Baseline study collections were conducted bimonthly from September 1971 through August 1972 and monthly from September 1972 through August 1973 (Walker and Steidinger, 1979). Chlorophyll-a concentrations and variability among ocean stations during operational studies have been similar to those observed during the baseline study (Figure D-9). There

were no differences between baseline and the January - May 1982 data which would indicate adverse effects. Comparisons between baseline and operational data indicate that no long-term or widespread impact on phytoplankton standing crop at ocean stations has resulted from plant operation.

SUMMARY

Phytoplankton density has typically been higher in the intake canal than in the discharge canal due to entrainment mortality. However, there has been a successive decrease in the occurrence of reduced densities between the intake and discharge canals with each succeeding year of monitoring. Phytoplankton density in the discharge canal has exceeded that in the intake canal on occasions when the plant was in a limited operational mode with reduced water circulation.

Entrainment effects on the composition and abundance of certain major phytoplankton taxa were consistently observed in certain seasons and were related to changing seasonal factors such as ambient water temperature and natural species succession. However, anomalous phytoplankton composition has not been observed at discharge Station 1 as compared to other ocean stations. Consistent long-term patterns of major phytoplankton species occurrence and the similarity in species composition and distribution among ocean stations suggest that overall changes in composition of the ocean community result from natural succession and are not influenced by ocean discharge.

Throughout operational monitoring at the St. Lucie Plant, phytoplankton densities and chlorophyll-a concentrations have been higher at Stations 0 and 1 than at other ocean stations. Consistently higher phytoplankton standing crop at both of these nearshore stations (control Station 0 south of the plant site and Station 1 at the point of ocean discharge) indicate that natural environmental factors common to both stations are predominant influences on phytoplankton abundance. There are other factors which may contribute to the high phytoplankton standing crop at Station 1. The discharge of water high in phytoplankton standing crop may account, in part, for the higher average phytoplankton abundance at Station 1. Phytoplankton density and chlorophyll-a concentration typically have been considerably higher in the intake and discharge canals than in the ocean, even after decreases between the intake and discharge canals following plant entrainment. Enhancement of phytoplankton productivity in the vicinity of the ocean discharge also has been indicated because during certain periods, phytoplankton standing crop at Station 1 has exceeded that at other ocean stations as well as that in the discharge canal.

Comparisons of operational and baseline data among stations and study years provided no evidence of long-term or widespread adverse impact on the ocean phytoplankton community. The most probable net effect of plant operation is phytoplankton enrichment in the immediate vicinity of the ocean discharge.

LITERATURE CITED

APHA (American Public Health Association). 1980. Standard methods for the examination of water and wastewater, 15th ed. American Public Health Association, Washington, D.C. 1173 pp.

ABI (Applied Biology, Inc.). 1977. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1976. Volume 1. AB-44. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

__________________________. 1978. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1977. Volume 1. AB-101. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

__________________________. 1979. Florida Power & Light Co. St. Lucie Plant, annual non-radiological environmental monitoring report 1978. Volume III, Biotic monitoring. AB-177. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

__________________________. 1980. Florida Power & Light Co. St. Lucie Plant, annual non-radiological environmental monitoring report 1979. Volume III, Biotic monitoring. AB-244. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

__________________________. 1981. Florida Power & Light Co. St. Lucie Plant, annual non-radiological environmental monitoring report 1980. Volume III, Biotic monitoring. AB-324. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

__________________________. 1982. Florida Power & Light Co. St. Lucie Plant, annual non-radiological environmental monitoring report 1981. Volume III, Biotic monitoring. AB-379. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

Briand, F.J -P. 1975. Effects of power-plant cooling systems on marine phytoplankton. Marine Biology 33:135-146.

Carpenter, E.J. 1971. Annual phytoplankton cycle of Cape Fear, North Carolina. Chesapeake Science 12:95-104.

______________. 1973. Brackish-water phytoplankton response to temperature elevation. Estuarine and Coastal Marine Science 1(1):37-44.

EPA (Environmental Protection Agency). 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA 670/4-73-001. Environmental Protection Agency, National Environment Research Center, Cincinnati, Ohio.

Fisher, N.S. and C.F. Wurster. 1973. Individual and combined effects of temperature and polychlorinated biphenyls on the growth of three species of phytoplankton. Environmental Pollution 5:205-212.

LITERATURE CITED

Flemer, D. and J.A. Sherk, Jr. 1977. The effects of steam electric station operation on entrained phytoplankton. Hydrobiologica 55(1): 33-44.

Fox, J.L. and M.S. Moyer. 1975. Effect of power plant chlorination on estuarine productivity. Cheasapeake Science 16:66-68.

Gentile, J.H., J. Cardin, M. Johnson and S. Sosnowski. 1976. Power plants, chlorine and estuaries. EPA Ecological Research Series. EPA-600/3-76-055. 28 pp.

Goldman, J.C. and H.L. Quinby. 1979. Phytoplankton recovery after power plant entrainment. Journal Water Pollution Control Federation 51(7):1816-1823.

Grayum, M. 1971. Effects of thermal shock and ionizing radiation on primary productivity. NTIS No. CONF-710501-P1. Proc. Third Nat. Symp. on Radioecology, Oak Ridge, Tenn. 1:639-644.

Griffiths, D.J. 1973. Factors affecting the photosynthetic capacity of laboratory cultures of the diatom Phaeodactylum tricornutum. Marine Biology 21(2):91-97.

Littleford, R.A., C.L. Newcombe and B.B. Shepherd. 1940. An experimental study of certain quantitative plankton methods. Ecology 21(3):309-322.

Marcy, B.C., A.D. Beck and R.E. Vlanowicz. 1978. Effects and impacts of physical stress on entrained organisms. Pages 135-188 in J.R. Schubel and B.C. Marcy, Jr., eds. Power plant entrainment, a biological assessment. Academic Press, New York. 271 pp.

Marshall, H.G. 1976. Phytoplankton distribution along the East Coast of the USA. I. Phytoplankton composition. Marine Biology 38:81-89.

Morgan, R.P., II and E.J. Carpenter. 1978. Biocides. Pages 95-134 in J.R. Schubel and B.C. Marcy Jr., eds. Power plant entrainment, a biological assessment. Academic Press, New York. 271 pp.

Mulford, R. and J. Norcross. 1971. Species composition and abundance of net phytoplankton in Virginia coastal waters, 1963-1964. Chesapeake Science 12:142-155.

Patrick, R. 1969. Some effects of temperature on freshwater algae. Pages 161-185 in P.A. Krenkel and F.L. Parker, eds. Biological aspects of thermal pollution. Vanderbilt University Press, Nashville, Tenn. 407 pp.

LITERATURE CITED (continued)

Patrick, R. 1974. Effects of abnormal temperatures on algal communities. Pages 335-349 in J.W. Gibbons and R.R. Sharitz, eds. Thermal ecology. NTIS No. CONF-730505. Technical Information Center, U.S. Atomic Energy Commission, Oak Ridge, Tenn. 670 pp.

Patten, B.C., R.A. Mulford and J.E. Warinner. 1963. An annual phytoplankton cycle in the lower Chesapeake Bay. Chesapeake Science 4:1-20.

Peck, B.B. and R.S. Warren. 1978. Nitrate reductase activity and primary productivity of phytoplankton entrained through a nuclear power station on northeastern Long Island Sound. Pages 392-409 in J.H. Thorp and J.W. Gibbons, eds. Energy and environmental stress in aquatic systems. CONF-771114. Technical Information Center, U.S. Dept. of Energy. 854 pp.

Reid, G.K. 1961. Ecology of inland waters and estuaries. Reinhold, New York, N.Y. 719 pp.

Roberts, M.H., Jr. 1977. Bioassay procedures for marine phytoplankton with special reference to chlorine. Chesapeake Science 18(1):130-136.

Smayda, T.J. 1957. Phytoplankton studies in lower Narragansett Bay. Limnology and Oceanography 2:343-359.

Strickland, J.D.H. and T.R. Parsons. 1972. A practical handbook of seawater analysis. Fisheries Research Board of Canada. Ottawa, Bulletin No. 167. 310 pp.

Thomas, W.H. and A.N. Dodson. 1974. Effect of interactions between temperature and nitrate supply on the cell-division rates of two marine phytoflagellates. Marine Biology 24:213-217.

UNESCO (United Nations Educational, Scientific and Cultural Organization). 1966. Determination of photosynthetic pigments in seawater. United Nations Educational, Scientific, and Cultural Organization. Place de Fontenoy, Paris-7. 69 pp.

Utermohl, H. 1958. Zur vervollkommung der quantitativen phytoplankton methodik. Mitt. Int. Ass. Theor. Appl. Limnol. 9. 38 pp.

Walker, L.M. and K.A. Steidinger. 1979. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974, VI. Plankton dynamics, 1971-1973. Florida Department of Natural Resources Marine Research Laboratory, Florida Marine Research Publication No. 34:1-15.

LITERATURE CITED (continued)

Worth, D.F. and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. III. Physical and chemical environment. Florida Department of Natural Resources Marine Research Laboratory, Florida Marine Research Publication No. 23:25-85.

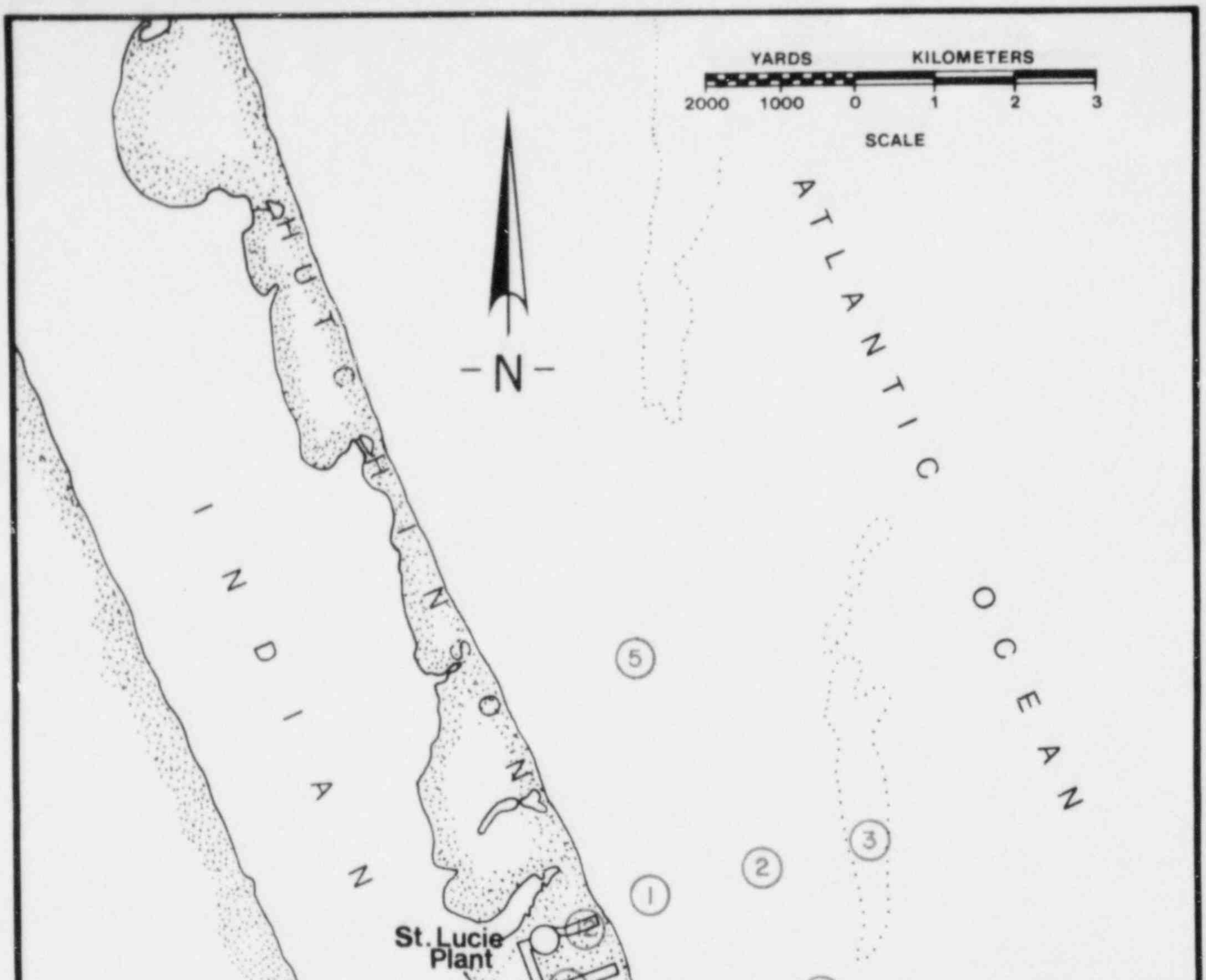


Figure D-1. Location of phytoplankton sampling stations, St. Lucie Plant, 1982.

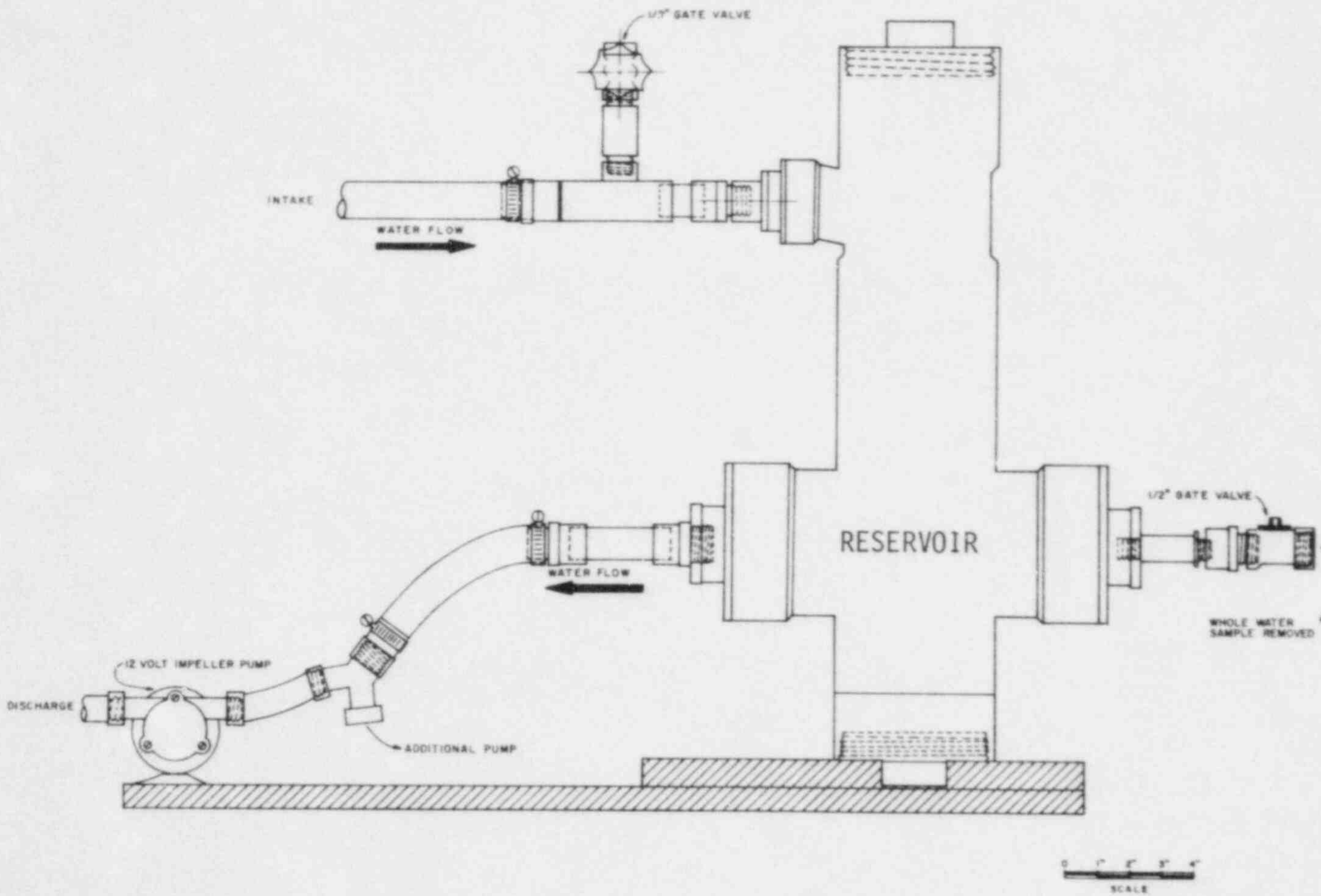


Figure D-2. Pump design for whole water sample collections, St. Lucie Plant.

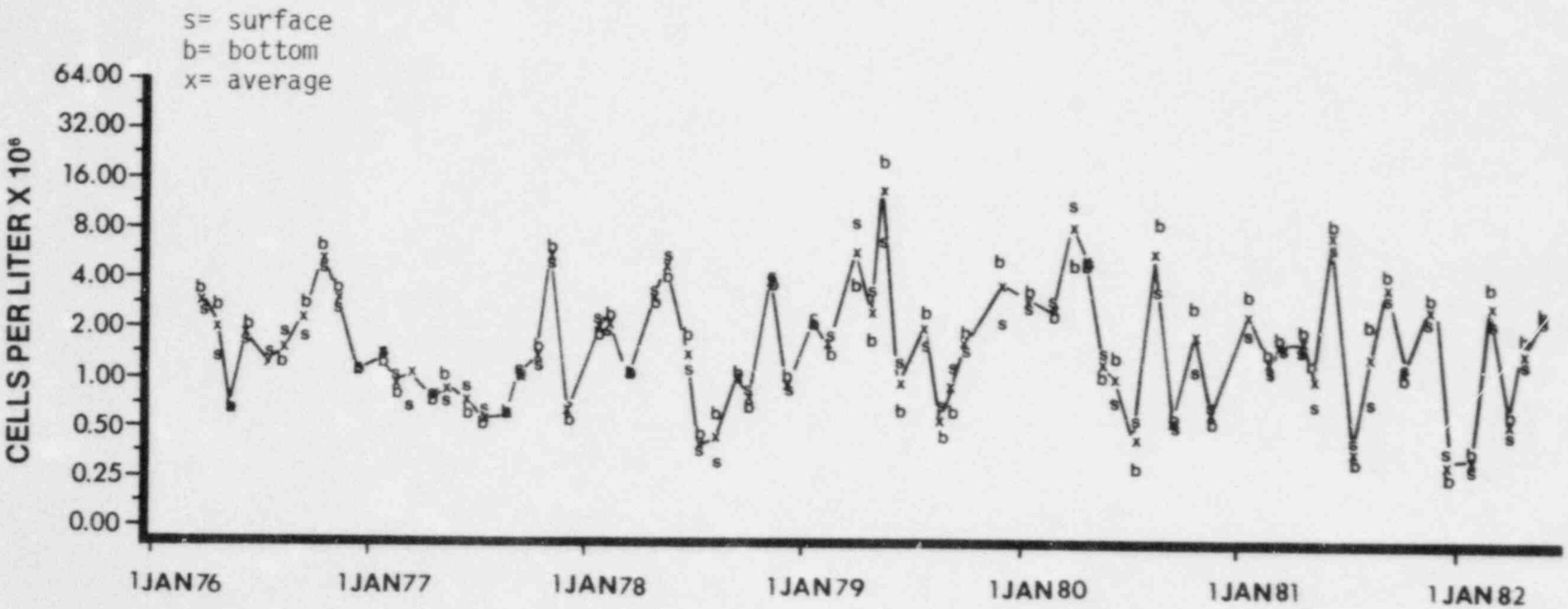


Figure D-3. Average monthly phytoplankton densities at ocean stations, St. Lucie Plant, 1982.

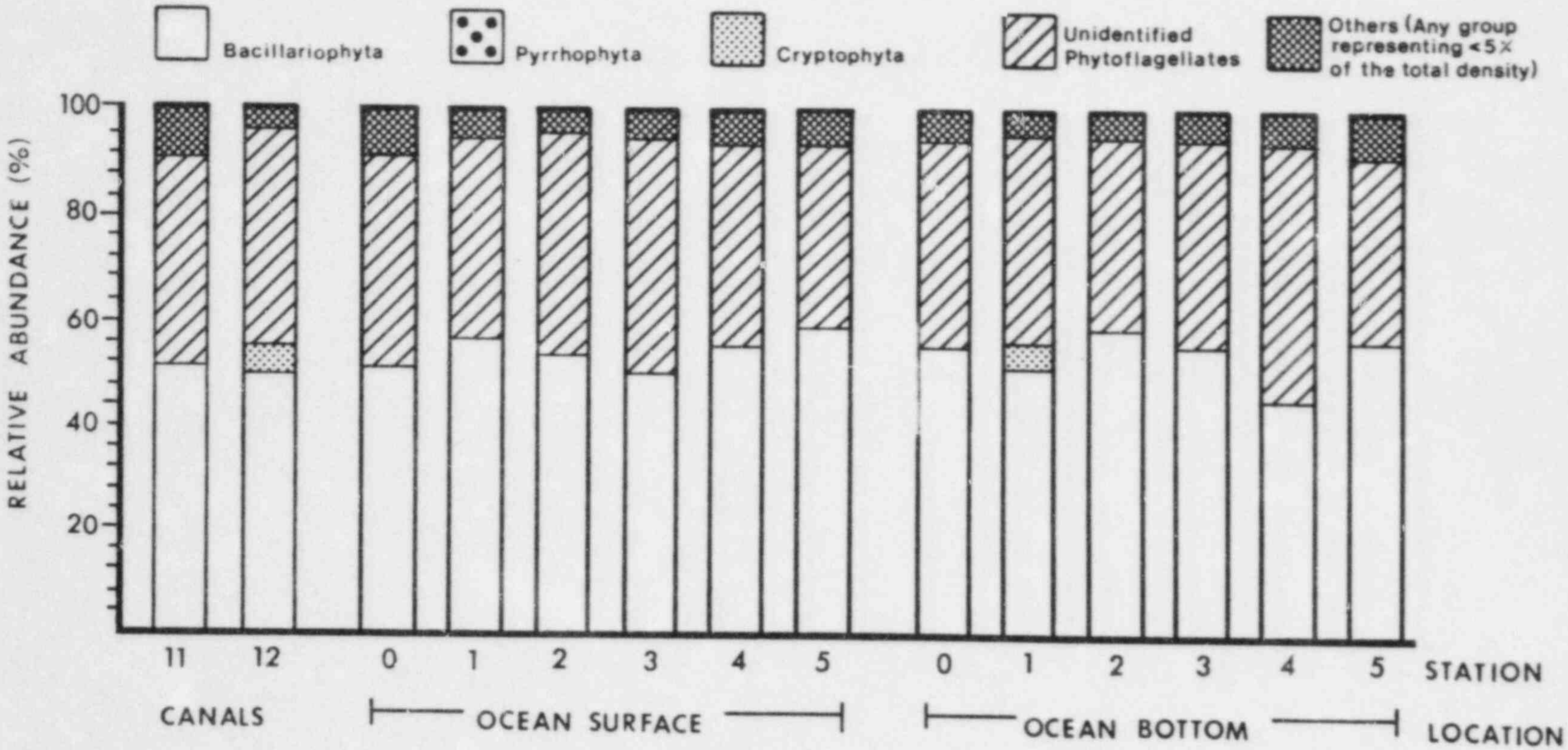


Figure D-4. Phytoplankton percentage composition, St. Lucie Plant, 20 January 1982.

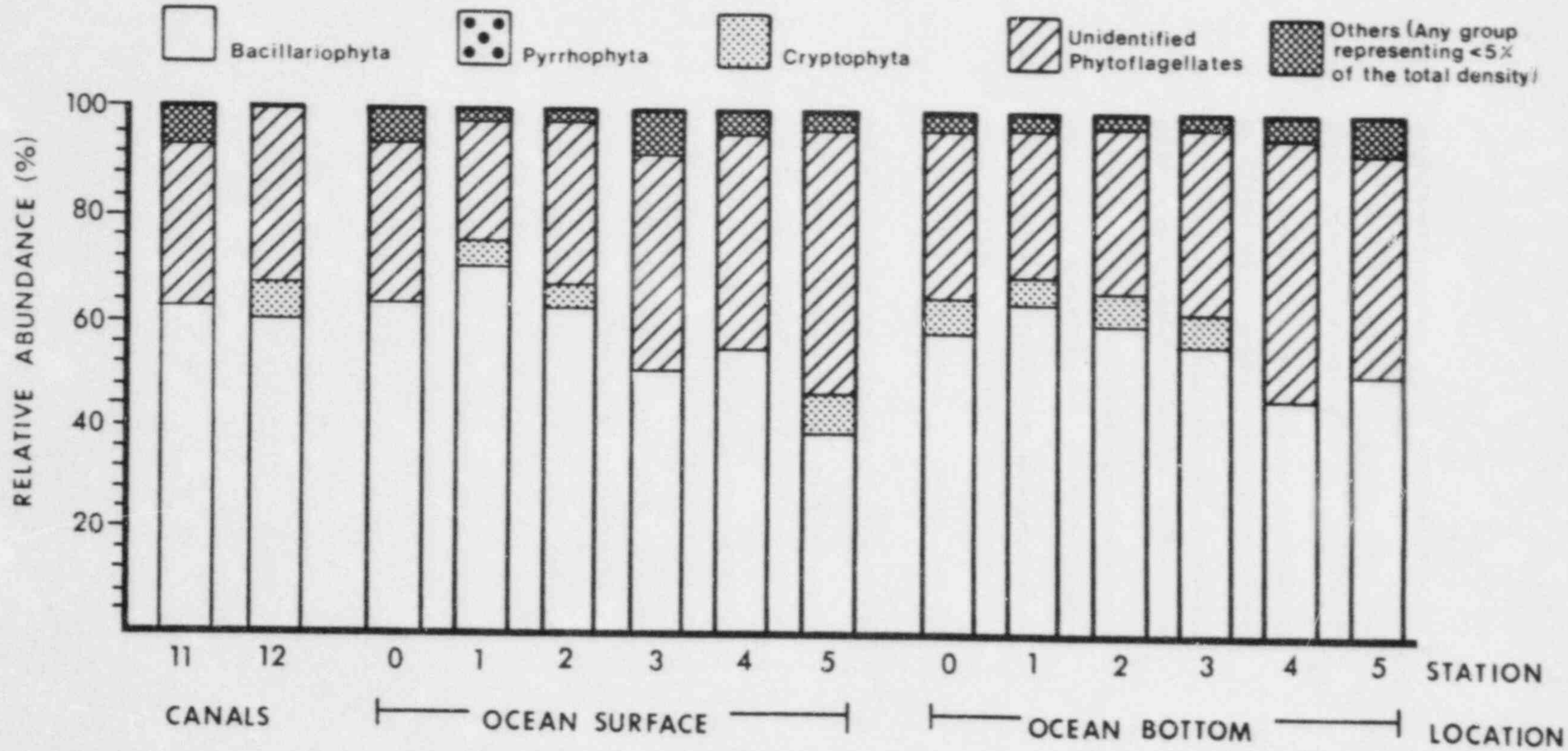


Figure D-5. Phytoplankton percentage composition, St. Lucie Plant, 24 February 1982.

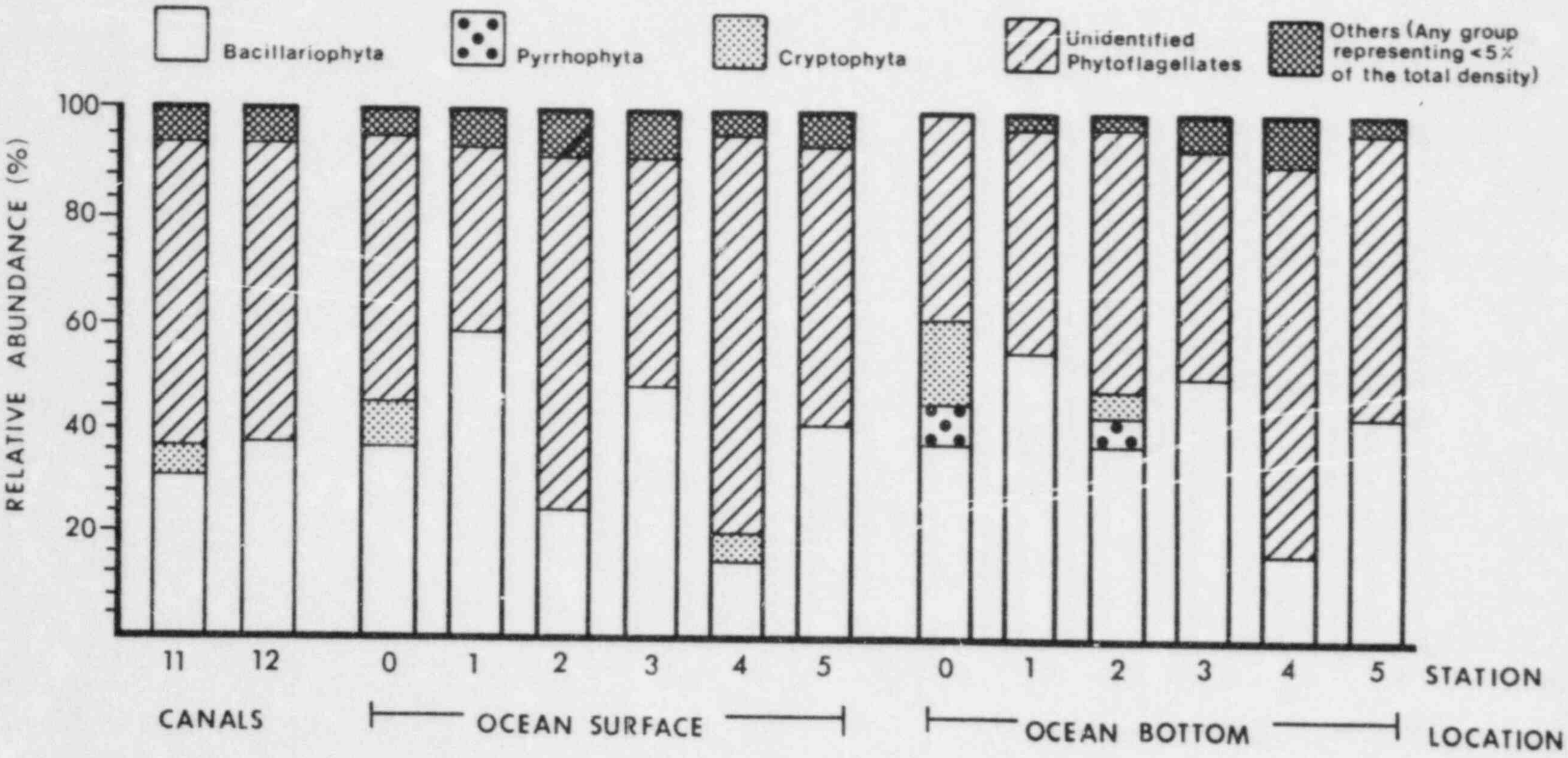


Figure D-6. Phytoplankton percentage composition, St. Lucie Plant, 17 March 1982.

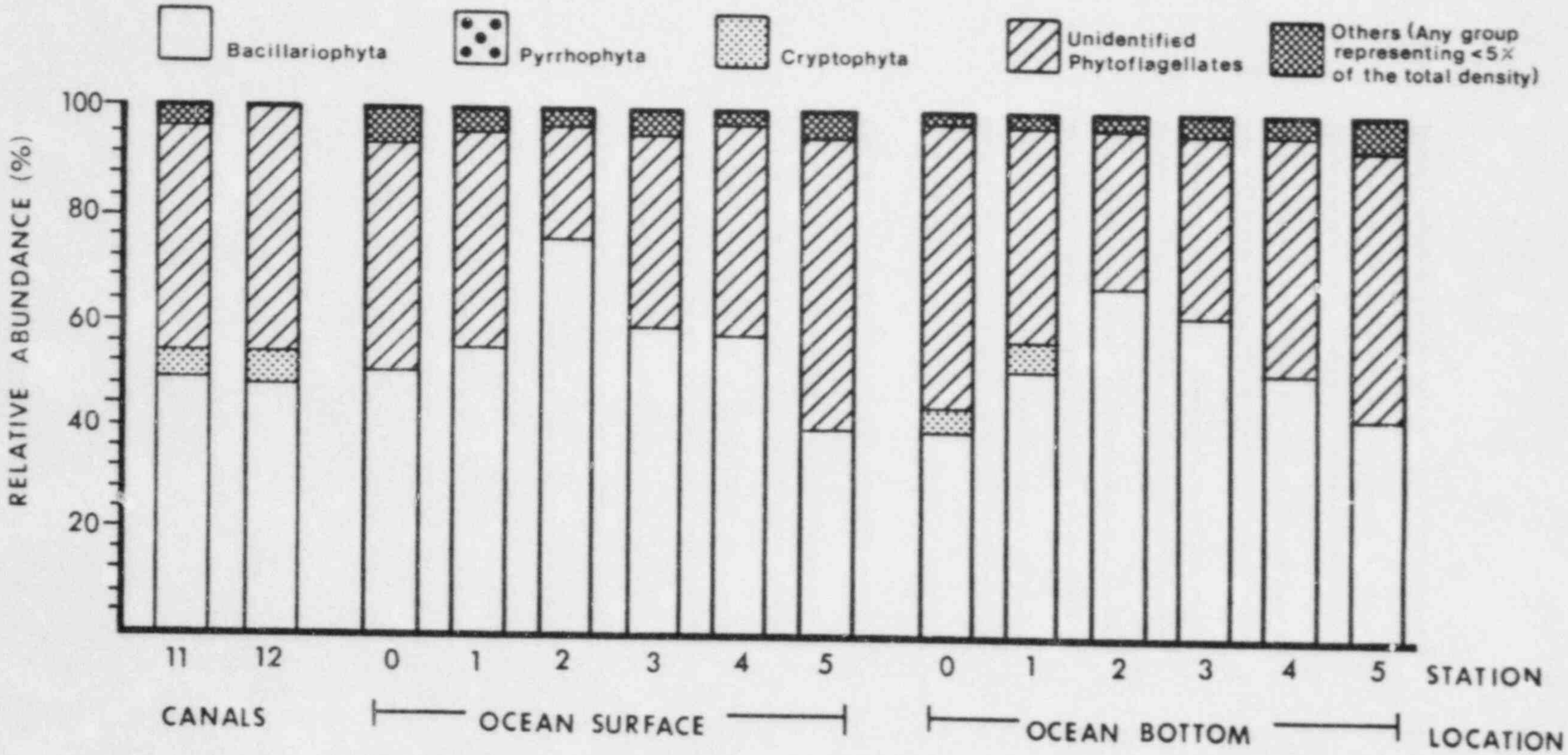


Figure D-7. Phytoplankton percentage composition, St. Lucie Plant, 14 April 1982.

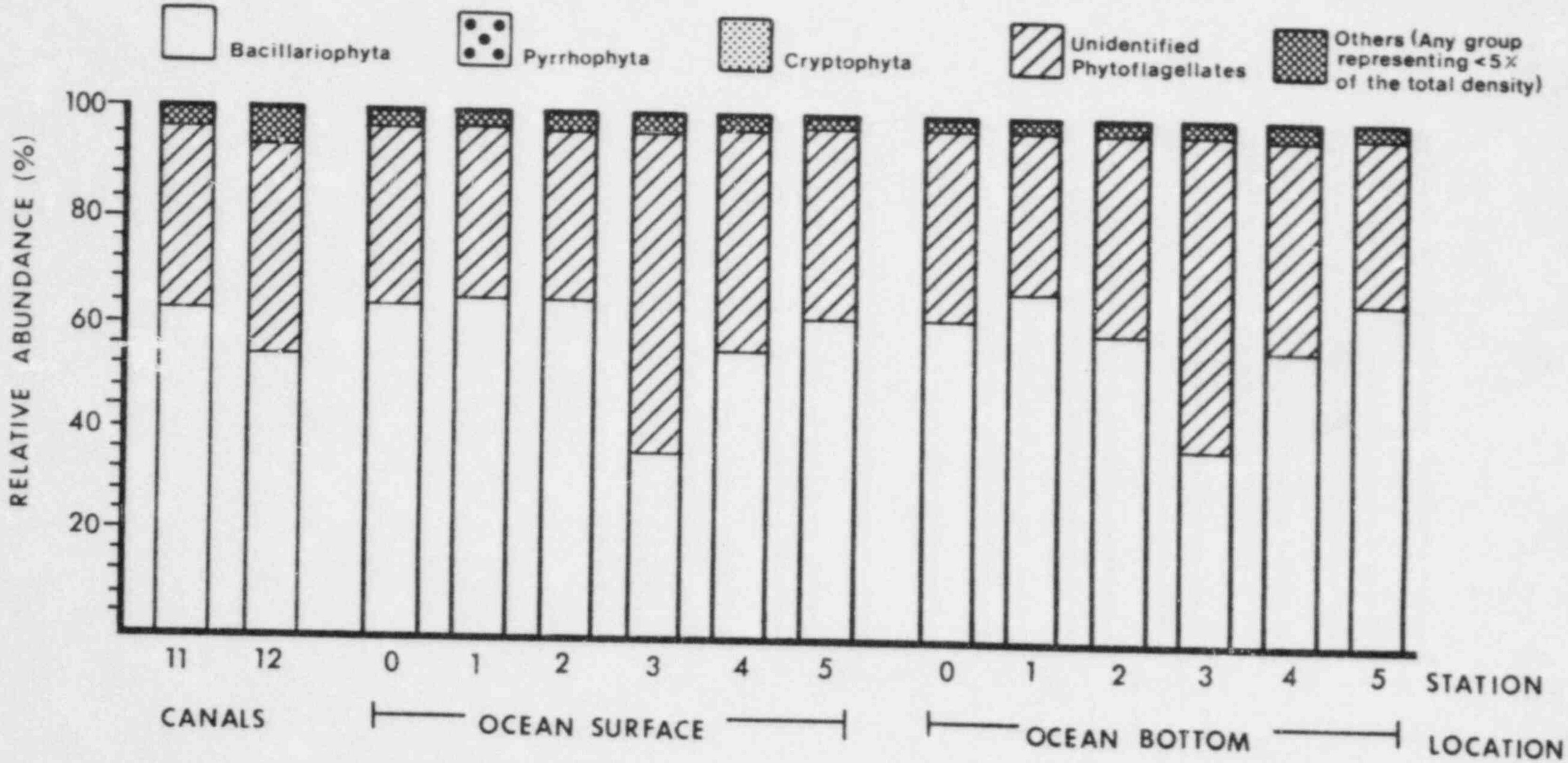


Figure D-8. Phytoplankton percentage composition, St. Lucie Plant, 18 May 1982.

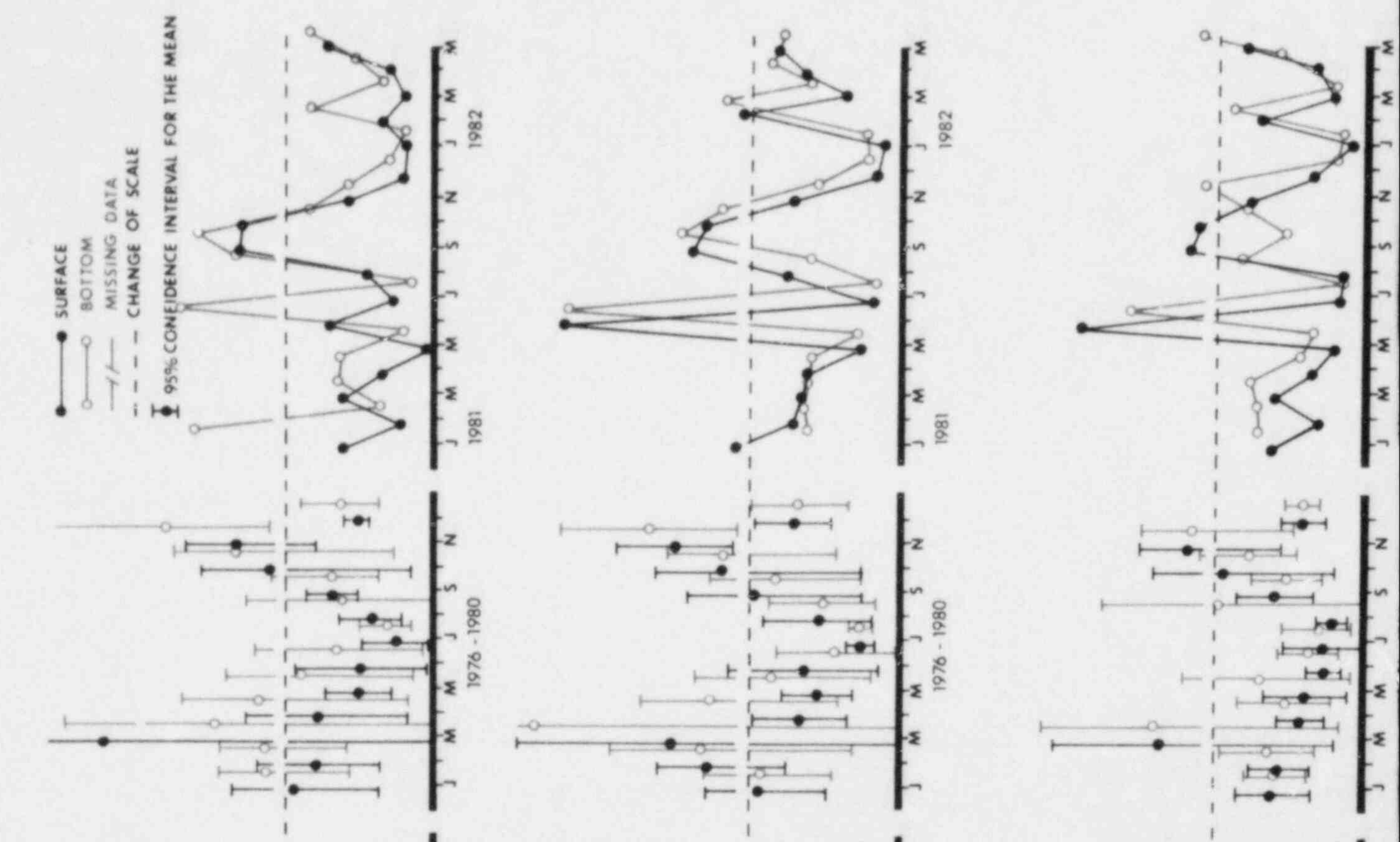
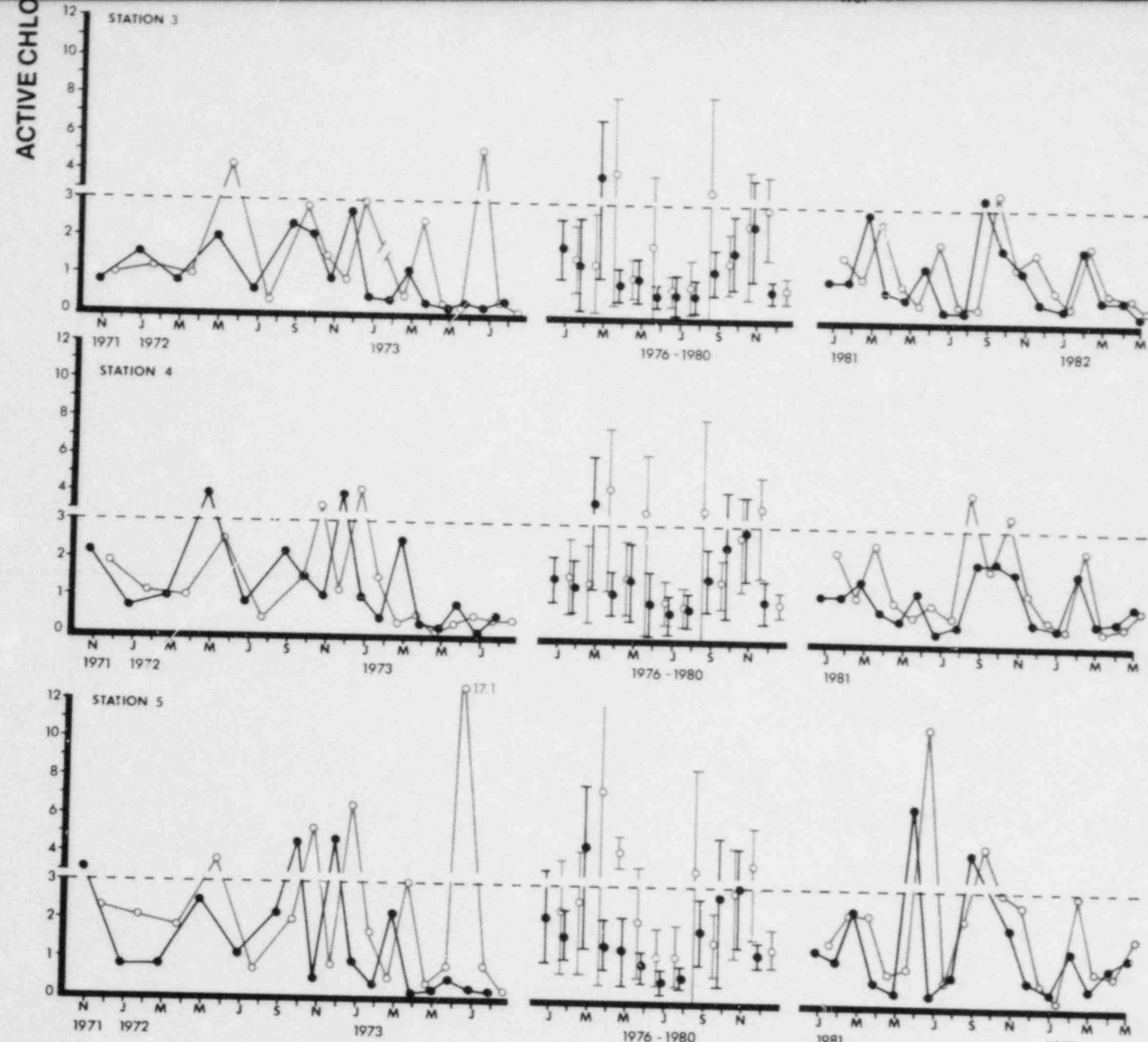


Figure D-9. Active chlorophyll-a at Stations 0 th



ugh 5, St. Lucie Plant, 1971-1973 and 1976-1982.

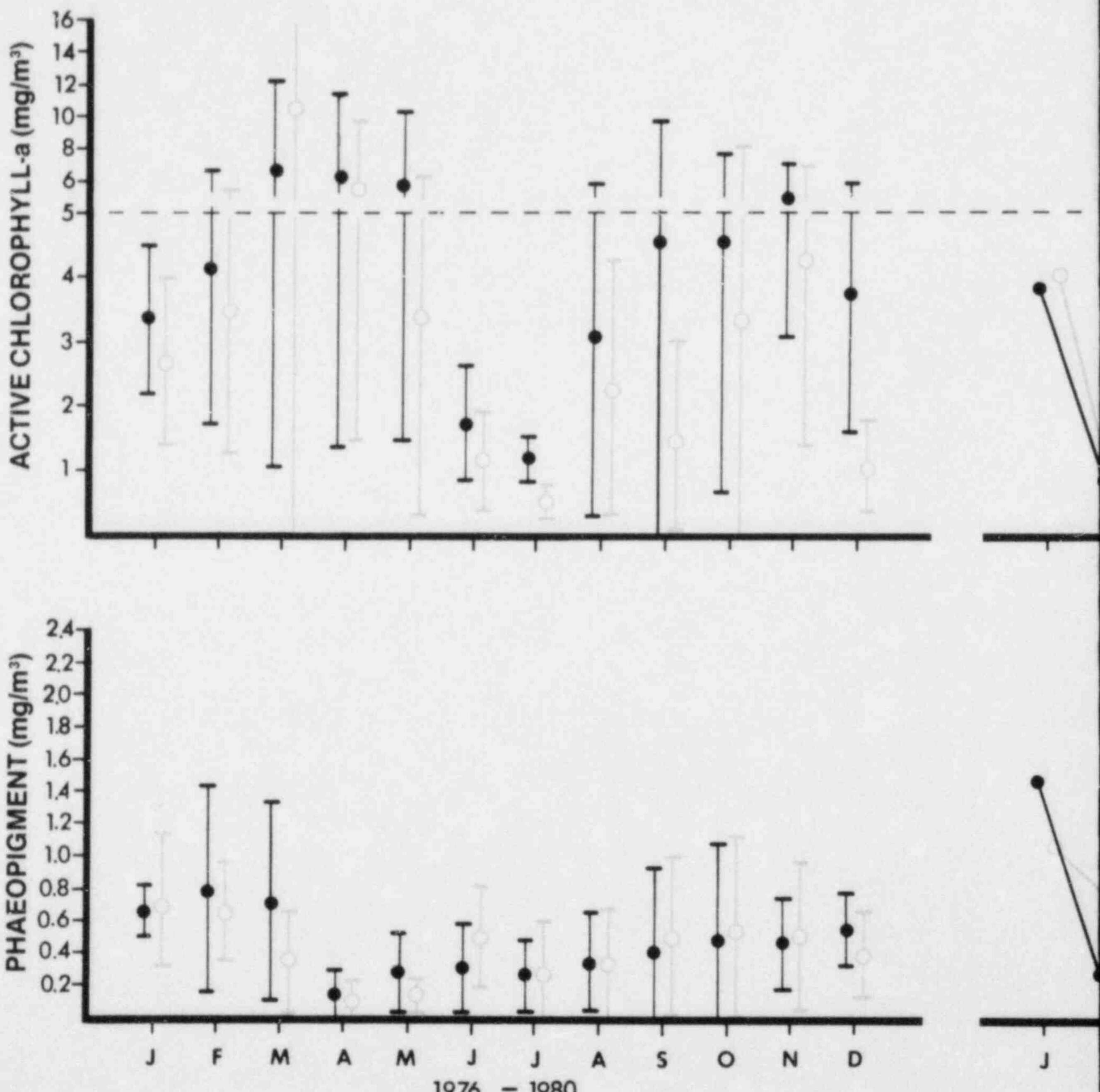
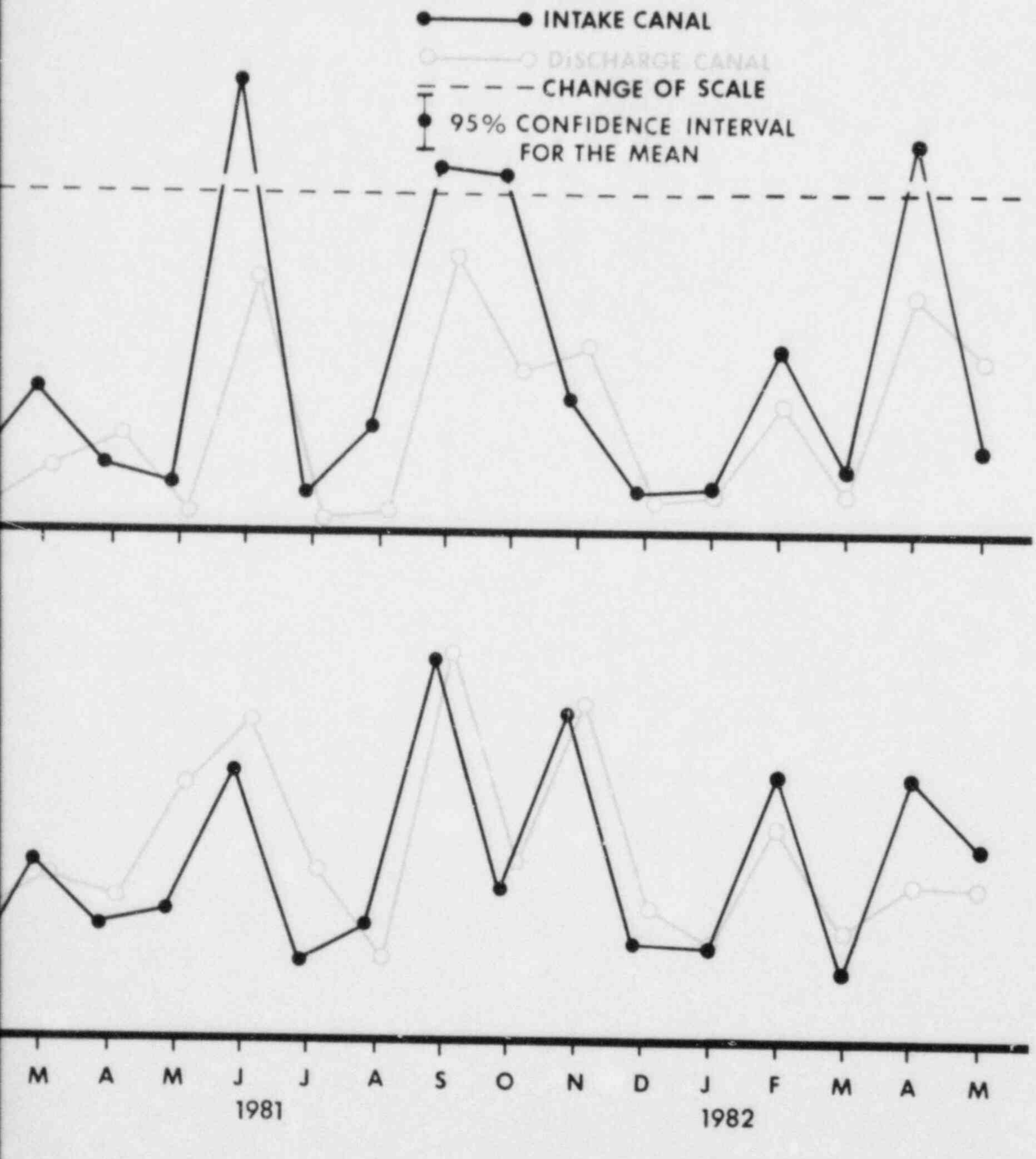


Figure D-10. Active chlorophyll-a at intake and di



arge canals, St. Lucie Plant, 1976-1982.

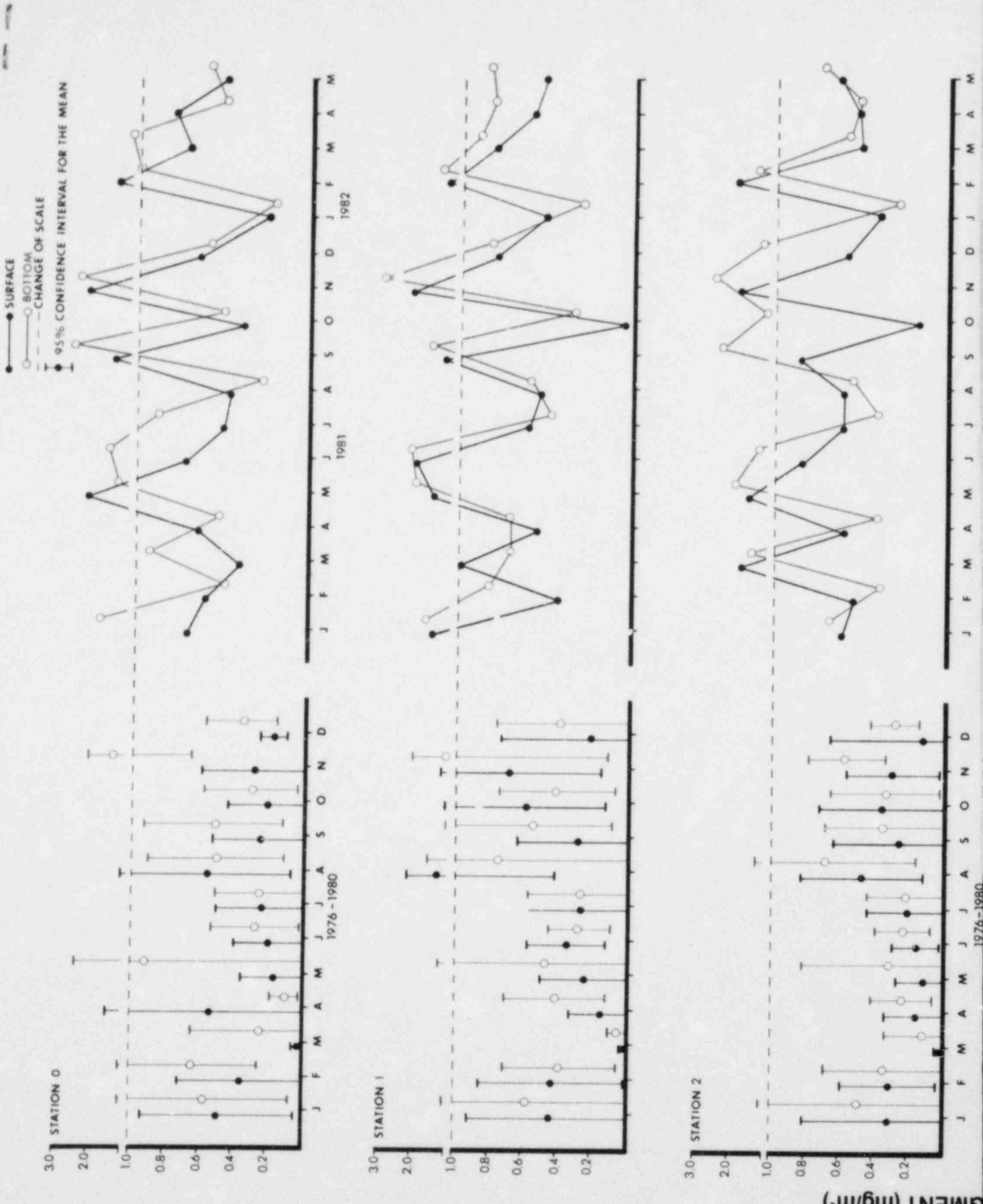
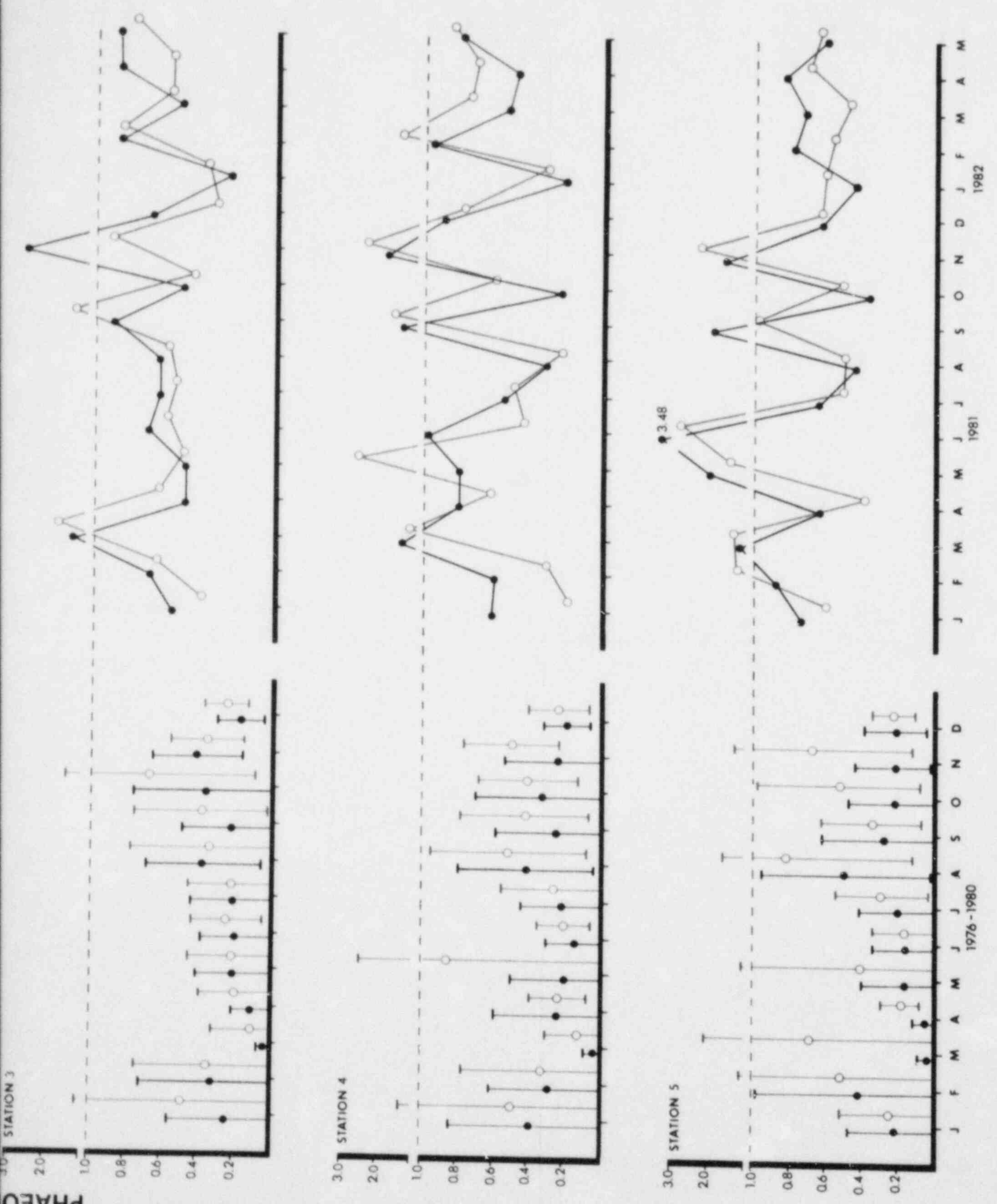


Figure D-11. Phaeopigment concentration at



Stations 0 through 5, St. Lucie Plant, 1976-1982.

TABLE D-1

PHYTOPLANKTON DENSITY[a] AND PERCENTAGE COMPOSITION[b]
ST. LUCIE PLANT
20 JANUARY 1982

Taxon	Station and depth[c] 11 S	11 B	11 x̄	12 S	0 S	0 B	1 S	1 B	2 S	2 B	3 S	3 B	4 S	4 B	5 S	5 B
Bacillariophyta (Diatoms)	231781 (47)	408917 (52)	320349 (50)	275486 (49)	185378 (50)	262054 (54)	201797 (55)	345718 (50)	101243 (52)	146867 (57)	147708 (49)	96394 (54)	152814 (55)	146805 (44)	120557 (58)	142473 (57)
Pyrrhophyta (Dinoflagellates)	12753 (3)	14088 (2)	13421 (2)	8675 (2)	13620 (4)	9578 (2)	6006 (2)	15408 (2)	3004 (2)	3054 (1)	1781 (<1)	1856 (1)	5341 (2)	8406 (2)	5570 (3)	5674 (2)
Chlorophyta (Green Algae)	1335 (<1)		667 (<1)		1201 (<1)	667 (<1)	601 (<1)	3080 (<1)	286 (<1)	381 (<1)			668 (<1)			667 (<1)
Cyanophyta (Blue-Green Algae)		8897 (1)	4448 (<1)	1001 (<1)		801 (<1)						265 (<1)	934 (<1)			
Euglenophyta (Euglenoids)	741 (<1)		371 (<1)					770 (<1)					667 (<1)		222 (<1)	
Cryptophyta (Cryptophytes)	25654 (5)	30894 (4)	28274 (4)	31030 (5)	11611 (3)	11978 (2)	8408 (2)	34649 (5)	3575 (2)	6101 (2)	6673 (2)	4766 (3)	9009 (3)	9886 (3)	6673 (3)	10343 (4)
Chrysophyceae (Yellow-brown algae and silicoflagellates)	1186 (<1)		593 (<1)		2002 (<1)		601 (<1)	2310 (<1)	858 (<1)	763 (<1)			667 (<1)		1112 (<1)	667 (<1)
Prasinophyceae (Prasinophytes)	6970 (1)	10504 (1)	8737 (1)	3559 (<1)	2402 (<1)	5539 (1)	1201 (<1)	6160 (<1)	296 (<1)	753 (<1)	4449 (1)	2393 (1)	1001 (<1)	5932 (2)	2002 (<1)	3670 (1)
Unidentified Phytoflagellates	207013 (42)	315118 (40)	261066 (41)	246125 (43)	151345 (41)	198190 (40)	148943 (40)	277190 (40)	85845 (44)	95330 (37)	138800 (46)	70702 (40)	104100 (38)	164603 (49)	72958 (35)	85415 (34)
Others	2224 (<1)		1112 (<1)		5205 (1)	667 (<1)	1802 (<1)	1540 (<1)	1239 (<1)	3051 (1)	445 (<1)	1059 (<1)	667 (<1)	989 (<1)	222 (<1)	1001 (<1)
Total Phytoplankton	489657	788418	639033	565876	372764	489474	369359	686825	196336	256310	299856	177425	275868	336621	209316	249910

[a]Values are expressed as cells per liter and represent the mean of three replicates.

[b]Percentage values are given in parentheses.

[c]S=Surface; B=Bottom; x̄ =The average of Station 11 S and B values.

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TAB-1

TABLE D-2

PHYTOPLANKTON DENSITY[a] AND PERCENTAGE COMPOSITION[b]
ST. LUCIE PLANT
24 FEBRUARY 1982

Taxon	Station and depth[c]: 11 S	11 B	11 x̄	12 S	0 S	0 B	1 S	1 B	2 S	2 B	3 S	3 B	4 S	4 B	5 S	5 B
Bacillariophyta (Diatoms)	2175554 (59)	1938440 (63)	2056997 (61)	2360731 (59)	863170 (63)	1726993 (56)	3035648 (69)	2646294 (62)	1882387 (61)	3360036 (58)	835647 (43)	1645304 (54)	761201 (53)	1325594 (44)	547243 (37)	1507013 (49)
Pyrrhophyta (Dinoflagellates)	48936 (1)	13799 (<1)	31367 (<1)	18537 (<1)	14235 (1)	38555 (1)	35590 (<1)	18536 (<1)	35590 (1)	88975 (2)	20391 (1)	32438 (1)	2085 (<1)	13902 (<1)	28600 (2)	60243 (2)
Chlorophyta (Green Algae)		5561 (<1)	2780 (<1)	10813 (<1)		4449 (<1)	4449 (<1)				3089 (<1)	9268 (<1)	2085 (<1)	4634 (<1)		4634 (<1)
Cyanophyta (Blue-Green Algae)		4119 (<1)	2059 (<1)	9886 (<1)	7118 (<1)		8897 (<1)	19772 (<1)	17795 (<1)		5561 (<1)	4634 (<1)	6256 (<1)	9268 (<1)	11440 (<1)	4634 (<1)
Euglenophyta (Euglenoids)	8897 (<1)		4448 (<1)													4634 (<1)
Cryptophyta (Cryptophytes)	115667 (3)	116367 (4)	116017 (3)	271866 (7)	51605 (4)	226884 (7)	200192 (5)	222436 (5)	151256 (5)	333654 (6)	64877 (3)	185363 (6)	41707 (3)	92682 (3)	104863 (7)	115852 (4)
Chrysophyceae (Yellow-brown algae and silicoflagellates)		9630 (<1)	4840 (<1)			3707 (<1)	4449 (<1)	6179 (<1)			2472 (<1)			4634 (<1)		
Prasinophyceae (Prasinophytes)	13346 (<1)	9680 (<1)	11513 (<1)		7118 (<1)	29658 (<1)	4449 (<1)	6179 (<1)		14829 (<1)	8032 (<1)		6256 (<1)	9268 (<1)		4634 (<1)
Unidentified Phytoflagellates	1303474 (36)	975422 (32)	1139448 (34)	1354700 (34)	425297 (31)	1026170 (34)	1116630 (25)	1328440 (31)	1014306 (33)	1987089 (34)	983660 (51)	1144622 (38)	617259 (43)	1533877 (51)	777889 (53)	1390225 (45)
Others					7118 (<1)	3707 (<1)	4449 (<1)				2472 (<1)	4634 (<1)	4171 (<1)	4634 (<1)	7526 (<1)	
Total Phytoplankton	3665874	3073068	3369470	4026533	1375661	3060123	4414753	4247836	3101334	5784593	1926201	3026263	1441020	2998493	1477661	3091869

[a]Values are expressed as cells per liter and represent the mean of three replicates.

[b]Percentage values are given in parentheses.

[c]S=Surface; B=Bottom; x̄ =The average of Station 11 S and B values.

TABLE D-3

PHYTOPLANKTON DENSITY[a] AND PERCENTAGE COMPOSITION[b]
ST. LUCIE PLANT
17 MARCH 1982

Taxon	Station and depth[c]															
	11			12	0		1		2		3		4		5	
	S	B	x̄	S	S	B	S	B	S	B	S	B	S	B	S	B
Bacillariophyta (Diatoms)	128757 (33)	122863 (30)	125810 (31)	200522 (37)	141441 (36)	207782 (36)	530196 (58)	931344 (54)	52405 (24)	81398 (36)	248285 (47)	264313 (49)	50760 (14)	62015 (15)	167778 (40)	160881 (42)
Pyrrhophyta (Dinoflagellates)	11385 (3)	8674 (2)	10030 (3)	4125 (<1)	10874 (3)	43003 (7)	22254 (2)	11863 (<1)	5676 (3)	12679 (6)	24023 (5)	19352 (4)	9787 (3)	6940 (2)	8453 (2)	3336 (<1)
Chlorophyta (Green Algae)	915 (<1)	6007 (1)	3461 (<1)	687 (<1)	989 (<1)			2966 (<1)	667 (<1)	801 (<1)	667 (<1)	667 (<1)	667 (<1)	534 (<1)	445 (<1)	667 (<1)
Cyanophyta (Blue-Green Algae)	1583 (<1)	2468 (<1)	2026 (<1)	3570 (<1)	1483 (<1)		1236 (<1)	2966 (<1)	1335 (<1)	400 (<1)		667 (<1)	3314 (<1)	2136 (<1)	1779 (<1)	1112 (<1)
Euglenophyta (Euglenoids)					494 (<1)			2966 (<1)						1068 (<1)		
Cryptophyta (Cryptophytes)	20591 (5)	20687 (5)	20639 (5)	21969 (4)	29329 (8)	90457 (16)	25951 (3)	26692 (2)	8675 (4)	10944 (5)	18017 (3)	17350 (3)	18240 (5)	28828 (7)	11567 (3)	5561 (1)
Chrysophyceae (Yellow-brown algae and silicoflagellates)											667 (<1)					
Prasinophyceae (Prasinophytes)	1735 (<1)	2669 (<1)	2202 (<1)		1483 (<1)	4449 (<1)	2472 (<1)		667 (<1)	1869 (<1)	667 (<1)	2002 (<1)	890 (<1)	1068 (<1)	445 [illegible]	667 (<1)
Unidentified Phytoflagellates	226903 (58)	243567 (60)	235235 (59)	317177 (58)	201840 (52)	237264 (41)	326239 (36)	739475 (43)	145473 (68)	117513 (52)	232890 (44)	240231 (44)	274708 (77)	314969 (75)	[illegible]	207533 (55)
Others										1134 (<1)				1068 (<1)	1335 (<1)	667 (<1)
Total Phytoplankton	391869	406935	399403	548050	387933	582955	908348	1718272	214898	226738	525216	544582	358366	418626	418687	380424

[a]Values are expressed as cells per liter and represent the mean of three replicates.

[b]Percentage values are given in parentheses.

[c]S=Surface; B=Bottom; x̄ =The average of Station 11 S and B values.

TABLE D-4

PHYTOPLANKTON DENSITY[a] AND PERCENTAGE COMPOSITION[b]
ST. LUCIE PLANT
14 APRIL 1982

Taxon	Station and depth[c] 11 S	11 B	11 $\bar{x}$	12 S	0 S	0 B	1 S	1 B	2 S	2 B	3 S	3 B	4 S	4 B	5 S	5 B
Bacillariophyta (Diatoms)	3981899 (48)	5147806 (48)	4564853 (48)	3650169 (47)	501917 (50)	823283 (38)	2111671 (54)	2941713 (50)	421173 (75)	553865 (66)	286223 (58)	304831 (60)	282770 (56)	350338 (50)	324928 (38)	206865 (41)
Pyrrhophyta (Dinoflagellates)	22244 (<1)	40856 (<1)	31550 (<1)	6673 (<1)	12874 (1)	11344 (<1)	47453 (1)	69511 (1)	3850 (<1)	2670 (<1)	3239 (<1)	3949 (<1)	2506 (<1)	4449 (<1)	3080 (<1)	5561 (1)
Chlorophyta (Green Algae)	33365 (<1)		16683 (<1)		7150 (<1)	2669 (<1)	5932 (<1)	11122 (<1)			1278 (<1)	790 (<1)			1540 (<1)	
Cyanophyta (Blue-Green Algae)		13619 (<1)	6809 (<1)						77 (<1)						1540 (<1)	
Euglenophyta (Euglenoids)					1430 (<1)	9342 (<1)					593 (<1)	790 (<1)			1540 (<1)	
Cryptophyta (Cryptophytes)	645064 (8)	299607 (3)	472336 (5)	453769 (6)	32889 (3)	98094 (5)	118632 (3)	269703 (5)	4620 (<1)	25358 (3)	9262 (2)	11056 (2)	7507 (1)	17795 (3)	36959 (4)	18907 (4)
Chrysophyceae (Yellow-brown algae and silicoflagellates)		13619 (<1)	6809 (<1)													1112 (<1)
Prasinophyceae (Prasinophytes)	77853 (<1)	68093 (<1)	72973 (<1)	42263 (<1)	4290 (<1)	17350 (<1)	17795 (<1)	50048 (<1)	3080 (<1)		1278 (<1)	790 (<1)	1668 (<1)	1112 (<1)	3080 (<1)	4449 (<1)
Unidentified Phytoflagellates	3536727 (43)	5038855 (47)	4287791 (45)	3619027 (47)	444712 (44)	1215837 (56)	1637128 (42)	2519085 (43)	128585 (23)	261585 (31)	192595 (39)	185583 (36)	212704 (42)	324756 (46)	488161 (57)	262474 (52)
Others	22244 (<1)	13619 (<1)	17932 (<1)		5720 (<1)				770 (<1)		1371 (<1)	1579 (<1)	1668 (<1)	1112 (<1)	1540 (<1)	1112 (<1)
Total Phytoplankton	8319396	10636074	9477736	7771901	1010982	2177919	3938611	5861182	562155	843478	496339	509368	508823	699562	862368	500480

[a]Values are expressed as cells per liter and represent the mean of three replicates.

[b]Percentage values are given in parentheses.

[c]S=Surface; B=Bottom; $\bar{x}$ =The average of Station 11 S and B values.

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TAB-4

TABLE D-5

PHYTOPLANKTON DENSITY[a] AND PERCENTAGE COMPOSITION[b]
ST. LUCIE PLANT
18 MAY 1982

Taxon	Station and depth[c]															
	11			12	0		1		2		3		4		5	
	S	B	x̄	S	S	B	S	B	S	B	S	B	S	B	S	B
Bacillariophyta (Diatoms)	814114 (63)	750718 (62)	782416 (62)	1426442 (52)	2961175 (63)	2179872 (60)	1935858 (64)	3073325 (66)	2163188 (64)	1445833 (58)	217004 (34)	131101 (36)	672596 (54)	1003630 (55)	750721 (60)	1327020 (65)
Pyrrhophyta (Dinoflagellates)	8341 (<1)	6673 (<1)	7507 (<1)	12512 (<1)	50084 (1)	7415 (<1)	33365 (1)	29659 (1)	27805 (<1)	13902 (<1)	8897 (1)	3565 (<1)	6673 (<1)	18084 (1)	7415 (<1)	32967 (2)
Chlorophyta (Green Algae)	1668 (<1)	5005 (<1)	3336 (<1)	12512 (<1)					16683 (<1)	4634 (<1)			2502 (<1)			5437 (<1)
Cyanophyta (Blue-Green Algae)	3336 (<1)	5005 (<1)	4171 (<1)	13346 (<1)				21317 (<1)					8147 (<1)	27760 (2)	5561 (<1)	1369 (<1)
Euglenophyta (Euglenoids)																2472 (<1)
Cryptophyta (Cryptophytes)	20019 (2)	6673 (<1)	13346 (1)	104267 (4)	45877 (<1)	18536 (<1)		18536 (<1)	16683 (<1)	26260 (1)	10010 (2)	6525 (2)	6673 (<1)	21354 (1)	11122 (<1)	
Chrysophyceae (Yellow-brown algae and silicoflagellates)								5561 (<1)								
Prasinophyceae (Prasinophytes)		3337 (<1)	1669 (<1)	8341 (<1)		7415 (<1)	5561 (<1)			4634 (<1)		890 (<1)				2966 (<1)
Unidentified Phytoflagellates	453768 (35)	430413 (36)	442090 (35)	1155274 (42)	1676612 (35)	1410611 (39)	1034326 (34)	1497734 (32)	1139983 (34)	1007140 (40)	401496 (63)	218284 (61)	553865 (44)	758061 (41)	485652 (39)	678866 (33)
Total Phytoplankton	1301246	1207324	1254535	2732694	4733712	3623849	3009110	4646132	3364342	2502403	637407	360365	1250456	1329489	1260471	2051097

[a] Values are expressed as cells per liter and represent the mean of three replicates.

[b] Percentage values are given in parentheses.

[c] S=Surface; B=Bottom; x̄ =The average of Station 11 S and B values.

TABLE D-6

SEASONAL[a] OCCURRENCE OF MAJOR PHYTOPLANKTON SPECIES
ST. LUCIE PLANT
MARCH 1976 - NOVEMBER 1981

Taxon	Winter 77	Winter 78	Winter 79	Winter 80	Winter 81	Spring 76	Spring 77	Spring 78	Spring 79	Spring 80	Spring 81	Summer 76	Summer 77	Summer 78	Summer 79	Summer 80	Summer 81	Autumn 76	Autumn 77	Autumn 78	Autumn 79	Autumn 80	Autumn 81
BACILLARIOPHYTA																							
Asterionella japonica		x	x	x	x	x	x	x		x	x												
Biddulphia aurita					x																		x
Campylosira cymbelliformis				x	x					x	x											x	x
Eunotogramma marinum																							x
Hemiaulus hauckii					x																		
Leptocylindrus danicus						x	x		x		x			x	x					x	x		x
Nitzschia acicularis v. *closterioides*																	x					x	
N. closterium	x		x	x	x			x	x	x	x						x	x	x	x	x		x
N. delicatissima		x			x	x		x	x	x	x	x		x	x	x	x		x	x	x		x
Rhaponeis surirella				x																			x
Rhizosolenia fragilissima																							x
R. stolterfothii															x								x
Skeletonema costatum	x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
Thalassionema nitzschioides				x	x			x	x	x	x					x	x		x	x		x	
Thalassiosira sp. 1			x	x					x	x		x						x	x	x	x		x
Tropidoneis lepidoptera			x								x								x	x			
CHLOROPHYTA																							
Chlorophyte sp. 1	x					x	x	x	x			x	x							x			
PRASINOPHYCEAE																							
Prasinophyte sp. 1	x			x	x													x		x			

[a] Winter=December (of preceding year), January and February
Spring=March, April, May
Summer=June, July, August
Autumn=September, October, November

Shaded areas indicate seasonal periods in which a major species occurred on at least 50 percent of all possible occasions.

TABLE D-7

COMPARISON OF INTAKE (STATION 11) AND DISCHARGE (STATION 12) PHYTOPLANKTON
ST. LUCIE PLANT
JANUARY - MAY 1982

Date	Temperature in °C Intake	Discharge	ΔT(°C)	Intake (cells/liter)	Discharge (cells/liter)	Change in cell count[a] (%)
20 Jan	22.1	33.7	+11.6	639,038	565,876	-11.4
24 Feb	19.9	32.4	+12.5	3,369,470	4,026,533	+19.5
17 Mar	23.1	35.3	+12.2	399,403	548,050	+37.2
14 Apr	22.8	35.6	+12.8	9,477,736	7,771,901	-18.0
18 May[b]	25.2	25.2	+0.2	1,254,535	2,732,694	+117.8

[a]Change in cell count = $\frac{\text{Discharge - Intake}}{\text{Intake}}$ X 100.

[b]Plant down or in limited operational capacity only.

TABLE D-8

ACTIVE CHLOROPHYLL-a AND PHAEOPIGMENTS[a]
ST. LUCIE PLANT
1982

		Pigment and depth[b]					
		Chlorophyll-a (mg/m^3)			Phaeopigment (mg/m^3)		
Date	Station	S	B	A	S	B	A
20 JAN	0	0.57	0.68	0.62	0.24	0.21	0.22
	1	0.44	0.61	0.52	0.51	0.31	0.41
	2	0.29	0.35	0.32	0.41	0.30	0.35
	3	0.31	0.29	0.30	0.25	0.38	0.31
	4	0.37	0.41	0.39	0.22	0.33	0.27
	5	0.28	0.19	0.24	0.45	0.63	0.54
	11	0.61	0.63	0.62	0.41	0.64	0.53
	12	0.59	-	0.59	0.59	-	0.59
24 FEB	0	1.25	2.69	1.97	1.36	1.01	1.18
	1	3.20	3.28	3.24	1.15	1.39	1.27
	2	2.09	2.67	2.38	1.98	1.44	1.71
	3	1.76	2.13	1.94	0.86	0.86	0.86
	4	1.77	2.52	2.14	0.96	1.50	1.23
	5	1.47	2.92	2.20	0.79	0.58	0.69
	11	3.13	2.18	2.65	1.65	1.47	1.56
	12	1.94	-	1.94	1.25	-	1.25

[a]Phaeopigment = Phaeophytin-a plus phaeophorbide-a.

[b]S = Surface; B = Bottom; A = Average. S and B values represent mean of duplicate determinations.

TABLE D-8
(continued)
ACTIVE CHLOROPHYLL-a AND PHAEOPIGMENTS[a]
ST. LUCIE PLANT
1982

		Pigment and depth[b]					
		Chlorophyll-a (mg/m^3)			Phaeopigment (mg/m^3)		
Date	Station	S	B	A	S	B	A
17 MAR	0	0.64	0.94	0.79	0.71	1.10	0.90
	1	1.27	1.78	1.52	0.81	0.91	0.86
	2	0.52	0.58	0.55	0.52	0.60	0.56
	3	0.71	0.79	0.75	0.52	0.59	0.55
	4	0.61	0.28	0.44	0.54	0.76	0.65
	5	0.54	0.97	0.75	0.74	0.49	0.61
	11	0.79	0.93	0.86	0.38	0.41	0.39
	12	0.58	-	0.58	0.66	-	0.66
14 APR	0	0.86	1.48	1.17	0.79	0.51	0.65
	1	1.97	2.60	2.28	0.57	0.83	0.70
	2	0.81	1.70	0.94	0.53	0.53	0.53
	3	0.56	0.66	0.61	0.86	0.59	0.72
	4	0.66	0.51	0.58	0.49	0.73	0.61
	5	1.08	0.79	0.94	0.85	0.72	0.79
	11	6.95	6.99	6.97	1.75	1.30	1.53
	12	3.53	-	3.53	0.95	-	0.95

[a]Phaeopigment = Phaeophytin-a plus phaeophorbide-a.

[b]S = Surface; B = Bottom; A = Average. S and B values represent mean of duplicate determinations.

TABLE D-8
(continued)
ACTIVE CHLOROPHYLL-a AND PHAEOPIGMENTS[a]
ST. LUCIE PLANT
1982

		Pigment and depth[b]					
		Chlorophyll-a (mg/m^3)			Phaeopigment (mg/m^3)		
Date	Station	S	B	A	S	B	A
18 MAY	0	2.40	2.71	2.56	0.49	0.60	0.55
	1	2.59	2.39	2.49	0.52	0.86	0.69
	2	2.74	3.10	2.92	0.64	0.75	0.70
	3	0.24	0.29	0.26	0.87	0.80	0.83
	4	1.08	0.89	0.99	0.80	0.86	0.83
	5	1.30	1.82	1.56	0.62	0.66	0.64
	11	1.37	1.03	1.20	0.80	1.44	1.12
	12	2.57	-	2.57	0.92	-	0.92

[a]Phaeopigment = Phaeophytin-a plus phaeophorbide-a.

[b]S = Surface; B = Bottom; A = Average. S and B values represent mean of duplicate determinations.

E. ZOOPLANKTON

Environmental Technical Specification (3.1.B.b; deleted May 1982)

> Plankton - Plankton samples will be collected monthly. Both zooplankton and phytoplankton species will be identified as to kind and abundance. Chlorophyll "a" analysis will be performed as a measure of primary productivity.

INTRODUCTION

Zooplankters are aquatic invertebrates that have limited motility or passively drift with water currents. Ecologically, zooplankters form the second trophic level in most aquatic food chains and can be divided into two main groups: 1) holoplankters, which spend their entire life cycle in the water column and 2) meroplankters, which consist predominantly of benthic macroinvertebrate larvae and are temporary members of the zooplankton community. Zooplankters are an integral part of the marine fauna near the St. Lucie Plant. They are the major consumers of primary producers, mainly phytoplankton and, in turn, provide an important food source for larger macroinvertebrates and fish. Changes in zooplankton community composition and density reflect the influences of water temperature, salinity, food availability and other biotic and abiotic parameters. Zooplankton populations in a nearshore environment, such as that near the St. Lucie Plant, exhibit considerable natural variation in both space and time.

This study is a continuation of studies begun by ABI in 1976 to determine the potential effects of St. Lucie Plant operation on the aquatic biota. This section of the report examines the composition and density of the zooplankton community during the January through May 1982 monitoring study at the St. Lucie Plant. The 1982 data were compared to those from similar periods during the 1976 through 1981 operational phase studies (ABI, 1977-1982) and during the 1972 through 1973 baseline study (Walker et al., 1979) to evaluate the potential effects of power plant operation. The new NPDES monitoring program deleted zooplankton as a study component, and collections at the St. Lucie Plant were terminated in May 1982.

General Effects of Power Plant Operation

Because of their small size and limited motility, zooplankters are easily entrained during power plant operation. Perturbations to the zooplankton community may occur as a result of entrainment in 1) power plant condenser cooling waters and 2) heated plant discharge waters.

Entrained zooplankters are subjected to sublethal or lethal exposure to rapid thermal elevation, mechanical and hydraulic stresses and biocides. These factors can act independently or synergistically with other physicochemical parameters to stress an organism. Pertinent studies on the effects of power plant entrainment on zooplankton have demonstrated impaired swimming and feeding capabilities, lowered resistance to predation, increased susceptibility to disease and potential inhibition of reproductive and growth processes (Mihursky and Kennedy, 1967; Coutant,

1970; Davies et al., 1976; Polgar et al., 1976). Mortality of entrained zooplankton may range from 15 to 100 percent depending on species and environmental conditions (Marcy et al., 1978).

The zooplankton subject to plant entrainment may include the larval stages of local benthic species such as echinoderms, molluscs, barnacles and decapod crustaceans (shrimp and crabs). The impact of the entrainment mortality of these larvae upon adult populations is important because most benthic invertebrates have long generation times and limited spawning periods. Entrainment of these meroplankters could result in a decrease in abundance of recruitable larvae in the waters adjacent to power plants (Enright, 1978). Holoplanktonic organisms, such as copepods, appendicularians and chaetognaths, have comparatively short generation times and potential losses attributable to plant passage would be minimized by recruitment from ocean communities.

The biological effects from entrainment in thermal effluents are difficult to assess because the resulting stress depends on the response of individual zooplankton species to the magnitude and duration of exposure. The extent of exposure, in turn, is a function of ambient and discharge water temperatures and mixing processes. An open coastal environment, such as that found at the St. Lucie Plant, provides rapid dissipation of waste heat. Thermal plume entrainment effects are therefore, likely to be negligible.

Effects of Other Environmental Components

Physical factors that potentially influence zooplankton distribution include salinity, dissolved oxygen and water temperature. The effect on zooplankton of these physical components and other biological elements of the ecosystem may result in uneven zooplankton distribution. This patchiness compounds the difficulty of estimating power plant influence on zooplankton densities and species composition.

MATERIALS AND METHODS

Duplicate zooplankton samples were collected monthly from January through May 1982 at six ocean stations (0 through 5) and in the intake and discharge canals (Stations 11 and 12, respectively; Figure E-1). Collections were made with 0.5-m diameter, 202-μ mesh plankton nets equipped with flowmeters to enable calculation of the volume of seawater filtered. Ocean stations were sampled at surface and bottom depths by discrete 5-minute horizontal tows at speeds of 0.5 to 2 knots. Intake and discharge samples were collected by 10 minute step-oblique tows taken at spaced intervals from the bottom to the surface. Zooplankters were preserved immediately after collection in a 5-percent formalin solution buffered with sodium borate.

For qualitative and quantitative analysis, zooplankton samples were split with a Folsom plankton splitter and diluted to a workable volume. Three replicate 1-ml aliquots were withdrawn with a Stempel pipette and placed in gridded counting trays for examination. Zooplankters were identified to the lowest practicable taxon.

Zooplankters per cubic meter were calculated by multiplying the number of organisms in the subsample by appropriate dilution factors and then dividing by the volume of water filtered in cubic meters. The volume of water filtered was calculated by:

$$V = \pi(r^2)l$$

where: V = Volume of water filtered, in cubic meters;

r = Radius of the net at the mouth, in meters;

l = Distance the net is towed, in meters.

Whole zooplankton samples were retained as vouchers in a permanent collection.

Zooplankton biomass for each station and depth was determined by the ash-free dry weight method (EPA, 1973). Results of these determinations were expressed as milligrams of ash-free dry weight per cubic meter of water sampled.

Data Analysis

Zooplankton collections at the St. Lucie Plant were terminated in May 1982. This precluded meaningful statistical comparisons of the annual data from previous years (12-month periods) with the partial data available from 1982 (5-month period). The 1982 data were qualitatively compared to prior data from the comparable operational phase monitoring periods.

RESULTS AND DISCUSSION

Zooplankton community composition between January and May 1982 was similar to that observed over the same monitoring periods during previous operational phase studies at the St. Lucie Plant (ABI, 1977-1982). As in previous studies, the ocean zooplankton community was characterized by neritic holoplanktonic species, principally copepods (Figure E-2). Copepods, which were most prevalent at the surface, were abundant throughout the sampling period and were the dominant zooplankton group at both surface and bottom depths. This group represented 40 to 86 percent of the zooplankton at ocean stations and composed at least 50 percent of the zooplankton community during every collection period, except March. During March, polychaete larvae were quite abundant at the bottom at ocean Stations 0, 1, 2 and 4, while urochordates were abundant at the bottom at Stations 0, 1 and 2. Copepods and urochordates have characteristically been major contributors to the holoplanktonic zooplankton community throughout monitoring at the St. Lucie Plant.

Paracalanus and *Acartia* were typically the most abundant copepod genera collected during baseline and previous operational phase studies. *Paracalanus* was the most abundant copepod during January, March and April 1982, while *Acartia* was the most prevalent copepod in February. Other copepod species which were major contributors to the zooplankton community during previous studies and in 1982 included *Temora turbinata*, *Labidocera aestiva*, *Corycaeus* spp., *Euterpina acutifrons* and *Oithona* spp. Both *T. turbinata* and *L. aestiva* were consistently abundant among stations and collection periods.

Urochordates were the second most important holoplanktonic zooplankton group with respect to abundance and frequency of occurrence. This group was abundant at either surface or bottom depths at ocean stations throughout the sampling period (Figure E-1; Tables E-1 through E-5). The urochordates were represented primarily by the two larvaceans, Oikopleura, which was most common throughout the sampling period, and Fritillaria.

Other holoplankters which were major contributors to the ocean zooplankton community during 1982 and in previous study years included the sergestid shrimp Lucifer sp., and the ostracod Conchoecia elegans, which is the most common planktonic marine ostracod. Ostracods were most prevalent at the bottom at Stations 2, 3 and 4 (Figure E-1), where they represented 14 to 32 percent of the total zooplankton in January and 12 to 31 percent in March (Tables E-1 and E-3).

Meroplanktonic groups were occasionally major contributors to the zooplankton community between January and May. As in previous studies, the more important meroplanktonic representatives included barnacle nauplii and polychaete, mollusc and decapod larvae. Echinoderm larvae and crustacean nauplii were also major contributors to the zooplankton at the surface in May. These meroplanktonic groups generally exhibited patchy distributions among depths and stations. Barnacle, polychaete and decapod groups were most abundant at bottom depths. Echinoderm larvae accounted for 50 percent of the total zooplankton at the surface at Station 5 in May, but generally represented less than six percent of the total zooplankton.

Zooplankton composition througnout the 1982 sampling period was typical of that observed over similar sampling periods in previous monitoring years. No major changes in species composition or abundance, indicative of adverse power plant operational effects, have been observed at ocean stations.

As in previous studies, species composition in the canals varied somewhat from that at ocean stations. Urochordates and copepods were less abundant in the canals than at ocean stations, while mollusc larvae were relatively more abundant than at ocean stations. The major zooplankton groups in the canals were copepods, barnacle nauplii and mollusc larvae. These three groups, which have typically been dominant in the canals, represented more than 60 percent of the total zooplankton over the 1982 sampling period.

Density Trends

Throughout monitoring studies at the St. Lucie Plant, peaks in zooplankton density at ocean stations have been observed in spring (March or April) and/or and late summer (July, August or September; Figure E-3). Between January and May 1982, monthly zooplankton density was highest in March. Average zooplankton density in March was the highest recorded since monitoring began at the St. Lucie Plant. The high densities were not attributable to a single group but rather resulted from increased densities of copepods, ostracods and urochordates at most ocean stations along with increased polychaete and decapod larvae at some of the ocean stations (Table E-3). In general, the ranges in zooplankton density were

consistent with those observed during previous monitoring studies at the St. Lucie Plant (Figures E-3 and E-4), and were generally similar to ranges reported for other Florida waters (Grice, 1957; Owre and Foyo, 1967; Reeve, 1970).

Overall, zooplankton density was slightly greater at bottom depths than at the surface between 1976 and 1981. This trend continued in 1982, when zooplankton densities ranged from 467/m^3 at the surface at Station 4 in February to 41,391/m^3 at the bottom at Station 0 in March. The high density at Station 0 resulted from exceptionally high densities of polychaete larvae and barnacle nauplii as compared to other ocean stations in March.

The temporal and spatial trends in zooplankton density were also reflected in the biomass variation at ocean stations between January and May 1982. Zooplankton biomass at ocean stations ranged from 1.8 mg/m^3 at the surface to 216.1 mg/m^3 at the bottom during the sampling period (Table E-6). Average biomass was highest in May and somewhat higher at bottom depths than at the surface over the sampling period.

Temporal and spatial variations in zooplankton abundance are normal responses to changing environmental conditions. Youngbluth (1980) found that variation in zooplankton composition and density was related to changes in water circulation, seasonal rainfall and diel behavior. Vidal (1980) observed fluctuations in the distribution and rates of recruitment, growth and mortality of various species resulting from changes in biotic and abiotic factors.

Canal Station Comparisons

Zooplankton densities in the intake canal have typically been greater than those in the discharge canal, although these differences have not been statistically significant. The overall reduction in zooplankton densities between the intake and discharge canals observed during previous studies was attributed to the loss of organisms upon passage through the plant (ABI, 1982). During the January to May 1982 sampling period, both zooplankton density and biomass were generally higher in the discharge canal (Tables E-6 and E-7; Figure E-5). There was no apparent relationship between change in water temperature and change in zooplankton density between the canals. However, the lowest ambient water temperatures are generally encountered between January and May. In 1981, the largest reductions in zooplankton density between the intake and discharge canals occurred between June and October, when ambient water temperatures are highest.

Densities of urochordates, coelenterates and mollusc larvae were generally reduced between the intake and discharge canals during 1982. Reduced zooplankton density in the discharge canal in March was primarily because of reduced abundance of urochordates and decapod larvae. Higher densities in the discharge canal in February, April and May were generally attributable to greater abundance of copepods and barnacle nauplii, although most zooplankton groups exhibited higher densities in the discharge canal in May when the plant was in a limited operational mode.

Fluctuations in zooplankton density and composition between the canal stations has typically been observed and result from interactions between physicochemical parameters and biotic factors as well as from plant related effects. Reductions in zooplankton density between the intake and discharge canals typically result from mortality due to turbulence, elevated water temperatures and mechanical stress associated with plant passage. However, during periods of limited plant operation, when water temperature and turbulence are reduced, zooplankton populations may increase in the discharge canals because zooplankters are opportunistic organisms which respond to improved environmental conditions through rapid increases in population.

Ocean Station Comparisons

As in previous monitoring, zooplankton density and biomass in 1982 were generally greatest at Stations 0, 1 and 5 (Tables E-1 through E-6). Stations located nearest Hutchinson Island (Stations 0 and 1) have typically been more productive than stations further offshore (Stations 2, 3 and 4). This differential productivity is likely related to the greater food availability in the nearshore area along Hutchinson Island.

Between January and May 1982, zooplankton abundance at Station 1 was not as great, relative to that at other ocean stations, as in previous study years. This was largely because of differences among the ocean stations in March, the peak productivity period, when peak densities observed at ocean Stations 0, 2, 4 and 5 were greater than at Station 1. Although zooplankton composition was generally similar among these sta-

tions in March, densities of copepods, chaetognaths, polychaete and decapod larvae at Station 0 and of copepods and decapod larvae at Station 5 were considerably greater than at Station 1.

It is not known whether the trend in density over the remainder of the year would have shown enhanced zooplankton abundance at Station 1 as had been observed in previous study years. However, there were no consistent differences in zooplankton abundance or composition among ocean stations from January through May 1982 that would indicate adverse influence from the ocean discharge at the St. Lucie Plant.

Baseline Versus Operational Study Comparisons

Data collected between January and May 1982 showed consistent similarities with baseline and previous operational studies. Holoplanktonic species dominated the zooplankton community and adult copepods were the most abundant zooplankton group. The calanoid copepod Paracalanus was one of the dominant copepod taxa recorded and has been observed in all zooplankton collections in the St. Lucie Plant study area. Other important copepod genera, which have frequently occurred in both baseline and operational studies, were Acartia, Temora, Oithona, Labidocera and Euterpina. Zooplankters that occurred seasonally during all study years and which were important in 1982 included the larvacean Oikopleura, mollusc and echinoderm larvae, coelenterates, the cladoceran Evadne, the ostracod Conchoecia, and barnacle nauplii. Zooplankton densities from January through May 1982 were generally within the ranges observed over comparable sampling periods during baseline and previous operational monitoring.

SUMMARY

Zooplankton composition between January and May 1982 was typical of that during similar sampling periods in previous studies. The ocean zooplankton community was characterized by neritic holoplanktonic species. As in previous studies, copepods were the dominant zooplankton group and the most important copepods were Paracalanus spp., Acartia spp., Temora turbinata and Labidocera aestiva. Holoplanktonic urochordates, principally represented by the larvaceans Oikopleura and Fritillaria, were the second most important zooplankton group. Meroplanktonic groups, which were major contributors to the zooplankton during brief periods, included barnacle and crustacean nauplii, polychaete, mollusc, decapod and echinoderm larvae. Major changes in zooplankton composition, which would indicate adverse power plant operation effects, have not been observed at ocean stations. Zooplankton composition in the canals varied somewhat from that at ocean stations, but was typical of the composition observed during previous studies.

The characteristic spring peak in zooplankton density occurred at ocean stations in March 1982, when average density was the highest recorded since monitoring began at the St. Lucie Plant. The high densities resulted from a general increase in the densities of several zooplankton groups. In general, the ranges in zooplankton density between January and May were consistent with data from previous monitoring studies at the St. Lucie Plant.

Fluctuations in zooplankton density and composition between the intake and discharge canals have typically been observed and result from interactions between physicochemical parameters and biotic factors as well as from plant related effects. Between January and May, when the lowest ambient water temperatures typically occur, both zooplankton density and biomass were generally higher in the discharge canal.

Zooplankton density and biomass were generally greater during the years of environmental monitoring at nearshore ocean Stations 0 and 1, which have typically been more productive than stations further offshore. Over the five month sampling period in 1982, however, zooplankton abundance was not as great at Station 1, relative to the other ocean stations. The low average density at Station 1 resulted from the relatively low density at this station in March, the peak productivity period, when peak densities at ocean Stations 0, 2, 4 and 5 were greater than those at Station 1. It is not known whether the density trend over the remainder of 1982 would have resulted in higher average density at Station 1. The 1982 data were generally consistent with those observed during previous baseline and operational studies. There were no consistent differences in zooplankton density and composition among ocean stations which indicates that there were no adverse influences resulting from ocean discharge at the St. Lucie Plant.

LITERATURE CITED

ABI (Applied Biology, Inc.). 1977. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1976. Vol. 1. AB-44. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

___________________________. 1978. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1977. Vol. 1. AB-101. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

______________________________. 1979. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1978. Volume III, Biotic monitoring. AB-177. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

______________________________. 1980. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1979. Volume III, Biotic monitoring. AB-244. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

______________________________. 1981. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1980. Volume III, Biotic monitoring. AB-324. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

______________________________. 1982. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report 1981. Volume III, Biotic monitoring. AB-379. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

Coutant, C.C. 1970. Biological aspects of thermal pollution. I. Entrainment and discharge canal effects. CRC Critical Reviews in Environmental Control 1(3):341-381.

Davies, R.M., C.H. Hanson and L.D. Jensen. 1976. Entrainment of estuarine zooplankton into a mid-Atlantic power plant: Delayed effects. Pages 349-357 in G.W. Esch and R.W. McFarlane, eds. Thermal ecology II. ERDA Symposium (CONF-750425). Augusta, Ga.

Enright, J.T. 1978. Power plants and plankton. Marine Pollution Bulletin 8(7):158-160.

EPA (Environmental Protection Agency). 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA-670/4-73-001. U.S. Environmental Protection Agency. National Environmental Research Center, Cincinnati, Ohio.

Grice, G.D. 1957. The copepods of the Florida west coast. Ph.D. Dissertation. Florida State University, Tallahassee. 253 pp.

LITERATURE CITED (continued)

Marcy, B.C., Jr., A.D. Beck and R.E. Ulanowicz. 1978. Effects and impacts of physical stress on entrained organisms. Pages 136-165 in J.R. Schubel and B.C. Marcy, Jr., eds. Power plant entrainment, a biological assessment. Academic Press, New York. 271 pp.

Mihursky, J.A. and V.S. Kennedy. 1967. Water temperature criteria to protect aquatic life. American Fisheries Society. Special Publication No. 4:20-32.

Owre, H.B. and M. Foyo. 1967. Copepods of the Florida current. Fauna Caribaea No. 1. Crustacea, Part 1: Copepoda. Institute of Marine Science, University of Miami. 137 pp.

Polgar, T.T., L.H. Bongers and G.M. Krainak. 19/5. Assessment of power plant effects on zooplankton in the near field. Pages 358-367 in G.W. Esch and R.W. McFarlane, eds. Thermal ecology II. ERDA Symposium (CONF-750425). Augusta, Ga.

Reeve, M.R. 1970. Seasonal changes in zooplankton of south Biscayne Bay and some problems of assessing the effects on the zooplankton of natural and artificial thermal and other fluctuations. Bulletin of Marine Science. 20:894-921.

Vidal, J. 1980. Physioecology of zooplankton. II. Effect of phytoplankton concentration, temperature and body size on the development and moulting rates of Calanus pacificus and Pseudocalanus sp. Marine Biology 56:135-146.

Walker, L.M., B.M. Glass and B.S. Roberts. 1979. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. IV. Zooplankton, 1971-1973. Florida Department of Natural Resources Marine Research Laboratory, Florida Marine Research Publication No. 34:62-98.

Youngbluth, M.J. 1980. Daily, seasonal and annual fluctuations among zooplankton populations in an unpolluted tropical embayment. Estuarine and Coastal Marine Science 10:265-287.

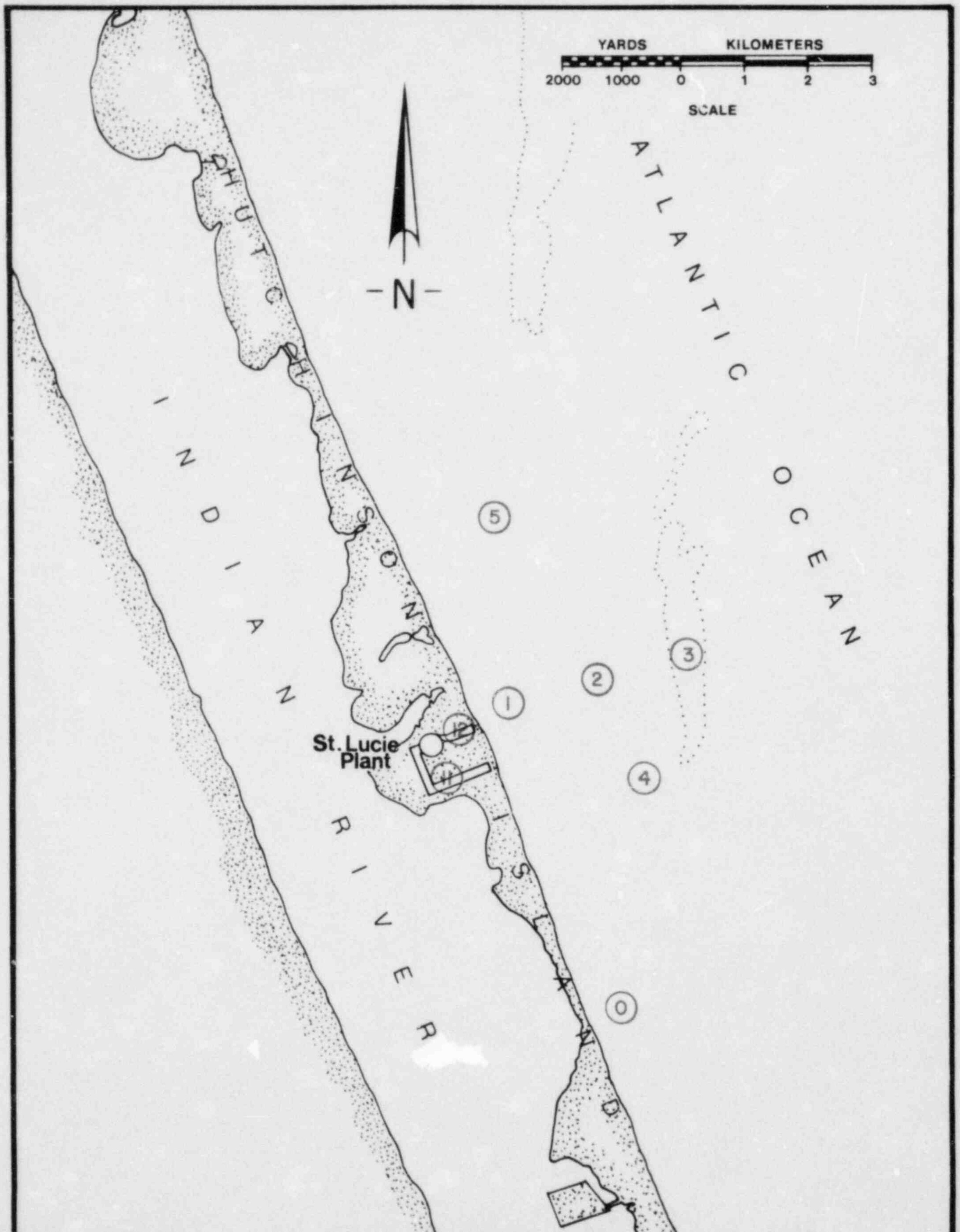

Figure E-1. Location of zooplankton sampling stations, St. Lucie Plant, 1982.

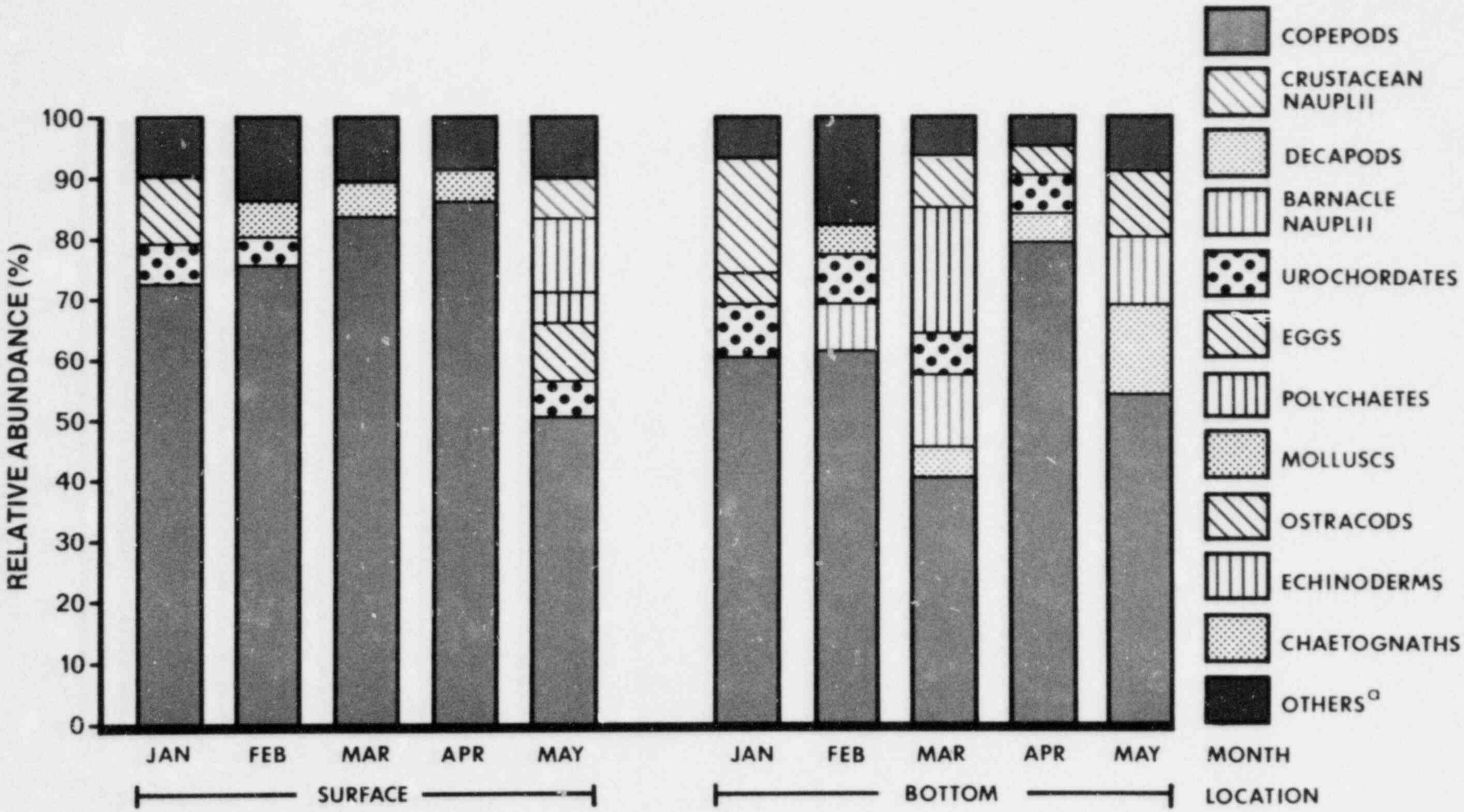

Figure E-2. Relative abundance of major zooplankton groups at ocean Stations 0 through 5, St. Lucie Plant, 1982.
[a]Any group representing less than five percent of the total phytoplankton density.

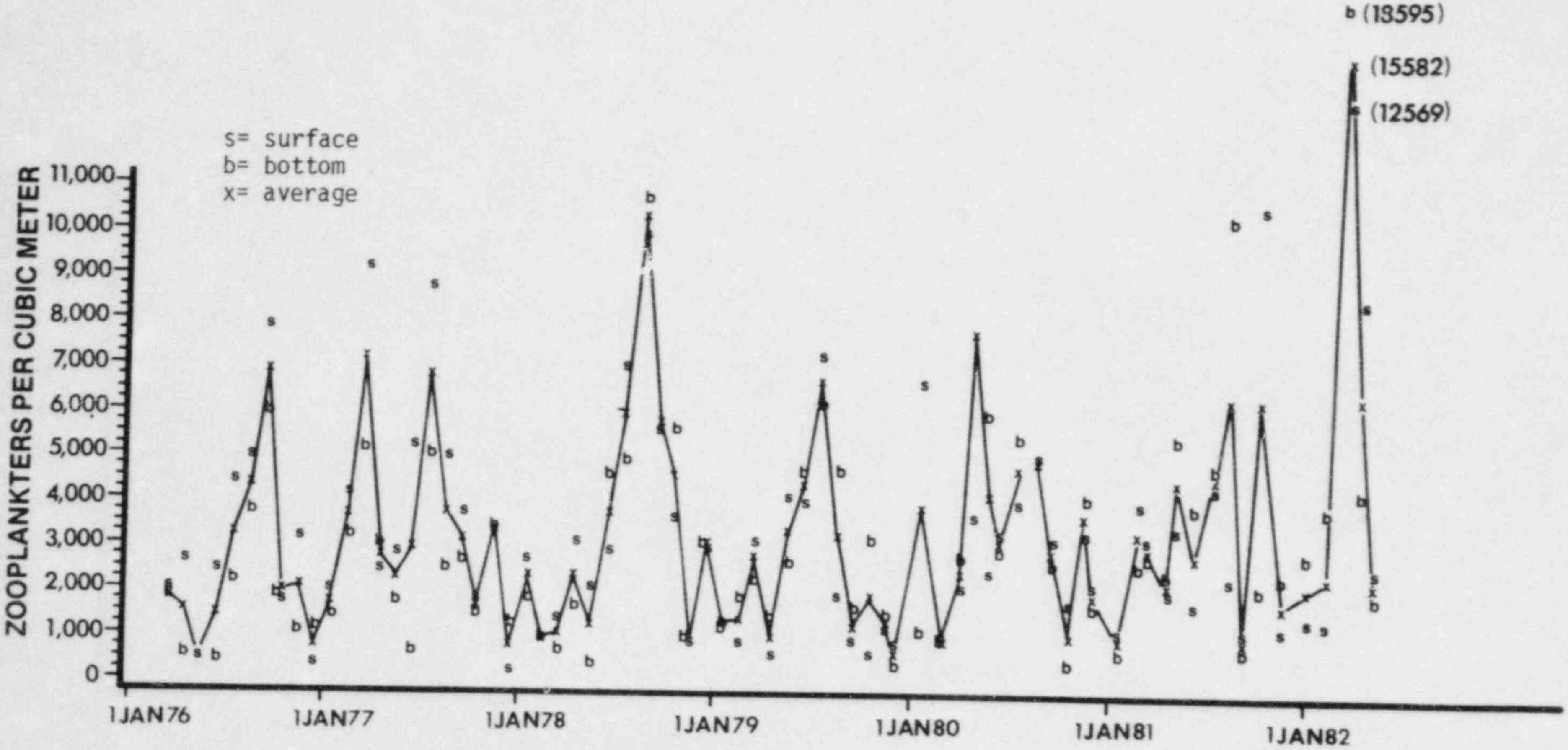

Figure E-3. Average monthly surface and bottom zooplankton desities at ocean Stations 0 through 5, St. Lucie Plant, March 1976 - May 1982.

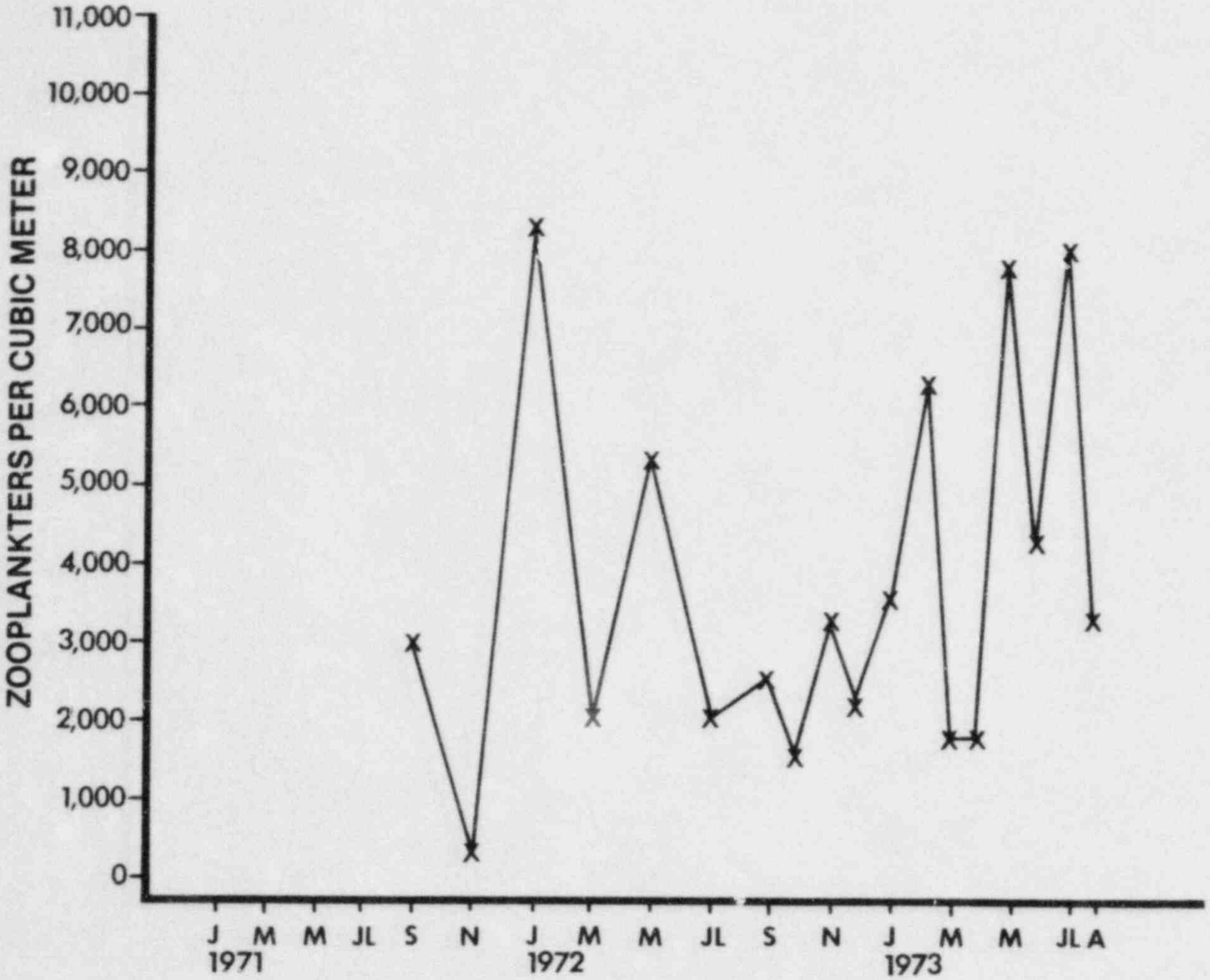

Figure E-4. Average density of zooplankton at ocean Stations 1 through 5 during baseline monitoring, St. Lucie Plant, September 1971 - August 1973.

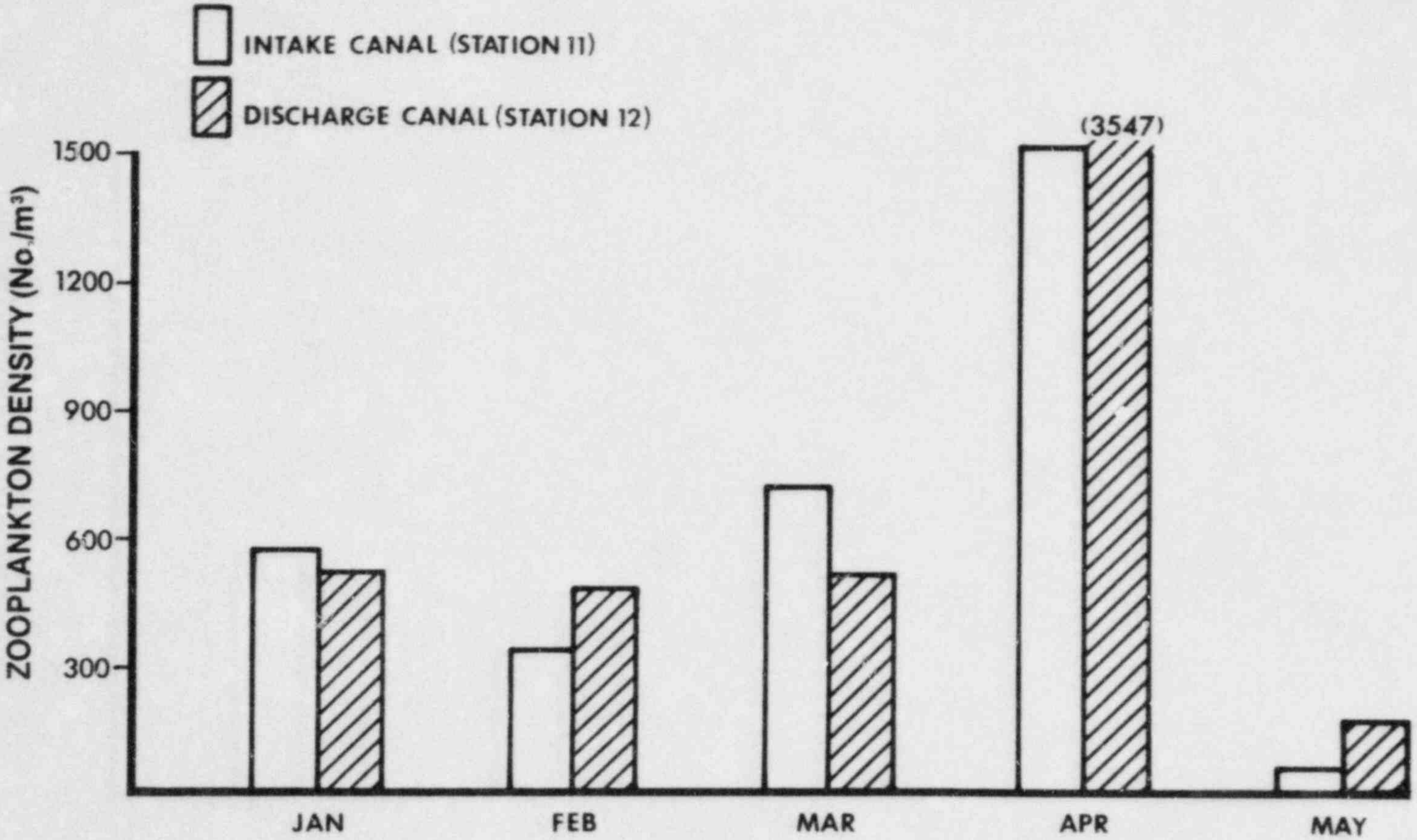

Figure E-5. Zooplankton density at Stations 11 and 12, St. Lucie Plant, January-May 1982.

TABLE E-1

DENSITY* AND PERCENTAGE COMPOSITION** OF MAJOR ZOOPLANKTON TAXA
ST.LUCIE PLANT
20 JANUARY 1982

	STATION AND DEPTH***													
	11	12	0		1		2		3		4		5	
	O	O	S	B	S	B	S	B	S	B	S	B	S	B
PROTOZOA	0.0	10.1 (2)	0.0	8.4 (<1)	15.0 (<1)	4.0 (<1)	31.7 (2)	0.0	11.4 (1)	6.0 (<1)	35.9 (3)	16.3 (<1)	11.8 (2)	9.4 (<1)
COELENTERATA	1.3 (<1)	0.0	23.0 (2)	9.8 (1)	16.9 (<1)	4.0 (<1)	2.4 (<1)	10.8 (<1)	9.5 (1)	6.0 (<1)	2.9 (<1)	16.3 (<1)	8.2 (1)	7.6 (<1)
MOLLUSCA	45.8 (8)	28.4 (6)	36.9 (3)	43.3 (5)	41.4 (2)	38.6 (4)	14.6 (1)	48.5 (<1)	11.4 (1)	66.0 (1)	11.5 (<1)	22.8 (1)	6.4 (<1)	28.4 (2)
POLYCHAETA	0.0	0.0	6.9 (<1)	2.8 (<1)	0.0	1.3 (<1)	4.9 (<1)	5.4 (<1)	5.7 (<1)	12.0 (<1)	7.2 (<1)	0.0	2.7 (<1)	0.0
CRUSTACEA nauplii	0.0	0.0	20.7 (1)	2.8 (<1)	30.1 (1)	6.6 (<1)	7.3 (<1)	0.0	5.7 (<1)	24.0 (<1)	17.3 (1)	9.8 (<1)	9.1 (1)	0.0
cladocera	0.0	0.0	4.6 (<1)	1.4 (<1)	0.0	0.0	0.0	0.0	0.0	0.0	2.9 (<1)	0.0	.9 (<1)	0.0
ostracoda	0.0	0.0	0.0	1.4 (<1)	3.8 (<1)	8.0 (<1)	7.3 (<1)	2084.8 (32)	38.1 (4)	666.2 (14)	0.0	309.9 (16)	.9 (<1)	28.3 (2)
copepoda	43.1 (8)	40.3 (8)	1088.0 (75)	666.1 (74)	1533.3 (74)	814.8 (78)	1026.9 (73)	3657.9 (56)	472.0 (54)	2640.8 (57)	1006.6 (78)	1053.6 (53)	469.6 (67)	1006.7 (74)
cirripedia (barnacle nauplii)	444.1 (79)	398.4 (78)	0.0	0.0	50.7 (2)	1.3 (<1)	0.0	32.3 (<1)	1.9 (<1)	36.0 (<1)	0.0	0.0	0.0	7.6 (<1)
decapoda	1.3 (<1)	3.0 (<1)	6.9 (<1)	30.8 (3)	22.6 (1)	27.9 (3)	7.2 (<1)	150.8 (2)	19.0 (2)	72.0 (2)	8.5 (<1)	45.8 (2)	4.5 (<1)	18.9 (1)
others	1.4 (<1)	3.0 (<1)	2.3 (<1)	1.4 (<1)	3.8 (<1)	2.6 (<1)	9.8 (<1)	43.1 (<1)	7.6 (<1)	0.0	0.0	0.0	0.0	3.8 (<1)
CHAETOGNATHA	.7 (<1)	0.0	9.2 (<1)	15.4 (2)	20.7 (1)	9.3 (<1)	19.5 (1)	43.1 (<1)	13.3 (2)	72.0 (2)	20.1 (2)	4[illegible].4 (2)	12.7 (2)	24.6 (2)
ECHINODERMATA	0.0	0.0	2.3 (<1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.9 (<1)	0.0
CHORDATA urochordata	1.4 (<1)	0.0	73.8 (5)	55.9 (6)	165.4 (8)	38.5 (4)	122.0 (9)	264.0 (4)	119.9 (14)	702.2 (15)	40.2 (3)	287.0 (14)	33.6 (5)	94.4 (7)
fish (eggs and larvae)	0.0	0.0	2.3 (<1)	0.0	3.8 (<1)	0.0	9.8 (<1)	0.0	1.9 (<1)	0.0	12.9 (<1)	3.3 (<1)	20.0 (3)	1.9 (<1)
EGGS	20.9 (4)	30.2 (6)	163.7 (11)	62.8 (7)	157.8 (8)	89.1 (9)	136.6 (10)	140.1 (2)	158.0 (18)	312.1 (7)	129.4 (10)	185.9 (9)	122.6 (17)	120.9 (9)
MISCELLANEOUS	0.0	0.0	4.6 (<1)	0.0	1.9 (<1)	0.0	0.0	0.0	1.9 (<1)	0.0	0.0	0.0	.9 (<1)	0.0
TOTAL ZOOPLANKTON	560.0	513.4	1445.2	902.3	2067.2	1046.0	1400.0	6480.8	877.3	4615.3	1295.4	1993.1	704.8	1352.5

* DENSITY IS EXPRESSED IN NUMBER OF ZOOPLANKTERS PER CUBIC METER

** NUMBER IN PARENTHESES IS PERCENTAGE COMPOSITION EXPRESSED IN PERCENT

*** O = OBLIQUE; S = SURFACE; B = BOTTOM

TABLE E-2

DENSITY[*] AND PERCENTAGE COMPOSITION[**] OF MAJOR ZOOPLANKTON TAXA
ST. LUCIE PLANT
24 FEBRUARY 1982

	11 O	12 O	0 S	0 B	1 S	1 B	2 S	2 B	3 S	3 B	4 S	4 B	5 S	5 B
	STATION AND DEPTH[***]													
PROTOZOA	0.0	25.8 (5)	0.0	0.0	4.4 (<1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COELENTERATA	6.2 (2)	.7 (<1)	2.4 (<1)	83.4 (2)	11.1 (<1)	87.7 (2)	2.1 (<1)	22.2 (1)	18.8 (2)	125.2 (2)	0.0	153.7 (6)	5.3 (<1)	211.4 (6)
MOLLUSCA	131.6 (41)	126.2 (27)	32.6 (5)	278.2 (8)	226.3 (12)	192.9 (5)	22.6 (3)	41.5 (3)	17.4 (2)	357.7 (6)	.1 (<1)	43.0 (2)	19.9 (2)	157.7 (4)
POLYCHAETA	4.8 (1)	5.3 (1)	8.2 (1)	182.8 (5)	37.7 (2)	219.2 (6)	0.0	31.1 (2)	7.7 (<1)	155.0 (2)	.1 (<1)	64.6 (3)	2.7 (<1)	87.3 (2)
CRUSTACEA nauplii	6.6 (2)	7.9 (2)	3.3 (<1)	79.5 (2)	51.0 (3)	175.4 (5)	5.0 (<1)	69.5 (4)	27.9 (3)	29.8 (<1)	0.0	132.2 (5)	87.5 (9)	73.8 (2)
ostracoda	0.0	0.0	0.0	4.0 (<1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
copepoda	88.6 (28)	155.2 (33)	480.4 (78)	2058.8 (60)	1399.9 (74)	2323.7 (64)	543.1 (79)	988.1 (62)	540.7 (65)	4184.8 (67)	11.5 (77)	1076.0 (43)	746.4 (77)	2399.5 (64)
cirripedia (barnacle nauplii)	43.9 (14)	107.0 (23)	0.0	226.5 (7)	15.5 (<1)	197.3 (5)	1.4 (<1)	147.9 (9)	12.5 (2)	321.9 (5)	.1 (<1)	470.4 (19)	5.3 (<1)	245.0 (7)
decapoda	10.0 (3)	6.0 (1)	1.6 (<1)	39.8 (1)	8.8 (<1)	48.3 (1)	28.9 (4)	56.2 (4)	33.5 (4)	208.7 (3)	1.5 (10)	67.6 (3)	30.4 (3)	157.7 (4)
others	4.8 (1)	21.1 (4)	0.0	4.0 (<1)	2.2 (<1)	8.8 (<1)	2.1 (<1)	4.4 (<1)	0.0	0.0	0.0	0.0	0.0	13.4 (<1)
CHAETOGNATHA	2.6 (<1)	5.9 (1)	4.9 (<1)	55.6 (2)	39.9 (2)	83.3 (2)	14.9 (2)	3.0 (<1)	22.3 (3)	232.5 (4)	.2 (1)	12.3 (<1)	9.3 (<1)	63.8 (2)
ECHINODERMATA	0.0	1.3 (<1)	.8 (<1)	15.9 (<1)	0.0	4.4 (<1)	2.1 (<1)	42.9 (3)	16.0 (2)	101.3 (2)	0.0	107.6 (4)	4.0 (<1)	23.5 (<1)
CHORDATA urochordata	5.7 (2)	2.7 (<1)	33.4 (5)	349.8 (10)	57.7 (3)	254.3 (7)	27.6 (4)	171.6 (11)	82.9 (10)	417.3 (7)	.6 (4)	310.5 (12)	37.1 (4)	255.1 (7)
fish (eggs and larvae)	2.6 (<1)	.7 (<1)	5.7 (<1)	7.9 (<1)	6.6 (<1)	0.0	.7 (<1)	8.9 (<1)	2.1 (<1)	17.9 (<1)	.1 (<1)	6.2 (<1)	1.3 (<1)	6.8 (<1)
EGGS	5.3 (2)	1.3 (<1)	43.2 (7)	19.9 (<1)	20.0 (1)	35.1 (<1)	40.3 (6)	1.5 (<1)	43.9 (5)	95.4 (2)	.7 (.5)	30.7 (1)	17.2 (2)	43.6 (1)
MISCELLANEOUS	7.9 (2)	4.6 (<1)	.8 (<1)	31.8 (<1)	6.7 (<1)	8.8 (<1)	.7 (<1)	7.4 (<1)	7.0 (<1)	29.8 (<1)	0.0	33.8 (1)	0.0	23.5 (<1)
TOTAL ZOOPLANKTON	320.6	471.7	617.3	3437.9	1887.8	3639.2	691.5	1596.2	832.7	6277.3	14.9	2508.6	966.4	3762.1

[*] DENSITY IS EXPRESSED IN NUMBER OF ZOOPLANKTERS PER CUBIC METER

[**] NUMBER IN PARENTHESES IS PERCENTAGE COMPOSITION EXPRESSED IN PERCENT

[***] O = OBLIQUE; S = SURFACE; B = BOTTOM

TABLE E-3

DENSITY* AND PERCENTAGE COMPOSITION** OF MAJOR ZOOPLANKTON TAXA
ST.LUCIE PLANT
17 MARCH 1982

	STATION AND DEPTH***													
	11	12	0		1		2		3		4		5	
	O	O	S	B	S	B	S	B	S	B	S	B	S	B
PROTOZOA	0.0	4.8 ((1)	0.0	0.0	0.0	55.7 ((1)	0.0	0.0	13.1 ((1)	32.6 ((1)	0.0	35.7 ((1)	0.0	40.0 ((1)
COELENTERATA	11.3 (2)	3.6 ((1)	149.8 ((1)	130.4 ((1)	64.0 (1)	111.5 ((1)	49.2 ((1)	78.6 ((1)	0.0	0.0	12.2 ((1)	0.0	184.9 ((1)	20.0 ((1)
MOLLUSCA	24.9 (3)	4.8 ((1)	535.1 (3)	456.2 (1)	248.0 (4)	27.9 ((1)	68.8 ((1)	118.0 ((1)	26.2 ((1)	32.6 ((1)	61.2 ((1)	53.6 ((1)	170.6 ((1)	20.0 ((1)
POLYCHAETA	173.9 (24)	10.7 (2)	1145.2 (6)	14405.4 (35)	184.1 (3)	1337.0 (9)	19.7 ((1)	4288.0 (19)	13.0 ((1)	774.9 (10)	61.2 ((1)	2126.7 (18)	113.8 ((1)	440.2 (4)
CRUSTACEA nauplii	6.8 ((1)	4.8 ((1)	42.8 ((1)	195.5 ((1)	48.0 ((1)	55.7 ((1)	98.4 (1)	78.7 ((1)	0.0	24.5 ((1)	0.0	0.0	0.0	100.0 ((1)
cladocera	0.0	1.2 ((1)	0.0	0.0	0.0	0.0	0.0	0.0	6.5 ((1)	0.0	24.5 ((1)	0.0	0.0	0.0
ostracoda	4.5 ((1)	1.2 ((1)	10.7 ((1)	65.2 ((1)	0.0	0.0	0.0	4170.0 (18)	13.1 ((1)	929.9 (12)	61.2 ((1)	3752.9 (31)	14.2 ((1)	20.0 ((1)
copepoda	135.5 (19)	173.0 (35)	13303.4 (69)	8669.3 (21)	4177.3 (68)	8133.7 (53)	6452.0 (82)	10110.3 (44)	4982.1 (89)	5204.3 (65)	11574.3 (88)	4771.6 (40)	22282.4 (96)	8143.3 (67)
cirripedia (barnacle nauplii)	18.1 (3)	88.3 (18)	909.8 (5)	11732.9 (28)	80.0 (1)	640.7 (4)	108.2 (1)	236.1 (1)	0.0	8.2 ((1)	0.0	35.7 ((1)	28.4 ((1)	720.3 (6)
decapoda	128.9 (18)	76.4 (15)	21.4 ((1)	2281.5 (6)	88.0 (1)	362.2 (2)	39.3 ((1)	629.4 (3)	26.1 ((1)	261.0 (3)	171.2 (1)	464.6 (4)	85.3 ((1)	1160.4 (10)
others	2.3 ((1)	10.8 (2)	0.0	195.6 ((1)	0.0	0.0	0.0	0.0	0.0	16.4 ((1)	12.2 ((1)	17.9 ((1)	0.0	40.0 ((1)
CHAETOGNATHA	42.9 (6)	7.2 (1)	2729.2 (14)	782.2 (2)	448.1 (7)	640.7 (4)	550.8 (7)	668.8 (3)	163.5 (3)	318.1 (4)	636.2 (5)	125.1 (1)	113.8 ((1)	760.3 (6)
ECHINODERMATA	0.0	0.0	10.7 ((1)	0.0	0.0	27.9 ((1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHORDATA urochordata	119.7 (17)	8.4 (2)	32.1 ((1)	1564.4 (4)	536.1 (9)	3649.0 (24)	147.5 (2)	2203.1 (10)	39.2 ((1)	122.3 (2)	110.1 ((1)	339.6 (3)	56.9 ((1)	360.1 (3)
fish (eggs and larvae)	0.0	0.0	0.0	65.2 ((1)	0.0	27.9 ((1)	0.0	78.6 ((1)	0.0	8.2 ((1)	12.2 ((1)	17.9 ((1)	0.0	0.0
EGGS	47.4 (7)	101.4 (20)	428.1 (2)	847.4 (2)	272.1 (4)	195.0 (1)	295.1 (4)	236.0 (1)	307.3 (5)	261.0 (3)	489.4 (4)	196.6 (2)	256.0 (1)	260.1 (2)
TOTAL ZOOPLANKTON	716.2	496.6	19318.3	41391.2	6145.7	15264.9	7829.0	22895.6	5590.1	7994.0	13225.9	11937.9	23306.3	12084.7

* DENSITY IS EXPRESSED IN NUMBER OF ZOOPLANKTERS PER CUBIC METER
** NUMBER IN PARENTHESES IS PERCENTAGE COMPOSITION EXPRESSED IN PERCENT
*** O = OBLIQUE; S = SURFACE; B = BOTTOM

TABLE E-4

DENSITY* AND PERCENTAGE COMPOSITION** OF MAJOR ZOOPLANKTON TAXA
ST. LUCIE PLANT
14 APRIL 1982

	STATION AND DEPTH***													
	11	12	0		1		2		3		4		5	
	O	O	S	B	S	B	S	B	S	B	S	B	S	B
PROTOZOA	15.5 (1)	0.0	10.9 ((1)	0.0	9.3 ((1)	0.0	12.4 ((1)	0.0	4.8 ((1)	0.0	18.5 ((1)	1.8 ((1)	24.4 ((1)	38.3 ((1)
COELENTERATA	0.0	0.0	43.6 ((1)	27.9 ((1)	93.2 ((1)	13.4 ((1)	0.0	0.0	4.8 ((1)	2.6 ((1)	6.9 ((1)	3.7 ((1)	34.2 ((1)	0.0
MOLLUSCA	423.2 (28)	1302.2 (37)	250.8 (1)	97.4 (1)	1845.8 (16)	391.8 (9)	60.0 (3)	30.5 (2)	26.2 (1)	1.3 ((1)	78.7 (3)	34.9 (2)	156.4 (2)	76.6 (1)
POLYCHAETA	0.0	16.2 ((1)	0.0	14.0 ((1)	37.3 ((1)	13.4 ((1)	5.3 ((1)	0.0	2.4 ((1)	0.0	9.2 ((1)	0.0	0.0	7.7 ((1)
CRUSTACEA														
cladocera	0.0	0.0	0.0	0.0	0.0	0.0	1.8 ((1)	0.0	4.8 ((1)	0.0	2.3 ((1)	0.0	0.0	0.0
ostracoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8 ((1)	0.0	0.0	0.0	9.2 ((1)	4.9 ((1)	0.0
copepoda	772.9 (51)	1699.1 (48)	21652.3 (93)	8162.4 (86)	8464.6 (75)	3566.2 (80)	1733.5 (79)	1170.3 (61)	1987.2 (77)	430.1 (85)	2362.8 (81)	1035.8 (64)	5490.4 (85)	4812.7 (76)
cirripedia (barnacle nauplii)	175.8 (12)	304.1 (9)	119.9 ((1)	20.9 ((1)	83.9 ((1)	151.4 (3)	10.6 ((1)	7.6 ((1)	16.7 ((1)	4.0 ((1)	25.5 ((1)	5.5 ((1)	317.7 (5)	84.2 (1)
decapoda	9.7 ((1)	71.9 (2)	87.2 ((1)	334.1 (4)	93.1 ((1)	66.9 (1)	35.4 (2)	213.9 (11)	173.8 (7)	20.7 (4)	71.7 (2)	102.7 (6)	92.9 (1)	375.1 (6)
others	40.5 (3)	37.1 (1)	0.0	0.0	0.0	17.9 ((1)	0.0	3.8 ((1)	0.0	1.4 ((1)	0.0	1.8 ((1)	9.8 ((1)	7.7 ((1)
CHAETOGNATHA	0.0	13.9 ((1)	185.3 ((1)	20.9 ((1)	111.9 ((1)	4.5 ((1)	19.4 ((1)	76.5 (4)	33.3 (1)	12.7 (2)	11.6 ((1)	42.2 (3)	83.1 (1)	122.4 (2)
ECHINODERMATA	0.0	0.0	0.0	0.0	37.3 ((1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHORDATA														
urochordata	0.0	0.0	577.8 (2)	501.0 (5)	270.3 (2)	129.1 (3)	58.3 (3)	130.0 (7)	102.4 (4)	12.7 (2)	39.4 (1)	157.6 (10)	78.2 (1)	528.0 (8)
fish (eggs and larvae)	0.0	4.6 ((1)	0.0	27.8 (1)	0.0	4.5 ((1)	3.6 ((1)	42.1 (2)	14.3 ((1)	.7 ((1)	4.6 ((1)	49.5 (3)	14.7 ((1)	15.3 ((1)
EGGS	67.6 (4)	97.5 (3)	283.5 (1)	320.1 (3)	251.7 (2)	120.2 (3)	252.7 (12)	252.4 (13)	199.9 (8)	22.7 (4)	282.6 (10)	165.0 (10)	180.9 (3)	252.5 (4)
TOTAL ZOOPLANKTON	1505.2	3546.6	23211.3	9526.5	11298.4	4479.3	2193.0	1930.9	2570.6	508.9	2913.8	1609.7	6487.6	6320.5

* DENSITY IS EXPRESSED IN NUMBER OF ZOOPLANKTERS PER CUBIC METER

** NUMBER IN PARENTHESES IS PERCENTAGE COMPOSITION EXPRESSED IN PERCENT

*** O = OBLIQUE; S = SURFACE; B = BOTTOM

TABLE E-5

DENSITY* AND PERCENTAGE COMPOSITION** OF MAJOR ZOOPLANKTON TAXA
ST.LUCIE PLANT
18 MAY 1982

	STATION AND DEPTH***													
	11	12	0		1		2		3		4		5	
	O	O	S	B	S	B	S	B	S	B	S	B	S	B
PROTOZOA	2.2 (4)	3.5 (2)	14.4 (1)	8.7 ((1)	14.6 ((1)	0.0	59.0 (3)	26.3 (1)	60.0 (3)	14.6 (1)	45.4 (3)	72.6 (2)	24.1 ((1)	1.6 ((1)
COELENTERATA	0.0	0.0	2.6 ((1)	0.0	4.5 ((1)	.7 ((1)	2.3 ((1)	8.8 ((1)	0.0	0.0	3.5 ((1)	3.5 ((1)	3.4 ((1)	0.0
MOLLUSCA	15.4 (29)	29.1 (17)	54.9 (4)	33.0 (3)	72.0 (5)	31.6 (5)	54.4 (2)	108.1 (5)	115.2 (6)	51.1 (5)	27.9 (2)	124.5 (4)	70.1 (3)	87.4 (5)
POLYCHAETA	.6 (1)	3.9 (2)	64.0 (5)	3.5 ((1)	148.5 (10)	7.3 (1)	34.0 (1)	17.5 ((1)	96.0 (5)	4.9 ((1)	75.0 (5)	0.0	87.4 (4)	6.6 ((1)
CRUSTACEA nauplii	0.0	0.0	81.0 (6)	22.6 (2)	23.6 (2)	2.5 ((1)	342.4 (15)	49.7 (2)	45.6 (3)	0.0	267.0 (16)	34.6 (1)	21.8 ((1)	8.2 ((1)
cladocera	0.0	0.0	0.0	0.0	0.0	.7 ((1)	0.0	0.0	7.2 ((1)	2.4 ((1)	1.7 ((1)	0.0	0.0	4.9 ((1)
copepoda	10.6 (20)	19.8 (11)	478.3 (34)	480.7 (42)	635.9 (43)	429.2 (73)	1598.5 (69)	1188.8 (50)	1238.3 (69)	654.0 (63)	1012.0 (62)	1586.3 (52)	527.6 (21)	1049.8 (60)
cirripedia (barnacle nauplii)	2.3 (4)	51.9 (30)	41.8 (3)	87.6 (8)	19.1 (1)	12.4 (2)	4.5 ((1)	449.8 (19)	4.8 ((1)	4.8 ((1)	40.1 (2)	304.1 (10)	124.1 (5)	245.5 (14)
decapoda	3.2 (6)	8.5 (5)	40.5 (3)	39.1 (3)	7.9 ((1)	17.1 (3)	22.8 ((1)	356.3 (15)	81.6 (5)	167.7 (16)	10.5 ((1)	698.4 (23)	81.5 (3)	247.2 (14)
others	1.0 (2)	5.5 (3)	6.5 ((1)	6.9 ((1)	6.8 ((1)	1.9 ((1)	2.3 ((1)	0.0	0.0	3.6 ((1)	0.0	6.9 ((1)	0.0	0.0
CHAETOGNATHA	.1 ((1)	0.0	0.0	.9 ((1)	4.5 ((1)	.7 ((1)	4.5 ((1)	2.9 ((1)	16.8 ((1)	1.2 ((1)	10.5 ((1)	0.0	1.1 ((1)	0.0
ECHINODERMATA	0.0	0.0	0.0	0.0	91.2 (6)	.7 ((1)	2.3 ((1)	0.0	2.4 ((1)	0.0	0.0	0.0	1233.3 (50)	0.0
CHORDATA urochordata	0.0	0.0	45.7 (3)	26.0 (2)	339.9 (23)	21.8 (4)	49.9 (2)	23.3 ((1)	55.2 (3)	20.6 (2)	47.1 (3)	24.2 ((1)	159.7 (6)	9.9 ((1)
fish (eggs and larvae)	9.5 (18)	27.1 (15)	0.0	0.0	9.0 ((1)	4.4 ((1)	4.5 ((1)	2.9 ((1)	0.0	0.0	1.7 ((1)	0.0	0.0	4.9 ((1)
EGGS	8.8 (16)	26.0 (15)	556.7 (40)	446.0 (39)	102.4 (7)	56.3 (10)	127.0 (5)	154.8 (6)	64.8 (4)	108.2 (10)	89.0 (5)	221.2 (7)	132.2 (5)	77.5 (4)
MISCELLANEOUS	.1 ((1)	0.0	0.0	0.0	0.0	0.0	6.8 ((1)	0.0	9.6 ((1)	0.0	1.7 ((1)	0.0	0.0	0.0
TOTAL ZOOPLANKTON	53.8	175.3	1386.4	1155.0	1479.9	587.3	2315.2	2389.2	1797.5	1033.1	1633.1	3076.3	2465.3	1743.5

* DENSITY IS EXPRESSED IN NUMBER OF ZOOPLANKTERS PER CUBIC METER

** NUMBER IN PARENTHESES IS PERCENTAGE COMPOSITION EXPRESSED IN PERCENT

*** O = OBLIQUE; S = SURFACE; B = BOTTOM

TABLE E-6

ZOOPLANKTON BIOMASS (mg/m^3)
ST. LUCIE PLANT
1982

	Station and depth[a]																		
	11	12	0			1			2			3			4			5	
Date	0	0	S	B	$\bar{x}$	S	B	$\bar{x}$	S	B	$\bar{x}$	S	B	$\bar{x}$	S	B	$\bar{x}$	S	B	$\bar{x}$
20 Jan	1.45	1.83	8.93	12.89	10.91	21.96	7.48	29.44	16.96	71.55	44.25	8.53	24.78	16.65	8.56	29.53	19.04	3.95	23.93	13.94
24 Feb	1.09	8.88	2.64	9.64	6.14	5.82	13.06	9.44	1.96	2.68	2.32	2.33	17.71	10.02	1.78	3.60	2.69	2.16	16.06	9.11
17 Mar	10.53	2.60	52.87	216.09	134.48	40.25	117.19	78.72	63.72	177.75	120.73	39.45	91.63	65.54	68.92	130.25	99.58	71.54	62.23	66.88
14 Apr	6.27	8.51	99.48	38.69	69.08	40.47	15.93	28.20	8.37	17.71	13.04	10.16	5.66	7.91	11.20	17.69	14.44	28.67	37.00	32.83
18 May	0.64	6.65	6.72	6.55	6.63	7.22	3.87	5.54	7.52	10.12	8.82	9.66	10.12	9.89	5.81	16.01	10.91	3.40	10.22	6.81

a0 = oblique tow; S = surface; B = bottom.

TABLE E-7

COMPARISON OF ZOOPLANKTON DENSITY AND WATER TEMPERATURE
IN THE INTAKE (STATION 11) AND DISCHARGE (STATION 12) CANALS
ST. LUCIE PLANT
1982

	Temperature (°C)			Zooplankton density (no./m^3)		
Date	Intake	Discharge	ΔT(°C)	Intake	Discharge	Percentage change (%)[a]
20 Jan	22.1	33.7	+11.6	560.0	513.4	-8.3
24 Feb	19.9	32.4	+12.5	320.6	471.7	+47.1
17 Mar	23.1	35.3	+12.2	716.2	496.6	-30.7
14 Apr	22.8	35.6	+12.8	1505.2	3546.6	+135.6
18 May[b]	25.0	25.2	+0.2	53.8	175.3	+225.8

[a]Percentage change = $\frac{\text{Discharge-Intake}}{\text{Intake}} \times 100$

[b]Plant down or in limited operational capacity only.

F. AQUATIC MACROPHYTES

Environmental Technical Specification (Section 3.1.B.d.; deleted May 1982).

> Macrophytes - Macroscopic aquatic vegetation will be collected quarterly and identified as to species and abundance.

INTRODUCTION

The community of macroscopic algae present in the ocean adjacent to the St. Lucie Plant has been monitored from 1976 through the first quarter of 1982. The purpose of the macrophyte sampling program was to determine if operation of the St. Lucie Plant has affected community composition and distribution. In areas exposed to power plant effluents, temperature increases toward lethal limits have resulted in reduced macrophyte coverage and changes in species composition (Patrick, 1974; Thorhaug et al., 1978). The NPDES required studies do not include macrophyte monitoring and this study component was therefore terminated in May 1982.

MATERIALS AND METHODS

Aquatic macrophytes were collected in March 1982 at each of six ocean stations (Figure F-1). Each sample was collected by towing a box-type dredge (46 cm x 46 cm x 25 cm) along the ocean bottom for 5 minutes. The speed of each tow was recorded and used to compute the surface area sampled. The area sampled at each station was approximately 190 m^2.

Attached macrophytes were scraped from shell and rock surfaces and sorted in the laboratory. The algae were identified to the lowest practical taxon and species lists were prepared for each sample. Representative material was retained for voucher specimens.

RESULTS AND DISCUSSION

In March 1982, 16 species of marine algae were collected at the six stations (Figure F-2). The Rhodophyta (red algae) composed 62.5 percent (10 species) of those collected. Of the remaining species, 25 percent (4 species) were Phaeophyta (brown algae) and 12.5 percent were Chlorophyta (green algae). Species composition for each station is given in Table F-1.

Spatial and temporal trends in the composition, abundance and distribution of marine algae which have occurred in all study years from 1976 to 1981 (ABI, 1977-1982) were also observed in March 1982. Generally, algal diversities and abundances have been lower in the winter and spring than in the summer and fall. This is usually true for marine plants in a subtropical zone such as Hutchinson Island (Phillips, 1961).

More algae were collected at Stations 0 and 1, closest to the beach, than at the other stations. The majority of these algae were not attached but detached or drift algae. The fine sand sediments at Stations 0 and 1 do not offer a suitable substrate for attached forms. Drift algae are a seasonal aspect of the summer and fall flora at Hutchinson Island and collections at nearby worm reefs suggest that drift algae found at the nearshore stations probably came from these adjacent

reefs (Moffler and Van Breedveld, 1975). Additionally, several species collected are typically estuarine, making the Indian River and nearby inlets another likely source. Drift algae may also originate on offshore reefs, but the algae on these reefs have been investigated little. Wind and wave action move these drift alr . into the study area where they are washed up onto the beach terrace. Their accumulation in this shallower water probably accounts for their abundance at Stations 0 and 1.

Attached algae were found on broken mollusc shell pieces, the major component of the shell hash sediments at Stations 2, 4 and 5. They usually consisted of only small plant fragments and had an insignificant biomass when compared to that of the drift algae. Little or no algae were collected at Station 3, the most seaward station. The loose sand sediment here was as unsuitable for algal attachment as that at Stations 0 and 1.

Members of the Rhodophyta have dominated the macrophyte collections each sampling period. The most commonly collected genera have been Gracilaria, Hypnea, Chondria, Ceramium and Solieria. A majority of the algae in the world are red algae and they predominate in lower latitude regions (Dawson, 1966). This accounts for their dominance in the study area. The brown algae and the green algae have contributed less to community diversity and abundance. Sargassum, Dictyota and Spatoglossum were the most frequently encountered genera of the brown algae and Codium, Cladophora and Caulerpa of the green algae. Most green algae are freshwater forms while brown algae, an almost strictly marine group, are the dominant forms in high latitude seas.

SUMMARY

The lack of stable, hard substrate for algal attachment limits the occurrence of benthic macrophytes in the study area. Attached benthic algae consist primarily of small plants or fragments on pieces of shell and rock. Therefore, the importance of this community as primary producers in the study area is minor.

General trends in species diversity and abundance over different sampling periods and among stations have been observed throughout the 6-year study period. More algae were collected in June and September, primarily because of the seasonal appearance of drift algae whose origin is outside the study area. More algae also were collected at stations on the beach terrace where drift algae tend to accumulate. No effects of power plant operation on this marine community have been observed.

LITERATURE CITED

ABI (Applied Biology, Inc.). 1977. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1976. Vol. 1. AB-44. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________. 1978. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1977. Vol. 1. AB-101. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________. 1979. Florida Power & Light Company St. Lucie Plant annual non-radiological environmental monitoring report 1978. Vol. III, Biotic monitoring. AB-177. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________. 1980. Florida Power & Light Company St. Lucie Plant annual non-radiological environmental monitoring report 1979. Vol. III, Biotic monitoring. AB-244. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________. 1981. Florida Power & Light Company St. Lucie Plant annual non-radiological environmental monitoring report 1980. Vol. III, Biotic monitoring. AB-324. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

________________. 1982. Florida Power & Light Company St. Lucie Plant annual non-radiological environmental monitoring report 1981. Vol. III, Biotic monitoring. AB-379. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

Dawson, E.Y. 1966. Marine botany. Holt, Rinehart and Winston, Inc., New York. 371 pp.

Moffler, M.D. and J. Van Breedveld. 1975. A species list of marine benthic macroalgae collected off Hutchinson Island, Florida. Report to Florida Power & Light Co., Miami. 12 pp.

Patrick, R. 1974. Effects of abnormal temperatures on algal communities. Pages 335-349 *in* J.W. Gibbons and R.R. Sharitz, eds. Thermal ecology. AEC Symposium (CONF-73505). Augusta, Ga.

Phillips, R. C. 1961. Seasonal aspects of the marine algal flora of the St. Lucie Inlet and adjacent Indian River, Florida. Quarterly Journal Florida Academy of Science 24(2).

Thorhaug, A., N. Blake and P.B. Schroeder. 1978. The effect of heated effluents from power plants on seagrass (*Thalassia*) communities quantitatively comparing estuaries in the subtropics to the tropics. Marine Pollution Bulletin 9(7):181-186.

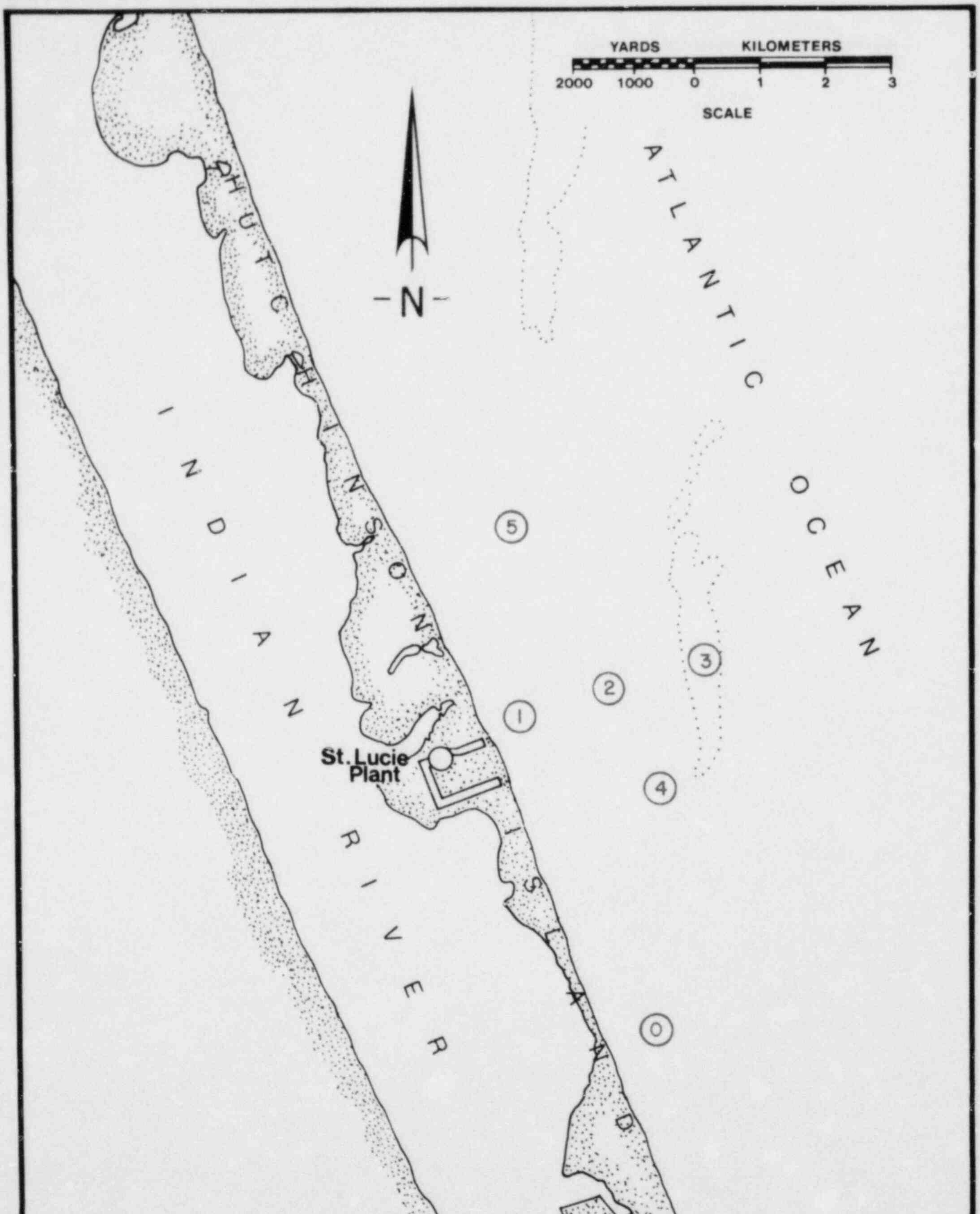

Figure F-1. Location of macrophyte sampling stations, St. Lucie Plant, 1982.

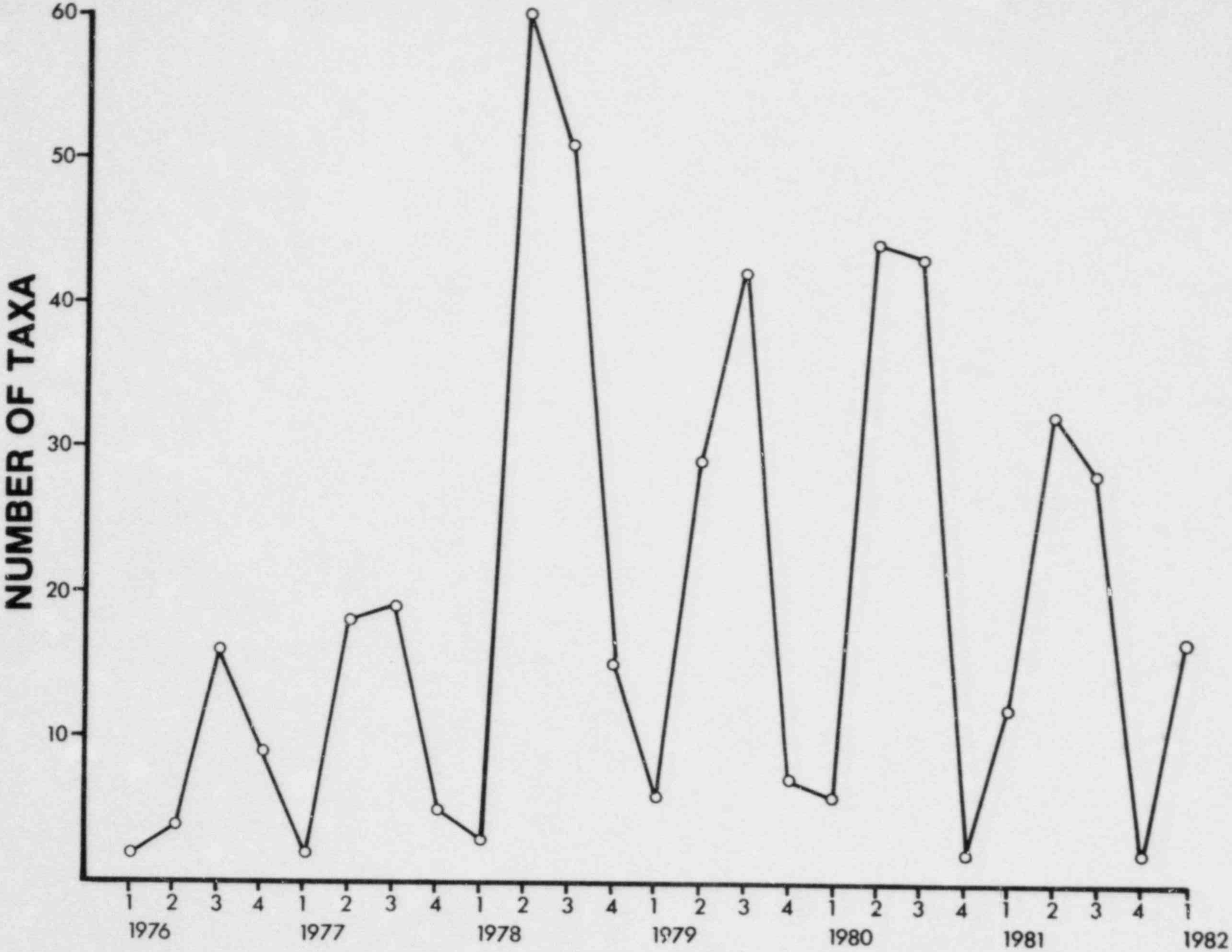

Figure F-2. Number of macrophyte taxa collected in quarterly samples, St. Lucie Plant, 1976-1982.

TABLE F-1

MACROPHYTE SPECIES COLLECTED AT OCEAN STATIONS
ST. LUCIE PLANT
MARCH 1982

Species	Station 0	1	2	3	4	5
CHLOROPHYTA (green algae)						
Cladophoropsis membranacea	X					
Codium decorticatum	X					
PHAEOPHYTA (brown algae)						
Dictyopteris delicatula						X
Dictyota sp.	X	X	X			
Sargassum sp.	X					X
Spatoglossum schroederi			X			X
RHODOPHYTA (red algae)						
Botyocladia occidentalis		X				X
Bryothamnion seaforthii		X				X
Chondria tenuissima	X		X		X	
Gracilaria verrucosa						X
Gracilaria sp.					X	X
Hypnea musciformis	X	X				X
Hypnea sp.	X					X
Laurencia papillosa		X				X
Laurencia sp.						X
Solieria tenera		X	X			X

G. WATER QUALITY

INTRODUCTION

Environmental Technical Specification (Section 3.1.B.e.; deleted May 1982)

> Water Quality - Analysis will be made on water samples taken at bottom, mid-depth and surface levels at the same time as the biotic samples are collected. Parameters studied will be temperature, salinity, dissolved oxygen content and turbidity. Water samples for selected nutrient analysis will be collected at the time of plankton sampling.

This study was designed to monitor selected physical and chemical parameters of the waters offshore the St. Lucie Plant and within the intake and discharge canals immediately adjacent to the plant. The purpose of monitoring these parameters was to 1) determine if selected physical and chemical parameters of the water discharged by the plant were significantly different from ocean waters, 2) provide a more unified view of the ocean habitat than would be obtained from sampling only the biotic components of the area and 3) examine the relationships between the abiotic and biotic components of the aquatic environment.

PHYSICAL PARAMETERS

Materials and Methods

Physical oceanographic parameters measured at designated ocean stations (0 through 5; Figure G-1) at surface, middle and bottom depths were water temperature, salinity, dissolved oxygen, turbidity and light

transmittance (Table G-1). Wind direction and velocity and general weather conditions were also determined at the ocean stations. Parameters measured within the intake and discharge canals (Stations 11 and 12) were temperature, salinity, dissolved oxygen and turbidity. These were measured at surface and bottom depths in the intake canal and at the surface in the discharge canal. Physical parameters were measured monthly for all stations from January through May 1982 at the same time that sampling for phytoplankton and chemical parameters was being conducted.

Water Temperature

Water temperature was measured *in situ* with a Yellow Springs Instrument Co. (YSI) Model 33 salinity-conductivity-temperature meter with an accuracy of ±0.1°C. Data were recorded in degrees Celsius.

Salinity

Salinity was measured in the field with a YSI Model 33 salinity-conductivity-temperature meter or in the laboratory with an American Optical refractometer (Model 10419 Goldberg; temperature compensating). Both instruments were precalibrated using stock solutions containing known sea-salt concentrations. Data were recorded in parts per thousand.

Dissolved oxygen

Dissolved oxygen was measured *in situ* with either a YSI Model 54 or 51B oxygen meter. These meters were precalibrated by using readings taken from oxygen saturated seawater. Data were recorded in milligrams per liter.

Turbidity

Turbidity was measured with a Hellige turbidimeter. Turbidity was measured as a function of light attenuation over a fixed path length, as recommended by the EPA (1974). Turbidity was recorded in Formazine Turbidity Units (FTU).

Light Transmittance

Light transmittance (luminosity) was measured at the ocean stations with an Interocean Marine Illuminance Meter Model 510. Incident solar radiation at the surface and at various depths was recorded as luminosity in lux units (1 lux = 0.09 foot-candles).

Other Physical Parameters

Other physical parameters were measured when pertinent to the ecological investigations. Wind direction and velocity were recorded according to Marine Forecast reports issued by the National Oceanographic and Atmospheric Administration, U.S. Weather Bureau. Other weather conditions were expressed as clear, partly cloudy, rainy or by similar descriptors. Data on weather conditions, as well as those obtained on tidal cycles and lunar phases, are maintained in the laboratory and are not included in this report.

Data Analysis

Collection of physical parameters in conjunction with plankton were terminated in May 1982. This precluded meaningful statistical comparisons of the annual data from previous years (12-month periods) with

the partial data available from 1982 (5-month period). The 1982 data were qualitatively compared to prior data from comparable operational phase monitoring periods.

Results and Discussion

Water Temperature

Water temperature is of prime importance in the marine environment because it acts 1) directly upon the physiological processes of the biota and 2) indirectly through its influence on solubility of gases and solids, water viscosity and density distribution. Throughout the oceans there are temperature barriers controlled by latitude, water depth and general circulation, which segregate faunas into geographical regions (Sverdrup et al., 1942).

Organisms within a particular geographical region are generally adapted to prevailing temperature conditions and may be adversely affected if temperatures shift too far or too rapidly. For example, massive mortalities of fishes have occurred in Florida during unusually cold winters (Snelson and Bradley, 1978). Organisms can be similarly affected by unusually warm conditions; this is pertinent to the present study, because the St. Lucie Plant discharges water offshore at temperatures generally higher than the receiving waters.

Ocean water temperatures within the study area are appreciably moderated by the proximity of the Gulf Stream which periodically flows to within 19 km of the St. Lucie Power Plant. Periodically, spin-off eddies

from the Gulf Stream and intrusions of colder offshore bottom water measurably modify ambient thermal regimes (ABI, 1980a).

Water temperatures measured during the 1982 sampling period ranged from 19.8° to 25.2°C at the ocean stations, from 19.9° to 25.1°C in the intake canal, and from 25.2° to 35.6°C in the discharge canal (Table G-2). Water temperatures in the discharge canal (Station 12) were high enough (>32°C), except in May when the plant was in a limited operational mode, to approach or exceed levels considered to be upper tolerance limits for much of the local (indigenous) fauna. Nevertheless, these high temperatures were not found at the ocean discharge (Station 1) because of rapid heat dissipation at the discharge diffuser (Table G-3). The Y-port diffuser was not in use during all of the 5 months of 1982 sampling; however, this rapid heat dissipation had been evident during previous monitoring years when the diffuser was in continuous use.

As expected, mean water temperature in the discharge canal was several degrees higher than that in the intake canal or at Control Station 0. However, there were no notable differences in water temperatures among the six ocean stations (Table G-3). The range in water temperature at ocean Station 1 was actually slightly lower than that at control Station 0 during the January to May sampling period (Table G-2). Water temperatures were slightly cooler in February than in January. This was also observed in 1981 when water temperatures in March were slightly cooler than in February (ABI, 1982). The overall trend in water temperature reflected the seasonal warming observed during previous moni-

toring at the St. Lucie Plant. The only evident water temperature stratification over the 1982 sampling period occurred in March, when bottom water temperatures were 0.4° to 0.8°C lower than at the surface. This was most evident at the deeper ocean stations (0, 2, 4 and 5). Generally, currents and wave-induced turbulence, primary forms of physical disturbance near the plant, cause homogeneity of water temperatures throughout the water column.

Salinity

Salinity, or the salt content of the water, is the chief factor that causes marine life to be distinct from other faunal assemblages. Because of the salt, the ocean provides a medium that is 1) similar to salt concentrations in internal body fluids, thereby limiting the necessity for salt regulatory mechanisms, and 2) of high density, which is important to swimming forms and to those that depend entirely on the water to support their weight. As is the case with temperature limits, animals in the sea are also bound by salinity limits. Animals sensitive to relatively small salinity changes are particularly characteristic of deep water and the open sea, where salinity ranges only from 34 to 36 ppt. Those animals with a high degree of tolerance are characteristic of the coastal regions, lagoons and estuaries, where wide salinity variations occur.

Salinities within the study area are typically representative of oceanic conditions, generally fluctuating between 34 and 36 ppt (Worth and Hollinger, 1977). Except for precipitation, the only freshwater

inputs are from the Ft. Pierce and St. Lucie Inlets, 14.5 and 21.5 km, respectively, from the plant site. During the rainy summer months (June-September) freshwater runoff entering the Atlantic Ocean from the inlets may influence salinity regimes near the plant if long-shore currents are favorable. Such deviations from typical oceanic salinity are short-lived, usually not persisting for more than a few days (Worth and Hollinger, 1977). Within the oceanic water column, haloclines are rare, and when they do exist, they are of short duration.

The salinities measured at the St. Lucie Plant, both in the ocean and in the canals, were in the narrow range of 34.5 to 36.6 ppt (Table G-2). The lowest salinity occurred in the intake canal (Station 11), while the highest salinity was recorded at ocean Station 4 in January and ocean Station 0 in March (Table G-4). As expected, this salinity range is more characteristic of the open sea than of a nearshore location. This results from the plant's location relatively far from sources of freshwater input.

Oxygen

Oxygen is indispensable for the maintenance of life processes in all organisms, with the notable exception of anaerobic bacteria. Oxygen is available for the normal metabolic activities of aquatic organisms only when it is in solution in a free state. Free oxygen is similar to carbon dioxide (necessary for photosynthesis) in being one of the two most important dissolved gases in the sea. Oxygen is seldom a determining factor in the distribution and abundance of most marine life, however, because it is generally well supplied throughout the oceans.

Dissolved oxygen concentrations were typically higher at surface as compared to bottom stations. The ranges in dissolved oxygen at all stations during the 1982 sampling period were slightly higher than the annual ranges from previous studies because generally greater mixing and lower water temperatures during the early part of the year (January-May) result in higher dissolved oxygen concentrations. Oxygen solubility is higher at lower water temperatures. Dissolved oxygen values ranged from 6.9 to 8.5 mg/liter at the ocean stations (Table G-2). The ranges at ocean stations (Table G-5) were similar to those from comparable periods during previous operational monitoring. There were no notable differences among ocean stations. Measurements in the intake canal ranged from 6.1 to 9.2 mg/liter, while concentrations in the discharge canal ranged from 6.2 to 7.9 mg/liter. Dissolved oxygen was lowest in the discharge canal because of the higher water temperatures, which decrease oxygen solubility, and the range in dissolved oxygen was generally greater in the intake canal than at ocean stations because of the more variable conditions within the intake canal. However, concentrations at all stations exceeded the minimum requirements of the indigenous aquatic biota.

Turbidity

Turbidity, which affects the clarity of seawater, reflects the presence of suspended matter in the water column. It is often quite variable in shallow coastal waters where wind or tidal currents can stir up bottom sediments and where runoff from the land can add additional suspended materials. Turbidity may be a direct limiting factor to certain animals, such as filter feeders that strain food from the water. It

is more often an indirect limiting factor, however, because it restricts light penetration through the water column and, in this way, limits growth and reproduction of phytoplankton in the deeper waters where light would otherwise penetrate.

As expected, turbidity was generally higher at bottom stations than at surface stations. Turbidity measurements at the six ocean stations ranged from 0.0 to 8.5 FTU (Table G-2). Turbidities were generally similar at ocean control Station 0 and at ocean Station 1, in the immediate vicinity of the ocean discharge. As in previous studies, turbidity at these two near-shore stations, where wave action is greatest, was typically higher than at ocean stations further from shore (Table G-6). Plankton densities have also been greater at these two stations and higher numbers of plankters in the water column also contribute to higher turbidity at these stations. Turbidity in the intake canal ranged from 0.1 to 4.9 FTU and from 0.7 to 4.9 FTU in the discharge canal. Turbidities were slightly higher in the canals than offshore because of higher phytoplankton standing crop and turbulence which suspends particulates in the water column.

Light

Light in the sea directly affects chemical reactions associated with the metabolism of organisms, and its greatest importance is as an energy source for the photosynthetic processes of plants upon which all animals directly or indirectly depend for their nourishment. Considering this tremendous importance, it is noteworthy that light sufficient for photosynthesis extends from the surface only to a depth of about 80 m.

Light transmittance measured at the six ocean stations ranged from <1 to 750 lux (Table G-2). The upper range was slightly lower than previously reported annual ranges because maximum incident solar radiation would not occur until after May. The considerable variation in light transmittance reflected such light-influencing factors as turbidity in the water, wave action, cloud cover, time of day, season and depth. Light transmittance (the amount of available light in the water column) at the near-shore stations was frequently lower than that at stations further from shore (Stations 3 and 4), reflecting the inverse of the trend observed for turbidity (Table G-7). With the exception of the expected decrease in light with increased depth and proximity to shore, no consistent patterns of light transmittance were apparent at the ocean stations. It is doubtful if light reduction would ever exclude photosynthetic processes offshore Hutchinson Island because the water there is so shallow.

CHEMICAL PARAMETERS

Materials and Methods

Chemical parameters measured during the study were total organic carbon and the nutrients ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, silicates and orthophosphate. These parameters were measured from samples collected monthly from January through May 1982 at ocean Stations 0 through 5, intake canal Station 11 and discharge canal Station 12 (Figure G-1; Table G-1). Ocean samples were taken from surface, middle and bottom depths; intake canal samples from surface and bottom depths; and discharge canal samples from the surface. Subsurface samples

were obtained either by pumping or with a Niskin bottle; surface samples were obtained directly. Water samples to be analyzed for ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, reactive silica and orthophosphate were passed through 0.45-μ membrane filters, placed in acid-washed polyethylene bottles and frozen. Water samples to be analyzed for total organic carbon were spiked with 5 ml of concentrated sulfuric acid. All samples for chemical analysis were shipped to the laboratory on the day of collection.

Methods of analysis used to measure these selected chemical parameters (Table G-8) appear in either the Environmental Protection Agency manual (EPA, 1979) or the American Public Health Association manual (APHA, 1980). Each chemical parameter was independently compared over the sampling period. Stations 0 through 5 were compared to detect differences among ocean stations. Nutrient concentrations measured in the intake and discharge canals were compared to those at control Station 0 to determine nutrient differences between the canals and ocean. The partial data available for 1982 were compared to previous operational data from comparable time periods as described in the Data Analysis section for physical parameters.

Results and Discussion

Nutrients such as the forms of inorganic nitrogen, silicates and phosphates are essential for the growth of phytoplankton populations (Yentsch, 1962). Since phytoplankton provides the basis for the ocean food chain, upon which all higher forms subsist either directly or

indirectly, the inclusion of nutrients is particularly relevant to any marine biological study.

The distribution of nutrients in the marine environment is a function of diffusion, currents and biological turnover. High concentrations of nutrients are spatially limited and usually associated with upwelling (Spencer, 1975), a river-ocean interface (Steffansson and Richardson, 1963) or ocean waste disposal outfalls (EPA, 1971). Nutrient concentrations in nearshore localities are usually homogeneous because of mixing from turbulence induced by winds or currents (Bowden, 1970). However, runoff from the land can have substantial effects on nutrient concentration and additional variability may be caused by biological turnover rates. Biological turnover is the process in which nutrients are assimilated by aquatic organisms during growth and population expansion and released following death and decomposition of the organisms.

Nitrogen

Nitrogen, an essential constituent of living matter, is found within organic compounds both in organisms and in particulate and dissolved organic material. It occurs within seawater as ammonia (NH_3-N), nitrate (NO_3-N) and nitrite (NO_2-N), in many organic compounds, and as free dissolved nitrogen gas. Only the first three nitrogen forms are measured extensively in environmental monitoring studies.

Concentrations measured at the ocean stations during 1982 ranged from <0.01 to 0.11 mg/liter for ammonia nitrogen, 0.003 to 0.099 mg/liter

for nitrate nitrogen, and 0.001 to 0.018 mg/liter for nitrite nitrogen (Table G-9). Complete data by collection period are contained in Tables G-10 through G-14. In previous studies, peak nutrient values were generally observed in the early part of the year. This is expected because nutrients are recycled and typically accrue over the winter when productivity is low and decrease in concentration through spring and early summer as productivity increases. The nitrogeneous nutrients generally decreased from January or February through May 1982 in response to increasing phytoplankton productivity. Ammonia and nitrite nitrogen concentrations in the canals were somewhat higher than at ocean stations. As in 1981 (ABI, 1982), there were no consistent differences in nitrogen compound concentrations among ocean stations or between canal stations which would indicate influence from plant operation.

Silicon

Silicon is monitored because it is utilized by diatoms, which are the predominant phytoplankters off the St. Lucie Plant. Silicate-silicon (SiO_2-Si) concentrations measured during 1982 at the ocean stations ranged from <0.02 to 0.19 mg/liter (Table G-9). Reactive silica concentrations during the January-May collection period were low, as compared to annual ranges, because the highest silica concentrations have generally been observed later in the year. Concentrations were similar among ocean stations and lower than concentrations in the canals.

Phosphorus

Phosphorus is present in sea water primarily in the form of various

types of phosphate and is an essential constituent of living organisms. In addition to the nitrogen and silicon compounds, phosphate-phosphorus has been considered one of the substances that may limit production of plant life (Sverdrup et al., 1942). Orthophosphate (PO_4-P) concentrations measured at the St. Lucie Plant between January and May 1982 were generally less than 0.01 mg/liter (Table G-9). There were no notable differences among phosphate values either among the ocean stations or among the intake canal, discharge canal and control station.

Total Organic Carbon

Total organic carbon (TOC) is the sum of the suspended organic carbon and the dissolved organic carbon in the water. It includes carbon in detritus, within living organisms such as the phytoplankton, and carbon dissolved in the water and available for use by organisms. Because different water masses can vary considerably in levels of organic production, TOC levels may also vary. TOC concentrations at stations off the St. Lucie Plant during 1982 ranged from 1.2 to 11.8 mg/liter (Table G-9). The TOC values at the canal stations (1.7 to 7.0 mg/liter) were in the same general range as at the ocean stations, although average TOC concentration was slightly lower in the canals and at ocean Station 1 than at most other ocean stations. However, the average concentration at Station 1 was within the range of average concentrations observed at the other ocean stations. Average TOC concentration at ocean Station 3 (Figure G-1) was higher than at most other ocean stations during the 1982 sampling period as it had been in 1982 (ABI, 1982). This was primarily due to high TOC concentrations at the surface and mid-depth in January, although the reason for the high concentrations was not evident.

Comparison of 1982 Chemistry Data to 1976-1981 Operational Monitoring and 1972-1973 Baseline Data

The ranges and means of nutrient concentrations recorded at ocean Stations 0 through 5 during the 1976-1982 operational monitoring (ABI, 1977, 1978, 1979, 1980b, 1981, 1982 and the present study) and Stations 1 through 5 during the 1972-1973 baseline study (Worth and Hollinger, 1977) are shown in Figures G-2 through G-6. The 1982 means represent only five months of data. The baseline study, which was performed from February 1972 to August 1973, monitored the same nutrients as the current study with the exception of TOC.

Mean ammonia concentrations for the six years of environmental monitoring ranged from 0.014 to 0.125 mg/liter (Figure G-2). The 1982 mean ammonia concentration of 0.050 mg/liter was at about the mid-point of this range. Ammonia concentrations were higher during the years of operational monitoring than during the baseline study, with the exception of the 1980 study year. There was no apparent explanation for the lower ammonia values reported in the baseline study and 1980 monitoring. However, the similarity in ammonia concentration between the control and other ocean stations shows that operation of the St. Lucie Plant is not the cause of the difference.

Nitrate concentrations measured during operational monitoring and the baseline studies fluctuated considerably (Figure G-3). The mean values were generally in the same range except in 1976 and 1981 when nitrate values were higher. The exceptionally high values in 1976 were probably caused by sample techniques that have since been shown to be

inadequate. The high nitrate values in 1981 likely resulted from construction of the second discharge pipe, which would have disturbed the bottom sediments, releasing nitrates. The mean value for 1982 is likely higher because the January through May sampling encompassed the period when characteristically higher nitrate concentrations occur and the lower values which typically occur in late summer were not included in the mean.

Nitrite concentrations also varied considerably during baseline and operational monitoring (Figure G-4). Mean nitrite values were fairly uniform during the first five years of operational monitoring and slightly below the mean reported for the baseline study. The mean nitrite value for 1981 was considerably higher than earlier years. As with nitrates, the high 1981 nitrite values are likely the result of sediment disturbance caused by construction of the second discharge pipe and the high 1982 mean likely results from the partial year's data.

Mean silica concentrations ranged from 0.26 mg/liter in 1976 down to 0.03 mg/liter in 1979 and back up to 0.20 mg/liter in 1981 (Figure G-5). The mean reactive silica concentration in 1982 was similar to that during baseline monitoring and within the range of means observed over previous operational monitoring. The 1982 mean would likely be slightly higher, if based on a full year's data, because the higher concentrations which characteristically occur late in the year were not represented in the January-May mean. Silica measurements vary considerably both within and among years. This variation is primarily related to changes in climatic

conditions and cycling of silicates by phytoplankton. The ranges and trends shown in silica values reported for the St. Lucie Plant (Figure G-5) are considered usual.

Orthophosphate concentrations were similar during operational monitoring years with most of the values below the detection limit of 0.01 mg/liter. The highest value measured during operational monitoring (0.14 mg/liter) was considerably below the highest concentration reported during the baseline study (>1.40 mg/liter; ABI, 1981). Reasons for the high concentration during the baseline study are not known, although it was apparently not related to runoff from the land during heavy rains (Worth and Hollinger, 1977), which is the usual cause of high phosphate concentrations.

Mean total organic carbon concentrations at the ocean stations have decreased from 1976 and 1977 to the relatively narrow range of 2 to 5 mg/liter in subsequent years (Figure G-6). The reasons for this trend in ocean TOC concentrations are not apparent. However, it should be noted that, even though TOC concentrations were lower in latter than in earlier years, phytoplankton and zooplankton standing crop did not decrease during this period (Sections D. Phytoplankton and E. Zooplankton). TOC concentrations were not measured during the baseline study.

SUMMARY

There were no notable differences in water temperature, dissolved oxygen or turbidity among the six ocean sampling stations which would

indicate the influence of plant operation. As expected, mean water temperature in the discharge canal was higher than at the ocean control station. However, these high temperatures were not found at the ocean discharge station because of rapid heat dissipation. The differences in physical parameters among the various ocean stations were generally attributable to natural environmental influences.

Nutrients in the marine environment adjacent to the plant were dispersed homogeneously among stations but varied with the time of year. There were some annual differences in nutrient values over the years of operational and baseline studies although, overall, nutrient concentrations among years were similar. Analysis of nutrient concentrations indicated that plant operation had no significant effects on the nutrients measured in this study.

LITERATURE CITED

ABI (Applied Biology, Inc.). 1977. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1976. Volume I. AB-44. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1978. Ecological monitoringat the Florida Power & Light Co. St. Lucie Plant, annual report 1977. Volume I. AB-101. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1979. Florida Power & Light Company St. Lucie Plant annual non-radiological environmental monitoring report 1978. Vol. III, Biotic monitoring. AB-177. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1980a. Florida Power & Light Company St. Lucie Plant. Effects of increased water temperature on the marine biota of the St. Lucie Plant area. AB-261. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1980b. Florida Power & Light Company St. Lucie Plant annual non-radiological environmental monitoring report 1979. Vol. III, Biotic monitoring. AB-244. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1981. Florida Power & Light Company St. Lucie Plant annual non-radiological environmental monitoring report 1980. Vol. III, Biotic monitoring. AB-324. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1982. Florida Power & Light Company St. Lucie Plant annual non-radiological environmental monitoring report 1980. Vol. III, Biotic monitoring. AB-379. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

APHA (American Public Health Association). 1980. Standard methods for the examination of water and wastewater, 15th ed. American Public Health Association, Washington, D.C. 1134 pp.

Bowden, K.F. 1970. Turbulence II. Oceanogr. Mar. Biol. Ann. Rev. 8:11-32.

EPA (Environmental Protection Agency). 1971. Limitations and effects of waste disposal on an ocean shelf. Grant 16070EFG. U.S. Environmental Protection Agency, Water Pollution Control Res. Ser.

____. 1974. Proceedings of a seminar on methodology for monitoring the marine environment. U.S. Environmental Protection Agency, Office of Monitoring Systems Program Element No. 1HA326. Washington, D.C.

LITERATURE CITED (continued)

____. 1979. Methods for chemical analysis of water and wastes. U.S. Environmental Protection Agency, U.S. Environmental Monitoring and Support Laboratory, Cincinnati.

Snelson, F.F., Jr. and W.K. Bradley, Jr. 1978. Mortality of fishes due to cold on the east coast of Florida, January, 1977. Florida Scientist 41(1):1-12.

Spencer, C.P. 1975. Nutrient distributions. Pages 245-300 in J.P. Riley and G. Skirrow, eds. Chemical oceanography, Vol. 2. Academic Press, New York.

Steffansson, O. and F.A. Richardson. 1963. Processes contributing to the nutrient distributions of the Columbia River and Strait of Juan de Fuca. Limnology and Oceangraphy 8(4):394-410.

Sverdrup, H.U., M.W. Johnson and R.H. Fleming. 1942. The oceans: Their physics, chemistry, and general biology. Prentice-Hall, Inc., Englewood Cliffs, N.J. 1087 pp.

Worth, D.F. and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. III. Physical and chemical environment. Florida Department of Natural Resources Marine Research Laboratory, Florida Marine Research Publication No. 23: 25-85.

Yentsch, C.S. 1962. Marine plankton in R.A. Lewin, ed. Physiology and biochemistry of algae. Academic Press, New York.

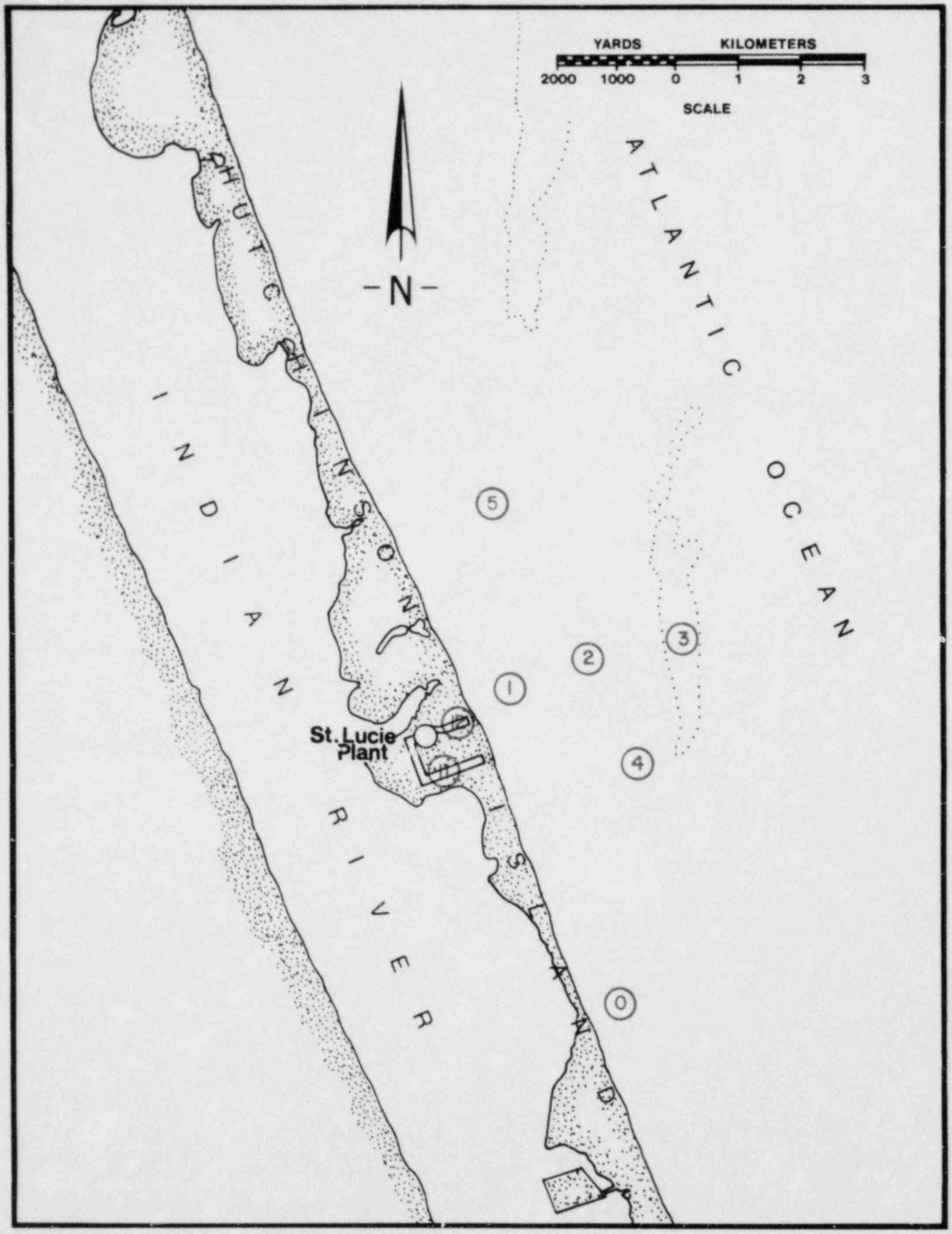

Figure G-1. Location of water quality sampling stations, St. Lucie Plant, 1982.

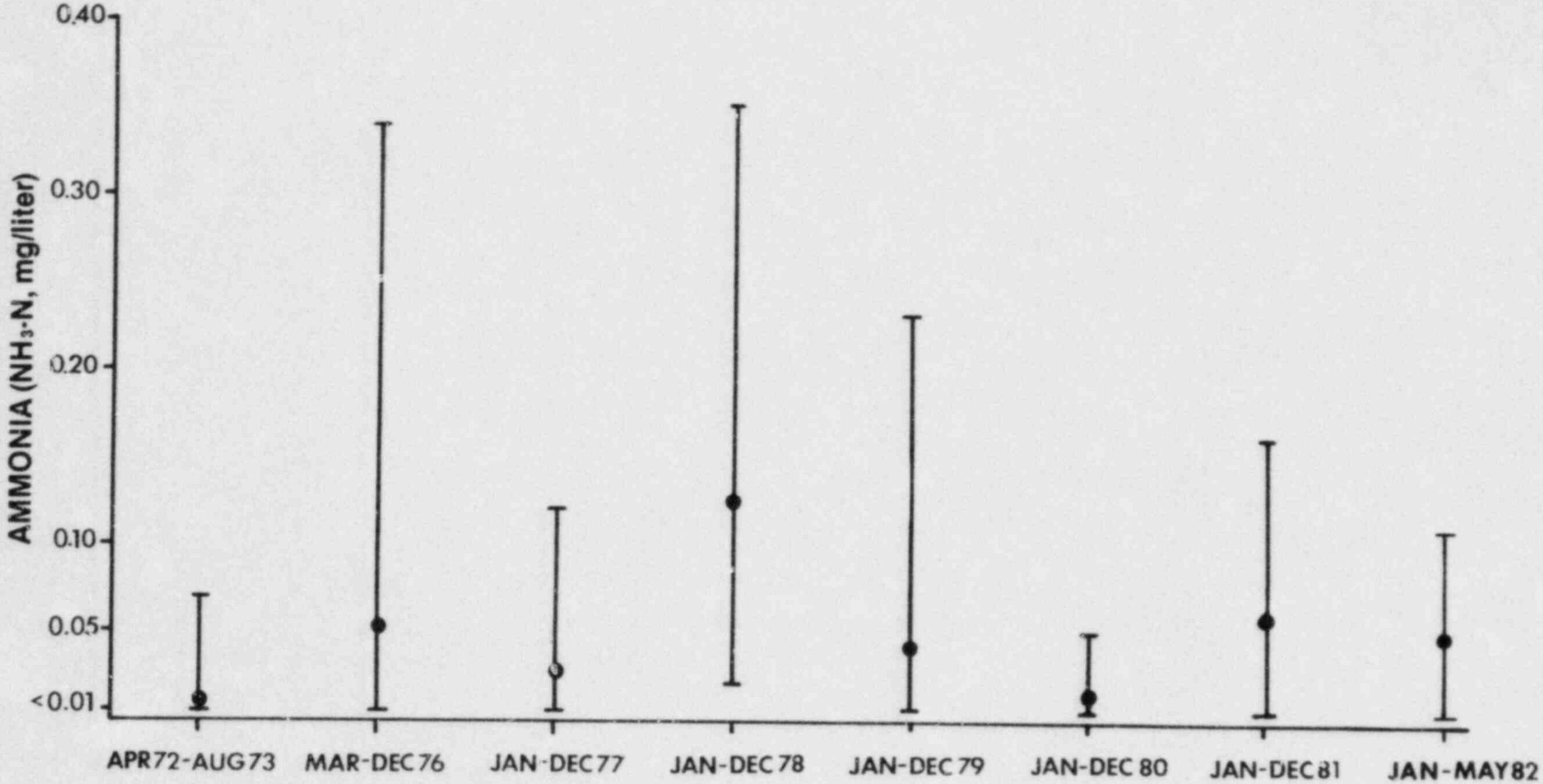

Figure G-2. Range and mean of ammonia values for the 1972-1973 baseline study Stations 1 through 5 combined) and the 1976-1982 operational study (Stations 0 through 5 combined), St. Lucie Plant.

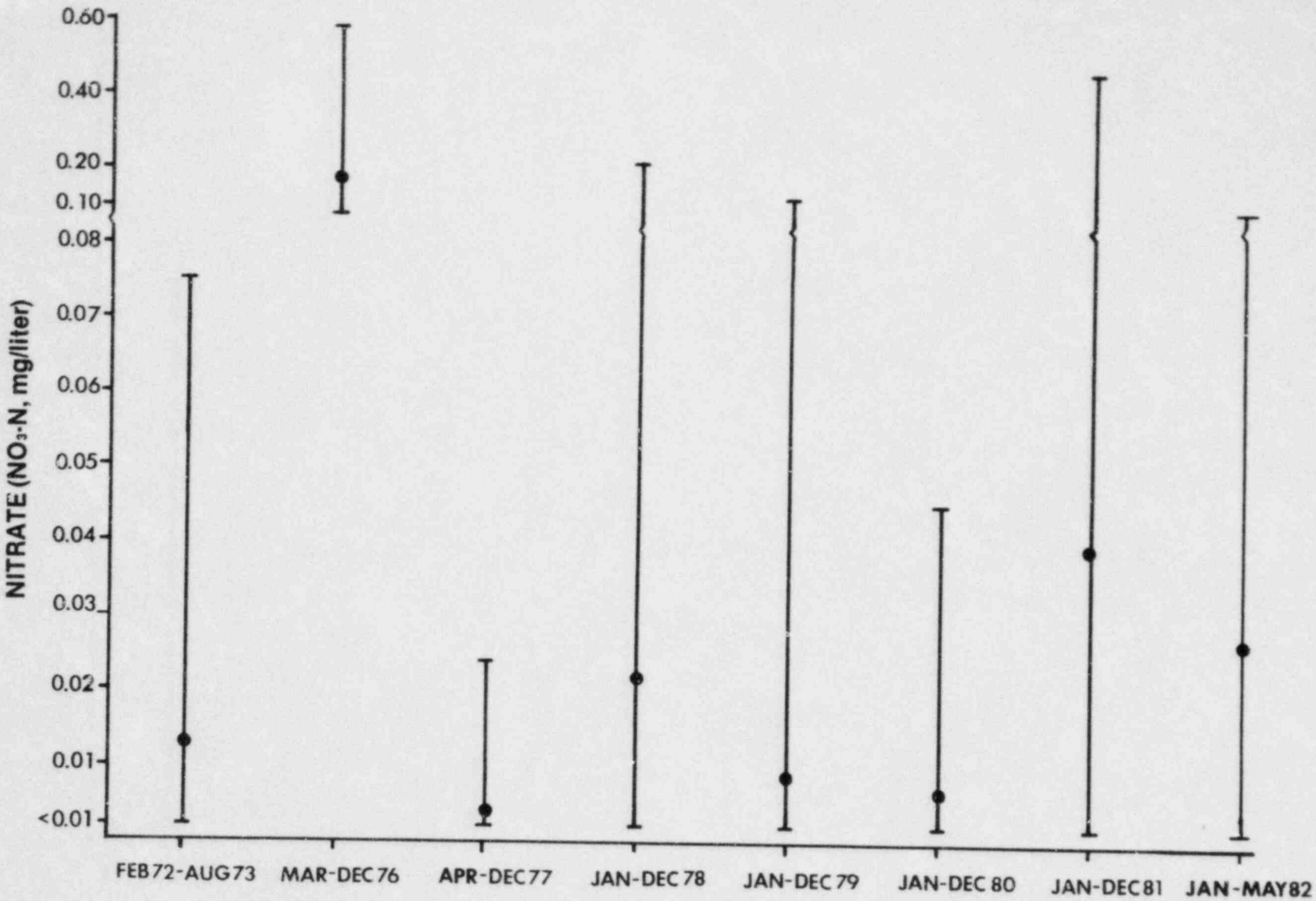

Figure G-3. Range and mean of nitrate values for the 1972-1973 baseline study (Stations 1 through 5 combined) and the 1976-1982 operational study (Stations 0 through 5 combined), St. Lucie Plant.

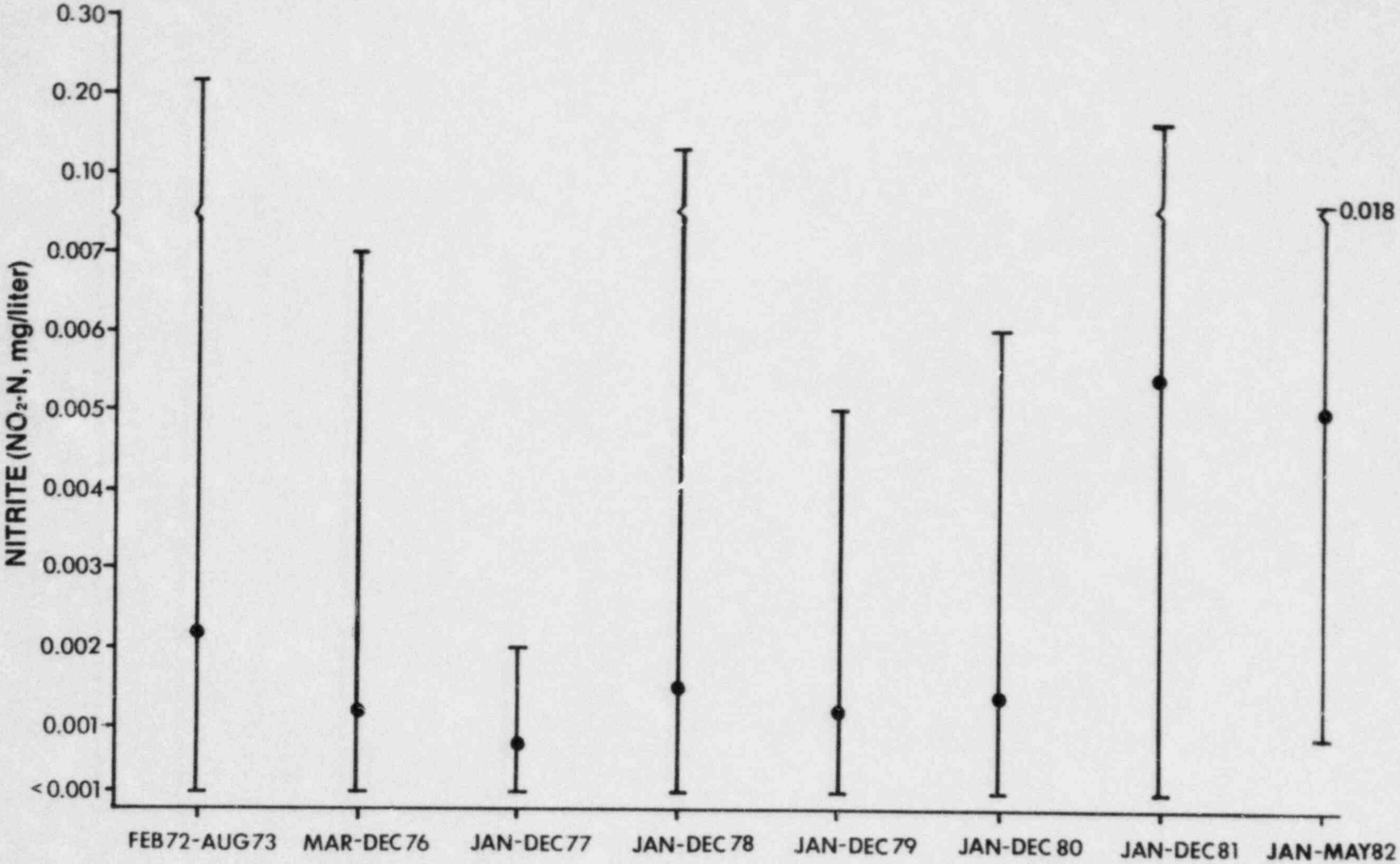

Figure G-4. Range and mean of nitrite values for the 1972-1973 baseline study (Stations 1 through 5 combined) and the 1976-1982 operational study (Stations 0 through 5 combined), St. Lucie Plant.

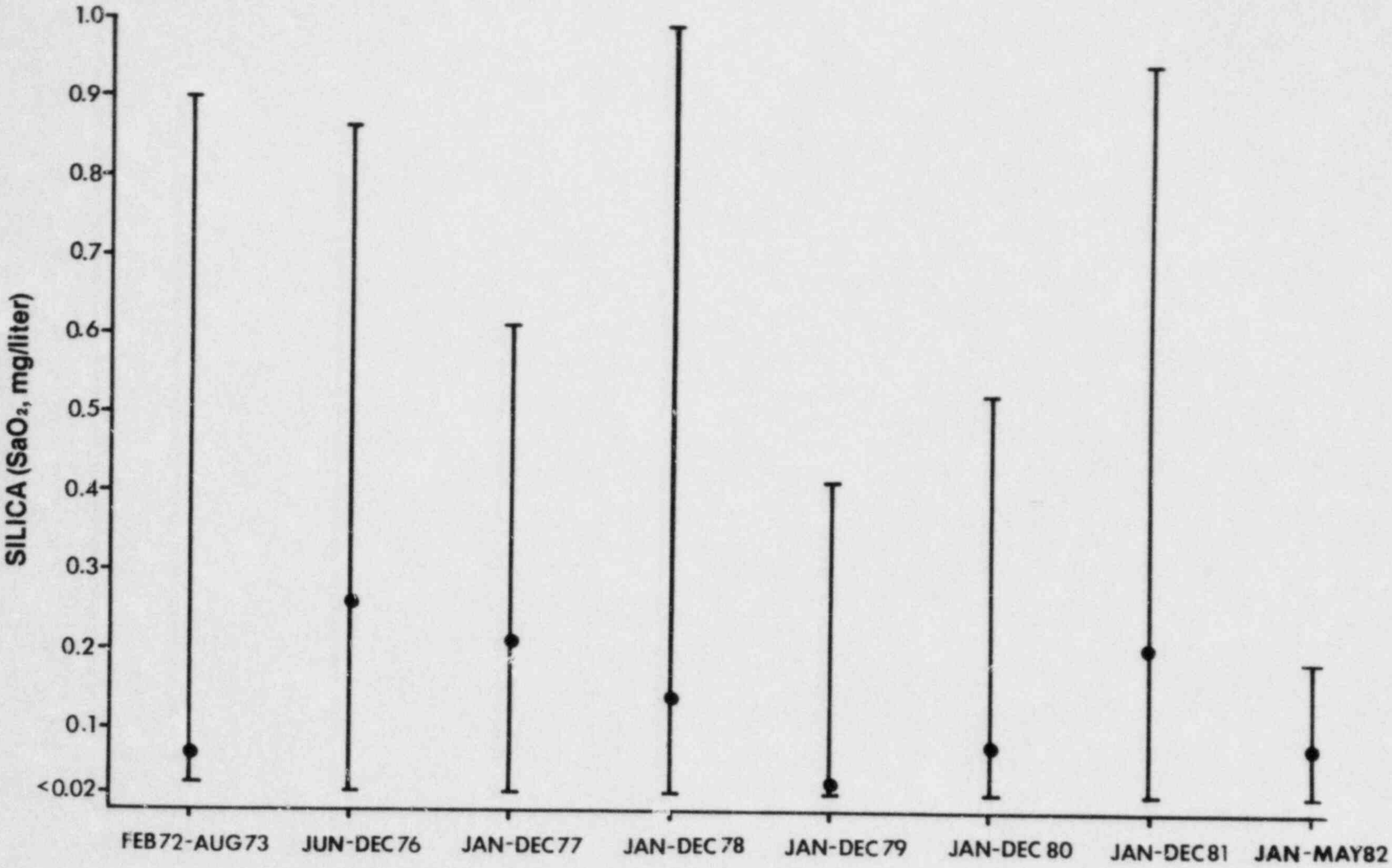

Figure G-5. Range and mean of silica values for the 1972-1973 baseline study (Stations 1 through 5 combined) and the 1976-1982 operational study (Stations 1 through 5 combined), St. Lucie Plant.

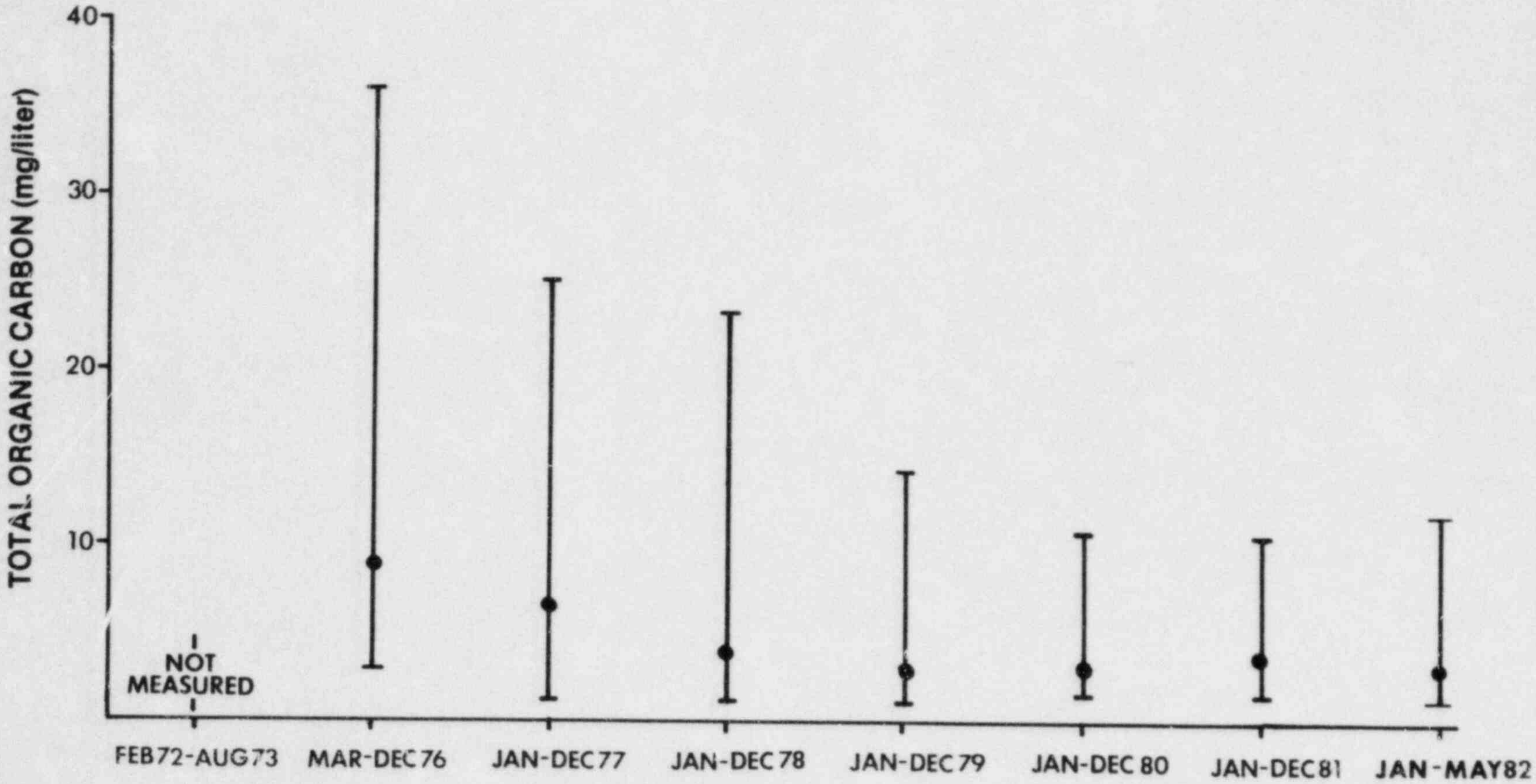

Figure G-6. Range and mean of total organic carbon values for the 1976-1982 operational study (Stations 0 through 5 combined), St. Lucie Plant.

TABLE G-1

PHYSICAL/CHEMICAL PARAMETERS MEASURED FOR EACH STATION
ST. LUCIE PLANT
JANUARY - MAY 1982

Parameter	Station							
	0	1	2	3	4	5	11	12
Water temperature (*in situ*)	x	x	x	x	x	x	x	x
Salinity	x	x	x	x	x	x	x	x
Dissolved oxygen	x	x	x	x	x	x	x	x
Turbidity	x	x	x	x	x	x	x	x
Light transmittance	x	x	x	x	x	x		
Ammonia nitrogen	x	x	x	x	x	x	x	x
Nitrate nitrogen	x	x	x	x	x	x	x	x
Nitrite nitrogen	x	x	x	x	x	x	x	x
Silicates	x	x	x	x	x	x	x	x
Orthophosphate	x	x	x	x	x	x	x	x
Total organic carbon	x	x	x	x	x	x	x	x

TABLE G-2

RANGES OF PHYSICAL PARAMETERS RECORDED AT
OCEAN AND CANAL STATIONS
ST. LUCIE PLANT
JANUARY - MAY 1982

Station and depth[a]		Temperature (°C)	Salinity (ppt)	Dissolved oxygen (mg/l)	Turbidity (FTU)	Light transmittance (LUX)
ocean						
0	S	20.0-25.2	35.5-36.1	6.9-8.4	0.1-2.3	250-750
	M	19.9-25.1	35.5-36.6	6.9-8.4	0.1-2.5	30-230
	B	19.8-25.1	35.5-36.1	6.9-8.5	0.0-4.4	3-135
1	S	19.8-25.1	35.5-36.1	6.9-8.2	0.0-2.5	200-490
	M	19.8-25.1	35.5-36.1	6.9-8.3	0.0-2.5	17-105
	B	19.8-24.9	35.5-36.1	6.7-8.3	0.0-3.0	<1-34
2	S	20.0-25.0	35.5-36.1	6.9-8.0	0.0-1.7	129-600
	M	20.0-25.0	35.5-36.1	7.0-8.0	0.0-2.1	20-144
	B	20.0-25.1	35.5-36.1	6.9-7.9	0.0-2.1	<1-69
3	S	20.0-24.7	35.5-36.1	7.1-8.2	0.0-1.5	400-580
	M	20.0-24.8	35.5-36.1	7.1-8.0	0.0-2.1	35-290
	B	20.0-24.7	35.5-36.1	6.9-7.8	0.0-2.1	3-186
4	S	20.0-24.9	35.5-36.1	7.0-7.9	0.0-1.7	450-750
	M	20.0-24.8	35.5-36.6	6.9-7.9	0.0-1.7	25-320
	B	20.0-24.9	35.5-36.6	6.9-8.0	0.0-2.8	<1-96
5	S	19.8-25.1	35.5-36.1	7.0-8.1	0.0-1.1	75-480
	M	19.8-25.1	35.5-36.1	7.1-8.1	0.0-0.9	15-102
	B	19.8-25.0	35.5-36.1	7.0-8.1	0.1-1.5	<1-32
canal						
11	S	19.9-25.0	34.5-36.1	6.1-9.2	0.1-3.9	-
	B	19.9-25.1	35.0-36.1	6.1-9.0	0.5-4.9	-
12	S	25.2-35.6	35.0-36.1	6.2-7.9	0.7-4.9	-

[a]S = Surface; M = Mid-depth; B = Bottom.

TABLE G-3

WATER TEMPERATURES (°C) RECORDED DURING
PHYTOPLANKTON AND NUTRIENT SAMPLING
ST. LUCIE PLANT
JANUARY - MAY 1982[b]

Station	Depth[a]	Jan	Feb	Mar	Apr	May
0	S	21.0	20.0	23.4	24.0	25.2
	M	21.0	19.9	22.6	23.9	25.1
	B	21.0	19.8	22.6	23.9	25.1
1	S	21.9	19.8	23.4	23.2	25.1
	M	21.5	19.8	23.3	23.0	25.1
	B	21.0	19.8	22.9	23.0	24.9
2	S	21.0	20.0	23.4	23.8	25.0
	M	21.0	20.0	23.4	23.7	25.0
	B	21.0	20.0	22.8	23.7	25.1
3	S	21.0	20.0	23.5	24.1	24.7
	M	21.0	20.0	23.3	24.0	24.8
	B	21.0	20.0	23.2	23.9	24.7
4	S	21.0	20.0	23.2	24.1	24.9
	M	21.0	20.0	22.9	24.0	24.8
	B	21.0	20.0	22.8	24.0	24.9
5	S	21.0	19.8	23.0	23.2	25.1
	M	21.0	19.8	22.8	23.0	25.1
	B	21.0	19.8	22.6	23.1	25.0
11	S	22.2	19.9	23.1	22.8	25.0
	B	22.1	19.9	23.2	22.8	25.1
12	S	33.7	32.4	35.3	35.6	25.2

[a]S = Surface; M = Mid-depth; B = Bottom.

[b]This aspect of the program terminated after the May sampling period.

TABLE G-4

SALINITY MEASUREMENTS (ppt) RECORDED DURING
PHYTOPLANKTON AND NUTRIENT SAMPLING
ST. LUCIE PLANT
JANUARY - MAY 1982

Station	Depth[a]	Jan	Feb	Mar	Apr	May
0	S	36.1	35.5	36.1	35.5	36.1
	M	36.1	35.5	36.6	36.1	36.1
	B	36.1	35.5	35.5	36.1	36.1
1	S	36.1	35.5	36.1	35.5	36.1
	M	36.1	35.5	36.1	35.5	36.1
	B	36.1	35.5	36.1	35.5	36.1
2	S	36.1	35.5	36.1	35.5	36.1
	M	36.1	35.5	36.1	35.5	36.1
	B	36.1	35.5	35.5	35.5	36.1
3	S	36.1	35.5	36.1	35.5	36.1
	M	36.1	35.5	36.1	35.5	36.1
	B	36.1	35.5	36.1	35.5	36.1
4	S	36.1	35.5	36.1	35.5	36.1
	M	36.6	35.5	36.1	35.5	36.1
	B	36.6	35.5	36.1	35.5	36.1
5	S	35.5	36.1	35.5	35.5	36.1
	M	35.5	36.1	35.5	35.5	36.1
	B	35.5	36.1	35.5	35.5	36.1
11	S	36.1	34.5	35.5	35.0	36.1
	B	36.1	35.0	35.5	35.0	36.1
12	S	36.1	35.0	35.5	35.0	36.1

[a]S = Surface; M = Mid-depth; B = Bottom.

TABLE G-5

DISSOLVED OXYGEN MEASUREMENTS (mg/liter) RECORDED DURING PHYTOPLANKTON AND NUTRIENT SAMPLING
ST. LUCIE PLANT
JANUARY - MAY 1982

Station	Depth[a]	Jan	Feb	Mar	Apr	May
0	S	7.1	8.4	6.9	7.4	7.5
	M	7.0	8.4	6.9	7.4	7.4
	B	6.9	8.5	6.9	7.3	7.4
1	S	6.9	8.2	6.9	7.3	7.5
	M	7.0	8.3	6.9	7.2	7.6
	B	7.0	8.3	6.7	7.2	7.5
2	S	7.1	8.0	6.9	7.3	7.6
	M	7.1	8.0	7.0	7.3	7.6
	B	6.9	7.9	7.1	7.2	7.5
3	S	7.1	8.2	7.2	7.3	7.5
	M	7.1	8.0	7.3	7.3	7.5
	B	7.0	7.8	6.9	7.1	7.4
4	S	7.0	7.9	7.0	7.3	7.4
	M	6.9	7.9	7.0	7.2	7.4
	B	6.9	8.0	6.9	7.2	7.3
5	S	7.2	8.1	7.0	7.4	7.6
	M	7.1	8.1	7.1	7.4	7.7
	B	7.1	8.1	7.0	7.2	7.4
11	S	7.0	9.2	6.5	6.9	6.1
	B	6.1	9.0	6.8	7.4	6.2
12	S	6.4	7.9	6.2	6.3	7.0

[a]S = Surface; M = Mid-depth; B = Bottom.

TABLE G-6

TURBIDITY MEASUREMENTS (FTU) RECORDED DURING PHYTOPLANKTON AND NUTRIENT SAMPLING ST. LUCIE PLANT JANUARY - MAY 1982

Station	Depth[a]	Jan	Feb	Mar	Apr	May
0	S	0.1	2.1	1.1	0.7	2.3
	M	0.1	2.5	0.5	0.7	2.1
	B	0.0	4.4	1.5	0.9	1.5
1	S	0.0	2.3	1.3	1.5	2.5
	M	0.0	2.5	0.9	1.3	2.1
	B	0.0	3.0	1.7	1.1	1.5
2	S	0.0	1.7	0.5	0.3	0.5
	M	0.0	2.1	0.3	0.3	1.1
	B	0.0	2.1	0.7	0.2	0.9
3	S	0.0	1.5	0.7	0.2	0.9
	M	0.0	2.1	0.2	0.1	0.9
	B	0.0	2.1	0.3	0.1	0.9
4	S	0.0	1.7	0.3	0.2	0.5
	M	0.0	1.7	0.2	0.2	0.2
	B	0.0	2.8	0.5	0.2	0.3
5	S	0.0	1.1	1.1	0.2	0.7
	M	0.0	0.9	0.3	0.3	0.9
	B	0.1	1.5	0.7	0.5	1.1
11	S	0.1	2.3	0.9	3.9	1.1
	B	0.5	3.9	1.1	4.9	1.1
12	S	0.7	4.9	1.1	3.7	1.5

[a]S = Surface; M = Mid-depth; B = Bottom.

TABLE G-7

LIGHT TRANSMITTANCE MEASUREMENTS (LUX) RECORDED DURING
PHYTOPLANKTON AND NUTRIENT SAMPLING
ST. LUCIE PLANT
JANUARY - MAY 1982

Station	Depth[a]	Jan	Feb	Mar	Apr	May
0	S	600	600	750	650	250
	M	180	30	230	186	42
	B	60	4	135	43	3
1	S	200	300	470	490	350
	M	40	17	105	62	30
	B	14	<1	34	2	3
2	S	300	450	450	600	129
	M	75	20	126	144	25
	B	30	<1	69	42	3
3	S	400	450	550	580	550
	M	135	35	198	290	141
	B	75	3	147	186	90
4	S	450	500	710	750	600
	M	120	25	320	234	168
	B	55	<1	96	58	40
5	S	75	250	480	460	210
	M	20	15	78	102	22
	B	11	<1	32	18	6

[a]S = Surface; M = Mid-depth; B = Bottom.

TABLE G-8

METHODS OF ANALYSIS USED TO MEASURE CHEMICAL PARAMETERS
ST. LUCIE PLANT
1982

Parameter	Method	Reference
Ammonia nitrogen (NH_3-N)	Indophenol (Phenate, Automated)	APHA, 1980, p 363
Nitrate notrogen (NO_3-N)	Cadmium reduction (Automated)	EPA, 1979, Method 383.2
Nitrite nitrogen (NO_2-N)	Diazotization	EPA, 1979, Method 383.2
Silicates (SiO_2-Si)	Heteropoly blue	APHA, 1980, p 432
Orthophosphate (PO_4-P)	Ascorbic acid	APHA, 1980, p 420
Total organic carbon (TOC)	Combustion-infrared	APHA, 1980, p 471

TABLE G-9

RANGES OF CHEMICAL PARAMETERS (NUTRIENTS)
AT OCEAN AND CANAL STATIONS
ST. LUCIE PLANT
JANUARY - MAY 1982

Station and depth[a]		Ammonia (mg/l)	Nitrate-nitrogen (mg/l)	Nitrite-nitrogen (mg/l)	Silicate-silicon (mg/l)	Orthophosphate (mg/l)	Total organic carbon (mg/l)
ocean							
0	S	0.01-0.11	0.017-0.048	0.002-0.009	<0.02-0.14	<0.01	2.0-4.2
	M	0.01-0.09	0.008-0.041	0.002-0.009	<0.02-0.14	<0.01	2.6-3.6
	B	0.03-0.09	0.011-0.045	0.002-0.010	0.02-0.14	<0.01	2.1-11.8
1	S	0.02-0.10	0.017-0.050	0.002-0.010	<0.02-0.15	<0.01	1.9-6.1
	M	0.02-0.09	0.015-0.055	0.002-0.009	<0.02-0.16	<0.01	1.7-3.3
	B	0.03-0.09	0.014-0.061	0.002-0.008	<0.02-0.16	<0.01	1.2-3.2
2	S	0.01-0.08	0.004-0.038	0.002-0.013	<0.02-0.16	<0.01	1.7-3.3
	M	0.02-0.07	0.003-0.067	0.002-0.014	0.03-0.15	<0.01	2.0-4.4
	B	0.01-0.06	0.005-0.032	0.003-0.014	0.02-0.14	<0.01	1.4-2.5
3	S	<0.01-0.06	0.010-0.044	0.002-0.017	0.03-0.13	<0.01	2.1-6.1
	M	0.01-0.08	0.009-0.099	0.003-0.017	0.03-0.15	<0.01	2.2-7.4
	B	0.03-0.08	0.017-0.041	0.003-0.013	0.03-0.13	<0.01	1.8-4.3
4	S	0.02-0.08	0.005-0.033	0.001-0.005	0.03-0.14	<0.01	2.5-3.8
	M	0.03-0.07	0.013-0.038	0.001-0.007	0.05-0.12	<0.01	2.1-5.4
	B	0.02-0.07	0.018-0.039	0.001-0.006	0.02-0.13	<0.01	2.2-2.9
5	S	0.02-0.07	0.003-0.038	0.001-0.016	0.05-0.18	<0.01	2.0-6.0
	M	0.01-0.09	0.005-0.081	0.002-0.018	0.05-0.17	<0.01	1.5-3.8
	B	0.02-0.08	0.007-0.064	0.002-0.015	0.07-0.19	<0.01	1.6-3.3

TABLE G-9
(continued)
RANGES OF CHEMICAL PARAMETERS (NUTRIENTS)
RECORDED AT OCEAN AND CANAL STATIONS
ST. LUCIE PLANT
JANUARY - MAY 1982

Station and depth[a]		Ammonia (mg/l)	Nitrate-nitrogen (mg/l)	Nitrite-nitrogen (mg/l)	Silicate-silicon (mg/l)	Orthophosphate (mg/l)	Total organic carbon (mg/l)
canal							
11	S	0.01-0.20	0.007-0.061	0.004-0.031	0.06-0.20	<0.01-0.01	1.7-3.2
	B	0.02-0.22	0.012-0.032	0.003-0.031	0.08-0.21	<0.01	1.9-3.7
12	S	<0.01-0.23	0.008-0.047	0.003-0.029	0.16-0.28	<0.01	1.8-7.0

[a] S = Surface; M = Mid-depth; B = Bottom.

TABLE G-10

SEAWATER NUTRIENT ANALYSIS
ST. LUCIE PLANT
20 JANUARY 1982

Station	Depth[a]	Nutrients (ppm)					
		PO_4-P	SiO_2	NH_3-N	NO_3-N	NO_2-N	TOC
0	S	<0.01[b]	0.11[b]	0.09[b]	0.022[b]	0.003[b]	4.2[b]
	M	<0.01	0.11	0.09	0.030	0.002	2.9
	B	<0.01	0.11	0.09	0.027	0.002	11.8
1	S	<0.01	0.11	0.08	0.017	0.002	6.1
	M	<0.01	0.12	0.09	0.055	0.002	3.3
	B	<0.01	0.13	0.09	0.044	0.002	1.2
2	S	<0.01	0.11	0.07	0.025	0.003	3.3
	M	<0.01	0.10	0.06	0.016	0.002	2.3
	B	<0.01	0.10	0.06	0.019	0.003	1.4
3	S	<0.01	0.09	0.06	0.018	0.003	6.1
	M	<0.01	0.09	0.06	0.027	0.003	7.4
	B	<0.01	0.09	0.06	0.017	0.003	2.8
4	S	<0.01	0.10	0.08	0.033	0.003	2.8
	M	<0.01	0.09	0.07	0.013	0.002	5.4
	B	<0.01	0.10	0.07	0.018	0.003	2.6
5	S	<0.01	0.11	0.07	0.018	0.003	5.9
	M	<0.01	0.10	0.09	0.013	0.003	1.5
	B	<0.01	0.10	0.08	0.015	0.003	2.3
11	S	<0.01	0.20	0.10	0.030	0.004	1.7
	B	<0.01	0.15	0.08	0.019	0.003	1.9
12	S	<0.01	0.18	0.08	0.021	0.003	1.8

[a]S = Surface; M = Mid-depth; B = Bottom.

[b]Each value is the mean of two replicates.

TABLE G-11

SEAWATER NUTRIENT ANALYSIS
ST. LUCIE PLANT
25 FEBRUARY 1982

		Nutrients (ppm)					
Station	Depth[a]	PO_4-P	SiO_2	NH_3-N	NO_3-N	NO_2-N	TOC
0	S	<0.001[b]	0.12[b]	0.07[b]	0.022[b]	0.009[b]	2.8[b]
	M	<0.001	0.14	0.04	0.021	0.009	3.3
	B	<0.001	0.14	0.04	0.024	0.010	3.0
1	S	<0.001	0.15	0.04	0.038	0.007	1.9
	M	<0.001	0.16	0.06	0.035	0.006	2.6
	B	<0.001	0.16	0.04	0.022	0.007	2.7
2	S	<0.001	0.16	0.05	0.022	0.013	2.2
	M	<0.001	0.15	0.05	0.028	0.014	2.0
	B	<0.001	0.14	0.05	0.032	0.014	2.3
3	S	<0.001	0.13	0.05	0.039	0.017	2.8
	M	<0.001	0.15	0.08	0.099	0.017	2.6
	B	<0.001	0.13	0.07	0.041	0.013	4.1
4	S	<0.001	0.14	0.03	0.021	0.005	3.8
	M	<0.001	0.12	0.03	0.021	0.005	2.1
	B	<0.001	0.13	0.03	0.039	0.004	2.8
5	S	<0.001	0.18	0.03	0.038	0.004	3.5
	M	<0.001	0.17	0.05	0.081	0.004	2.1
	B	<0.001	0.19	0.04	0.064	0.004	3.3
11	S	<0.001	0.20	0.05	0.015	0.007	2.3
	B	<0.001	0.21	0.03	0.017	0.006	2.8
12	S	<0.001	0.28	0.05	0.008	0.008	2.7

[a]S = Surface; M = Mid-depth; B = Bottom.

[b]Each value is the mean of two replicates.

TABLE G-12

SEAWATER NUTRIENT ANALYSIS
ST. LUCIE PLANT
18 MARCH 1982

		Nutrients (ppm)					
Station	Depth[a]	PO_4-P	SiO_2	NH_3-N	NO_3-N	NO_2-N	TOC
0	S	<0.001[b]	0.14[b]	0.05[b]	0.048[b]	0.002[b]	2.0[b]
	M	<0.001	0.09	0.05	0.041	0.002	2.7
	B	<0.001	0.11	0.06	0.045	0.002	2.1
1	S	<0.001	0.09	0.10	0.017	0.010	2.1
	M	<0.001	0.09	0.09	0.015	0.009	1.7
	B	<0.001	0.09	0.08	0.014	0.008	2.0
2	S	<0.001	0.08	0.08	0.038	0.008	1.7
	M	<0.001	0.05	0.07	0.067	0.004	2.1
	B	<0.001	0.07	0.05	0.005	0.003	1.8
3	S	<0.001	0.05	0.05	0.021	0.002	2.1
	M	<0.001	0.04	0.05	0.019	0.003	2.2
	B	<0.001	0.05	0.08	0.030	0.010	1.8
4	S	<0.001	0.08	0.05	0.029	0.003	2.5
	M	<0.001	0.07	0.07	0.032	0.007	2.9
	B	<0.001	0.06	0.04	0.032	0.003	2.2
5	S	<0.001	0.06	0.07	0.004	0.005	2.0
	M	<0.001	0.06	0.08	0.005	0.007	1.9
	B	<0.001	0.07	0.06	0.007	0.004	1.6
11	S	<0.001	0.13	0.07	0.050	0.004	1.8
	B	<0.001	0.14	0.08	0.032	0.004	1.9
12	S	<0.001	0.19	0.08	0.031	0.004	1.9

[a]S = Surface; M = Mid-depth; B = Bottom.

[b]Each value is the mean of two replicates.

TABLE G-13

SEAWATER NUTRIENT ANALYSIS
ST. LUCIE PLANT
16 APRIL 1982

		Nutrients (ppm)					
Station	Depth[a]	PO_4-P	SiO_2	NH_3-N	NO_3-N	NO_2-N	TOC
0	S	<0.001[b]	0.06[b]	0.11[b]	0.022[b]	0.007[b]	2.9[b]
	M	<0.001	0.07	0.04	0.008	0.004	2.6
	B	<0.001	0.07	0.04	0.011	0.004	2.7
1	S	<0.001	0.07	0.05	0.050	0.002	2.6
	M	<0.001	0.06	0.04	0.025	0.005	2.7
	B	<0.001	0.07	0.05	0.061	0.004	2.6
2	S	<0.001	0.04	0.04	0.017	0.002	3.3
	M	<0.001	0.05	0.03	0.003	0.004	2.5
	B	<0.001	0.04	0.04	0.010	0.003	2.9
3	S	<0.001	0.05	0.04	0.017	0.003	2.7
	M	<0.001	0.05	0.05	0.009	0.004	3.2
	B	<0.001	0.05	0.04	0.021	0.004	2.9
4	S	<0.001	0.06	0.04	0.021	0.001	2.7
	M	<0.001	0.05	0.04	0.030	0.001	3.5
	B	<0.001	0.06	0.05	0.039	0.001	2.9
5	S	<0.001	0.06	0.05	0.014	0.001	2.9
	M	<0.001	0.06	0.05	0.023	0.002	3.8
	B	<0.001	0.07	0.05	0.049	0.002	2.7
11	S	<0.001	0.08	0.20	0.061	0.031	3.1
	B	<0.001	0.09	0.22	0.017	0.031	3.7
12	S	<0.001	0.20	0.23	0.047	0.029	7.0

[a]S = Surface; M = Mid-depth; B = Bottom.

[b]Each value is the mean of two replicates.

TABLE G-14

SEAWATER NUTRIENT ANALYSIS
ST. LUCIE PLANT
19 MAY 1982

Station	Depth[a]	Nutrients (ppm)					
		PO_4-P	SiO_2	NH_3-N	NO_3-N	NO_2-N	TOC
0	S	<0.001[b]	<0.02[b]	0.01[b]	0.017[b]	0.004[b]	3.9[b]
	M	<0.001	<0.02	0.01	0.028	0.004	3.6
	B	<0.001	0.02	0.03	0.018	0.004	2.7
1	S	<0.001	<0.02	0.02	0.028	0.003	3.3
	M	<0.001	<0.02	0.02	0.022	0.003	3.3
	B	<0.001	<0.02	0.03	0.020	0.003	3.2
2	S	<0.001	<0.02	0.01	0.004	0.004	2.5
	M	<0.001	0.03	0.02	0.014	0.004	4.4
	B	<0.001	0.02	0.01	0.017	0.003	2.1
3	S	<0.001	0.03	<0.01	0.044	0.003	2.5
	M	<0.001	0.03	0.01	0.022	0.004	3.0
	B	<0.001	0.03	0.03	0.025	0.004	4.3
4	S	<0.001	0.03	0.02	0.005	0.005	3.0
	M	<0.001	0.08	0.03	0.038	0.006	2.1
	B	<0.001	0.02	0.02	0.024	0.006	2.3
5	S	<0.001	0.05	0.02	0.003	0.016	6.0
	M	<0.001	0.05	0.01	0.033	0.018	2.9
	B	<0.001	0.07	0.02	0.024	0.015	2.8
11	S	0.001	0.06	0.01	0.007	0.021	3.2
	B	<0.001	0.08	0.02	0.012	0.025	2.7
12	S	<0.001	0.16	<0.01	0.021	0.018	2.6

[a]S = Surface; M = Mid-depth; B = Bottom.

[b]Each value is the mean of two replicates.

H. TURTLES

NRC Environmental Technical Specification (Section 3.1.B.f; deleted May 1982; updated sea turtle study specifications will be included in the NRC St. Lucie Plant Environmental Protection Plan when issued for Unit 2).

> Migratory Sea Turtles - The species, numbers, and nesting characteristics of sea turtles that migrate in from the sea and nest along the east coast of Florida will be determined on the FPL shoreline property and selected adjacent control areas in 1975 and 1977. A study shall be conducted to determine the effects of the discharge thermal plume on turtle nesting patterns and turtle hatchling migration. In addition, control studies on temperature stress, hatching, and rearing factors will be conducted using turtle eggs from displaced nests.

INTRODUCTION

Hutchinson Island, Florida, is an important rookery for the Atlantic loggerhead turtle, *Caretta caretta*, and also supports some nesting of the Atlantic green turtle, *Chelonia mydas*, and the leatherback turtle, *Dermochelys coriacea* (Caldwell et al., 1959; Routa, 1968; Gallagher et al., 1972; Worth and Smith, 1976). All marine turtles are protected by State and Federal statutes. The Federal Government classifies the loggerhead turtle as a threatened species, the green turtle as endangered in Florida (threatened throughout the remainder of its range) and the leatherback turtle as an endangered species. Because of reductions in world populations of marine turtles resulting from coastal development and fishing pressure (NMFS, 1978), maintaining the vitality of the Hutchinson Island rookery is important.

It has been a prime concern of FPL that the construction and subsequent operation of the St. Lucie Plant would not adversely affect the Hutchinson Island rookery. Because of this concern, FPL has sponsored monitoring of marine turtle nesting activity on the island.

Daytime surveys to quantify nesting, as well as nighttime turtle tagging programs, were conducted in odd numbered years from 1971 through 1979. Nine 1.25-km-long survey areas were monitored 5 days per week during the daytime nesting programs. The St. Lucie Plant began operation in 1976; therefore, the first three survey years (1971, 1973 and 1975) are preoperational. Though the power plant was not operating during 1975, St. Lucie Plant Unit No. 1 ocean intake and discharge systems were installed during that year. Installation of these systems included construction activities conducted offshore from, and perpendicular to, the beach. Construction activities had been completed and the plant was in full operation during the 1977 and 1979 surveys.

A modified daytime nesting survey was conducted in 1980 during the preliminary construction of the ocean discharge system for St. Lucie Plant Unit No. 2. During this study, four of the previously established 1.25-km-long survey areas were monitored. Additionally, eggs from turtle nests potentially endangered by construction activities were relocated.

During 1981 and 1982, thirty-six 1-km-long survey areas comprising the enti - island were monitored seven days a week during the nesting season. St. Lucie Plant Unit No. 2 discharge and intake systems were

installed during 1981 and 1982, respectively. Construction activities associated with installation of both systems were similar to those conducted when Unit 1 intake and discharge systems were installed. Eggs from turtle nests potentially endangered by construction activities were relocated during both years.

In addition to monitoring sea turtle nesting activities and relocating nests away from plant construction areas, monitoring of turtles in the intake canal and removal of trapped turtles has been an integral part of the St. Lucie Plant environmental monitoring program. Turtles that enter the ocean intake structures are carried with the intake cooling water through the intake pipe and end up in that portion of the intake canal between the intake headwall and the trash barrier net located at the Highway A1A bridge. Since the plant became operational in 1976, turtles that enter the intake canal have been captured, measured, tagged and released alive back into the ocean.

Previous reports have presented results of the nesting surveys and nest relocation activities (Gallagher et al., 1972; Worth and Smith, 1976; ABI, 1978, 1980, 1982) and documented studies on potential effects of the discharge plume on turtle hatchlings (ABI, 1978; O'Hara, 1980). The purpose of this section is to 1) present 1982 survey data and summarize observed spatial and temporal trends in nest density, 2) document and summarize nesting success and predation since 1971, 3) describe the results of the 1982 nest relocation program, and 4) present results of intake canal monitoring since its inception in 1976.

MATERIALS AND METHODS

Nesting Survey and Nest Relocation

Methodologies used during previous turtle nesting surveys on Hutchinson Island were described by Gallagher et al. (1972), Worth and Smith (1976), and ABI (1978, 1980, 1981, 1982). Methods used during the 1982 survey were designed to allow comparisons with these previous studies.

From 8 April through 15 September 1982, nest surveys were conducted daily along Hutchinson Island from Ft. Pierce Inlet south to St. Lucie Inlet. Biologists used small off-road motorcycles to survey the island each morning. New nests, non-nesting emergences (false crawls) and nests destroyed by predators were recorded for each of the thirty-six 1-km-long survey areas comprising the entire island (Figure H-1). The nine 1.25-km-long survey areas established by Gallagher et al. (1972) were also monitored so comparisons could be made with previous studies.

Turtle nests deposited within 0.4 km of the intake construction site were relocated to a beach area 4 km south of the power plant (Figure H-1). Nests were reburied and allowed to incubate and hatch under natural conditions. To reduce egg mortality from nest relocation, nests were removed within 12 hours of deposition and handled gently as recommended by Limpus et al. (1979). Relocated nests were covered with poultry wire to prevent raccoon predation. All relocated nests and a comparable number of undisturbed nests were examined after signs of hatchling emergence to determine hatch success. Records were kept of the

incubation period, number of hatched and unhatched eggs, and live or dead hatchlings remaining in the nests. The hatching success of undisturbed nests was compared to relocated nests to detect any adverse effects from handling the eggs.

In a cooperative effort, the Florida Department of Natural Resources (DNR) was notified of all green and leatherback turtle nests. Eggs from many of the green turtle nests were collected as part of the Florida DNR Headstart Program. Because loggerhead turtles are the predominate species nesting on the island, discussions are based on this species unless otherwise noted.

Intake Canal Monitoring

Turtles were removed from the intake canal with large-mesh nets fished between the intake headwall and the barrier net located at the Highway A1A bridge. Nets were usually set Monday mornings and removed Friday afternoons. On a few occasions, such as during dredging in the intake canal or when several turtles were observed in the canal, nets were also fished over the weekends. The nets were checked for turtles several times per day by either Applied Biology or plant security personnel. Applied Biology was on-call 24 hours per day to remove turtles when the nets were fishing.

Various sizes, numbers and locations of nets have been used to date as capture techniques continue to be refined. Nets in recent use were from 32 to 61 m in length, 2.7 to 3.7 m in depth and 30 to 40 cm in

stretch mesh. Large floats kept the nets at the surface and, because nets were not weighted with lead lines, turtles which became entangled remained at the water's surface until removed.

The utmost care was taken in handling the turtles to prevent injury or trauma. After removal from the nets, turtles were identified to species, measured, weighed, tagged, examined for overall condition (wounds, abnormalities, parasites, etc.) and released back into the ocean. In 1982, blood and feces were sampled to investigate the potential occurrence and significance of anemia and/or parasite load in these animals (results of this study are preliminary and will not be presented in this report).

Sick or injured turtles were treated and occasionally held for observation prior to release. When treatment was warranted, injections of antibiotics and vitamins were administered by a local veterinarian. Resuscitation techniques were used if a turtle was found that appeared to have died recently. Beginning in 1982, necropsies were conducted on dead turtles found in fresh condition. Only one animal was found suitable for necropsy in 1982. Necropsy was conducted by S.N. Wampler, DVM, Jensen Beach, Florida, and histological analysis by Anita George, Marine Pathology Laboratory, University of Rhode Island, Kingston.

RESULTS AND DISCUSSION

Nesting Survey

Distribution of Nests

Nest density has varied considerably within each study area from year to year (Table H-1). However, linear regression analysis of distribution of nest density with respect to location of the nine 1.25-km-long survey areas has consistently shown a gradient of increasing nest density from north to south along the island. Nest density was fairly uniform among the nine areas only in 1973. Worth and Smith (1976) attributed this uniform nest distribution to beach accretion in Areas 1 through 3 (Figure H-1) that year. The severe erosion of the northern portion of the island in 1979 corresponds with the strongest gradient observed. The similarity between erosion and accretion gradients and nest density indicates that these processes can influence the selection of nesting sites by turtles. Thus, localized short-term erosion or accretion may account for much of the annual variations in nest densities among sample areas. Regardless of these variations, the distribution of nests among the nine areas were similar between combined preoperational and operational years (Figure H-2). The distribution of nest densities among the thirty-six 1-km-long survey areas also showed a gradient of increasing densities from north to south. However, this gradient was apparently curvilinear rather than linear during both 1981 and 1982 (Figure H-3). During both years, the gradient was strongest among the northernmost areas and gradually decreased from north to south.

During 1982, as in 1981, nest densities were high in Areas S through W (Figure H-3), a portion of beach that had not been sampled prior to 1981. Though no quantitative data are available, observations during previous surveys suggested that this has been an area of heavy nesting since at least 1979. As in 1981, nest densities were lowest in Areas A and B (Ft. Pierce Public Beach) during 1982. These low densities may be attributed to unsuitable substrates (compact sand and scattered rocks), as well as intense lighting and considerable human activity on the beach at night. The last two factors may also be responsible for relatively low nest densities in Area Z (Jensen Public Beach) compared to adjacent areas.

Relatively low nest densities in Areas DD, HH and JJ during 1982 may be related to beach topography. Much of the beach in Area DD was very narrow and, therefore, unsuitable for nesting. Nesting activities in Area HH may have been complicated by the presence of a nearshore intertidal reef, rock outcroppings on the beach and steep ledges along certain sections. Most of the beach in Area JJ was extremely wide (30-100 m) and flat, similar to the barren areas described by Baldwin and Lofton (1959). Baldwin and Lofton suggested that the apparent hesitancy of turtles to emerge on these barren areas may be related to the unbroken horizons provided by such beaches.

Low nest densities in Areas O and P (and Area 4) during 1982 apparently resulted from construction of the St. Lucie Plant Unit No. 2 intake system. Construction activities were similar to those conducted

during 1975 and 1981. These activities consisted of construction crews using heavy equipment and strong lights offshore from, and perpendicular to, the beach.

In order to determine whether construction of power plant intake and discharge systems has had a significant effect on nesting adjacent to the St. Lucie Plant, nest densities in Areas 4 and 5 were compared between construction years (1975, 1980, 1981 and 1982) and non-construction years (1971, 1973, 1977 and 1979). Area 5 was chosen as a control because it is outside of the area expected to be influenced by either power plant operation or intake/discharge construction. Also, Area 5 was similar to Area 4 with respect to beach topography and nest densities prior to plant operation and intake/discharge construction in 1971 and 1973.

Results of a G-test of independence (Sokal and Rohlf, 1981) indicated that nest densities in Area 4 were significantly ($P \leq 0.05$) lower during intake/discharge construction. Though nest densities were reduced in this area during 1981 and 1982, they are expected to return to normal levels after construction activities are completed, as was observed during years following construction in 1975.

A G-test of independence also was used to determine if nest densities differed significantly before and after power plant operation (exclusive of intake/discharge construction). After excluding years (1975, 1980, 1981 and 1982) during which intake/discharge construction occurred, nest densities in Areas 4 and 5 were compared between preopera-

tional years (1971 and 1973) and operational years (1977 and 1979). No significant ($P \leq 0.05$) effect of power plant operation on nest densities was indicated.

To determine whether overall plant operation since 1976 has had a significant effect on turtle nesting activities, nest densities in Areas 4 and 5 were compared between all preoperational and operational years. A two-way ANOVA indicated no significant ($P \leq 0.05$) difference in nest densities between preoperational and operational years.

Number of Nests and Population Estimates

Various methods have been used during previous surveys to estimate the total number of nests on Hutchinson Island, based on the number of nests found in the 1.25-km survey areas (Gallagher et al. 1972; Worth and Smith, 1976; ABI, 1980). The most reliable methods appeared to be either extrapolation of the nine-area total to the whole island or an estimate resulting from linear regression analysis. The latter method was based on the apparent linear relationship between nest densities in the nine study areas and their distance from Ft. Pierce Inlet. Since all nests on the entire island were counted during 1981 and 1982, the accuracy of the estimation techniques can be determined for these two years.

The regression method overestimated the total number of nests on the island by 26 percent in 1981 and 32 percent in 1982 (Table H-2). The inaccuracy of this method is probably related to differences between the distribution of nests in the nine study areas and the actual distribution

of nests along the entire island. As mentioned earlier, the distribution of nests in the nine study areas appears to exhibit a linear relationship, however, this does not appear to be the case for the distribution of nests along the entire island (Figure H-3). Based on nest densities within the thirty-six areas comprising the entire island, a curvilinear relationship between nest densities and distance from Ft. Pierce Inlet was indicated. Therefore, equations which describe the nine-area distribution of nest densities do not accurately describe the actual distribution of nest densities and, thus, are not accurate when used to estimate the total number of nests on the island.

The extrapolation method produced more accurate estimates of total nesting on the island during both 1981 and 1982. This method overestimated the actual total number of nests by only 6 percent in 1981 and 11 percent in 1982 (Table H-2). Additional data on the relationship of nest densities in the nine areas compared to nest densities along the entire island may reveal a more accurate predictive method. Based on present data, however, extrapolation appears to be the most accurate method.

Regardless of the method used to estimate total nesting, considerable year-to-year fluctuations in nesting activity on Hutchinson Island occurred (Table H-2). Year-to-year variations in nest densities are also common at other rookeries (Hughes, 1976; Davis and Whiting, 1977; Ehrhart, 1979) and may result from overlapping of non-annual breeding populations. No relationships between total nesting activity on the island and power plant operation or intake/discharge construction were indicated.

In order to determine the total number of female loggerhead turtles nesting on Hutchinson Island during a given season, an estimate of the number of nests produced by each female must be determined. A comparison of the number of nests produced by tagged turtles during 1975, 1977 and 1979 surveys indicated that an average of two nests were produced per female during a nesting season (ABI, 1980). Thus, estimates of total numbers of females nesting during previous survey years may be obtained by dividing the calculated total number of nests by two. Based on extrapolation estimates of total nesting, the number of female loggerhead turtles nesting on Hutchinson Island varied from approximately 1500 to 2300 individuals during survey years 1971-1979. Based on whole-island nest counts during 1981 and 1982, the total number of nesting females was 1558 and 2345 individuals, respectively.

Temporal Nesting Patterns

The loggerhead turtle nesting season on Hutchinson Island usually begins in early May, reaches a maximum during June or July, and ends by late August or early September. The onset of nesting activity on the island occurs when ocean temperatures reach 23° or 24°C. Shifts in the temporal pattern may be influenced by fluctuations in water temperature. As in 1975, early nesting occurred in 1982 and coincided with average ocean temperatures above 24°C in April (Figure H-4).

Cool-water intrusions frequently occur off southeastern Florida during the summer (Taylor and Stewart, 1958; Smith, 1982). During 1982, cool-water intrusions were noted during early June and July (Figure H-4).

Sharp declines in nesting were probably related to decreases in water temperature on several occasions during 1982. However, these declines were of short duration and followed by equally sharp increases. Thus, cool-water intrusions were not considered to have significantly affected total nesting activity in 1982.

To determine if plant operation affected seasonal nesting patterns (nest density on a month-to-month basis), the nesting patterns for preoperational years (1971, 1973 and 1975) and for operational years (1977, 1979, 1981 and 1982) were determined from pooled data for Area 4 (plant site) and Area 5 (control site) and statistically compared (Kolmogorov-Smirnov test; Sokal and Rohlf, 1981). There were no significant ($P \leq 0.05$) differences in temporal nesting patterns between Areas 4 and 5, either before or during plant operation. In addition, there was no significant difference in the temporal nesting pattern at Area 4 between preoperational and operational years. The results of these analyses indicated that plant operation has not significantly affected temporal nesting patterns. Furthermore, when data from all nine areas are combined, the temporal nesting pattern for preoperational years was virtually identical to the temporal nesting pattern for operational years (Figure H-5).

Nesting Success

Not all ventures onto the beach by a female turtle culminate in successful nests. These "false crawls" may occur for many reasons and are commonly encountered at other rookeries (Davis and Whiting, 1977; Talbert

et al., 1980). Davis and Whiting (1977) suggested that relatively high percentages of false crawls may reflect disturbances or unsatisfactory nesting beach characteristics. Therefore, an index which relates the number of nests deposited in an area to the number of false crawls in that area is useful in estimating the suitability of that beach for nesting. In the present study this index is termed "nesting success" and is defined as the percentage of total crawls that result in nests.

Nesting success has varied from year to year among the areas surveyed (Table H-3). Most of the variation was probably caused by short-term, localized erosion that reduced the suitability of the beach for nesting. Though there was a general decline in overall nesting success from 1971 through 1981, this trend reversed in 1982. Nesting success increased in all nine of the 1.25-km-long survey areas between 1981 and 1982 (Table H-3). An overall increase in nesting success between 1981 and 1982 was also shown for the thirty-six 1-km-long survey areas comprising the entire island (Figure H-6).

Reduced nesting success in the vicinity of the power plant during 1981 and 1982 was indicated by data for the thirty-six survey areas. Construction activities associated with installation of power plant intake and discharge systems may have been responsible for these reductions. Possibly because of the localized nature of the effects, reductions did not appear as pronounced when the larger 1.25-km-long areas were compared. Success rates are expected to return to normal levels after construction activities are completed. Other than during intake/

discharge construction, operation of the St. Lucie Plant has had no observable effect on turtle nesting success.

Nesting success values for the whole-island survey illustrate the variability caused by local beach conditions. The low nesting success in Area DD during 1982 (Figure H-6) was likely attributable to the narrowness of the beach in that area. Extremely low nesting success in Area B was probably due to unsuitable substrates, as well as intense lighting and considerable human activity on the beach at night. Though nesting success in Area A was approximately twice as high as in Area B, similar numbers of nests were recorded in the two areas. So few turtles emerged in Area A that nest success values may not reflect the relative suitability of the nesting beach in that area.

Raccoon Predation on Turtle Nests

Raccoon predation was probably the major cause of turtle nest destruction on Hutchinson Island. Researchers at other locations have reported raccoon predation levels as high as 70 to nearly 100 percent (Davis and Whiting, 1977; Hopkins et al., 1979; Talbert el al., 1980). Raccoon predation of loggerhead turtle nests on Hutchinson Island has not approached this level during any study year, though levels for individual 1.25-km-long areas have been as high as 80 percent (Table H-4). Overall predation rates for survey years 1971 through 1977 were between 21 and 44 percent, with the high of 44 percent recorded in 1973. A pronounced decrease in raccoon predation occurred after 1977, and overall predation rates for the nine areas have continued to decrease during subsequent

surveys. During 1982, only 3 percent of the nests in the nine areas and 2 percent of the nests on the whole island were destroyed by raccoons.

It is assumed that reduced predation is associated with a reduction in the raccoon population on the island. A number of factors may be responsible for the overall decline in raccoon predation. Habitat destruction associated with beach development, mortalities because of increased vehicular traffic, and disease could contribute to a decline in the raccoon population. Additionally, production of alternate food sources (such as garbage) and increased human activity on beaches may deter raccoons from preying upon turtle nests.

During 1982, raccoon predation was most prevalent just north and just south of the power plant (Figure H-7). Low raccoon predation in the immediate vicinity of the plant (Area 0) is attributed to construction activities and the fact that most of the nests in Area 0 were relocated.

Green and Leatherback Turtle Nesting

Green and leatherback turtles also nest on Hutchinson Island, but in fewer numbers than loggerhead turtles. Temporal nesting patterns for these species differ from the pattern for loggerhead turtles. During 1982, leatherback turtles nested from 15 April through 22 July, and green turtles nested from 22 May through 5 September. Prior to 1982, the number of nests observed on the island each survey year has ranged from 5 to 37 for green turtles and from 1 to 11 for leatherbacks (Figure H-8). During the 1982 season, 68 green turtle and 20 leatherback turtle nests

were recorded on Hutchinson Island. [NOTE: Prior to 1981, thirty-one kilometers of beach from Area 1 south to the St. Lucie Inlet were surveyed for green and leatherback turtle nests. During whole-island surveys in 1981 and 1982, no leatherback nests and only two green turtle nests were recorded north of Area 1. Therefore, green and leatherback nest densities on the southern thirty-one kilometers on the island were probably not appreciably different from total densities for the entire island. Based on this assumption, green and leatherback nest densities may be compared between all survey years except 1980 when less than fifteen kilometers of beach were surveyed.]

Considerable fluctuations in green turtle nesting on the island have occurred among survey years. Though nest densities were higher during 1982 than during any previous year, this may not necessarily indicate a long-term trend towards increased nesting by green turtles on Hutchinson Island. Annual data compiled by Dodd (1981) for green turtles nesting on Hutchinson Island since 1971 showed a similar increase in 1978 followed by a substantial decrease in 1979.

During 1982, green turtles nested most frequently in Areas R through X and AA through JJ (Figure H-9). These were the areas of high green turtle nest densities during 1973 and 1975 (the other survey years when green turtle nesting activity was relatively high). Though no northward shift in preferred nesting beaches was indicated, green turtles did nest in a number of the northern areas where nesting had not previously been recorded.

Leatherback turtle nest densities have been low on Hutchinson Island, although there has been a continual increase since 1975. This increase may reflect an overall increase in the number of nesting females or may be part of a long-term cycle of increasing and decreasing nesting activity in the Hutchinson Island area. During 1982, leatherback turtles nested from Area O to Area HH.

Turtle Nest Relocation

During 1982, 44 loggerhead turtle nests were relocated from the St. Lucie Plant intake construction area. No green or leatherback turtles nested in the vicinity of the construction.

Clutch Size

The mean clutch size (number of eggs per nest) for loggerhead turtle nests relocated during 1982 was 106, with a range of 43 to 165 eggs. The average clutch size of 45 undisturbed nests monitored during the same period was 110 eggs (range 82-161). The considerable variation in clutch size noted at Hutchinson Island has also been reported for other rookeries (Baldwin and Lofton, 1959; LeBuff and Beatty, 1971; Davis and Whiting, 1977; Ehrhart, 1979).

As in 1981, no correlation between clutch size and date of nesting was indicated during 1982. Likewise, Ehrhart (1979) found no trend towards increased or decreased clutch size as the season progressed in the Cape Canaveral area.

Incubation Period

Incubation period is defined as the time from nest deposition until the majority of the hatchlings leave the nest. The mean incubation period for relocated nests during 1982 was 52.8 days (range 48 to 66). Mean incubation period for undisturbed nests could not be reliably determined due to loss of virtually all nest markers. However, the mean incubation period for nests relocated during 1982 was similar to those for undisturbed nests monitored during 1980 and 1981 (50.1 and 51.5 days, respectively).

Hatch Success

Hatch success was determined by digging up nests after hatchling emergence and counting the number of hatched eggs, unhatched eggs, and live or dead hatchlings still in the nest. Hatch success was calculated for each relocated and undistrubed nest using the formula:

$$S = \frac{N - (U+D)}{E} \times 100\ \%$$

where: S = Hatch success,

N = Number of hatched eggs,

U = Number of unhatched eggs,

D = Number of dead hatchlings,

E = Total number of eggs (N + U)

The mean hatch success for all nests relocated during 1982 was 77.3 percent (range 29 to 96 percent); the mean hatch success for 45 undisturbed nests was 87.4 percent (range 46 to 99 percent). Mean hatch success for relocated nests was greater than means of 75.5 and 67.2 per-

cent reported for undisturbed nests in South Carolina (Hopkins et al., 1979; Talbert et al., 1980). However, results of a Mann-Whitney U test indicated a significant difference ($P \leq 0.05$) in hatch success between nests relocated during 1982 and undisturbed nests monitored during the same period.

Hatch success for undisturbed nests on Hutchinson Island in 1982 may be artificially high compared to average conditions. Though several undisturbed nests were marked every time a nest was relocated, beach goers removed virtually all markers. Therefore, when a relocated nest hatched, a recently hatched natural nest had to be located for comparison. Since nests with numerous hatchling tracks emerging from them were probably more obvious than those with very few tracks, nests with high hatch success (i.e., many hatchling tracks) were more likely to be located than those with low hatch success.

Intake Canal Monitoring

Species, Number and Temporal Distribution

Intake canal monitoring began in May 1976. Through December 1982, 702 loggerhead turtles, 67 green turtles, 7 leatherback turtles and 1 each of hawksbill and Kemp's ridley turtles were removed from the intake canal (Tables H-5 and H-6).

The yearly catch of loggerhead turtles increased from 33 individuals in 1976 (partial year of sampling) to 175 in 1979, decreased to 61 in 1981, and increased to 101 in 1982 (Figure H-10). The monthly catch of

loggerheads ranged from 0 to 29 individuals. Over the past 6 study years, the most loggerheads were collected during February (mean of 15.2 individuals); the fewest were collected during May (mean of 5.0 individuals; Table H-5). Differences in the number of loggerhead turtles found among years or among months were not statistically significant ($P \leq 0.05$; two-way ANOVA), primarily because of the large within-year and within-month variation in catch.

The yearly catch of green turtles ranged from 0 to 6 individuals between 1976 and 1979, increased to 13 in 1980 and 32 in 1981, and decreased to 8 in 1982 (Figure H-10). Forty-eight of the 67 greens (71.6 percent) found during intake canal monitoring were taken during the winter months of January through March.

Three of the 7 leatherback turtles were found in 1978 (Figure H-10); 4 of the 7 leatherbacks (57.1 percent) were found during the month of March. The single hawksbill turtle was taken in March 1978 and the Kemp's ridley turtle in February 1981.

Differences in the numbers of sea turtles found during different years and different months are attributed to natural variations in the occurrence of turtles in the vicinity of the St. Lucie Plant, rather than to any influence of the plant itself. With the exception of refueling outages, Unit 1 has been in operation from 1977 through the present time, so variation in intake cooling water flow rate is not considered a factor causing differences in the numbers of turtles found. In 1982 only 8

green turtles were captured, the lowest number since 1979 (Figure H-10). Although construction activities in the area of the ocean intake may have frightened away some green turtles, it is unlikely that construction significantly reduced the number of 1982 captures because most green turtles in the past have been taken during the winter months and intake construction was not in progress during these months in 1982.

Size Distribution

The majority of the loggerhead turtles captured in the canal ranged from 51 to 70 cm in straight-line carapace length (SLCL) and the majority of the green turtles ranged from 21 to 40 cm SLCL (Figure H-11). Based on minimum lengths of nesting females (Gallagher et al., 1972; Hirth, 1980) and morphometric analyses (F.H. Berry, National Marine Fisheries Service, personal communication), individuals of both species attain adulthood when somewhere between 70 and 85 cm in SLCL. The majority of loggerhead and green turtles found in the intake canal were thus considered to be sub-adults.

The leatherback turtles ranged in size from 113 to 150 cm in SLCL (Figure H-11). The hawksbill turtle was 46 cm in SLCL and the Kemp's ridley was 32 cm in SLCL.

Mortalities

Over the seven years of monitoring, 67 of the 702 loggerhead turtles (9.5 percent) and 10 of the 67 green turtles (14.9 percent) found in the intake canal were dead (Tables H-5 and H-6). All of the leatherbacks, the hawksbill and the Kemp's ridley were found alive.

Of the 67 dead loggerheads, 52 individuals (77.6 percent) were found floating in the canal, either along shore, against the barrier net or, in a few cases, against the bar screens (grizzlies) at the plant. Most of these "floaters" were in advanced stages of decomposition. Six of the loggerheads were found dead in the turtle nets, 2 in the gill nets used for fish sampling and 1 in the barrier net; these 9 individuals (13.4 percent of the mortalities) were presumed to have drowned. Of the 6 other loggerheads found dead (9 percent), 2 had been accidentally killed by the rake at the grizzlies and information is lacking on 4. Of the 10 dead greens, 8 individuals were found in either the turtle nets or the fish gill nets, 1 was found floating and information is lacking on 1.

To reduce or eliminate mortalities caused by the nets, particularly for the smaller green turtles, the turtle nets have been modified so that they are lighter and the fish gill nets are no longer used east of the Highway A1A bridge. Reducing mortalities of those turtles which are "floaters" is more of a problem because the causes of death are generally unknown. Drowning may occur during infrequent periods of reduced flow when the plant is off-line. When the plant is not in operation, a turtle entering the intake pipe might not find its way out and could drown because the flow would not be sufficient to carry the turtle through the pipe (this will be less of a possibility when Unit 2 becomes operational). However, under normal operations, the flow through the two presently-used intake pipes is 3 m/sec and a parcel of water would pass through one of these 503-m pipes in less than 3 minutes. Presumably, a turtle would also pass through an intake pipe in approximately this

amount of time, which is well within the amount of time that turtles can safely stay submerged. For example, during a series of simulated prolonged deep-diving experiments, Berkson (1966, 1967) recorded submersion times of 40 minutes to 5 hours for green turtles.

Injury sustained during passage through the intake pipes is another possible cause of mortalities. However, only 55 (7.1 percent) of the 778 sea turtles removed from the intake canal had recent lacerations, abrasions or other injuries that may have resulted from passage through the pipes. Wounds were considered minor in 39 of these 55 animals and major (deep cuts, broken flippers, etc.) in 16. The intake pipes in present use are 3.7 m in inside diameter, and it appears that the vast majority of the turtles are carried through the pipes without hitting the walls and sustaining injury.

The majority (66 percent) of the turtles found alive and released back into the ocean were considered to be in good physical condition, 19 percent were in poor condition and 15 percent were in excellent condition. Criteria used to evaluate condition were weight, activity, parasite coverage and wounds or injury (Table H-7). Turtles found dead in the canal may have been in poor condition prior to entering the canal. Turtles in poor condition could enter the ocean intakes seeking refuge and end up in the canal, where they die from causes unrelated to plant operations.

Only one dead turtle found in 1982 was a recent mortality and therefore in suitable condition for necropsy. This turtle was a 63-cm SLCL loggerhead found by a diver at the bottom of the barrier net. It was heavily parasitized internally. Probable cause of death was diagnosed as enteritis (inflammation of the intestine), dehydration, starvation and, possibly, secondary septicemia (bacterial toxins in the blood).

Capture Efficiency

A capture/recapture study was conducted from October 1980 through January 1981 to determine the length of time turtles were in the intake canal prior to being captured with the nets and to determine if there was any significant weight loss of turtles while they were in the canal.

Eleven individual loggerhead turtles were captured, tagged, released back into the canal and recaptured. Recapture occurred one to nine times before the individuals were released to the ocean (Table H-8). There was a total of 32 recaptures. The elapsed time between capture and recapture ranged from 0.25 to 38 days, with an average of 10.3 days. Twenty-three of the 32 recaptures (72 percent) occurred within 11 days.

Seven of the 11 turtles were in the canal at least 15 days (range 15 to 90 days, average 44 days) between first capture and subsequent release to the ocean (Table H-9). Weight loss during this time ranged from 0 to 2 kgs; the average was 0.7 kg. The turtles all appeared to be in healthy condition when released into the ocean.

In general, turtles entrapped in the intake canal are caught and released within a relatively short time span and, during this time, body weights do not change appreciably.

SUMMARY

A gradient of increasing nest densities from north to south along Hutchinson Island has been indicated during all survey years. This gradient may, in part, result from variations in beach topography which change from year to year as a result of localized erosion or accretion. Substrate suitability, lighting and human activity may also influence nesting activity. Low nesting activity in the vicinity of the power plant during 1975, 1981 and 1982 was attributed to construction of power plant intake and discharge systems. Nesting returned to normal levels following construction in 1975 and is expected to do so again when present construction activities are completed. Power plant operation since 1976 has had no significant effect on nest densities.

There have been considerable year-to-year fluctuations in nesting activity on Hutchinson Island from 1971 to 1982. Fluctuations are common at other rookeries and may result from overlapping of non-annual breeding populations. No relationship between total nesting on the island and power plant operation or intake/discharge construction were indicated.

Results of three years of tagging studies on Hutchinson Island indicated that an average of two nests per year were produced by each nesting loggerhead turtle. Based on this average, the nesting population of

loggerhead turtles on the island has varied from approximately 1500 individuals in 1977 to over 2300 in 1982. The temporal nesting pattern of this population may be influenced by fluctuations in water temperature. Though natural temperature fluctuations have apparently affected temporal nesting patterns on Hutchinson Island, no significant effect due to power plant operation was indicated.

Nesting success varied among survey areas from year to year. Much of this variation probably resulted from the same factors suggested for variations in nest densities. Though there was a general decline in overall nesting success from 1971 through 1981, this trend reversed in 1982 when success rates increased in all nine areas. Reduced nesting success in the vicinity of the power plant was indicated during 1981 and 1982. These reductions were apparently localized effects due to intake and discharge construction. Nesting success is expected to return to normal levels when construction is completed.

Raccoon predation was probably the major cause of turtle nest destruction on Hutchinson Island. However, a pronounced decrease in raccoon predation has been observed since 1977. It was assumed that reduced predation was associated with a reduction in the raccoon population on the island.

During 1982, forty-four loggerhead turtle nests were relocated from the plant intake construction area. The mean clutch size for relocated nests was 106 eggs. No correlation between clutch size and time of the

nesting season was indicated. The average incubation period for relocated nests was 52.8 days. Though the mean hatch success for relocated nests was high (77.3 percent), it was significantly lower than that for undisturbed nests. The difference may be exaggerated due to an artificially high average success rate for undisturbed nests.

Sixty-eight green turtle and twenty leatherback turtle nests were recorded on Hutchinson Island during 1982. Green turtle nesting activity exhibited considerable annual fluctuations, while annual leatherback nest densities have continually increased since 1975.

Intake canal monitoring began in May 1976. Since that time, 702 loggerhead turtles, 67 green turtles, 7 leatherback turtles and 1 each of hawksbill and Kemp's ridley turtles were removed from the intake canal. The yearly catch of loggerhead turtles ranged from 33 individuals in 1976 (partial year of sampling) to 175 in 1979. The yearly catch of greens has ranged from 0 in 1976 to 32 in 1981. Differences in the numbers of turtles found during different years and different months were attributed to natural variations in the occurrence of turtles in the vicinity of the St. Lucie Plant, rather than to any influence of the plant itself.

Nine and one-half percent of the loggerhead turtles and 14.9 percent of the green turtles removed from the intake canal since 1976 were dead. All of the leatherbacks, the hawksbill and the Kemp's ridley were alive. The majority of the dead turtles were found floating in the canal, while a few others were found dead in the nets. The turtle nets have since

been modified and the fish gill nets removed from the area to eliminate or reduce mortalities caused by nets. The causes of death for the turtles found floating are generally unknown. Drowning may occur if the plant is off-line, but this is an infrequent occurrence. Similarly, only 7 percent of all turtles were found with injuries that may have been sustained during passage through the intake pipe and for the most part, these injuries were minor. It appeared that the vast majority of the turtles were carried through the pipes without hitting the walls and sustaining injury. A possible cause of dead turtles in the canals is from turtles in already poor condition entering the ocean intakes seeking refuge and dying in the intake canal from causes unrelated to plant operations. The poor condition of many live turtles found in the canal supports this as a possible cause of mortalities.

The majority of the loggerhead turtles captured in the canal ranged from 51 to 70 cm in straight-line carapace length; the majority of the green turtles from 21 to 40 cm. Turtles of these sizes are considered to be sub-adults. Sixty-six percent of the turtles found alive and released back into the ocean were considered to be in good physical condition, 19 percent were in poor condition, and 15 percent were in excellent condition.

A capture/recapture study showed that turtles entering the canal were captured in an average 10.3 days and that weight loss of turtles that had been in the canal at least 15 days averaged 0.7 kg. In general, turtles entrapped in the intake canal are caught and released within a

relatively short time span and, during this time, body weights do not change appreciably.

LITERATURE CITED

ABI (Applied Biology, Inc.). 1978. Ecological monitoring at the Florida Power & Light Co. St. Lucie Plant, annual report 1977, Volume I. AB-101. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1980. Florida Power & Light Company St. Lucie Plant annual non-radiological environmental monitoring report, 1979. Volume III, Biotic monitoring. AB-244. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1981. Successful relocation of sea turtle nests near the St. Lucie Plant, Hutchinson Island, Florida. AB-317. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________________. 1982. Florida Power & Light Company St. Lucie Plant, annual non-radiological monitoring report 1981. Volume III, Biotic monitoring. AB-379. Prepared by Applied Biology, Inc. for Florida Power & Light Co. Miami.

Baldwin, W.P., Jr. and J.P. Lofton, Jr. 1959. The loggerhead turtles of Cape Romain, South Carolina. Previously unpublished manuscript abridged and annotated by D.K. Caldwell, without the authors. in D.K. Caldwell and A. Carr, coordinators, The Atlantic loggerhead sea turtle, Caretta caretta caretta (L.), in American. Bulletin of the Florida State Museum, Biological Sciences, 4(10):319-348.

Berkson, H. 1966. Physiological adjustments to prolonged diving in the Pacific green turtle (Chelonia mydas agassizii). Comparative Biochemistry and Physiology 18:101-119.

__________. 1967. Physiological adjustments to deep diving in the Pacific green turtle (Chelonia mydas agassizii). Comparative Biochemistry and Physiology 21:507-524.

Caldwell, D.K., A. Carr and L.H. Ogren. 1959. Nesting and migration of the Atlantic loggerhead turtle. in D.K. Caldwell and A. Carr, coordinators, The Atlantic loggerhead sea turtle, Caretta caretta caretta (L.), in America. Bulletin of the Florida State Museum, Biological Sciences, 4(10):295-308.

Davis, G.E. and M.S. Whiting. 1977. Loggerhead sea turtle nesting in Everglades National Park, Florida, U.S.A. Herpetologica 33:18-28.

Dodd, C.K., Jr. 1981. Nesting in the green turtle, Chelonia mydas (L.), in Florida: Historic review and present trends. Brimleyana 7:39-54.

LITERATURE CITED (continued)

Ehrhart, L.M. 1979. Threatened and endangered species of the Kennedy Space Center: Marine turtle studies in A continuation of baseline studies for environmentally monitoring space transportation systems (STS) at John F. Kenndey Space Center. Contract No. NAS 10-8986. Vol. IV NASA Report. 163122. August 21, 1979.

Gallagher, R.M., M.C. Hollinger, R.M. Ingle and C.R. Futch. 1972. Marine turtle nesting on Hutchinson Island, Florida in 1971. Florida Department of Natural Resources, Special Scientific Report No. 37:1-11.

Hirth, H.H. 1980. Some aspects of the nesting behavior and reproductive biology of sea turtles. American Zoologist 20:507-523.

Hopkins, S.R., T.M. Murphy, Jr., K.B. Stansell and P.M. Wilkinson. 1979. Biotic and abiotic factors affecting nest mortality in the Atlantic loggerhead turtle. Proceedings Annual Conference of Southeastern Fish and Wildlife Agencies 32:213-223.

Hughes, G.R. 1976. Irregular reproductive cycles in the Tongaland loggerhead sea turtle, Caretta caretta L. (Cryptodira: Chelonidae). Zoologica Africana 11(2):285-291.

LeBuff, C.R. and R.W. Beatty. 1971. Some aspects of nesting of the loggerhead turtle, Caretta caretta caretta, (Linne), on the Gulf Coast of Florida. Herpetologica 27(a):153-156.

Limpus, C.J., V. Baker and J.D. Miller. 1979. Movement induced mortality of loggerhead eggs. Herpetologica 35(4):335-338.

NMFS (National Marine Fisheries Service). 1978. Final EIS listing and protecting the green sea turtle (Chelonia mydas), loggerhead sea turtle (Caretta caretta) and the Pacific ridley sea turtle (Lepidochelys olivacea) under the Endangered Species Act of 1973. National Marine Fisheries Service, Dept. of Commerce, Washington, D.C.

O'Hara, J. 1980. Thermal influences on the swimming speed of loggerhead turtle hatchlings. Copeia 1980(4):773-780.

Routa, R.A. 1968. Sea turtle nest survey of Hutchinson Island, Florida. Quarterly Journal Florida Academy of Sciences 30(4):287-294.

Smith, N.P. 1982. Upwelling in Atlantic shelf waters of South Florida. Florida Scientist 45(2):125-138.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry. The principles and practice of statistics in biological research. W.H. Freeman and Company, San Francisco.

LITERATURE CITED (continued)

Talbert, O.R., Jr., S.E. Stancyk, J.M. Dean and J.M. Will. 1980. Nesting activity of the loggerhead turtle (*Caretta caretta*) in South Carolina. I: A rookery in transition. Copeia 1980:709-718.

Taylor, C.B. and H.B. Stewart. 1959. Summer upwelling along the east coast of Florida. Journal of Geophysical Research 64(1):33-40.

Worth, D.F. and J.B. Smith. 1976. Marine turtle nesting on Hutchinson Island, Florida, in 1973. Florida Department of Natural Resources Florida Marine Research Publication No. 18:1-17.

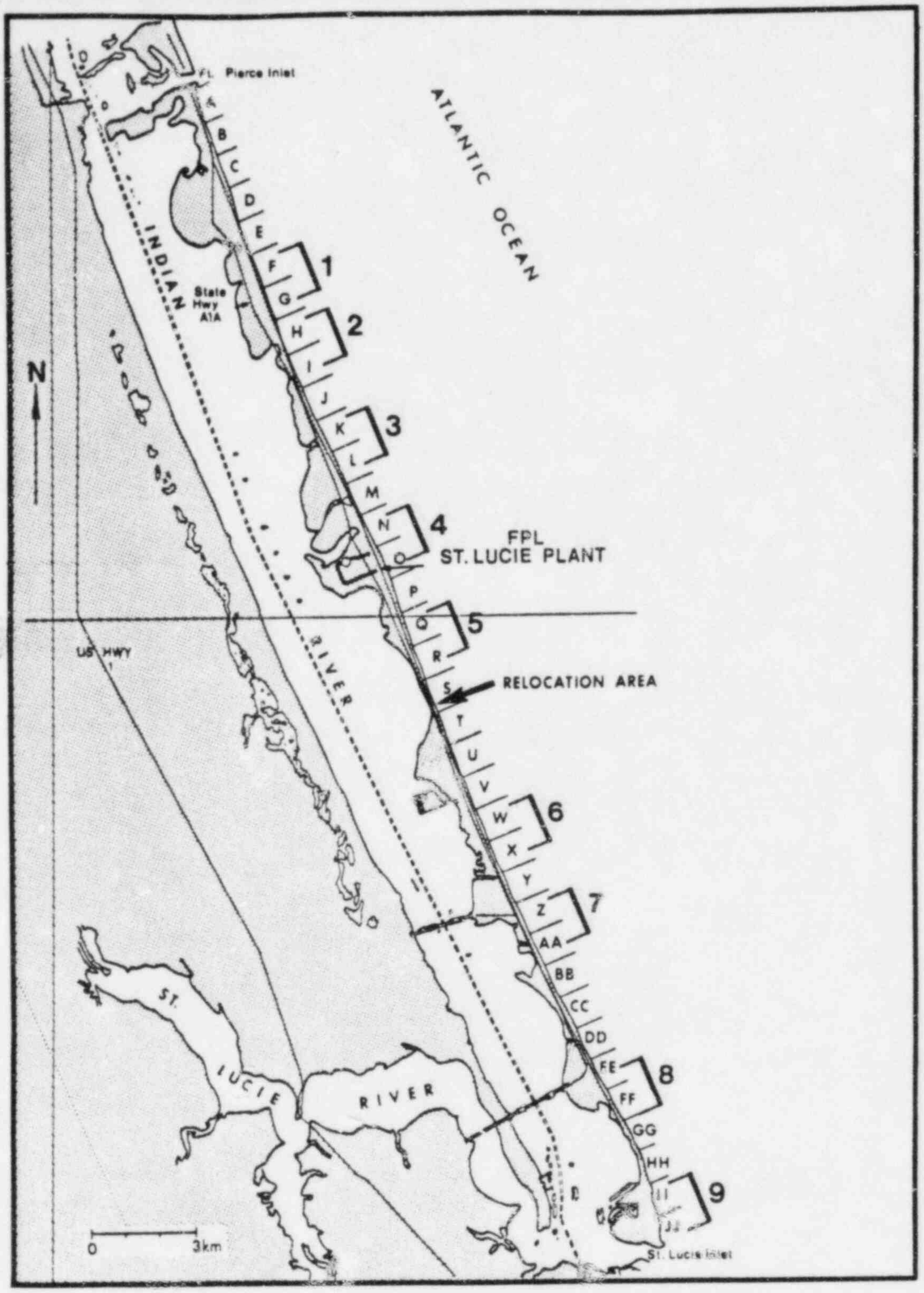

Figure H-1. Designation and location of nine 1.25-km-long survey areas and thirty-six 1-km-long survey areas monitored for sea turtle nesting, Hutchinson Island, 1971-1982.

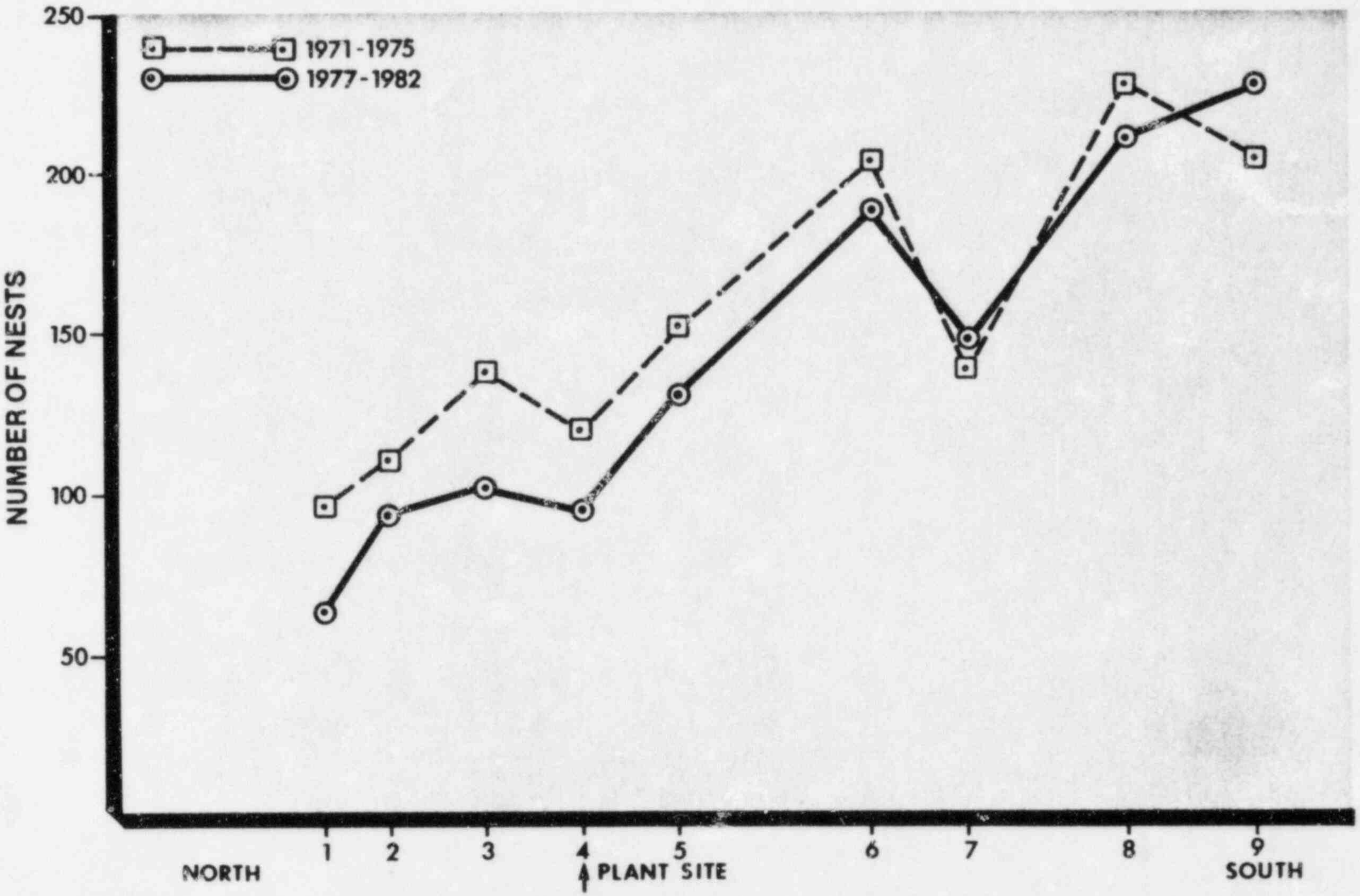

Figure H-2. Average number of loggerhead turtle nests in each of the nine 1.25-km-long survey areas during preoperational years (1971,1973,1975) and operational years (1977, 1979,1981,1982), Hutchinson Island.

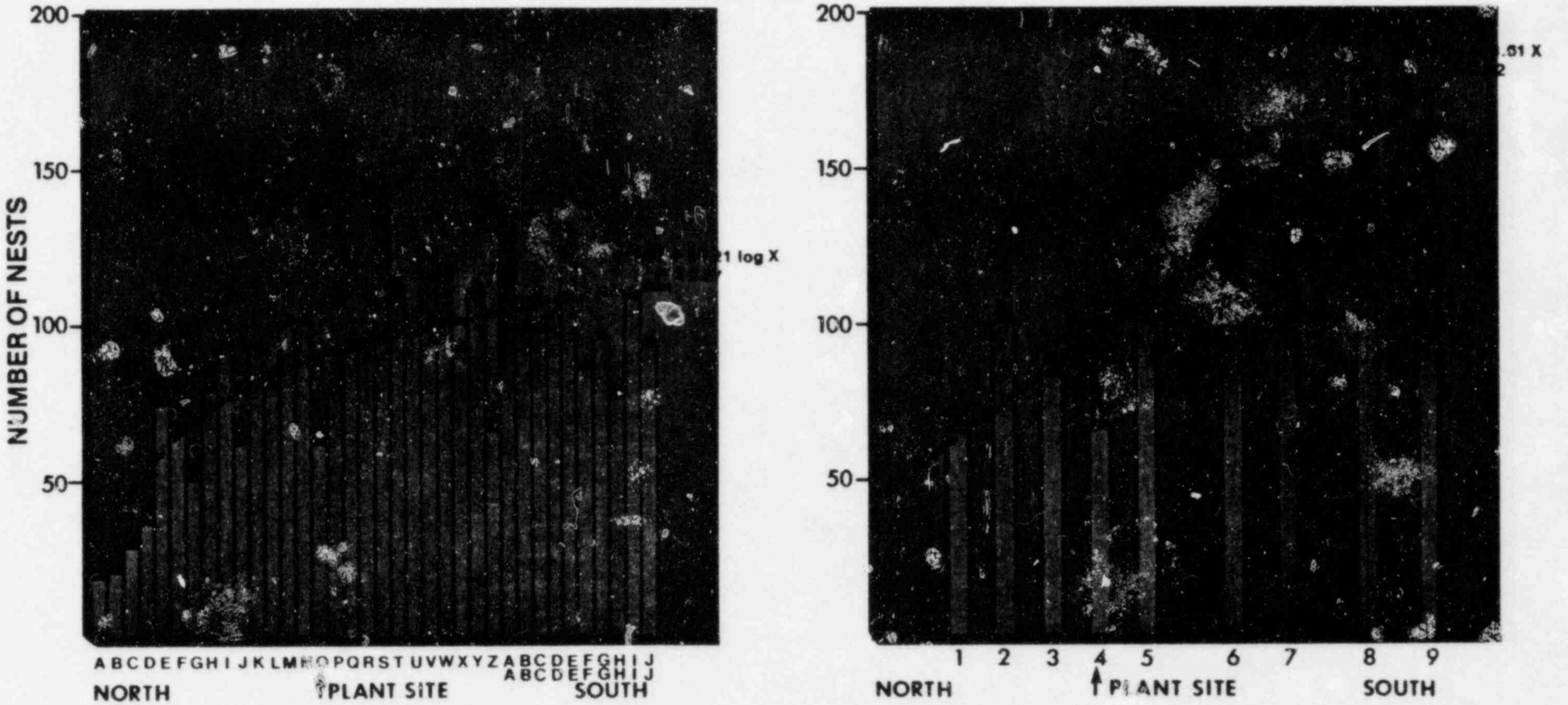

Figure H-3 . Number of loggerhead turtle nests in each of the 36 1-km-long survey areas comprising the entire island and each of the nine 1.25-km-long survey areas, Hutchinson Island, 1981 and 1982.

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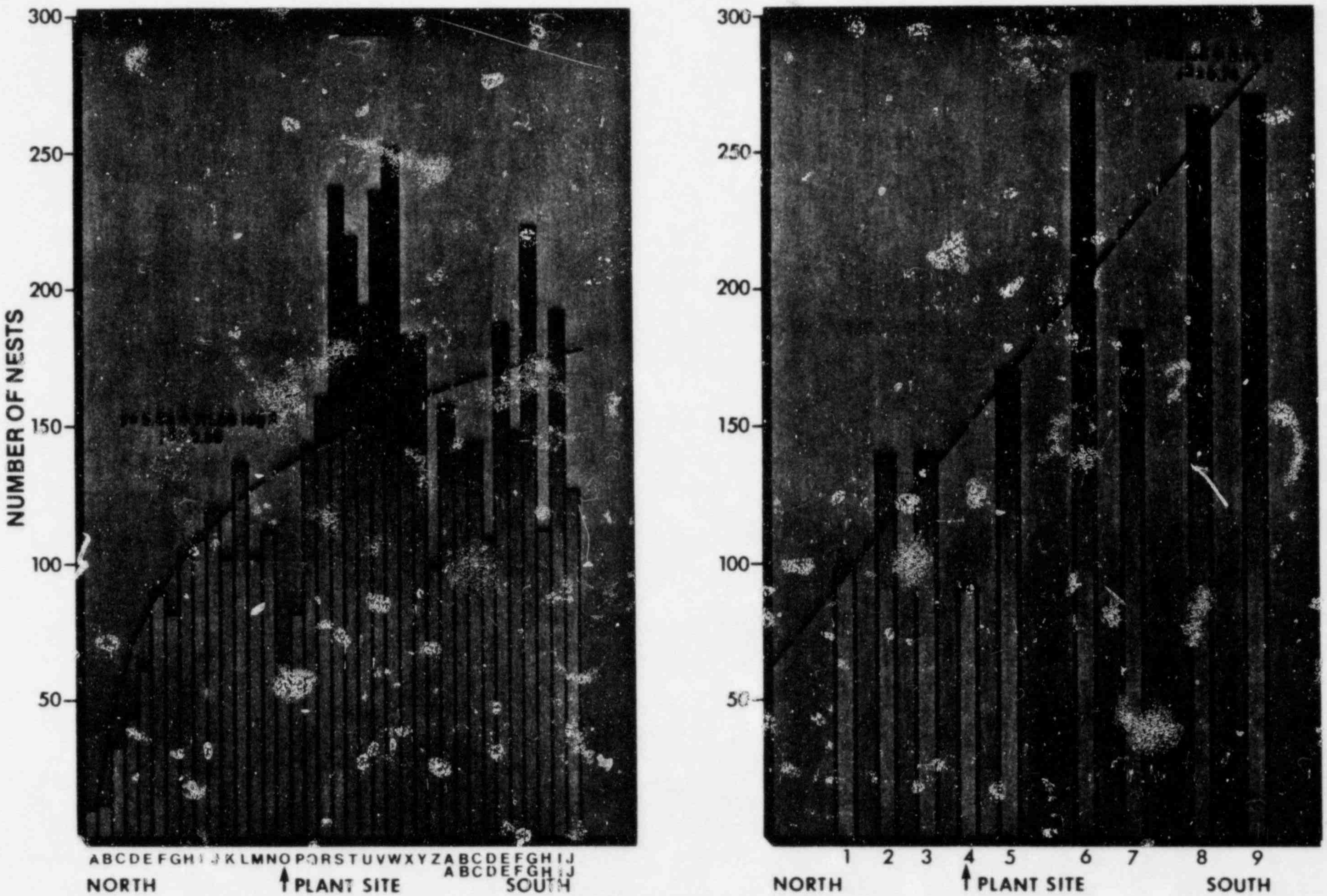

Figure H-3 (continued).

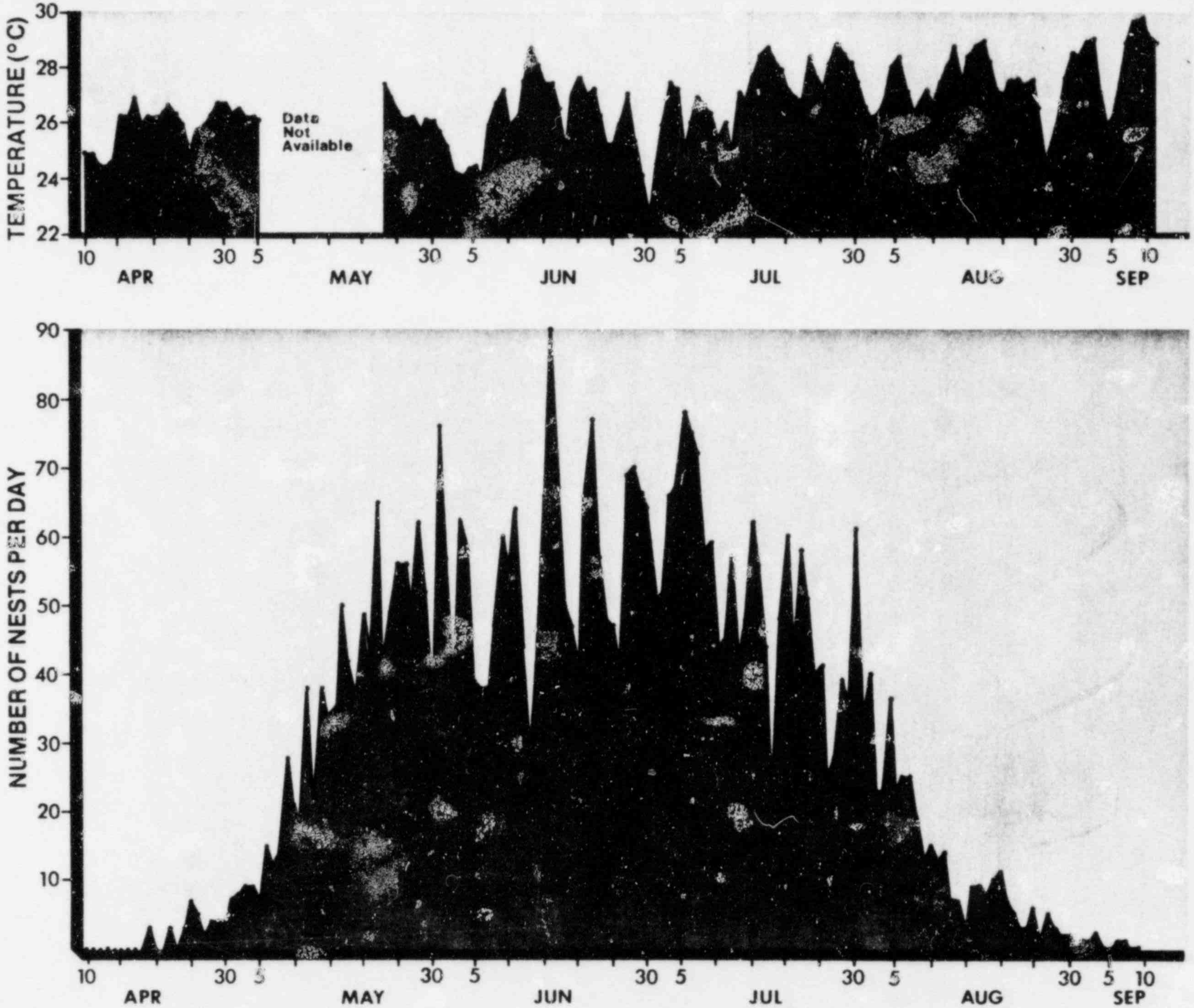

Figure H-4. Mean water temperature and daily loggerhead turtle nesting activity, Hutchinson Island, 1982.

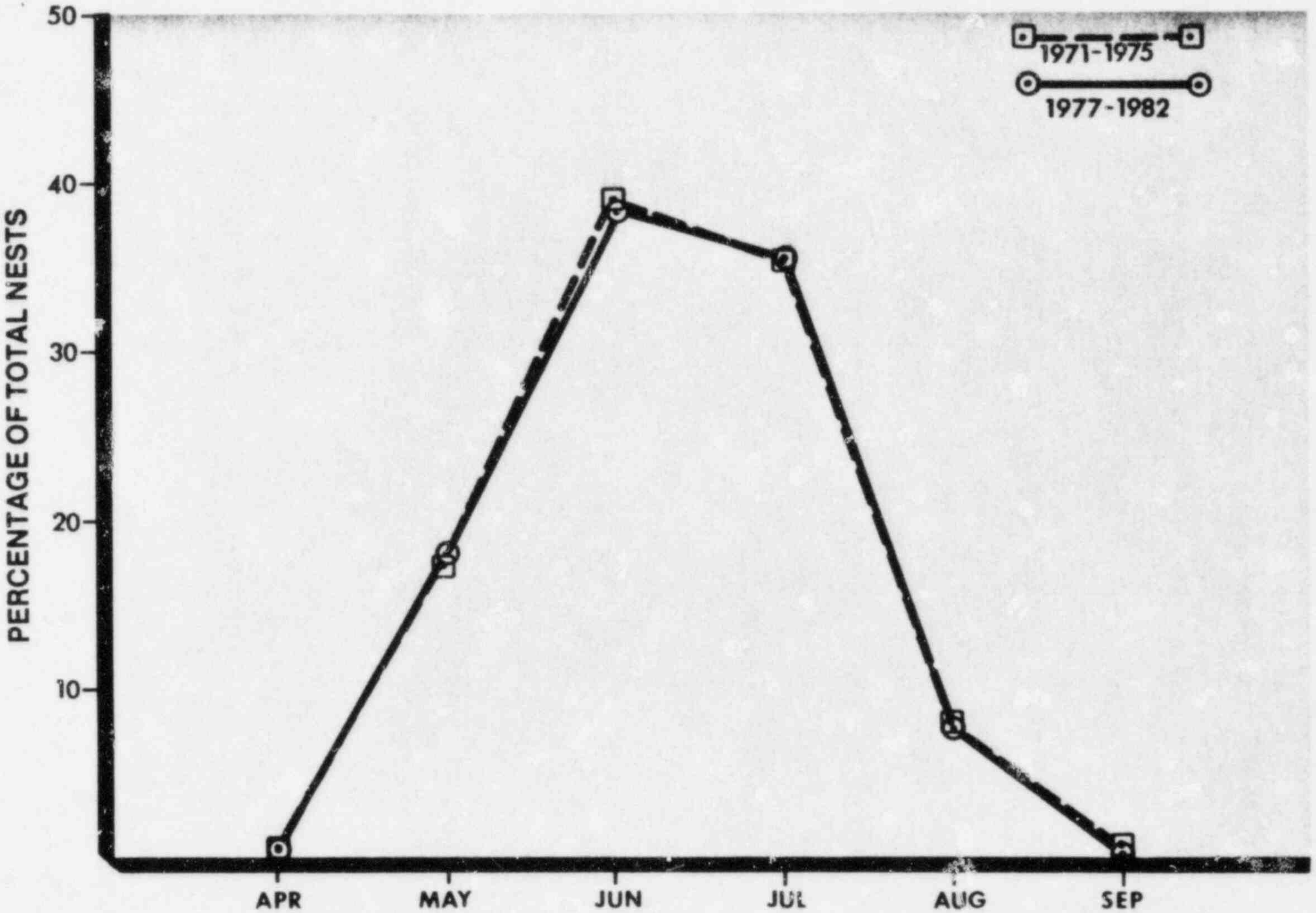

Figure H-5. Comparison of the percentage of the total number of loggerhead turtle nests observed in the nine 1.25-km-long survey areas during each month for pooled preoperational years (1971,1973,1975) and operational years (1977,1979,1981, 1982), Hutchinson Island.

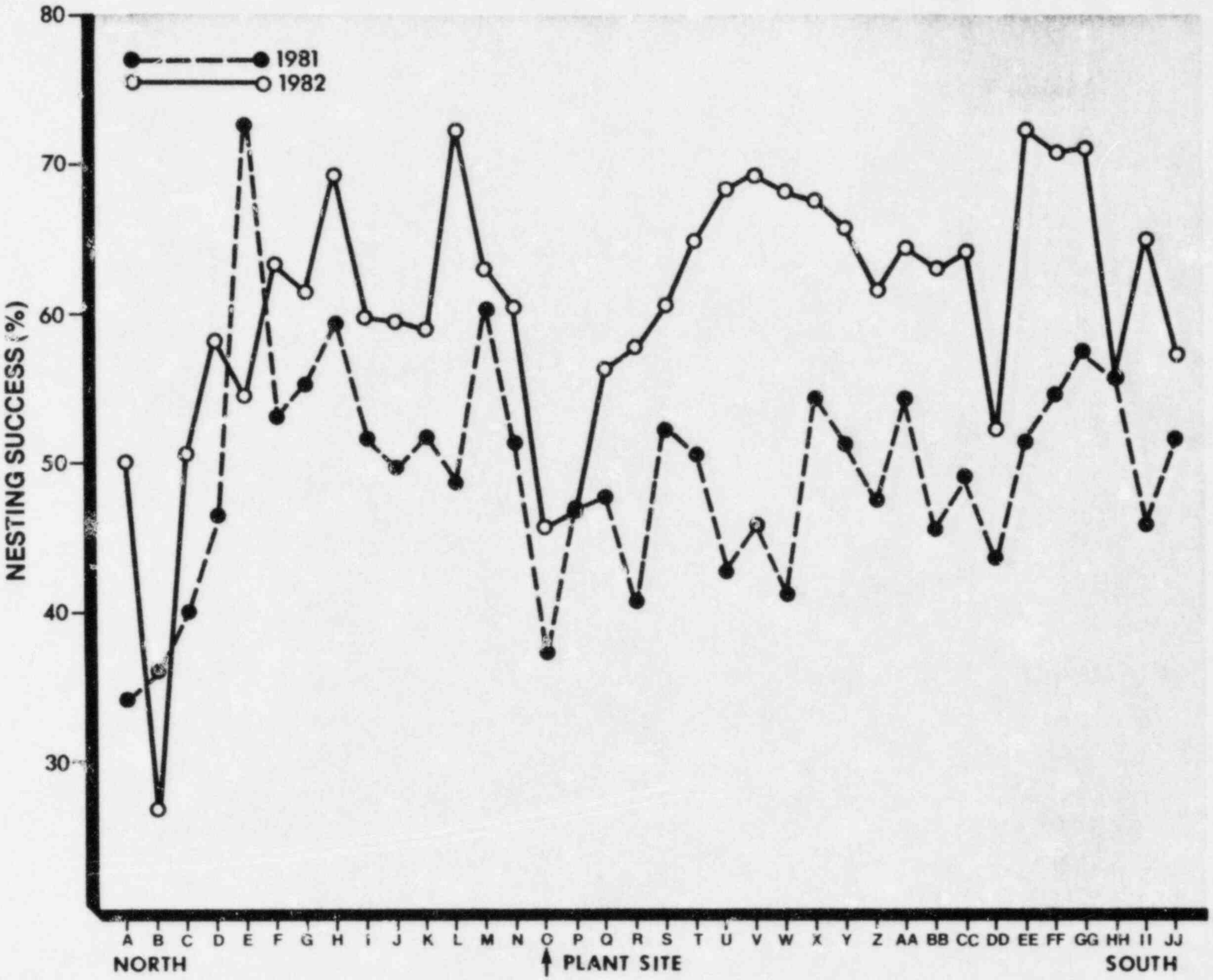

Figure H-6. Loggerhead turtle nesting success (percentage of total crawls that result in nests) for each 1-km-long survey area, Hutchinson Island, 1981 and 1982.

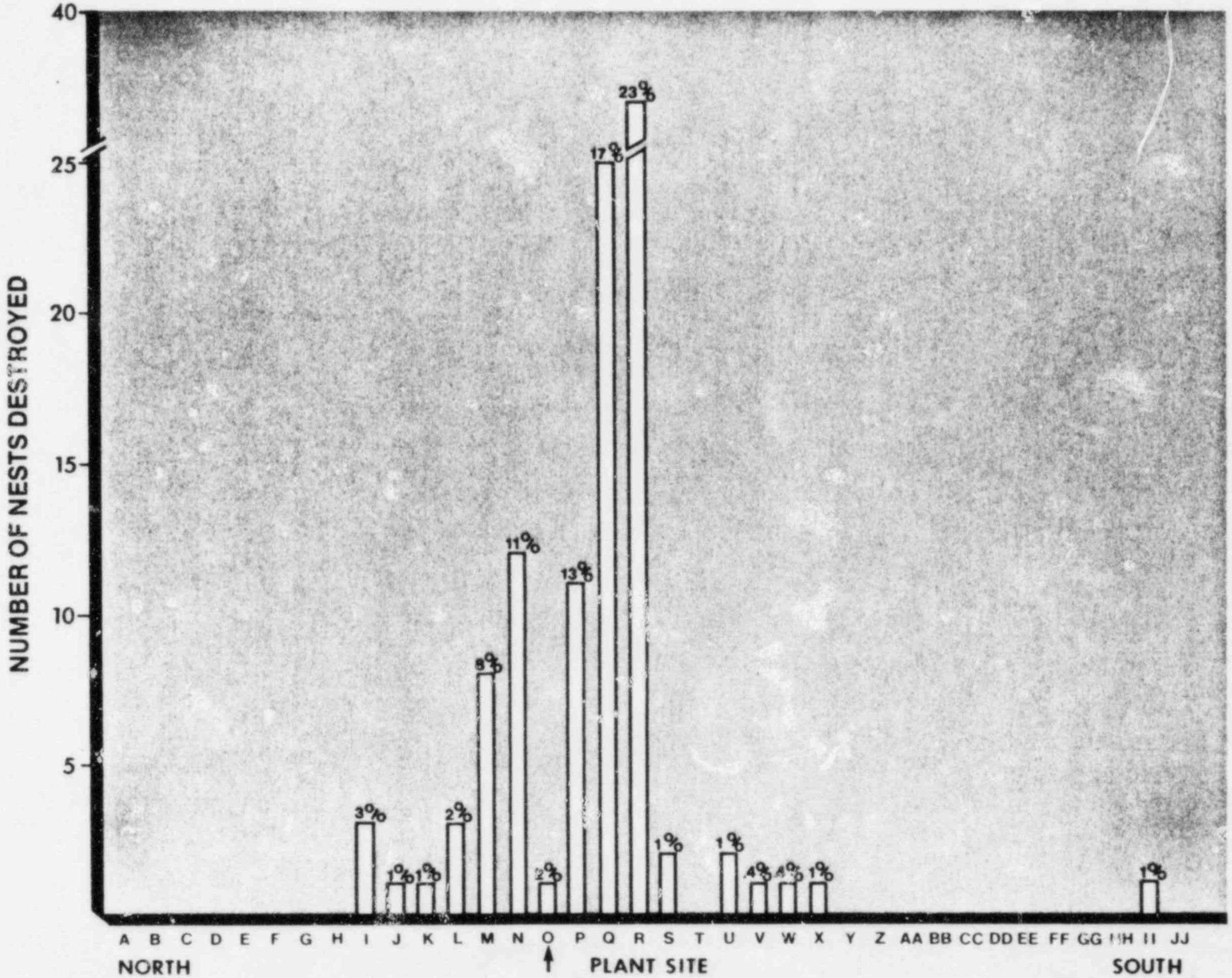

Figure H-7. Number of loggerhead turtle nests destroyed by raccoons and destroyed nests as a percentage of the total number of nests for each 1-km-long survey area, Hutchinson Island, 1982.

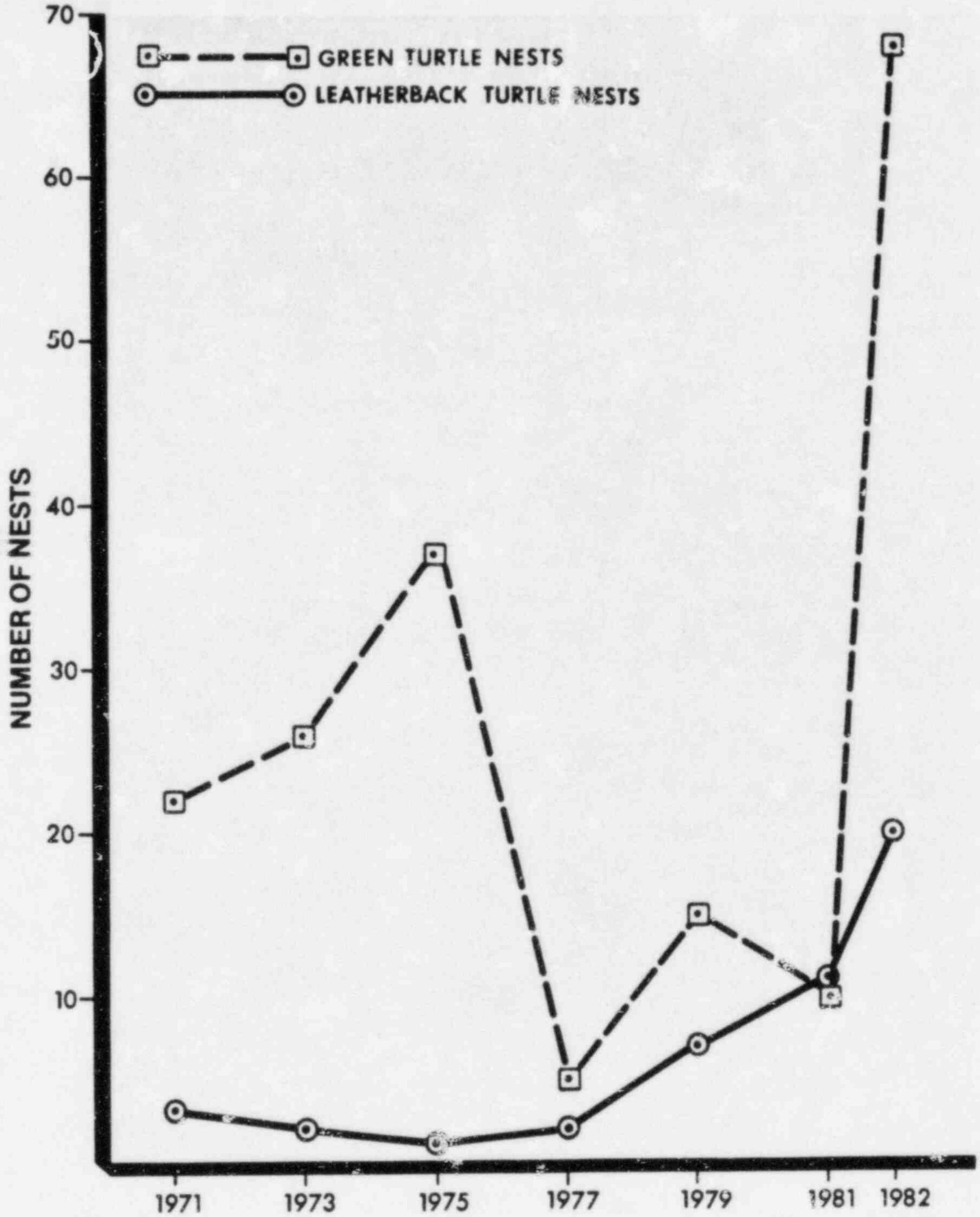

Figure H-8. Number of green turtle and leatherback turtle nests observed, Hutchinson Island, 1971-1982.

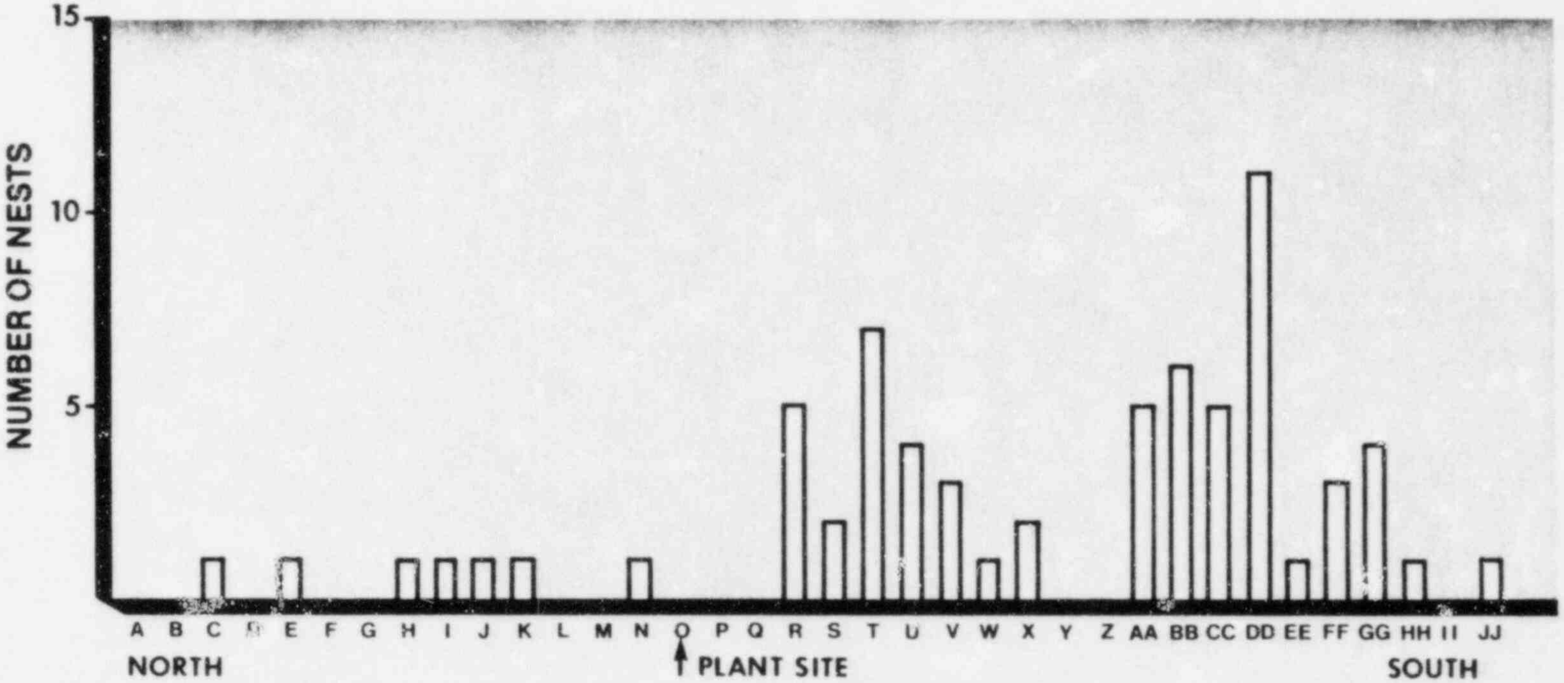

Figure H-9. Number of green turtle nests found in each 1-km-long survey area, Hutchinson Island, 1982.

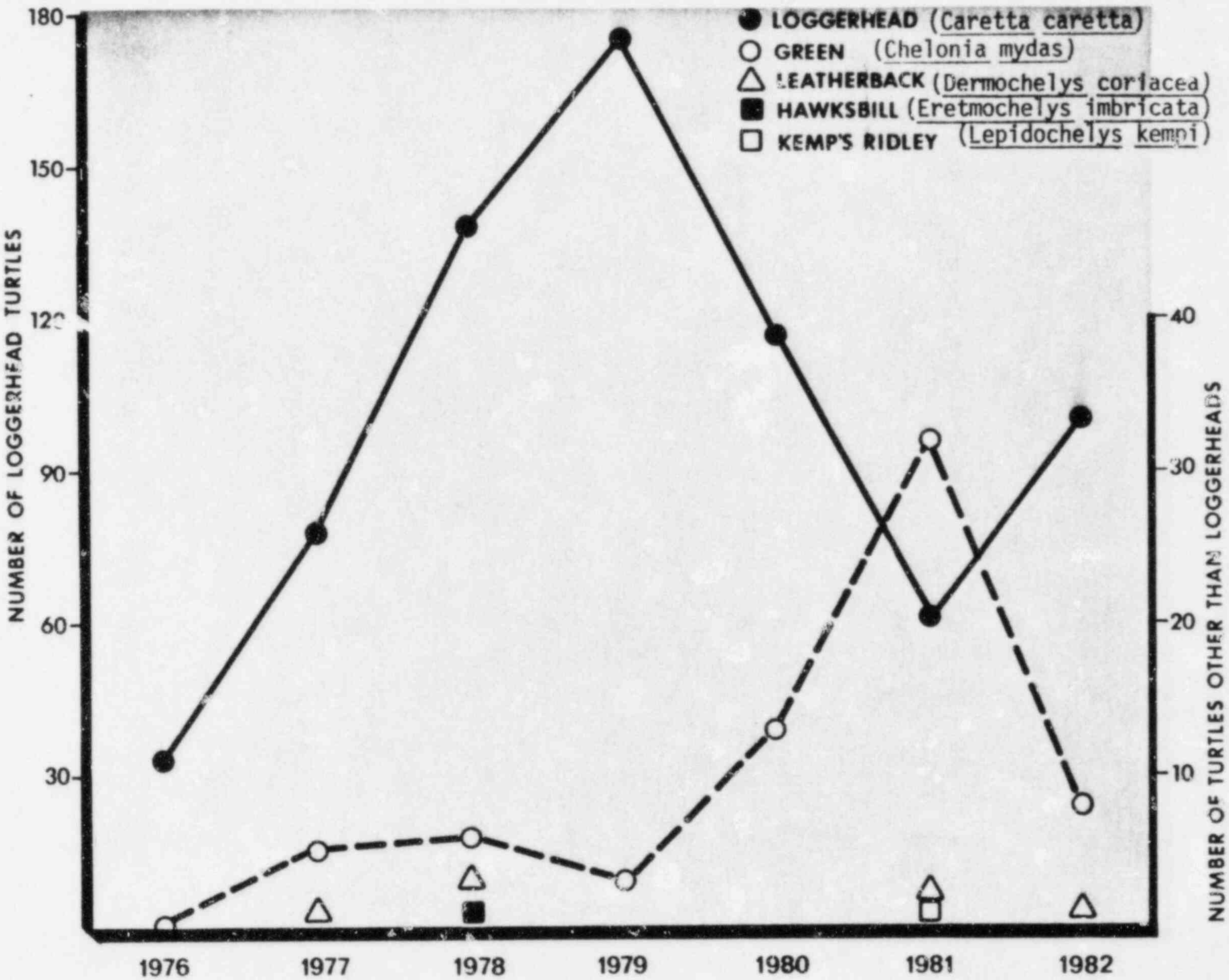

Figure H-10. Number of turtles removed from the intake canal, St. Lucie Plant, 1976-1982.

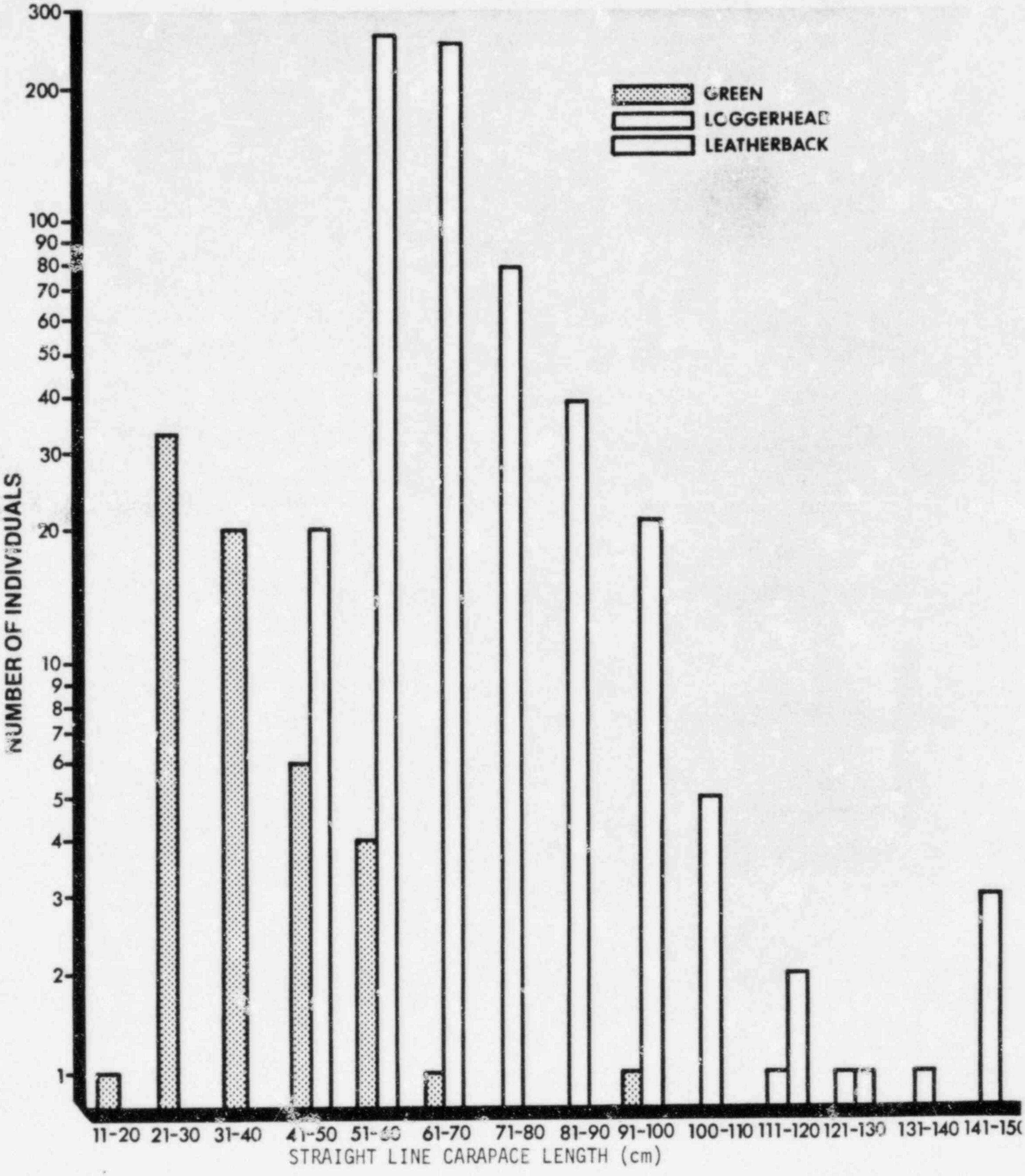

Figure H-11. Length distribution of sea turtles removed from the intake canal, St. Lucie Plant, 1976-1982.

TABLE H-1

NUMBER OF LOGGERHEAD TURTLE NESTS
IN EACH OF THE 1.25-KM-LONG SURVEY AREAS
HUTCHINSON ISLAND
1971 - 1982

Area	Preoperational			Operational				
	1971	1973	1975	1977	1979	1980[a]	1981	1982
1	85	110	96	48	47	-	66	98
2	92	132	108	55	80	-	101	139
3	113	144	156	90	93	109	83	140
4[b]	152	134	73	100	123	133	67	91
5	171	126	158	106	144	111	104	169
6	218	141	250	109	233	175	139	278
7	136	127	155	76	204	-	126	184
8	238	164	281	161	237	-	181	265
9	215	182	216	187	288	-	164	270
TOTAL	1420	1260	1493	932	1449	528	1031	1634

[a]Only Areas 3-6 were surveyed during 1980.

[b]St. Lucie Plant Site.

TABLE H-2

ESTIMATES OF THE NUMBERS OF LOGGERHEAD TURTLE NESTS BASED ON SURVEYS OF NINE 1.25-KM SURVEY AREAS IN 1971-1982 AND THE ACTUAL NUMBER OF NESTS FOUND 1981-1982 HUTCHINSON ISLAND

Year	Linear regression equation (Y=a+bx)[a]	r^2	Number of nests in the nine 1.25-km survey areas	Estimates of the number of nests on the entire island: Regression	Estimates of the number of nests on the entire island: Extrapolation	Actual number of nests on the entire island
1971	Y = 65.87 + 4.71x	0.73	1420	5423	4544	-
1973	Y = 108.34 + 1.62x	0.60	1260	4950	4032	-
1975	Y = 61.31 + 5.36x	0.61	1493	5680	4778	-
1977	Y = 29.26 + 3.81x	0.74	932	3522	2982	-
1979	Y = 7.53 + 7.87x	0.96	1449	5371	4637	-
1981	Y = 44.24 + 3.61x	0.82	1031	3932	3299	3115
1982	Y = 62.35 + 6.11x	0.74	1634	6204	5229	4690

[a]Y = The number of nests;
a = The Y intercept;
b = The slope of the regression line;
x = The distance (km) south of Ft. Pierce Inlet.

TABLE H-3

LOGGERHEAD TURTLE NESTING SUCCESS[a]
IN EACH OF THE 1.25-KM-LONG SURVEY AREAS
HUTCHINSON ISLAND
1973 - 1982[b]

	Preoperational		Operational				
Area	1973	1975	1977	1979	1980[c]	1981	1982
1	67	60	62	46	-	52	59
2	76	59	70	54	-	56	63
3	69	52	65	53	50	47	69
4[d]	78	53	54	51	46	42	57
5	75	55	50	41	41	45	58
6	62	58	49	53	44	45	68
7	64	55	46	54	-	53	65
8	71	67	48	52	-	56	71
9	70	61	56	61	-	52	62

[a]Nesting success is the percentage of total crawls that result in nests.

[b]False (non-nesting) crawls were not recorded during 1971.

[c]Only Areas 3-6 were surveyed during 1980.

[d]St. Lucie Plant Site.

TABLE H-4

NUMBER AND PERCENT OF LOGGERHEAD TURTLE NESTS DESTROYED BY RACCOONS
IN EACH OF THE NINE 1.25-KM-LONG SURVEY AREAS
HUTCHINSON ISLAND
1971-1982

	Preoperational						Operational									
	1971		1973		1975		1977		1979		1980[a]		1981		1982	
Area	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1	28	33	79	72	40	42	36	75	2	4	-	-	9	14	0	0
2	30	33	71	54	27	25	18	33	4	5	-	-	14	14	3	2
3	66	58	115	80	101	65	63	70	5	5	10	9	7	8	2	1
4[b]	32	21	44	33	9	12	47	47	8	7	5	4	2	3	1	1
5	60	35	69	55	16	10	25	24	47	33	35	32	9	9	47	28
6	30	14	13	9	0	0	0	0	0	0	0	0	1	1	0	0
7	5	4	2	2	1	1	13	17	10	9	-	-	0	0	0	0
8	63	26	66	40	24	9	3	2	1	.4	-	-	0	0	0	0
9	79	37	90	49	92	43	146	78	49	17	-	-	10	6	1	.4
TOTAL	393	28	549	44	310	21	351	38	126	9	50	10	52	5	54	3

[a]Only Areas 3-6 were surveyed during 1980.

[b]St. Lucie Plant Site.

TABLE H-5

TOTAL NUMBER AND (NUMBER OF DEAD) LOGGERHEAD TURTLES
REMOVED EACH MONTH FROM THE INTAKE CANAL
ST. LUCIE PLANT
1976 - 1982

Month	1976	1977	1978	1979	1980	1981	1982	Total	Monthly Mean
January	-	13	19	24(3)	16	10	6(2)	88	14.7
February	-	8(1)	11(2)	29(1)	21(2)	11(3)	11	91	15.2
March	-	6	27(2)	11	14	6	14	78	13.0
April	-	6(2)	19(5)	17	0	10	14	66	11.0
May	2	0	3(1)	0	7	6	17(4)	35	5.0
June	0	4	10	3(1)	8(3)	6	7	38	5.4
July	7(1)	4	0	27(2)	0	1	7	46	6.6
August	2	3	12	17(2)	12	6	2(1)	54	7.7
September	1	15(1)	1	8(1)	19	2(1)	9(1)	55	7.9
October	7	9(1)	17(2)	15(3)	7	0	9(5)	64	9.1
November	5(3)	5	15(7)	13	4	0	4(2)	46	6.6
December	9	5	4	11	8	3	1 (1)	41	5.9
Total	33(4)	78(5)	138(19)	175(13)	116(6)	61(4)	101(16)	702(67)	-

TABLE H-6

TOTAL NUMBER AND (NUMBER OF DEAD) SEA TURTLES
OTHER THAN LOGGERHEADS REMOVED FROM THE INTAKE CANAL
ST. LUCIE PLANT
1976 - 1982

Species	1976	1977	1978	1979	1980	1981	1982	Total	Annual Mean[a]
green		5(2)	6(1)	3(1)	13(4)	32(2)	8	67(10)	11.3
leatherback		1	3			2	1	7(0)	1.2
hawksbill			1					1(0)	0.2
Kemp's ridley						1		1(0)	0.2

[a]Excludes 1976 (partial year of plant operation).

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TABLEH-6

TABLE H-7

RELATIVE CONDITION OF LIVE SEA TURTLES
REMOVED FROM THE INTAKE CANAL
ST. LUCIE PLANT
1976 - 1982

	Poor[a]		Good[b]		Excellent[c]		Total[d]	
Species	Number of individuals	Percent	Number	Percent	Number	Percent	Number	Percent
hawksbill			1	(100)			1	(100)
Kemp's ridley	1	(100)					1	(100)
leatherback			6	(86)	1	(14)	7	(100)
green	4	(8)	37	(76)	8	(16)	49	(100)
loggerhead	123	(20)	395	(65)	87	(15)	605	(100)

[a]Poor - emaciated
slow or inactive
heavy barnacle and/or leach infestation
debilitating wounds or missing appendages

[b]Good - normal weight
active
light to medium coverage of barnacles and/or leaches
wounds absent, healed or do not appear to debilitate the animal

[c]Excellent - normal or above normal weight
active
very few or no barnacles or leaches
no wounds

[d]Thirty loggerheads and eight greens were not included because of insufficient information.

TABLE H-8

SUMMARY OF LOGGERHEAD TURTLE CAPTURE EFFICIENCY
ST. LUCIE PLANT INTAKE CANAL
OCTOBER 1980 - JANUARY 1981

Tag numbers	1st capture	1st recapture date (days)	2nd recapture date (days)	3rd recapture date (days)	4th recapture date (days)	5th recapture date (days)	6th recapture date (days)	7th recapture date (days)	8th recapture date (days)	9th recapture date (days)
3234,3235	10/10	10/20 (10)	11/24 (34)	11/24 (0.25)	12/02 (8)	01/09 (38)[a]				
3261,3273	10/14	10/20 (6)	10/29 (9)	11/03 (4)	11/06 (3)	11/07 (3)	11/10 (3)	11/10 (0.25)	12/01 (21)	12/16 (15)[a]
3263,3274	10/14	10/17 (3)	11/01 (16)	11/12 (11)	11/14 (2)[a]					
3221,3276	11/01	11/20 (19)	12/01 (11)	12/08 (7)[a]						
3264,3277	11/06	11/06 (0.25)	11/17 (11)	12/01 (14)	12/03 (2)	12/11 (8)[a]				
3262,3275	11/11	11/14 (3)[a]								
3236,3237	11/24	12/09 (15)[a]								
3222,3238	12/01	01/06 (36)[b]								
3278,3279	12/03	12/08 (5)[a]								
3280,3281	12/04	12/12 (8)[a]								
3282,3283	12/05	12/10 (5)[a]								

[a]The turtle was released to the ocean at this time.

[b]The turtle was found dead at this time.

TABLE H-9

WEIGHT DIFFERENCES OF LOGGERHEAD TURTLES
BETWEEN DATES OF CAPTURE AND RECAPTURE
ST. LUCIE PLANT INTAKE CANAL
OCTOBER 1980 - JANUARY 1981

Tag numbers	Date of capture	Date of last recapture	Number of recaptures	Total elapsed time (days)	Weight at capture (kg)	Weight at last recapture (kg)	Weight difference (kg)
3234,3235	10/10	01/09	5	90	26	26	0
3261,3273	10/14	12/16	9	63	39	37	-2
3263,3274	10/14	11/14	4	31	45	44	-1
3221,3276	11/01	12/08	3	37	73	73	0
3264,3277	11/06	12/11	5	35	26	26	0
3236,3237	11/24	12/09	1	15	17	15	-2
3222,3238	12/01	01/06	1	36	20	20	0
				$\bar{x}$ = 44			$\bar{x}$ = -0.7