FLORIDA POWER & LIGHT COMPANY

ST. LUCIE UNIT 2

ANNUAL ENVIRONMENTAL OPERATING REPORT

VOLUME I

1989

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ST. LUCIE UNIT 2

ANNUAL ENVIRONMENTAL

OPERATING REPORT

1989

VOLUME 1

APRIL 1990

FLORIDA POWER & LIGHT COMPANY

JUNO BEACH, FLORIDA

APPLIED BIOLOGY, INC.

ATLANTA, GEORGIA

ENVIRONMENTAL OPERATING REPORT

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TABLE OF CONVERSION FACTORS FOR METRIC UNITS

To convert	Multiply by	To obtain
centigrade (degrees)	$(^{o}C \times 1.8) + 32$	fahrenheit (degrees)
centigrade (degrees)	$^{o}C + 273.18$	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)
hectares (ha)	2.471	acres
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 (US liquid)
meters (m)	3.281	feet
meters (m)	3.937×10^{1}	inches
meters (m)	1.094	yards
milligrams (mg)	1.0×10^{-3}	grams
milligrams/liters (mg/l)	1.0	parts per million
milliliters (ml)	1.0×10^{-3}	liters (US 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

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 in May 1983. This document has been prepared to satisfy the requirements contained in the United States Nuclear Regulatory Commission's Appendix B Environmental Protection Plan (EPP) to St. Lucie Unit 2 Facility Operating License No. NPF-16. This report discusses environmental protection activities related to sea turtles as required by Subsection 4.2 of the EPP. Other routine annual reporting requirements are addressed in Volume 2, also entitled "St. Lucie Unit No. 2 Annual Environmental Operating Report."

TURTLE NESTING SURVEY

There have been considerable year-to-year fluctuations in sea turtle nesting activity on Hutchinson Island since monitoring began in 1971. Low nesting activity in 1975 and 1981 - 1983 in the vicinity of the power plant was attributed to construction of plant intake and discharge structures. Nesting returned to normal or above normal levels following both periods of construction. Power plant operation exclusive of construction has had no significant effect on nesting near the plant. Data collected through 1989 have shown no long-term reductions in total nesting, total emergences or nesting success on the island. Formal requirements to conduct this program expired in 1986 but were voluntarily continued in 1989 with agreement from federal and state agencies.

INTAKE CANAL MONITORING

Since plant operation began in 1976, 2,061 sea turtles (including 90 recaptures) representing five different species have been removed from the intake canal. Eighty-four percent of these were loggerheads. Differences in the numbers of turtles found during different months and years were attributed to natural variation in the occurrences of turtles in the vicinity of the plant, rather than to any influence of the plant itself. The majority of turtles removed from the intake canal (about 93 percent) were captured alive, tagged and released back into the ocean. Turtles confined between the A1A barrier net and intake headwalls usually resided in the canal for a relatively short period of time, and most were in good to excellent condition when caught.

OTHER RELATED ACTIVITIES

Studies to evaluate various cooling water intake sea turtle deterrent systems, as required by the NRC's Unit 2 Environmental Protection Plan, were conducted during 1982 and 1983. Results and evaluations of those studies were presented to regulatory agencies during 1984, and the requirement is now considered completed.

INTRODUCTION

BACKGROUND

This document has been prepared to satisfy the requirements contained in the United States Nuclear Regulatory Commission's (NRC) Appendix B Environmental Protection Plan to St. Lucie Unit 2 Facility Operating License No. NPF-16.

In 1970, Florida Power & Light Company (FPL) was issued Permit No. CPPR-74 by the United States Atomic Energy Commission, now the Nuclear Regulatory Commission, 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. 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 was placed on-line in May 1983 and began commercial operation in August of that year.

St. Lucie Plant Units 1 and 2 use the Atlantic Ocean as a source of water for once-through condenser cooling. Since 1971, the potential environmental effects resulting from the intake and discharge of this water have been the subject of FPL-sponsored biotic studies at the site.

Baseline environmental studies of the marine environment adjacent to the St. Lucie Plant were described in a series of reports published by the Florida Department of Natural Resources (Camp et al., 1977; Futch and Dwinell, 1977; Gallagher, 1977; Gallagher and Hollinger, 1977; Worth and Hollinger, 1977; Moffler and Van Breedveld,

1979; Tester and Steidinger, 1979; Walker, 1979; Walker et al., 1979; Walker and Steidinger, 1979). The results of Unit 1 operational and Unit 2 preoperational biotic monitoring at the St. Lucie Plant were presented in six annual reports (ABI, 1977, 1978, 1979, 1980a, 1981b, 1982). In January 1982, a National Pollutant Discharge Elimination System (NPDES) permit was issued to FPL by the US Environmental Protection Agency (EPA). The EPA guidelines for the St. Lucie site biological studies were based on the document entitled "Proposed St. Lucie Plant Preoperational and Operational Biological Monitoring Program - August 1981" (ABI, 1981c). Findings from these studies were reported in three annual reports (ABI, 1983, 1984a, 1985a). The EPA biotic monitoring requirements were deleted from the NPDES permit in 1985.

Jurisdiction for sea turtle studies is with the NRC, which is considered to be the lead federal agency relative to consultation under the Endangered Species Act. Previous results dealing exclusively with sea turtle studies are contained in six environmental operating reports (ABI, 1984b, 1985b, 1986, 1987, 1988, 1989). This report describes the 1989 environmental protection activities related to sea turtles, as required by Subsection 4.2 of the St. Lucie Plant Unit 2 Environmental Protection Plan.

AREA DESCRIPTION

The St. Lucie Plant is located on a 457-ha site on Hutchinson Island on Florida's east coast (Figures 1 and 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 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 are present at the higher elevations, and mangroves abound at the lower elevations. Large stands of black mangroves, including some on the plant site, have been killed by flooding for mosquito control over past decades.

The Atlantic shoreline of Hutchinson Island is composed of sand and shell hash with intermittent rocky promontories protruding through the beach face along the southern end of the island. Submerged coquinoid rock formations parallel much of the island off the ocean beaches. The ocean bottom immediately offshore from the plant site consists primarily of sand and shell sediments. The unstable substrate limits the establishment of rooted macrophytes.

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 that use nearshore ocean waters for the plant's once-through condenser cooling water

system. Water for the plant enters through three submerged intake structures located about 365 m offshore (Figure 2). Each of the intake structures is equipped with a velocity cap to minimize fish entrainment. Horizontal intake velocities are less than 30 cm/sec. From the intake structures, the water passes through submerged pipes (two 3.7 m and one 4.9 m in diameter) under the beach and dunes that lead to a 1,500-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 line 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 line 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. 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.

TURTLES

The NRC's St. Lucie Unit 2 Appendix B Environmental Protection Plan issued April 1983 contains the following technical specifications:

4.2 Terrestrial/Aquatic Issues

Issues on endangered or threatened sea turtles raised in the Unit 2 FES-OL [NRC, 1982] and in the Endangered Species Biological Assessment (March 1982) [Bellmund et al., 1982] will be addressed by programs as follows:

4.2.1 Beach Nesting Surveys

Beach nesting surveys for all species of sea turtles will be conducted on a yearly basis for the period of 1982 through 1986. These surveys will be conducted during the nesting season from approximately mid-April through August.

The Hutchinson Island beach will be divided into 36 one-km-long survey areas. In addition, the nine 1.25-km-long survey areas used in previous studies (1971-1979) will be maintained for comparison purposes. Survey areas will be marked with numbered wooden plaques and/or existing landmarks.

The entire beach will be surveyed seven days a week. All new nests and false crawls will be counted and recorded in each area. After counting, all crawl tracks will be obliterated to avoid recounting. Predation on nests by raccoons or other predators will be recorded as it occurs. Records will be kept of any seasonal changes in beach topography that may affect the suitability of the beach for nesting.

4.2.2 Studies to Evaluate and/or Mitigate Intake Entrapment

A program that employs light and/or sound to deter turtles from the intake structure will be conducted. The study will determine with laboratory and field experiments if sound and/or light will result in a reduction of total turtle entrapment rate.

The study shall be implemented no later than after the final removal from the ocean of equipment and structures associated with construction of the third intake structure and the experiments shall terminate 18 months later. Four months after the conclusion of the experimental period, a report on the results of the study will be submitted to NRC, EPA, National Marine Fisheries Service (NMFS), and the US Fish and Wildlife Service (USFWS) for their evaluation. If a statistically significant reduction in annual total turtle entrapment rate of 80 percent or greater can be demonstrated, using the developed technology and upon FPL receiving written concurrence by NRC, EPA, NMFS, and USFWS then permanent installation of the deterrent system shall be completed and functioning no later than 18 months after the agencies' concurrence. The design of this study needs to take into account the significant annual variation in turtle entrapment observed in the past.

If an 80 percent reduction of turtle entrapment cannot be projected to all three intake structures, then an interagency task force composed of NRC, EPA, NMFS, USFWS, and FPL shall convene 18 months after completion of the third intake and determine if other courses of action to mitigate and/or reduce turtle entrapment are warranted (such as physical barrier, emergence of new technology or methods to deter turtles).

4.2.3 Studies to Evaluate and/or Mitigate Intake Canal Mortality

Alternative methods or procedures for the capture of sea turtles entrapped in the intake canal will be evaluated. If a method or procedure is considered feasible and cost effective and may reduce capture mortality rates, it will be field tested in the intake canal.

4.2.5 Capture and Release Program

Sea turtle removal from the intake canal will be conducted on a continuing basis. The turtles will be captured with large mesh nets, or other suitable nondestructive device(s), if deemed appropriate. A formalized daily inspection, from the shoreline, of the capture device(s) will be made by a qualified individual when the device(s) are deployed. The turtles will be identified to species, measured, weighed (if appropriate), tagged and released back into the ocean. Records of wounds, fresh or old, and a subjective judgement on the condition of the turtle (e.g., barnacle coverage, underweight) will be maintained. Methods of obtaining additional biological/physiological data, such as blood analyses and parasite loads, from captured

sea turtles will be pursued. Dead sea turtles will be subjected to a gross necropsy, if found in fresh condition.

INTRODUCTION

Hutchinson Island, Florida, is an important rookery for the loggerhead turtle, Caretta caretta, and also supports some nesting of the green turtle, Chelonia mydas, and the leatherback turtle, Dermochelys coriacea (Caldwell et al., 1959; Routa, 1968; Gallagher et al., 1972; Worth and Smith, 1976; Williams-Walls et al., 1983). All three species are protected by state and federal statutes. The federal government classified the loggerhead turtle as a threatened species. The leatherback turtle and the Florida nesting population of the green turtle are listed by the federal government as 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 since 1971.

Daytime surveys to quantify nesting, as well as nighttime turtle tagging programs, were conducted in odd numbered years from 1971 through 1979. During daytime nesting surveys, nine 1.25-km-long survey areas were monitored five days per week (Figure 3). The St. Lucie Plant began operation in 1976; therefore, the first three survey years (1971, 1973 and 1975) were preoperational. Though the power plant was not operating during 1975, St. Lucie Plant Unit No. 1 ocean intake and discharge structures were

installed during that year. Installation of these structures included construction activities conducted offshore from and perpendicular to the beach. Construction 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 structure for St. Lucie Plant Unit 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.

Every year from 1981 through 1989, thirty-six 1-km-long survey areas comprising the entire island were monitored seven days a week during the nesting season (Figure 3). The St. Lucie Plant Unit 2 discharge structure was installed during the 1981 nesting season. Offshore and beach construction of the Unit 2 intake structure proceeded throughout the 1982 nesting season and was completed near the end of the 1983 season. Construction activities associated with installation of both structures were similar to those conducted when Unit 1 intake and discharge structures were installed. Eggs from turtle nests potentially endangered by construction activities were relocated during all three years.

Requirement 4.2.1 of the NRC's St. Lucie Unit 2 Appendix B Environmental Protection Plan was completed with submission of the 1986 nesting survey data (ABI, 1987). The nesting survey was continued voluntarily through 1989 with agreement from federal and state agencies. Results are presented in this report and discussed in relation to previous findings.

In addition to monitoring sea turtle nesting activities and relocating nests away from plant construction areas, removal of turtles from the intake canal has been an integral part of the St. Lucie Plant environmental monitoring program. Turtles entering the ocean intake structures are entrained with cooling water and rapidly transported through the intake pipes into an enclosed canal system where they must be manually captured and returned to the ocean. Since the plant became operational in 1976, turtles entrapped in the intake canal have been systematically captured, measured, weighed, tagged and released.

Previous publications and technical reports have presented findings of the nesting surveys, nest relocation activities and canal capture program (Gallagher et al., 1972; Worth and Smith, 1976; ABI, 1978, 1980a, 1981a, 1982, 1983, 1984b, 1985b, 1986, 1987, 1988, 1989; Williams-Walls et al., 1983; Proffitt et al., 1986; Ernest et al., 1988, 1989; Martin et al., 1989a, 1989b; O'Hara and Wilcox, in press). Results of studies to assess the effects of thermal discharges on hatchling swimming speed have also been reported (ABI, 1978; O'Hara, 1980). The purpose of this report is to 1) present 1989 sea turtle nesting survey data and summarize observed spatial and temporal nesting patterns since 1971, 2) document and summarize predation on turtle nests since 1971, and 3) present 1989 canal capture data and summarize comparable data collected since 1976.

MATERIALS AND METHODS

Nesting Survey

Methodologies used during previous turtle nesting surveys on Hutchinson Island were described by Gallagher et al. (1972), Worth and Smith (1976) and ABI (1978, 1981a, 1982, 1987, 1988, 1989). Methods used during the 1989 survey were designed to allow comparisons with these previous studies.

On 10 and 13 April 1989, preliminary nest surveys were conducted along Hutchinson Island from the Ft. Pierce Inlet south to the St. Lucie Inlet. From 17 April through 8 September, nest surveys were conducted on a daily basis. After 8 September, several additional surveys were conducted to confirm that nesting had ceased, the last survey being conducted on 15 September. 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 3). The nine 1.25-km-long survey areas established by Gallagher et al. (1972) also were monitored so comparisons could be made with previous studies.

During the daily nest monitoring, any major changes in topography that may have affected the beach's suitability for nesting were recorded. In addition, each of the thirty-six 1-km-long survey areas has been systematically analyzed and categorized based on beach slope (steep, moderate, etc.), width from high tide line to the dune, presence of benches (areas of abrupt vertical relief) and miscellaneous characteristics (packed

sand, scattered rock, vegetation on the beach, exposed roots on the primary dune, etc.).

In a cooperative effort, data from stranded turtles found during beach surveys were routinely provided to the National Marine Fisheries Service through the Sea Turtle Stranding and Salvage Network.

Intake Canal Monitoring

Most turtles entrapped in the St. Lucie Plant intake canal were removed by means of large-mesh tangle nets fished between the intake headwalls and a barrier net located at the Highway A1A bridge (Figure 2). Nets used during 1989 were from 30 to 40 m in length, 3 to 4 m deep and composed of 40 cm stretch mesh nylon twine. Large floats were attached to the surface, and unweighted lines used along the bottom. Turtles entangled in the nets generally remained at the water's surface until removed.

Turtle nets were usually deployed on Monday mornings and retrieved on Friday afternoons. During periods of deployment, the nets were inspected for captures by ABI personnel at least twice each day (mornings and afternoons). Additionally, St. Lucie Plant personnel checked the nets periodically, and ABI was notified immediately if a capture was observed. ABI's sea turtle specialists were on call 24 hours a day to retrieve captured turtles from the plant.

The A1A barrier net is used to confine turtles to the easternmost section of the intake canal, where capture techniques have been most effective. This net is constructed of large diameter polypropylene rope and has a mesh size of 30.5 cm^2. A cable is used

to keep the top of the net above the water's surface and the bottom is anchored by a series of heavy blocks. The net is inclined at a slope of 3:1, with the bottom positioned upstream of the surface cable. This reduces bowing in the center and minimizes the risk of a weak or injured turtle being pinned against it by currents.

Occasionally, the integrity of the barrier net has been compromised, and turtles have been able to move west of A1A. These turtles are further constrained downstream by a security intrusion barrier positioned perpendicular to the north-south arm of the canal (Figure 2). The security barrier also consists of 30.5 cm^2 mesh, but the net is constructed of heavy chain links rather than rope.

Prior to the completion of the security intrusion barrier in December 1986, turtles uncontained by the A1A barrier net were usually removed from the canal at the intake wells of Units 1 and 2 (Figure 2). There they were retrieved by means of large mechanical rakes or specially designed nets. Following construction of the security intrusion barrier, only those individuals with carapace widths less than 30.5 cm were able to reach the intake wells. Thus, as required, tangle nets were set west of A1A to capture turtles larger than 30.5 cm.

In addition to ABI's netting activities, formal daily inspections of the intake canal were made to determine the numbers, locations and species of turtles present. Occasionally, turtles were observed in areas where they could be hand captured. Surface observations were augmented with periodic underwater inspections using SCUBA, particularly in and around the A1A barrier net and security intrusion barrier. Several turtles were hand captured during these dives.

Regardless of capture method, all turtles removed from the canal were identified to species, measured, weighed, tagged, and examined for overall condition (wounds, abnormalities, parasites, etc.). Healthy turtles were released back into the ocean the same day of capture. 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; no necropsies were performed during 1989.

Since 1982, blood samples have been collected and analyzed to determine the sex of immature turtles. Blood was removed from the paired dorsal cervical sinuses of subject turtles using the technique described by Owens and Ruiz (1980). The samples were maintained on ice and later centrifuged for 15 minutes to separate cells and serum. Sex determinations were subsequently made by researchers at Texas A & M University using radioimmunoassay for serum testosterone (Owens et al., 1978).

Florida Power & Light Company and Applied Biology, Inc. continued to assist other sea turtle researchers in 1989. Data, specimens and/or assistance have been given to the Florida Department of Natural Resources, National Marine Fisheries Service, US Fish and Wildlife Service, US Army Corps of Engineers, Smithsonian Institution, South Carolina Wildlife and Marine Resources Division, Center for Sea Turtle Research (University of Florida), Texas A & M University, University of Rhode Island, University of South Carolina, University of Illinois, University of Central Florida, University of Georgia, Virginia Institute of Marine Science and the Western Atlantic Turtle Symposium.

Studies to Evaluate and/or Mitigate Intake Entrapment

A program that assessed the feasibility of using light and/or sound to deter turtles from entering the St. Lucie Plant intake structures was conducted in 1982 and 1983 and completed in January 1984. As required, test results and evaluations were written up and a presentation was made to the NRC, National Marine Fisheries Service and the Florida Department of Natural Resources on 11 April 1984. Requirement 4.2.2 of the NRC's St. Lucie Unit 2 Appendix B Environmental Protection Plan is considered completed with submission of deterrent study findings.

RESULTS AND DISCUSSION

Nesting Survey

Distribution of Loggerhead Nests Along Hutchinson Island

When sea turtle nesting surveys began on Hutchinson Island, nine 1.25-km-long survey areas were used to estimate loggerhead nesting activity for the entire island. Since 1981, all 36 1-km-long segments comprising the island's coastline have been surveyed. Regardless of technique, loggerhead nest densities have shown considerable annual variation within individual survey areas (Figures 4 and 5). Yet, the annual spatial distribution of those nests among survey areas has produced a rather uniform gradient, nest densities consistently increasing from north to south (ABI, 1987). The gradient appears to be linear when only the nine 1.25-km-long survey areas are used (Figure 4), but becomes non-linear when all 36 1-km-long survey areas are included in the analysis (Figure 5). During 1989 the distribution of loggerhead nests along

the island followed the same general pattern as previously reported, nest densities increasing abruptly from north to south along the northern portion of the island, reaching maximum densities in central survey areas and then decreasing slightly toward the southern portion of the island (Figure 5).

In the past, the pronounced gradient observed on the northern end of the island was occasionally influenced by physical processes occurring there; periods of heavy accretion reduced the gradient, while periods of erosion accentuated it (Worth and Smith, 1976; Williams-Walls et al., 1983). However, during recent years no consistent relationship was apparent when field observations of beach widths were compared to the spatial distribution of nests along the island (ABI, 1987). Thus, even though beach dynamics may sometimes affect the selection of nesting sites by loggerhead turtles, other factors must also contribute to the selection process. Offshore bottom contours, spatial distribution of nearshore reefs, type and extent of dune vegetation, and degree of human activity on the beach at night have been identified as some of the factors affecting nesting (Caldwell, 1962; Hendrickson and Balasingam, 1966; Bustard, 1968; Bustard and Greenham, 1968; Hughes, 1974; Davis and Whiting, 1977; Mortimer, 1982). Relationships between spatial nesting patterns and specific environmental conditions are often difficult to establish because of the interrelationship of the factors involved.

Not all ventures onto the beach by a female turtle culminate in successful nests. These "false crawls" (non-nesting emergences) may occur for many reasons and are commonly encountered at other rookeries (Baldwin and Lofton, 1959; Schulz, 1975; Davis and Whiting, 1977; Talbert et al., 1980; Raymond, 1984). Davis and Whiting

(1977) suggested that relatively high percentages of false crawls may reflect disturbances or unsatisfactory nesting beach characteristics. Therefore, certain factors may affect a turtle's preference to emerge on a beach, while other factors may affect a turtle's tendency to nest after it has emerged. An index which relates the number of nests to the number of false crawls in an area is useful in estimating the post-emergence suitability of a beach for nesting. In the present study this index is termed "nesting success" and is defined as the percentage of total emergences that result in nests.

Historically, the pattern of loggerhead emergences on the island has generally paralleled the distribution of nests (ABI, 1987, 1988), and this same trend was apparent in 1989 (Figure 6). In contrast, nesting success by loggerheads along the island has typically lacked gradients (Figure 7). Thus, the relatively high numbers of loggerhead nests usually observed along the southern half of the island have resulted primarily from more turtles coming ashore in that area rather than from more preferable nesting conditions being encountered by the turtles after they emerged.

Hughes (1974) and Bustard (1968) found that loggerheads preferred beaches adjacent to outcrops of rocks or subtidal reefs. Williams-Walls et al. (1983) suggested that the nesting gradient on Hutchinson Island may be influenced by the offshore reefs if female turtles concentrate on the reefs closest to the beach to rest or feed. The proximity of offshore reefs would put the greatest concentration of turtles near the southern half of the island where coincidentally nesting is highest.

Loggerhead nesting densities during 1989 were generally within the range of values previously recorded (Figures 4 and 5). The most conspicuous exceptions occurred on

the northern half of the island where nesting was relatively high compared to previous years. There were no apparent changes in the physical characteristics of the beach that would account for this increase in nesting. Rather, it may be related to a decrease in human activity on the beach at night. Historically, nighttime vehicle use of the beaches has been extensive on the northern half of the island. However, between the 1988 and 1989 nesting seasons, successful blockage of many access points resulted in a forty percent reduction in this activity. If the lights, movements and noise associated with off-road vehicles previously deterred turtles from emerging to nest (see Hendrickson, 1958), a reduction in vehicle use during 1989 would account for record high emergence and nesting rates on the northern half of the island (Figures 5 and 6).

Relatively low nesting in Area F suggests that factors other than vehicle traffic continued to deter turtles from nesting in that area. As previously reported (ABI, 1988, 1989), reduced nesting in Area F may be related to the removal of beachfront vegetation prior to the 1987 nesting season. Additionally, extensive accumulations of shell and rock material along this section of beach during 1989 may have deterred turtles from nesting after they emerged and may explain the record low nesting success in this area (Figure 7).

Record low nesting success was also documented in Area L. The most notable change in this section of beach was an increase in the number of dead Australian pines that had fallen on the beach since the end of the 1988 nesting season. These fallen trees act as obstacles to turtles as they crawl up the beach to nest. When a turtle encounters such an obstacle, it usually returns to the ocean without nesting.

On the southern half of the island, loggerhead nesting was within the range of previously recorded values in all but one area (Area EE). Record low nesting in Area EE during 1989 was apparently attributable to conditions encountered by turtles after they emerged since the number of emergences were not low when compared to previous years. This is confirmed by the record low nesting success in this area during 1989. Beach conditions which would account for such a decrease in nesting success could not be identified; however, human activity on the beach cannot be ruled out since this area is backed by a large resort and a public beach.

Nesting surveys on Hutchinson Island were initiated in response to concerns that the operation of the St. Lucie Plant might negatively impact the local sea turtle rookery. Previous analysis, using log-likelihood tests of independence (G-test; Sokal and Rohlf, 1981) demonstrated that the construction of the plant's offshore intake and discharge structures significantly reduced nesting at the plant site during construction years – 1975, 1981, 1982 and 1983 (Proffitt et al., 1986; ABI, 1987). However, nesting at the plant consistently returned to levels similar to or greater than those at a control site in years following construction (Figure 8). Thus, power plant operation exclusive of intake/discharge construction had no apparent effect on nesting.

Data collected through 1989 have shown no long-term reduction in loggerhead nest densities, total emergences or nesting success in either the nine 1.25-km-long survey areas or the 36 1-km-long survey areas (Table 1; Figure 9).

Estimates of Total Loggerhead Nesting on Hutchinson Island

Various methods were used during surveys prior to 1981 to estimate the total number of loggerhead nests on Hutchinson Island based on the number of nests found in the nine 1.25-km-long survey areas (Gallagher et al., 1972; Worth and Smith, 1976; ABI, 1980a). Each of these methods were subsequently found to consistently overestimate island totals (ABI, 1987). Since whole-island surveys began in 1981, it has been possible to determine the actual proportion of total nests deposited in the nine areas. This has then allowed extrapolation from the nine survey areas to the entire island for years prior to 1981.

From 1981 through 1989 the total number of nests in the nine areas varied from 33.1 to 35.6 percent of the total number of nests on the island (Table 1). This is slightly higher than the 31.3 percent which would be expected based strictly on the proportion of linear coastline comprised by the nine areas. Using the nine-year mean of 34.0 percent, estimates of the total number of nests on Hutchinson Island can be calculated by multiplying the number of nests in the nine areas by 2.94. This technique, when applied to the nine survey areas during the nine years in which the entire island was surveyed, produced whole-island estimates within five percent of the actual number of nests counted. Because the proportion of nests recorded in the nine survey areas remained relatively constant over the last nine years, this extrapolation procedure should provide a fairly accurate estimate of total loggerhead nesting for years prior to 1981.

It is clear that loggerhead nesting activity on Hutchinson Island fluctuates considerably from year to year (Table 1). Annual variations in nest densities also are common at other rookeries (Hughes, 1976; Davis and Whiting, 1977; Ehrhart, 1980) and may result from the overlapping of non-annual breeding populations. During the last eight years, however, annual nest production has remained relatively high. Total nesting activity was greatest during 1986 when 5,483 loggerhead nests were recorded on the island. During 1989, 5,193 nests were counted. No relationships between total nesting activity and power plant operation or intake/discharge construction were indicated by year-to-year variations in total nesting on Hutchinson Island.

Temporal Loggerhead Nesting Patterns

The loggerhead turtle nesting season usually begins between mid-April and early May, attains a maximum during June or July, and ends by late August or early September (ABI, 1987). Nesting activity during 1989 followed this same pattern (Figure 10).

Cool water intrusions frequently occur over the continental shelf of southeast Florida during the summer (Taylor and Stewart, 1958; Smith, 1982). Worth and Smith (1976), Williams-Walls et al. (1983) and ABI (1982, 1983, 1984b, 1985b, 1986, 1987, 1988, 1989) suggested that these intrusions may have been responsible for the temporary declines in loggerhead turtle nesting activity previously observed on Hutchinson Island. Similarly, a substantial decrease in nesting during mid-June 1989 was apparently due to an intrusion of cool water (Figure 10).

Though natural fluctuations in temperature have been shown to affect temporal nesting patterns on Hutchinson Island, there has been no indication that power plant operation has affected these temporal patterns (ABI, 1988).

Predation on Loggerhead Turtle Nests

Since nest surveys began in 1971, raccoon predation probably has been 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; Ehrhart, 1979; Hopkins et al., 1979; Talbert et 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. Overall predation rates for survey years 1971 through 1977 were between 21 and 44 percent, with a 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 not exceeded 10 percent since 1979. A decline in predation rates on Hutchinson Island has been variously attributed to trapping programs, construction activities, habitat loss and disease (Williams-Walls et al., 1983; ABI, 1987).

During 1989, eight percent (423) of the loggerhead nests (n=5,193) on the island were depredated by raccoons. As in previous years (ABI, 1989), predation of turtle nests was primarily restricted to the most undeveloped portion of the island (i.e., Areas E through S; Figure 11).

Ghost crabs have been reported by numerous researchers as important predators of sea turtle nests (Baldwin and Lofton, 1959; Schulz, 1975; Diamond, 1976; Fowler,

1979; Hopkins et al., 1979; Stancyk, 1982). Though turtle nests on Hutchinson Island probably have been depredated by ghost crabs since nesting surveys began in 1971, this source of nest destruction did not become apparent until 1983. Quantification of ghost crab predation was initiated the same year.

Overall predation rates by ghost crabs have varied from 0.2 to 2.1 percent from 1983 - 1988 (ABI, 1989). During 1989, 0.1 percent (6) of the loggerhead nests (n=5,193) on the island were destroyed by ghost crabs (Figure 11). Nests destroyed by a combination of raccoon and ghost crab predation have been included as raccoon predations in previous discussions. When these combination predations are included as crab predations, the overall predation rates by ghost crabs range from 0.4 to 3.2 percent. During 1989, 0.4 percent (23 nests) were destroyed by either ghost crabs or a combination of ghost crabs and raccoons.

Green and Leatherback Turtle Nesting

Green and leatherback turtles also nest on Hutchinson Island, but in fewer numbers than loggerhead turtles. Prior to 1981, both survey (nine 1.25-km-long sections) and inter-survey areas were monitored for the presence of green and leatherback nests. Thirty-one kilometers of beach from Area 1 south to the St. Lucie Inlet were included in that effort. During whole-island surveys from 1981 through 1989, only two of 170 leatherback nests and only five of 469 green nests were recorded on the five kilometers of beach north of Area 1. Therefore, previous counts of green and leatherback nests within the 31 kilometers surveyed were probably not appreciably different from total densities for the entire island. Based on this assumption, green and leatherback nest

densities may be compared among all survey years, except 1980, when less than 15 kilometers of beach were surveyed.

Prior to 1989, the number of nests observed on the island ranged from 5 to 74 for green turtles and from 1 to 33 for leatherbacks (Figure 12). During the 1989 survey, 45 green turtle and 36 leatherback turtle nests were recorded on Hutchinson Island.

Temporal nesting patterns for these species differ from the pattern for loggerhead turtles. Green turtles typically nest on Hutchinson Island from mid-June through the first or second week of September. During 1989, green turtles nested from 15 June through 23 September. Leatherback turtles usually nest on the island from mid-April through early to mid-July. During 1989 this species nested from 30 March through 17 July.

Considerable fluctuations in green turtle nesting on the island have occurred among survey years (Figure 12). This is not unusual since there are drastic year-to-year fluctuations in the numbers of green turtles nesting at other breeding grounds (Carr et al., 1982). Despite these fluctuations, green turtle nesting has remained relatively high during the last eight years (1982 through 1989) and may reflect an increase in the number of nesting females in the Hutchinson Island area. During 1989, green turtles nested most frequently along the southern half of the island. This is consistent with results of previous surveys.

Leatherback turtle nest densities have remained low on Hutchinson Island; however, increased nesting during recent years (Figure 12) may reflect an overall increase in the

number of nesting females in the Hutchinson Island area. During 1989, leatherback turtles primarily nested on the southern half of the island.

Intake Canal Monitoring

Entrainment of sea turtles at the St. Lucie Plant has been attributed to the presumed physical attractiveness of the offshore structures housing the intake pipes rather than to plant operating characteristics (ABI, 1980b and 1986). Even when both units are operating at full capacity, turtles must actively swim into the mouth of one of the intake pipes before they encounter current velocities sufficiently strong to effect entrainment. Consequently, a turtle's entrapment relates primarily to the probability that it will detect and subsequently enter one of the intake structures. Assuming that detection distances do not vary appreciably over time and that all turtles (or a constant proportion) are equally attracted to the structures, capture rates will vary proportionally to the number of turtles occurring in the vicinity of the structures. If this assumption is true, data from the canal capture program should reflect natural variability in the structure of the population being sampled.

Relative Abundance and Temporal Distribution

During 1989, 133 sea turtle captures took place in the intake canal of the St. Lucie Plant (Table 2). All five species of sea turtles occurring in coastal waters of the southeastern United States were represented in the catches, including 111 loggerheads, 17 greens, 1 leatherback, 2 hawksbills and 2 Kemp's ridleys. Since intake canal monitoring began in May 1976, 1,741 loggerhead (including 89 recaptures), 286 green

(including 1 recapture), 9 leatherback, 8 hawksbill and 17 Kemp's ridley captures have been reported from the St. Lucie Plant.

Annual catches of loggerheads increased steadily from a low of 33 in 1976 (partial year of plant operation and monitoring) to 172 in 1979 (Figure 13). After declining between 1979 and 1981, yearly catches of loggerheads again rose steadily, reaching a high of 195 during 1986. Captures have been in decline since 1986, decreasing over 40 percent during the last three years.

Two offshore intake structures were in place prior to Unit 1 start-up in 1976; the third and largest structure was installed during 1982-1983. Even though all three structures are in relatively close proximity, the addition of another pipe may have increased the probability of a turtle being entrained. Because this change cannot be quantified, data collected prior to 1982 may not be comparable with that collected after 1983. Additionally, the influence of the construction itself on sea turtle entrainment during 1982 and 1983 is unknown. With these considerations in mind, neither a long-term increase nor decrease in the number of loggerheads captured at the St. Lucie Plant can be inferred from the data.

During 1989, the monthly catch of loggerheads ranged from 2 (September and December) to 21 (July), with a monthly mean of 9.3 ($\pm$6.4; Table 3). The number of captures between April and August were average or above average, while captures throughout the remainder of the year were generally lower than average (Figure 14). Over the entire monitoring period, monthly catches have ranged from 0 to 39; the greatest number of captures occurred during January 1983.

When data from all full years of monitoring (1977-1989) were combined, the highest number of loggerhead captures occurred in January (12.5 percent); fewest captures were recorded in November and December (Table 3). However, monthly catches have shown considerable annual variability. Months having relatively low catches one year often have had relatively high catches in another.

Catches of green turtles also have varied widely among years, ranging from 0 in 1976 (partial year of sampling) to 69 in 1984 (Table 4). During 1989, 17 individuals were captured. The average annual catch of green turtles, excluding 1976, was 22.0 ($\pm$18.7). Although highly variable, annual capture data for green turtles suggest a long-term increase in the number of individuals inhabiting the nearshore coastal area adjacent to the plant (Figure 13). Again, however, the influence of the addition of a third intake pipe in 1982 on these data is not known.

Green turtles have been caught during every month of the year, with average monthly catches for all years combined ranging from 0.4 in September to 7.2 in January (Table 4). However, seasonal abundance patterns of greens are much more pronounced than for loggerheads, about 80 percent of all captures occurring between November and April. During 1989, the largest number of greens (6) were captured in March. The most greens ever caught in one month was 37 in January 1984.

Catches of leatherbacks, hawksbills and Kemp's ridleys have been infrequent and scattered throughout the 14 year study period (Table 2). Each species has shown rather pronounced seasonal occurrences; all but two of the nine leatherbacks were collected between February and May, seven of the eight hawksbills were collected

between June and September, and all but two of the 17 Kemp's ridleys were caught between November and April.

Size-Class Distributions

Although several straight-line and curved measurements were recorded for turtles removed from the intake canal, only one straight-line measurement has been used in analyses presented here. Straight-line carapace length (SLCL) was measured from the precentral scute to the notch between the postcentral scutes (minimum carapace length of Pritchard et al., 1983).

To date, loggerheads removed from the intake canal have ranged in length (SLCL) from 40.4 to 112.0 cm ($\bar{x}$ = 66.3 $\pm$ 13.3 cm) and in weight from 10.9 kg to 160.6 kg (Figures 15 and 16). About 71 percent of all loggerheads captured were 70 cm or less in length and weighed less than 50 kilograms.

A carapace length of 70 cm approximates the smallest size of nesting loggerhead females observed along the Atlantic east coast (Hirth, 1980). However, adults can only be reliably sexed on external morphological characteristics (e.g., relative tail length) after obtaining a length of about 80 cm. Based on these divisions, data were segregated into three groups: juvenile/sub-adults (<70 cm; the demarcation between these two components is not well established in the literature), adults (>80 cm) and transitional (70-80 cm). The latter group probably includes some mature and some immature individuals. Of the 1,666 captures for which length data were collected, 71 percent were juveniles/sub-adults, the majority of these measuring between 50 and 70 cm SLCL (Table 5). Adults accounted for about 18 percent of all captures, the remaining 11

percent comprised of animals in the transitional size class. Similar size-frequency distributions, indicating a preponderance of juveniles, have been reported for the Mosquito/Indian River Lagoon (Mendonca and Ehrhart, 1982), the Canaveral ship channel (Henwood, 1987), and Georgia and South Carolina (Hillestad et al., 1982). These data suggest that coastal waters of the southeastern United States constitute an important developmental habitat for _Caretta caretta_.

Seasonal patterns of abundance for various size classes indicated that juveniles and sub-adult loggerheads were slightly more abundant during the winter than at other times of the year (Table 5). About 36 percent of juvenile/sub-adult loggerheads were captured between January and March. Abundances decreased in spring and remained relatively constant during the summer and early fall before decreasing again to lowest levels in November and December. The seasonal distribution of adult loggerheads was much more pronounced, 58 percent of all captures occurring between June and August. This represents the period of peak nesting on Hutchinson Island. If other nesting months are included (May and September), 75 percent of all adults were captured during the nesting season.

Green turtles removed from the intake canal over the entire study period ranged in size from 20 to 108 cm SLCL ($\bar{x} = 35.8 \pm 14.4$ cm) and 0.9 kg to 177.8 kg (Figures 17 and 18). Nearly all (96 percent) were juveniles or sub-adults. About 80 percent were 40 cm or less in length, and 67 percent weighed 5 kilograms or less. These immature turtles exhibited distinct winter pulses suggesting migratory behavior (Table 4). However, some immature green turtles were present throughout the year. To date, only eight adult green turtles (SLCL >83 cm; Witherington and Ehrhart, 1989) have

been removed from the canal; all were captured during or shortly after the nesting season.

The eight hawksbills removed from the canal ranged in size from 34.0 to 70.0 cm SLCL ($\bar{x}$ = 46.2 $\pm$ 12.9 cm) and in weight from 6.4 to 52.2 kg ($\bar{x}$ = 17.3 $\pm$ 16.6 kg). All but one were juveniles (SLCL <63 cm; Witzell, 1983). Similarly, all but one of the 17 Kemp's ridleys captured at the St. Lucie Plant were juveniles (SLCL <60.0 cm; Hirth, 1980). Carapace lengths for the ridleys ranged from 27.0 to 62.0 cm SLCL ($\bar{x}$ = 36.1 $\pm$ 9.7 cm) and weights from 3.2 to 31.8 kg ($\bar{x}$ = 8.0 $\pm$ 8.1 kg). The nine leatherbacks removed from the canal ranged in length from 112.5 to 150.0 cm, and at least seven were adults (SLCL >121 cm; Hirth, 1980). The largest leatherback for which an accurate weight was obtained, a female with a curved carapace length of 158.5 cm, weighed 334.8 kg.

Sex Ratios

Since intake canal monitoring began in 1976, 297 adult loggerheads have been sexed. The smallest was 75.5 cm in length and was observed nesting on Hutchinson Island shortly after her capture in the canal. Females predominated males by a ratio of 5.6:1.0, which significantly departs from a 1:1 ratio (X^2, $P \leq 0.05$). Consequently, temporal patterns in the number of adult loggerhead captures are heavily influenced by the numbers of females present. When sexes were separated, it is evident that males were relatively evenly distributed among months, whereas over 80 percent of the females were taken during the nesting season (May through September; Figure 19).

The number of adult female loggerheads captured at the St. Lucie Plant has increased steadily over the last seven years. Prior to 1983, an average of 6.5 adult females ($\pm$ 3.8; range = 1-12) were entrapped each year, whereas since then, an average of 30.1 females per year ($\pm$ 11.6; range = 12-45) were captured. This increase corresponds to a general rise in loggerhead nesting activity near the plant (Figure 20). Increased nearshore movement associated with nesting increases the probability of a turtle detecting one of the intake structures and hence the probability of entrainment. Although the addition of the third offshore intake structure in 1982 may have accounted for some of the increase in the number of adults entrained each year, the continued rise since 1982 suggests a genuine increase in the number of females occurring in the vicinity of the plant.

Between September 1982 and December 1986, 267 individual juvenile and sub-adult loggerhead turtles captured in the canal were sexed by Texas A & M University researchers using a bioimmunoassay technique for blood serum testosterone. As previously reported, females outnumbered males by a ratio of 2.3:1.0 (ABI, 1989). These findings are consistent with those reported for samples taken from the Cape Canaveral ship channel (1.7:1.0) and the Indian River Lagoon (1.4:1.0), where sex ratios are also significantly skewed in favor of females (Wibbels et al., 1984). Blood samples collected since 1986 are currently being analyzed and these results will provide a valuable tool for assessing temporal variability in the sex ratios of the local loggerhead population.

Of the eight adult green turtles captured since monitoring began, six were males and two were females. Six immature green turtles have been sexed through blood work; all have been females. Of the six adult leatherback turtles for which sex was recorded,

three were females and three were males. The adult hawksbill and Kemp's ridley were both females. No sex information exists for juveniles of these species.

Capture Efficiencies

Capture methodologies evolved over the first several years of intake canal monitoring as net materials, configurations and placement were varied in an effort to minimize sea turtle entrapment times. Concurrently, alternative capture techniques were evaluated and potential deterrent systems tested in the laboratory. During this period, capture efficiencies varied in relation to netting effort and the effectiveness of the systems deployed.

A capture/recapture study conducted in the intake canal between October 1980 and January 1981 indicated that most turtles confined between the A1A bridge and the intake headwalls were captured within two weeks of their entrainment (ABI, 1983). Based on more recent formal daily inspections, it appears that capture efficiencies have further improved. Most turtles entering the canal are now caught within a few days of first sighting, and in many instances, turtles have been caught in the tangle nets without any prior sighting, suggesting residency times of less than 24 hours. Better utilization of currents and eddies, adjustments to tethering lines and multi-net deployments have contributed to reduced entrapment times.

Entrapment times may be extended for turtles swimming past the A1A barrier net (ABI, 1987). Occasionally, the top of the net has been submerged or the anchor cable pulled free from the bottom, allowing larger turtles to pass; turtles with carapace widths less than about 30.5 cm can swim through the large mesh. Because capture efforts

west of the A1A bridge have generally been less effective than those near the intake headwalls, most turtles breaching the barrier net were not caught until they entered the intake wells of Units 1 and 2. Since the canal capture program began, about 14 percent of all turtles entrapped in the canal have been removed from the intake wells. Because of their relatively small sizes, a greater proportion of greens (47.9 percent) reached the plant than loggerheads (8.1 percent).

After completion of the security intrusion barrier in December 1986, turtles larger than 30.5 cm in carapace width were prevented from reaching the intake wells. During 1989, only six loggerheads (5.4 percent of all loggerhead captures) breached the A1A barrier net. Four of these were removed from the canal at the intrusion barrier, while the other two were captured further upstream. By comparison, a total of six green and one Kemp's ridley (35 and 50 percent, respectively, of total captures) circumvented the A1A barrier net during 1989. All of these were removed at the plant's intake wells.

Relative Condition

Turtles captured alive in the intake canal of the St. Lucie Plant were assigned a relative condition based on weight, activity, parasite infestation, barnacle coverage, wounds, injuries and any other abnormalities which might have affected overall well-being (Table 6). During 1989, 89.2 percent (99) of all loggerheads found in the canal were alive and in good to excellent condition. Only 7.2 percent (8) of loggerhead captures involved individuals in fair or poor condition; 3.6 percent (4) of the loggerheads removed from the canal were dead.

Of the 17 green turtles removed from the intake canal during 1989, all but one (94.1 percent) were in good to excellent condition. The remaining individual was dead when recovered. Both hawksbills, the leatherback and one of the two Kemp's ridleys were in good to excellent condition when captured. The other Kemp's ridley was in poor condition.

Over the entire monitoring period, about 72 and 79 percent, respectively, of all loggerhead and green captures have involved turtles in good to excellent condition (Table 6). Captures of individuals in fair to poor condition have occurred about 20 percent of the time for loggerheads and 13 percent of the time for greens. All of the hawksbills and all but one leatherback have been removed from the canal in good to excellent condition, while about half of the Kemp's ridleys have fallen into these categories.

Relative condition ratings can be influenced by a number of factors, some related and others unrelated to entrainment and/or entrapment in the intake canal. Ratings of good to excellent indicate that turtles have not been negatively impacted by their entrapment in the canal, at least as evidenced by physical appearance. Although ratings of fair or poor imply reduced vitality, the extent to which entrainment/entrapment is responsible is often indeterminable. In some instances, conditions responsible for lower ratings, such as injuries, obviously were sustained prior to entrainment.

During 1989, only five percent of all captures involved individuals with noticeable injuries, such as missing appendages, broken or missing pieces of carapace and deep lacerations. Most of these were old, well-healed wounds. At least three loggerheads appeared to have been impacted by boat collisions as evidenced by substantial

carapace damage. They were examined by a veterinarian and released the same day. Two other loggerheads were entangled in fishing line and had sustained deep lacerations as a result.

Mortalities

During 1989, 4 loggerhead mortalities (3.6 percent of all loggerhead captures) were recorded in the intake canal. One was removed from the security intrusion barrier, one from the A1A barrier net and the other two were found floating unobstructed in the canal. Additionally, a small green turtle was found dead near the intake wells. The death of one of the loggerheads appears to have resulted either directly or indirectly from entanglement in monofilament fishing line. The two loggerheads removed from the containment nets may have drowned, but this could not be positively established.

Over the entire 14 year monitoring period, 126 (7.2 percent) of the 1,741 loggerheads and 19 (6.6 percent) of the 286 green turtles entrapped in the canal were found dead (Table 6). Mortalities spanned the range of size classes for loggerheads (SLCL = 47.5-103 cm), while all green turtle mortalities involved juveniles less than 41 cm in length. The four Kemp's ridley mortalities documented at the plant during 1987 and 1988 were the only deaths for this species to date; no leatherback or hawksbill mortalities have occurred at the St. Lucie Plant.

Mortalities have been closely monitored throughout the life of the canal capture program in an attempt to assign probable causes and take appropriate corrective measures to reduce future occurrences. Previous analyses of capture data identified drowning in nets, drowning in the intake pipes during periods of reduced intake flow,

injuries sustained from dredging operations and injuries sustained from the mechanical rakes used in the intake wells as probable mortality factors (ABI, 1987). Although difficult to quantify, the entrapment and subsequent demise of injured or sick turtles probably accounts for a portion of observed mortalities.

Most recent mortalities in the intake canal apparently resulted from drownings at the A1A barrier net and the newly constructed security intrusion barrier. A dramatic increase in loggerhead mortalities between 1985 and 1986 (Table 2) was thought to have been related to adjustments made to the A1A barrier net during the latter part of 1985 (ABI, 1987). Presumably, these adjustments increased the probability of a turtle drowning. A new barrier net installed in November 1987 apparently corrected previous problems, as only one mortality has been recorded at the A1A bridge since. That mortality occurred during 1989. However, it could not be determined if the loggerhead drowned as a result of entanglement in the barrier net or if it was dead before drifting into the net.

During 1989, six turtles wider than 35.0 cm breached the A1A barrier net and entered the western portion of the intake canal where capture efforts are less effective. All were loggerheads. Four were hand captured at the security intrusion barrier, while the other two were removed further upstream. Previous observations suggested that sick or injured turtles may be more susceptible to drowning at the intrusion barrier than healthy turtles (ABI, 1988). Of the four loggerheads recovered at the intrusion barrier during 1989, only one was dead. Similar to previous mortalities, this one involved an apparently underweight individual, suggesting that it may have been in poor health at the time of entrapment.

Recapture Incidents

Since the St. Lucie Plant capture program began, most turtles removed alive from the intake canal have been tagged and released into the ocean at various locations along Hutchinson Island. Consequently, individual turtles can be identified as long as they retain their tags. Over the 14 year history of turtle entrapment at the St. Lucie Plant, 56 individuals (55 loggerheads and 1 green) have been removed from the canal more than once. Several other turtles with tag scars have also been removed, indicating that the actual number of recaptures may be higher.

Of the 55 individual loggerheads known to have been caught more than once, 41 were caught twice, six were caught three times, four were caught four times, two were captured six times, one was caught seven times and one was caught on nine separate occasions, yielding a total of 89 recapture incidents. Release site did not appear to have any effect on a turtle's probability of being recaptured. Turtles released both north and south of the plant returned. Recaptures also did not appear to be related to size, as both juveniles and adults were captured more than once (range of SLCL = 47-89 cm). However, the majority of recapture incidents involved juveniles and sub-adults (SLCL <70 cm).

Recapture intervals for loggerheads ranged from four to 858 days, with a mean of 161 days ($\pm$175.4 days). The only green turtle caught more than once was captured on two occasions, returning to the canal 59 days after first being released into the ocean. About 53 percent of all loggerhead recapture incidents occurred within 90 days of previous capture and 90 percent within one year (Figure 21). The average interval

between first and last capture was 264 days ($\pm$322.2 days). The longest period between first and last capture was 5.3 years. These data suggest that residency times of loggerheads within the nearshore habitat adjacent to the St. Lucie Plant are relatively short. Similar findings have been reported for loggerheads inhabiting the Mosquito/Indian River Lagoons of east-central Florida (Mendonca and Ehrhart, 1982).

SUMMARY

A gradient of increasing loggerhead turtle nest densities from north to south along the northern half of Hutchinson Island has been shown during all survey years. This gradient may result from variations in beach topography, offshore depth contours, distribution of nearshore reefs, onshore artificial lighting and human activity on the beach at night. Low nesting activity in the vicinity of the power plant during 1975 and from 1981 through 1983 was attributed to construction of power plant intake and discharge systems. Nesting returned to normal or above normal levels following both periods of construction. Power plant operation, exclusive of intake/discharge construction, has had no significant effect on nest densities.

There have been considerable year-to-year fluctuations in loggerhead nesting activity on Hutchinson Island from 1971 through 1989. Fluctuations are common at other rookeries and may result from overlapping of non-annual breeding populations. Despite these fluctuations, loggerhead nesting activity has remained relatively high during the last eight years. No relationship between total nesting on the island and power plant operation or intake/discharge construction was indicated.

Temporary declines in loggerhead nesting activity have been attributed to cool water intrusions that frequently occur over the continental shelf of southeast Florida. Though temporal nesting patterns of the Hutchinson Island population may be influenced by natural fluctuations in water temperature, no significant effects due to power plant operation have been indicated.

Since nesting surveys began in 1971, raccoon predation was considered the major cause of turtle nest destruction on Hutchinson Island. From 1971 through 1977, overall predation rates in the nine survey areas were between 21 and 44 percent. However, a pronounced decrease in raccoon predation occurred after 1977, and overall predation rates in the nine survey areas have not exceeded ten percent since 1979. Decreased predation by raccoons probably reflects a decline in the raccoon population.

During 1989, 45 green turtle and 36 leatherback turtle nests were recorded on Hutchinson Island. Green turtle nesting activity exhibited considerable annual fluctuations, as has been recorded at other rookeries, but has remained relatively high during the last seven years. Leatherback turtle nest densities have remained low on Hutchinson Island; however, increased nesting during recent years may reflect an overall increase in the number of nesting females in the Hutchinson Island area.

During 1989, 111 loggerheads, 17 green turtles, 1 leatherback, 2 hawksbills and 2 Kemp's ridleys were removed from the St. Lucie Plant intake canal. Since monitoring began in May 1976, 1,741 loggerhead, 286 green, 9 leatherback, 8 hawksbill and 17 Kemp's ridley turtles have been captured. Over the life of the monitoring program,

annual catches for loggerhead turtles have ranged from 33 in 1976 (partial year of plant operation and monitoring) to a high of 195 in 1986. Yearly catches of green turtles have ranged from 0 in 1976 to 69 in 1984. Differences in the number of turtles entrapped during different years and months are attributed to natural variation in the occurrence of turtles in the vicinity of the offshore intake structures, rather than to any influence of the plant itself.

Size-class distributions of loggerhead turtles removed each year from the canal have consistently been predominated by juveniles and sub-adults between 50 and 70 cm in straight line carapace length. Most green turtles entrapped in the canal (about 80 percent) were juveniles 40 cm or less in length. For both species, the largest number of captures for all years combined occurred during the winter, but these seasonal peaks were much more pronounced for green turtles. Sex ratios of both adult and immature loggerheads caught in the canal continued to be biased towards females.

During 1989, about 89 percent of all loggerheads and green turtles removed from the canal were categorized by physical appearance as being in good to excellent condition. Over the entire 14 year monitoring period, 72 and 79 percent, respectively, of all loggerhead and green turtle captures have involved individuals in these categories; 20 percent of the loggerheads and 13 percent of the green turtles removed from the canal have been in fair or poor condition.

Only five percent of the turtles removed from the intake canal during 1989 had substantial injuries. It appeared that most of these injuries were sustained prior to entrapment. Once in the canal, turtles confined east of A1A usually had very brief residency

times and thus the relative condition of most turtles was not affected by their entrapment. During 1989, 6 loggerheads, 6 green turtles and 1 Kemp's ridley swam west of the A1A bridge. Most of the loggerheads were retrieved at the security intrusion barrier. All of the green turtles and the Kemp's ridley were removed from the canal at the intake wells. Since monitoring began, about 8 percent of all loggerhead and 48 percent of all green turtle captures have occurred at the intake wells.

During 1989, one green and four loggerhead mortalities were recorded for the intake canal. Two of these deaths appeared to have resulted from drowning, while a third may have resulted from entanglement in monofilament fishing line.

Since intake canal monitoring began in 1976, 7.2 percent of the loggerheads and 6.6 percent of the green turtles removed from the canal were dead. The four Kemp's ridley mortalities in 1987 and 1988 were the only deaths recorded for this species since monitoring began. All of the leatherbacks and hawksbills entrapped in the intake canal at the St. Lucie Plant have been captured alive and released into the ocean.

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.

_____________. 1980a. 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.

_____________. 1980b. Turtle entrainment deterrent study. AB-290. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

_____________. 1981a. 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.

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

_____________. 1981c. 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.

_____________. 1983. Florida Power & Light Company, St. Lucie Plant annual non-radiological aquatic monitoring report 1982. Volumes I and II. AB-442. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

ABI (Applied Biology, Inc.). 1984a. Florida Power & Light Company, St. Lucie Plant annual non-radiological environmental monitoring report 1983. Volumes I and II. AB-530. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________. 1984b. Florida Power & Light Company, St. Lucie Unit 2 annual environmental operating report 1983. AB-533. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Miami.

____________. 1985a. Florida Power & Light Company, St. Lucie Plant annual non-radiological environmental monitoring report 1984. AB-553. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Juno Beach.

____________. 1985b. Florida Power & Light Company, St. Lucie Unit 2 annual environmental operating report 1984. AB-555. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Juno Beach.

____________. 1986. Florida Power & Light Company, St. Lucie Unit 2 annual environmental operating report 1985. AB-563. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Juno Beach.

____________. 1987. Florida Power & Light Company, St. Lucie Unit 2 annual environmental operating report 1986. AB-579. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Juno Beach.

____________. 1988. Florida Power & Light Company, St. Lucie Unit 2 annual environmental operating report 1987. AB-595. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Juno Beach.

____________. 1989. Florida Power & Light Company, St. Lucie Unit 2 annual environmental operating report 1988. AB-596. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Juno Beach.

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 America. Bulletin of the Florida State Museum, Biological Sciences, 4(10):319-348.

Bellmund, S., M.T. Masnik and G. LaRoche. 1982. Assessment of the impacts of the St. Lucie 2 Nuclear Station on threatened or endangered species. US Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation.

Bustard, H.R. 1968. Protection for a rookery: Bundaberg sea turtles. Wildlife in Australia 5:43-44.

Bustard, H.R. and P. Greenham. 1968. Physical and chemical factors affecting hatching in the green sea turtle, Chelonia mydas (L.). Ecology 49(2):269-276.

Caldwell, D.K. 1962. Comments on the nesting behavior of Atlantic loggerhead sea turtles, based primarily on tagging returns. Quarterly Journal of the Florida Academy of Sciences 25(4):287-302.

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.

Camp, D.K., N.W. Whiting and R.E. Martin. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. V. Arthropods. Florida Marine Research Publications 25: 1-63.

Carr, A., A. Meylan, J. Mortimer, K. Bjorndal and T. Carr. 1982. Surveys of sea turtle populations and habitats in the Western Atlantic. NOAA Technical Memorandum NMFS-SEFC-91:1-82.

Davis, G.E., and M.C. Whiting. 1977. Loggerhead sea turtle nesting in Everglades National Park, Florida, U.S.A. Herpetologica 33:18-28.

Diamond, A.W. 1976. Breeding biology and conservation of Hawksbill turtles, Eretmochelys imbricata L., on Cousin Island, Seychelles. Biological Conservation 9:199-215.

Ehrhart, L.M. 1979. Reproductive characteristics and management potential of the sea turtle rookery at Canaveral National Seashore, Florida. Pages 397-399 in Linn, R.M., ed. Proceedings of the First Conference on Scientific Research in the National Parks, 9-12 November, 1976, New Orleans, La. NPS Trans. and Proc. Ser. No. 5.

Ehrhart, L.M. 1980. 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. Kennedy Space Center. Contract No. NAS-10-8986. Vol. IV, NASA Report 163122. September 1980.

Ernest, R.G., R.E. Martin, B.D. Peery, D.G. Strom, J.R. Wilcox and N.W. Walls. 1988. Sea turtle entrapment at a coastal power plant. Pages 270-301 in Mahadevan, K., R.K. Evans, P. Behrens, T. Biffar and L. Olsen, eds. Proceedings, Southeastern Workshop on Aquatic Ecological Effects of Power Generation. Report No. 124, Mote Marine Laboratory, Sarasota, Florida.

Ernest, R.G., R.E. Martin, N.W. Walls and J.R. Wilcox. 1989. Population dynamics of sea turtles utilizing shallow coastal waters off Hutchinson Island, Florida. Pages 57-59 in Eckert, S.A., K.L. Eckert and T.H. Richardson, compilers. Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-232.

Fowler, L.E. 1979. Hatching success and nest predation in the green sea turtle, Chelonia mydas, at Tortuguero, Costa Rica. Ecology 60(5):945-955.

Futch, C.R. and S.E. Dwinell. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. IV. Lancelets and Fishes. Florida Marine Research Publications 24: 1-23.

Gallagher, R.M. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. II. Sediments. Florida Marine Research Publications 23: 6-24.

Gallagher, R.M. and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. I. Introduction and rationale. Florida Marine Research Publications 23: 1-5.

Gallagher, R.M., M.L. 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 37:1-11.

Hendrickson, J.R. and E. Balasingam. 1966. Nesting beach preferences of Malayan sea turtles. Bulletin of the National Museum Singapore 33(10):69-76.

Henwood, T.A. 1987. Movements and seasonal changes in loggerhead turtle, Caretta caretta, aggregations in the vicinity of Cape Canaveral, Florida (1978-84). Biological Conservation 40:191-202.

Hillestad, H.O., J.I. Richardson, C. McVea, Jr. and J.M. Watson, Jr. 1982. Worldwide incidental capture of sea turtles. Pages 489-496 in Bjorndal, K.A., ed. Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, D.C.

Hirth, H.F. 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. 1974. The sea turtles of southeast Africa, 1. Status, morphology and distributions. South African Association for Marine Biological Research, Oceanographic Research Institute, Investigational Report No. 35:1-144.

______. 1976. Irregular reproductive cycles in the Tongaland loggerhead sea turtle, Caretta caretta (L.) (Cryptodira:Chelonidae). Zoologica Africana 11(2):285-291.

Martin, R.E., R.G. Ernest, N.W. Walls and J.R. Wilcox. 1989a. Size distribution and seasonal abundance of loggerhead and green turtles in nearshore waters off Hutchinson Island, Florida. Pages 334-335 in Ogren, L., F. Berry, K. Bjorndal, H. Kumpf, R. Mast, G. Medina, H. Reichart and R. Witham, editors. Proceedings of the Second Western Atlantic Turtle Symposium. Mayaguez, Puerto Rico, 12-16 October 1987. NOAA Technical Memorandum NMFS-SEFC-226.

______________________. 1989b. Long-term trends in sea turtle nesting on Hutchinson Island, Florida. Pages 111-113 in Eckert, S.A., K.L. Eckert and T.H. Richardson, compilers. Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-232.

Mendonca, M.T. and L.M. Ehrhart. 1982. Activity, population size and structure of the immature Chelonia mydas and Caretta caretta in Mosquito Lagoon, Florida. Copeia 1982:(1) 161-167.

Moffler, M.D. and J.F. Van Breedveld. 1979. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. X. Benthic algae species list. Florida Marine Research Publications 34: 118-122.

Mortimer, J.A. 1982. Factors influencing beach selection by nesting sea turtles. Pages 45-51 in Bjorndal, K.A., ed. Biology and Conservation of Sea Turtles. Smithsonian Institution Press. Washington, D.C.

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.

NRC (US Nuclear Regulatory Commission). 1982. Final environmental statement related to the operation of St. Lucie Plant Unit 2. Docket No. 50-389.

O'Hara, J. 1980. Thermal influences on the swimming speed of loggerhead turtle hatchlings. Copeia 1980(4):773-780.

O'Hara, J. and J.R. Wilcox. In Press. Avoidance response of loggerhead turtles, Caretta caretta, to low frequency sound. Copeia 1990.

Owens, D.W., J.R. Hendrickson, V. Lance and I.P. Callard. 1978. A technique for determining sex of immature Chelonia mydas using a radioimmunoassay. Herpetologica 34:270-273.

Owens, D.W. and G.J. Ruiz. 1980. New methods of obtaining blood and cerebrospinal fluid from marine turtles. Herpetologica 36:17-20.

Pritchard, P.C., P.R. Bacon, F.H. Berry, A.F. Carr, J. Fletemeyer, R.M. Gallagher, S.R. Hopkins, R.R. Lankford, R. Marques M., L.H. Ogren, W.G. Pringle, Jr., H.A. Reichart and R. Witham. 1983. Manual of sea turtle research and conservation techniques. Prepared for the Western Atlantic Turtle Symposium, San Jose, Costa Rica, July 1983. 126 pp.

Proffitt, C.E., R.E. Martin, R.G. Ernest, B.J. Graunke, S.E. LeCroy, K.A. Muldoon, B.D. Peery, J.R. Wilcox and N. Williams-Walls. 1986. Effects of power plant construction and operation on the nesting of the loggerhead sea turtle (Caretta caretta):1971-1984. Copeia 1986(3): 813-816.

Raymond, P.W. 1984. The effects of beach restoration on marine turtles nesting in south Brevard County, Florida. M.S. thesis, University of Central Florida.

Routa, R.A. 1968. Sea turtle nest survey of Hutchinson Island, Florida. Quarterly Journal Florida Academy of Sciences 30(4):287-294.

Schulz, J.P. 1975. Sea turtles nesting in Surinam. Zoologische Verhandelingen, uitgegeven door het Rijksmuseum van Natuurlijke Historie te Leiden, No. 143:1-144.

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. 859 pp.

Stancyk, S.E. 1982. Non-human predators of sea turtles and their control. Pages 139-152 in Bjorndal, K.A., ed. Biology and Conservation of Sea Turtles. Smithsonian Institution Press. Washington, D.C.

Talbert, O.R., 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:(4)709-718.

Taylor, C.B., and H.B. Stewart. 1958. Summer upwelling along the east coast of Florida. Journal of Geophysical Research 64(1):33-40.

Tester, L.A. and K.A. Steidinger. 1979. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. VII. Phytoplankton, 1971-1973. Florida Marine Research Publications 34: 16-61.

Walker, L.M. 1979. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. IX. Diel plankton, 1973-1974. Florida Marine Research Publications 34: 99-117.

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 Marine Research Publications 34: 62-98.

Walker, L.M. and K.A. Steidinger. 1979. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. VI. Plankton dynamics, 1971-1973. Florida Marine Research Publications 34: 1-15.

Wibbels, T., D. Owens, Y. Morris and M. Amoss. 1984. Sex ratios of immature loggerhead sea turtles captured along the Atlantic coast of the United States. Final Report to the National Marine Fisheries Service. Contract No. NA81-GA-C-0039. 47 pp.

Williams-Walls, N., J. O'Hara, R.M. Gallagher, D.F. Worth, B.D. Peery and J.R. Wilcox. 1983. Spatial and temporal trends of sea turtle nesting on Hutchinson Island, Florida, 1971-1979. Bulletin of Marine Science 33(1):55-66.

Witherington, B.E. and L.M. Ehrhart. 1989. Status and reproductive characteristics of green turtles (Chelonia mydas) nesting in Florida. Pages 351-352 in Ogren, L., F. Berry, K. Bjorndal, H. Kumpf, R. Mast, G. Medina, H. Reichart and R. Witham, editors. Proceedings of the Second Western Atlantic Turtle Symposium. Mayaguez, Puerto Rico, 12-16 October 1987. NOAA Technical Memorandum NMFS-SEFC-226.

Witzell, W.N. 1983. Synopsis of biological data on the hawksbill turtle, Eretmochelys imbricata (Linnaeus, 1766). FAO Fisheries Synopsis, 137:1-78.

Worth, D.F. and M.L. Hollinger. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. III. Physical and chemical environment. Florida Marine Research Publications 23: 25-85.

Worth, D.F., and J.B. Smith. 1976. Marine turtle nesting on Hutchinson Island, Florida, in 1973. Florida Marine Research Publications 18:1-17.

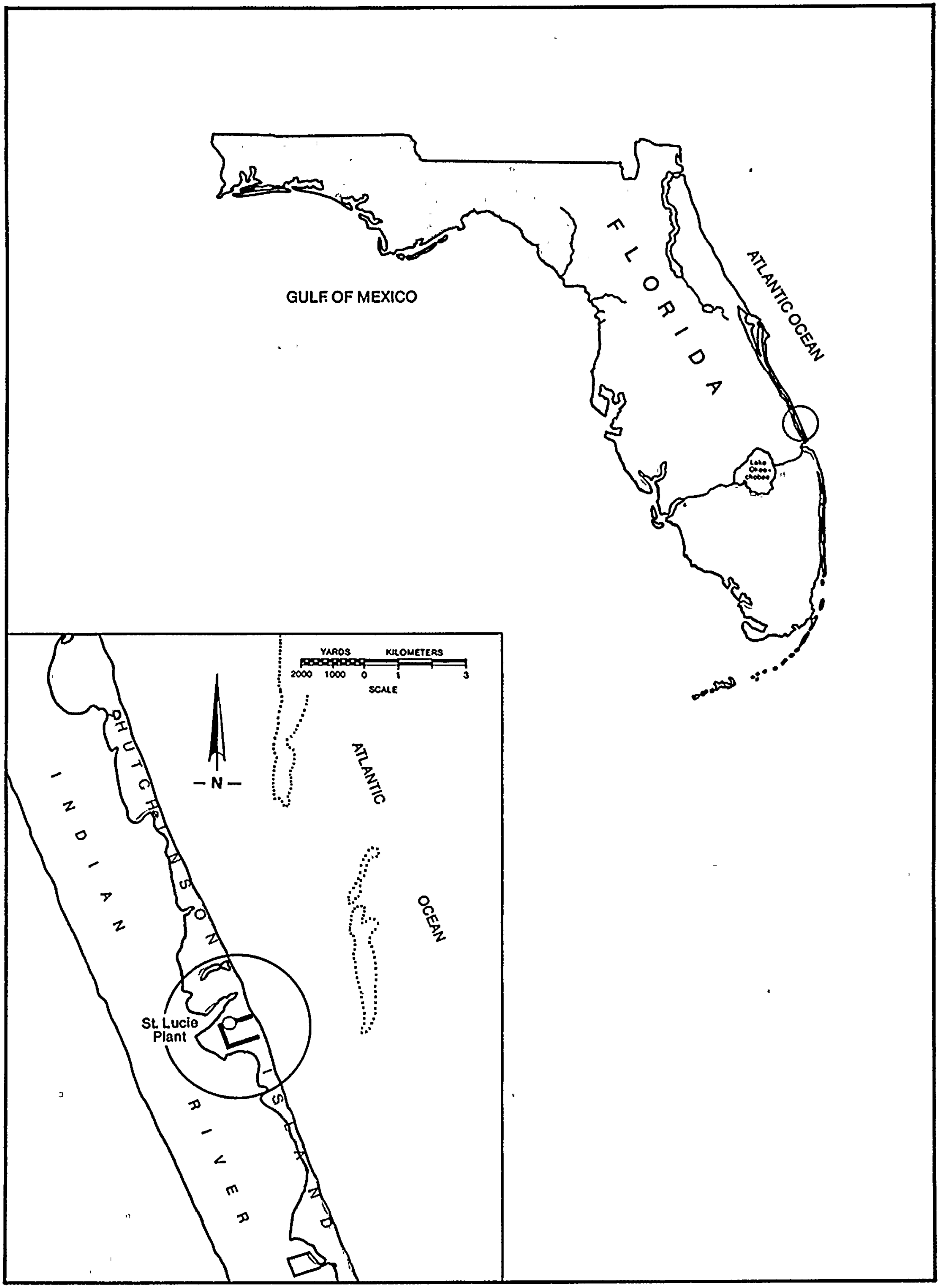

Figure 1. Location of the St. Lucie Plant.

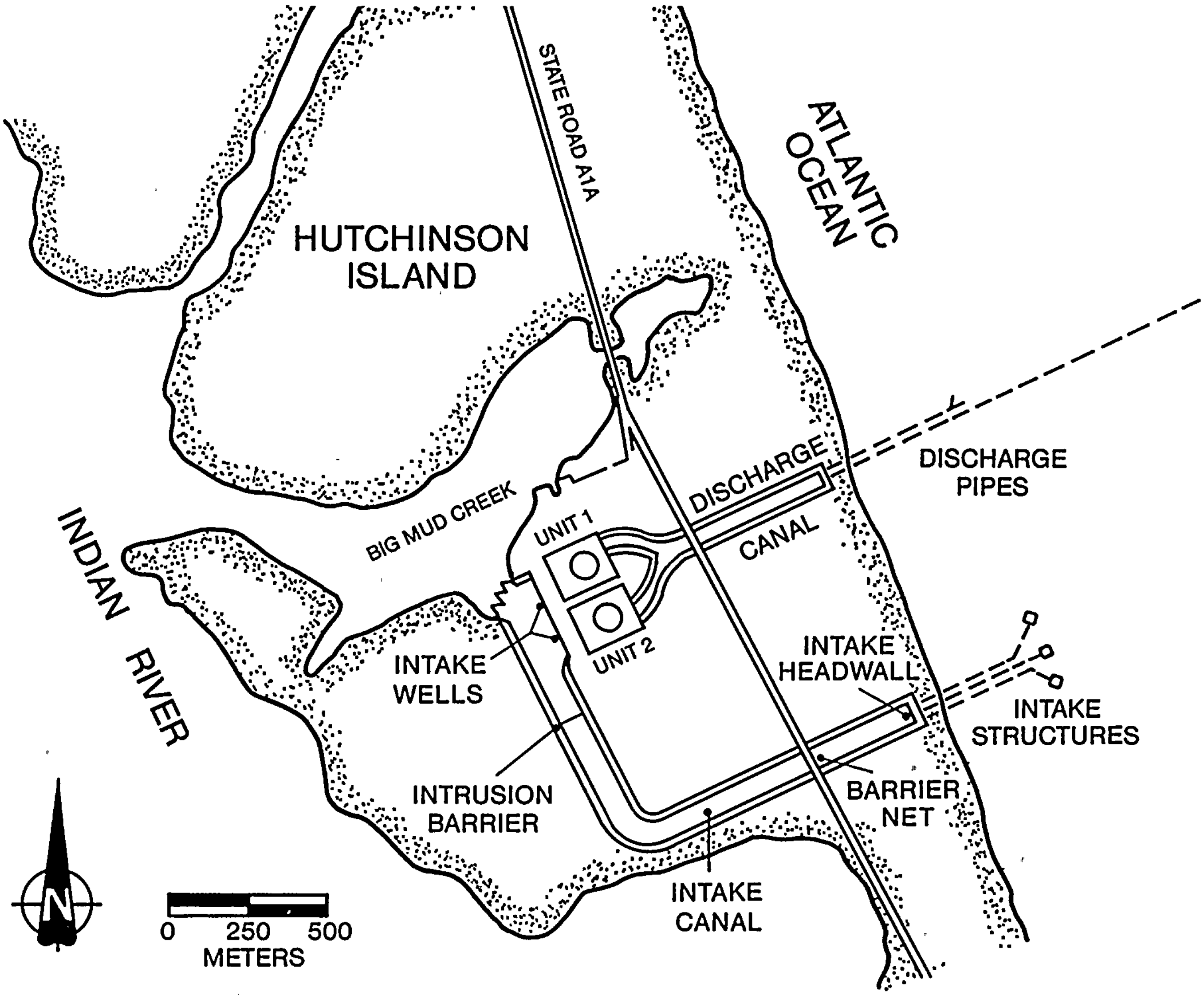

Figure 2. St. Lucie Plant cooling water intake and discharge system.

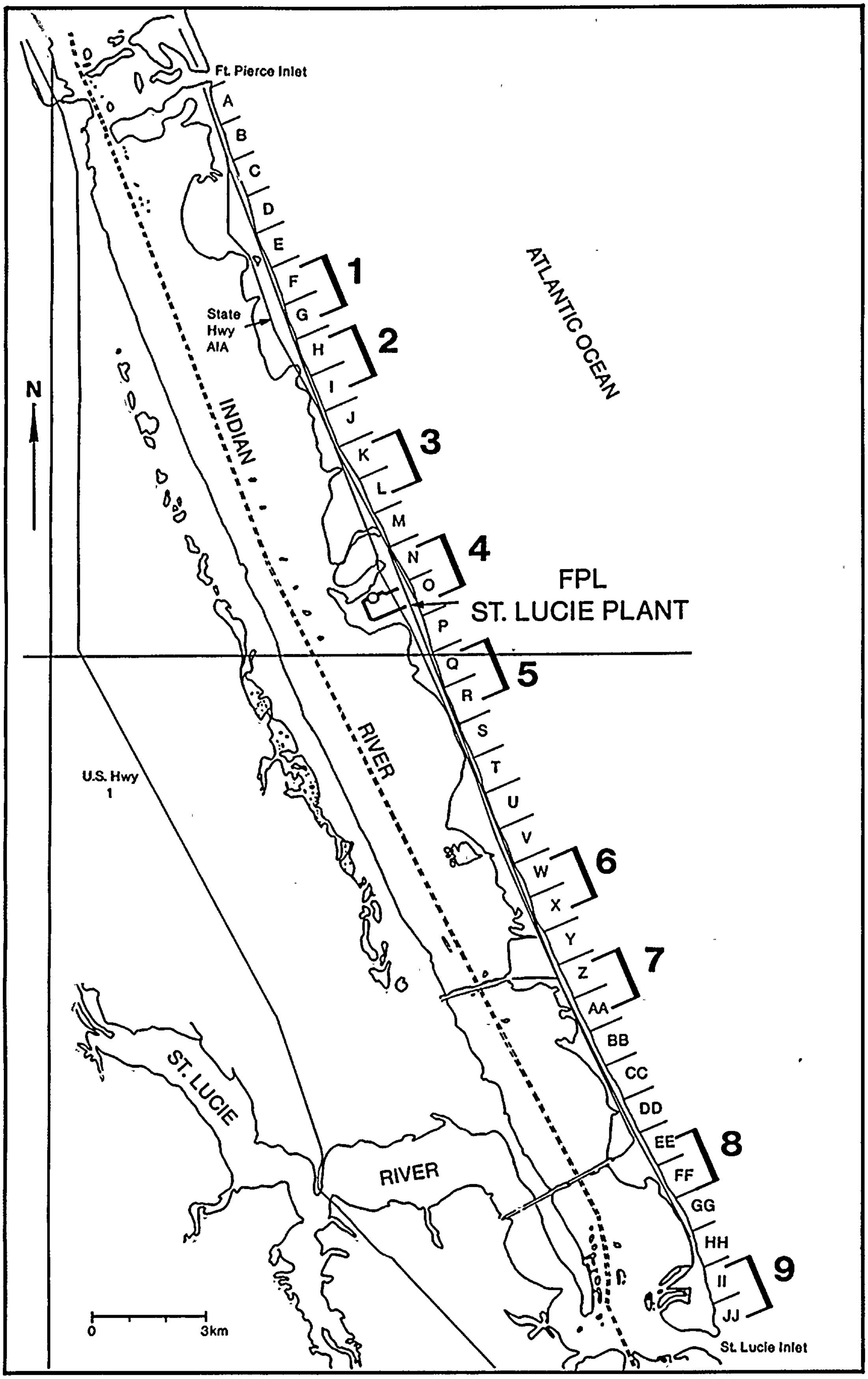

Figure 3. Designation and location of nine 1.25-km segments and thirty-six 1-km segments surveyed for sea turtle nesting, Hutchinson Island, 1971-1989.

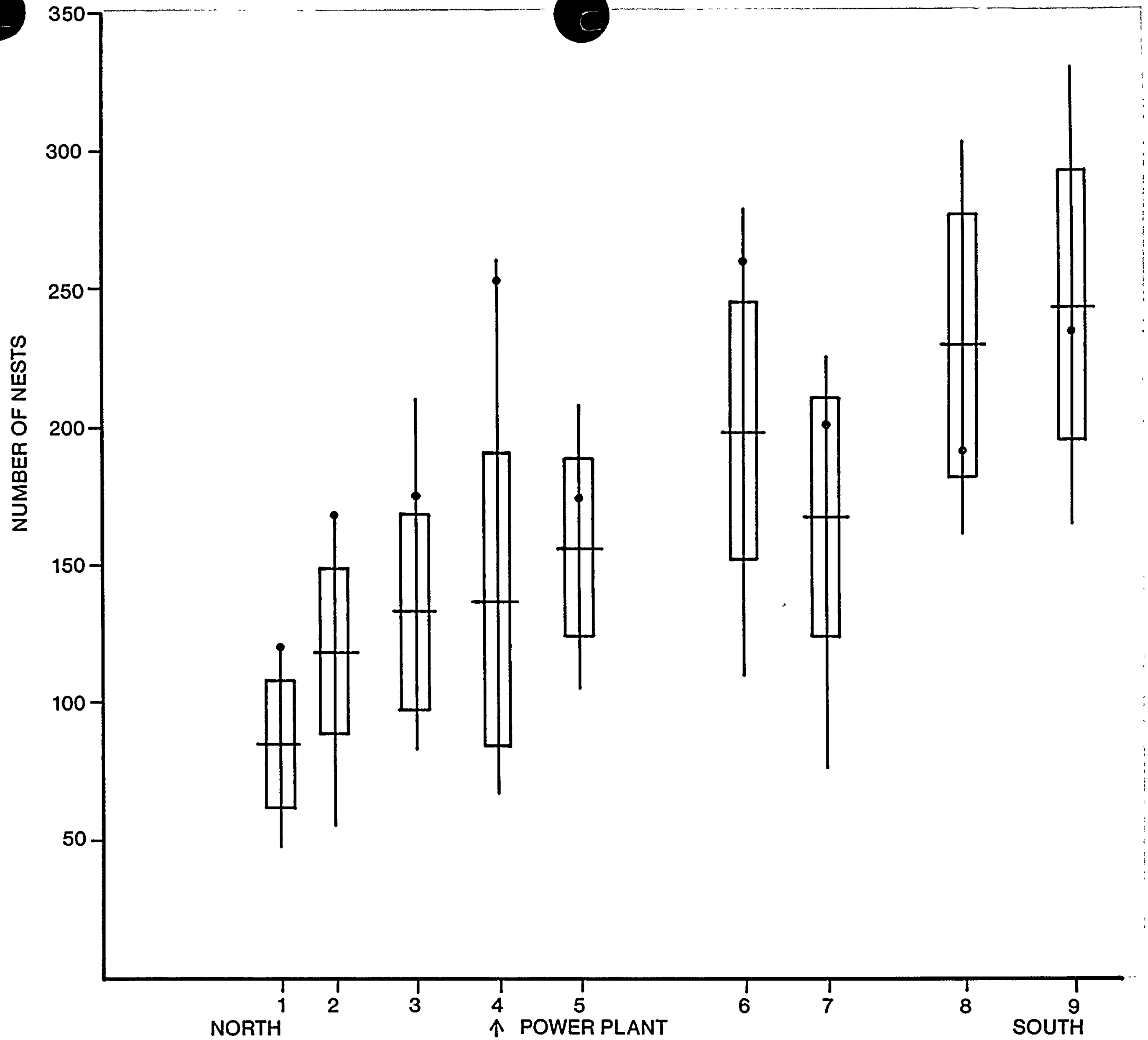

Figure 4. Mean annual number of loggerhead turtle nests in each of the nine 1.25-km-long survey areas, Hutchinson Island, 1971-1988, compared with number of nests during 1989. Horizontal lines are means, boxes enclose plus or minus one standard deviation, vertical lines are ranges, and closed circles are 1989 values (1980 data were excluded because not all areas were surveyed).

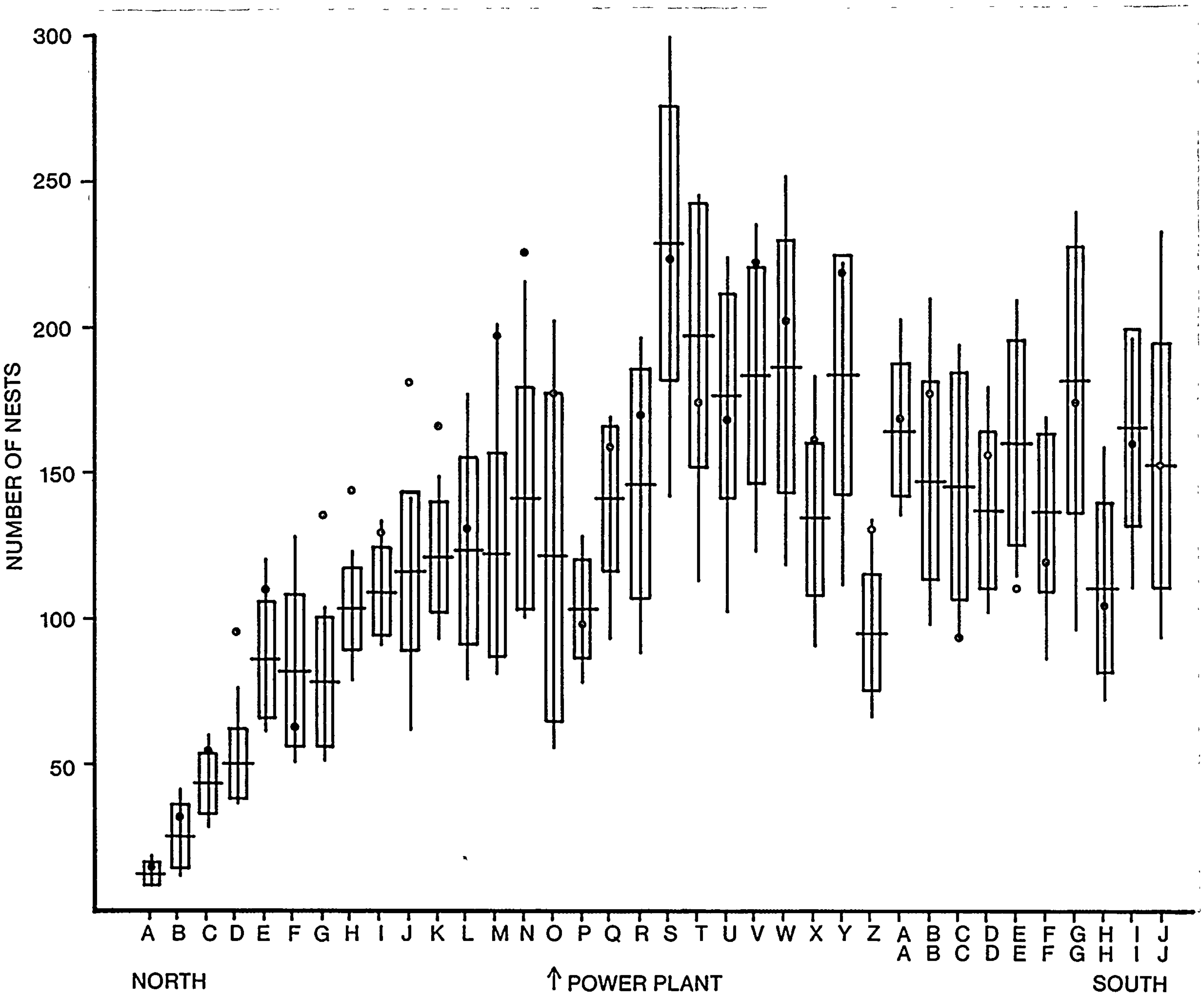

Figure 5. Mean annual number of loggerhead turtle nests in each of the thirty-six 1-km-long survey areas, Hutchinson Island, 1981-1988, compared with number of nests during 1989. Horizontal lines are means, boxes enclose plus or minus one standard deviation, vertical lines are ranges, and closed circles are 1989 values.

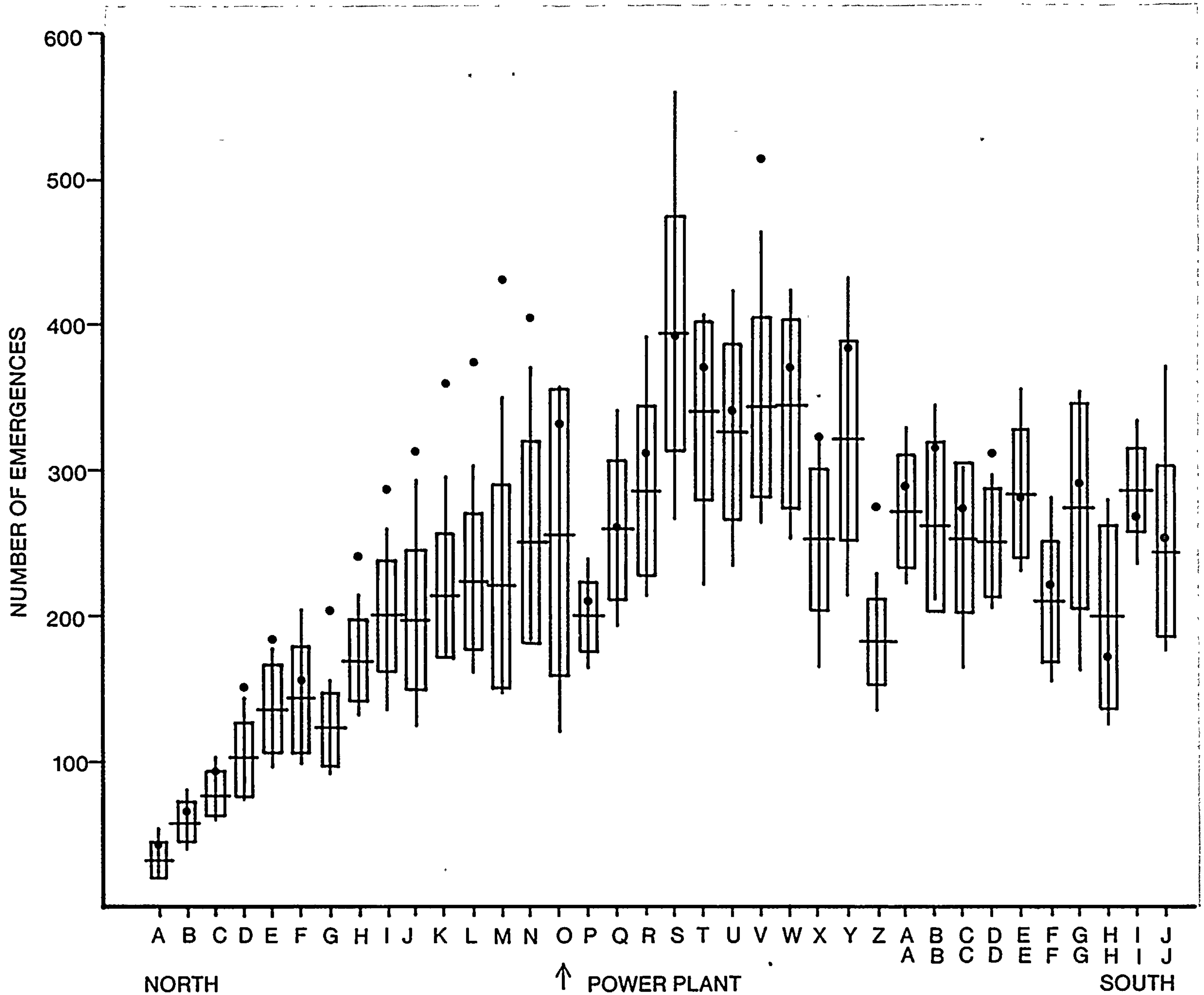

Figure 6. Mean annual number of loggerhead turtle emergences in each of the thirty-six 1-km-long survey areas, Hutchinson Island, 1981-1988, compared with the number of emergences during 1989. Horizontal lines are means, boxes enclose plus or minus one standard deviation, vertical lines are ranges, and closed circles are 1989 values.

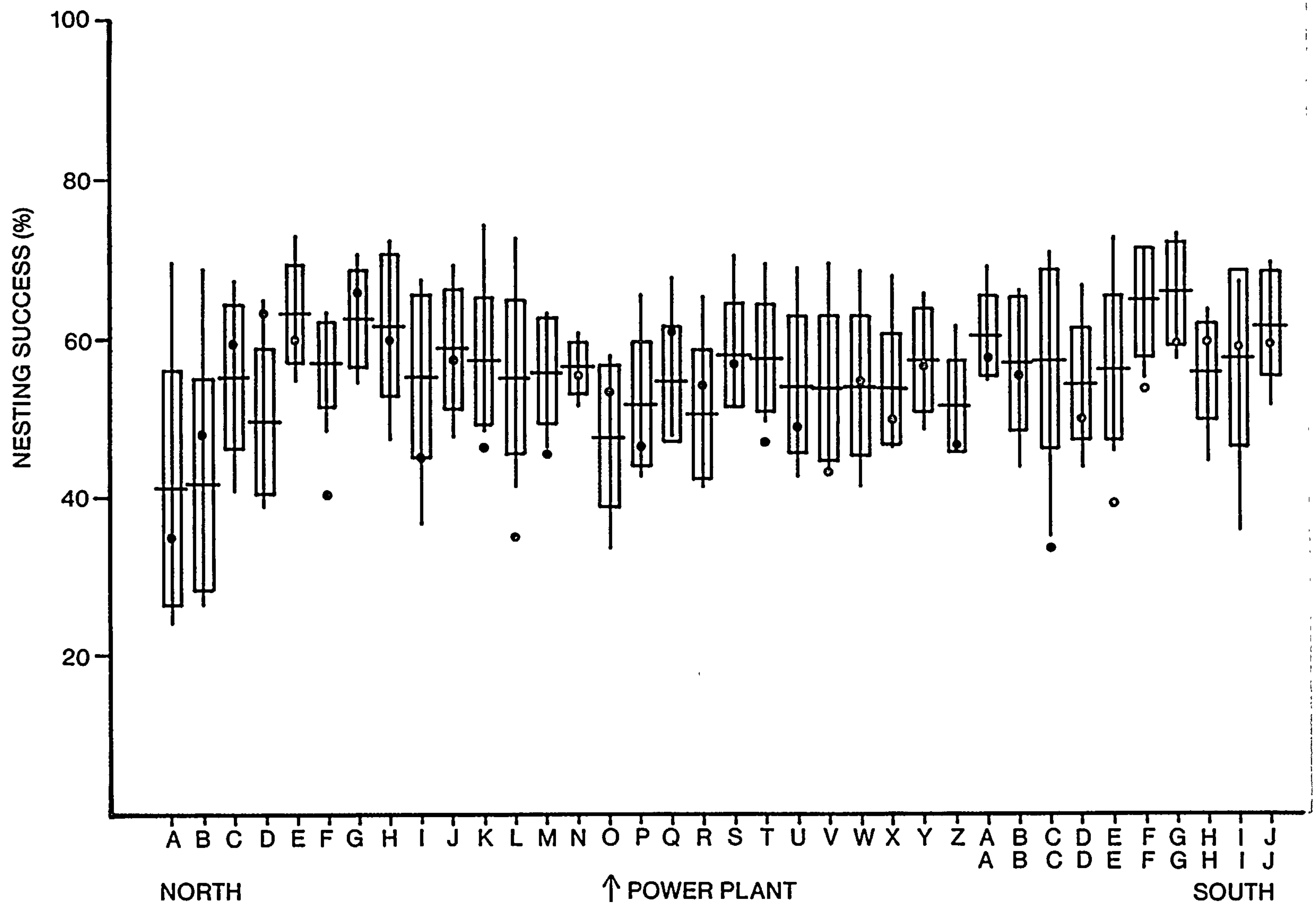

Figure 7. Mean annual loggerhead turtle nesting success (percentage of emergences that resulted in nests) for each of the thirty-six 1-km-long survey areas, Hutchinson Island, 1981-1988, compared with nesting success during 1989. Horizontal lines are means, boxes enclose plus or minus one standard deviation, vertical lines are ranges, and closed circles are 1989 values.

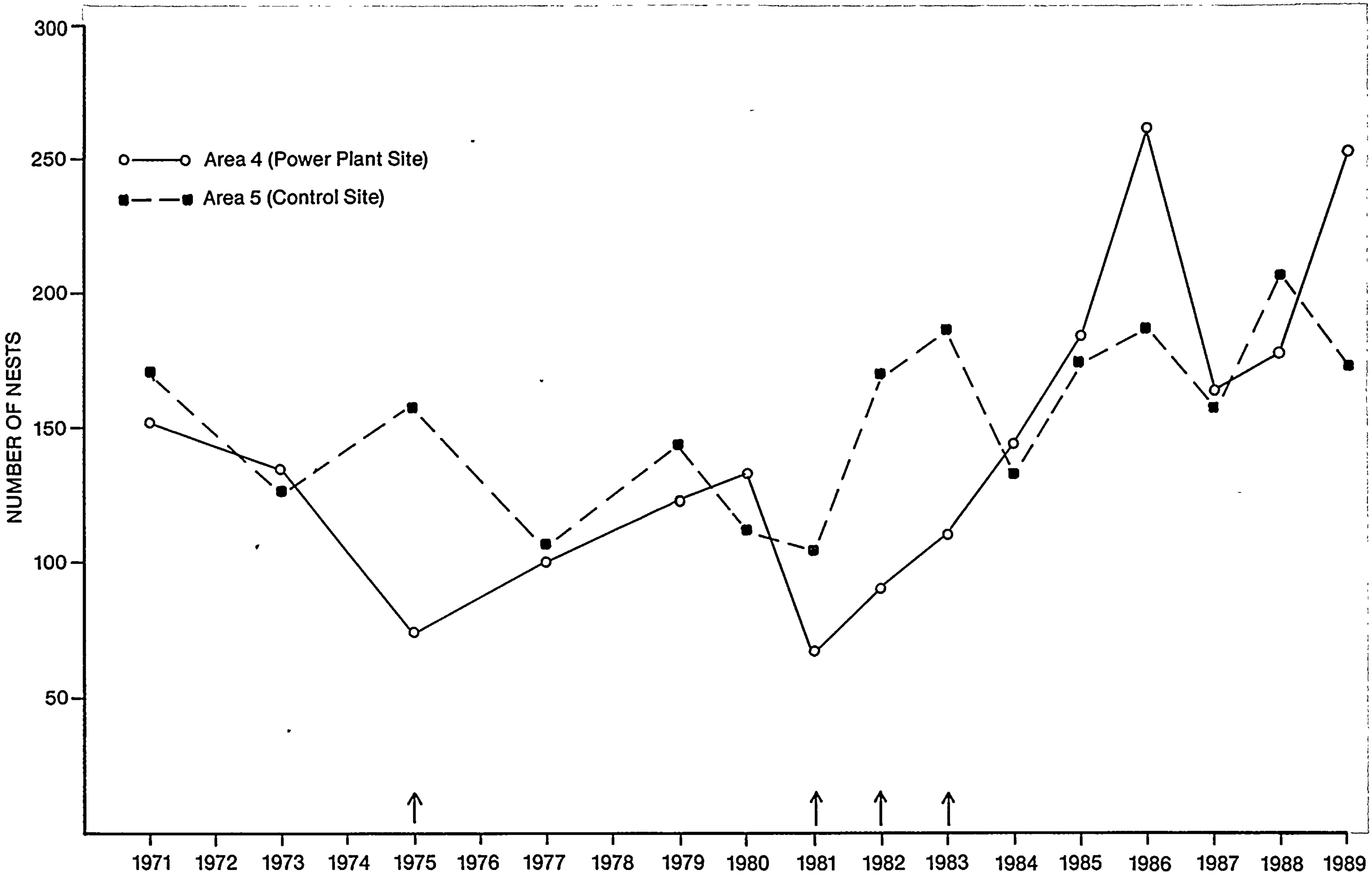

Figure 8. Number of loggerhead turtle nests in areas 4 and 5, Hutchinson Island, 1971-1989. Arrows denote years during which intake/discharge construction occurred in area 4.

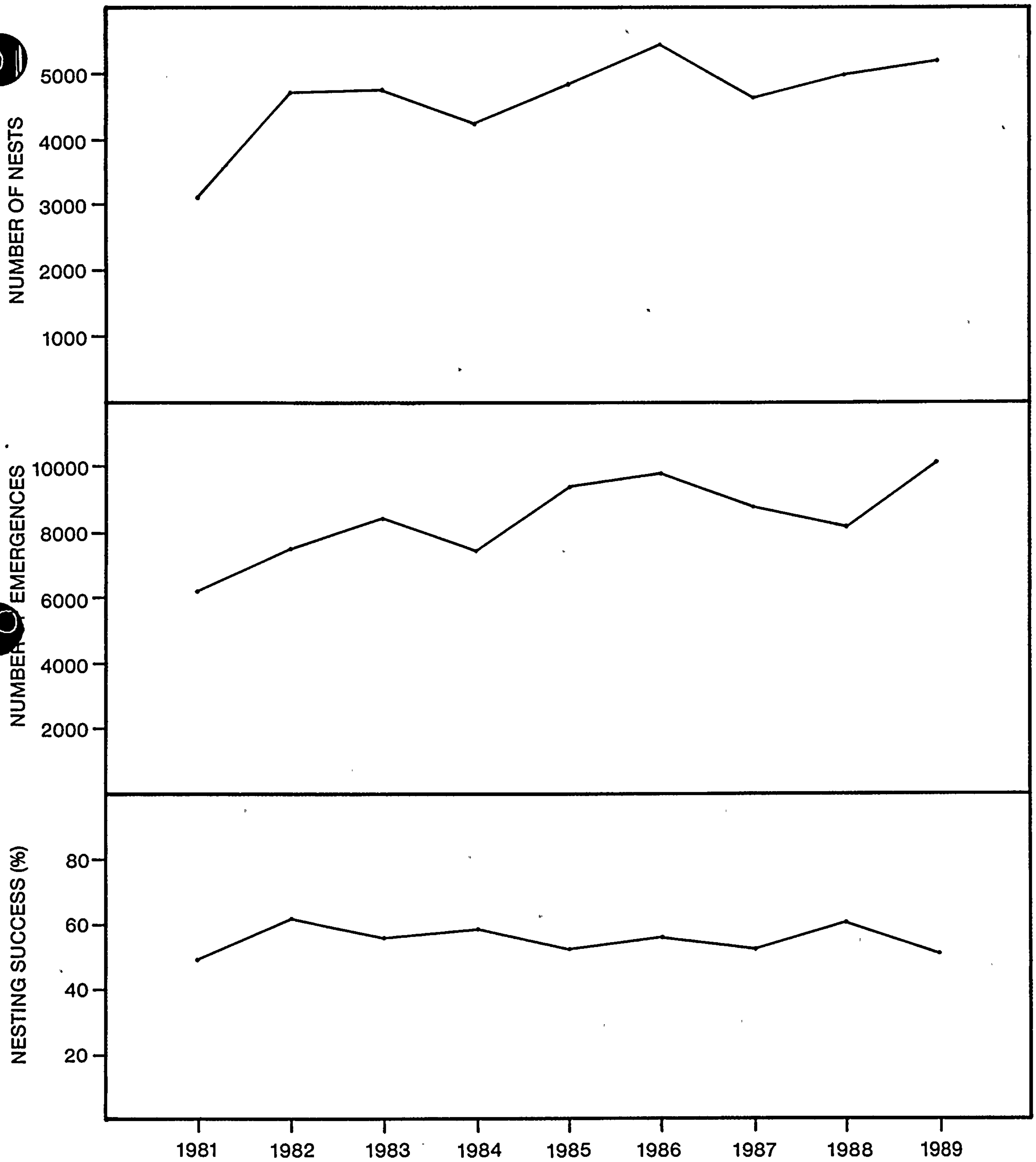

Figure 9. Annual number of nests, number of emergences and nesting success along the entire 36.0-km-long Atlantic coastline of Hutchinson Island, 1981-1989.

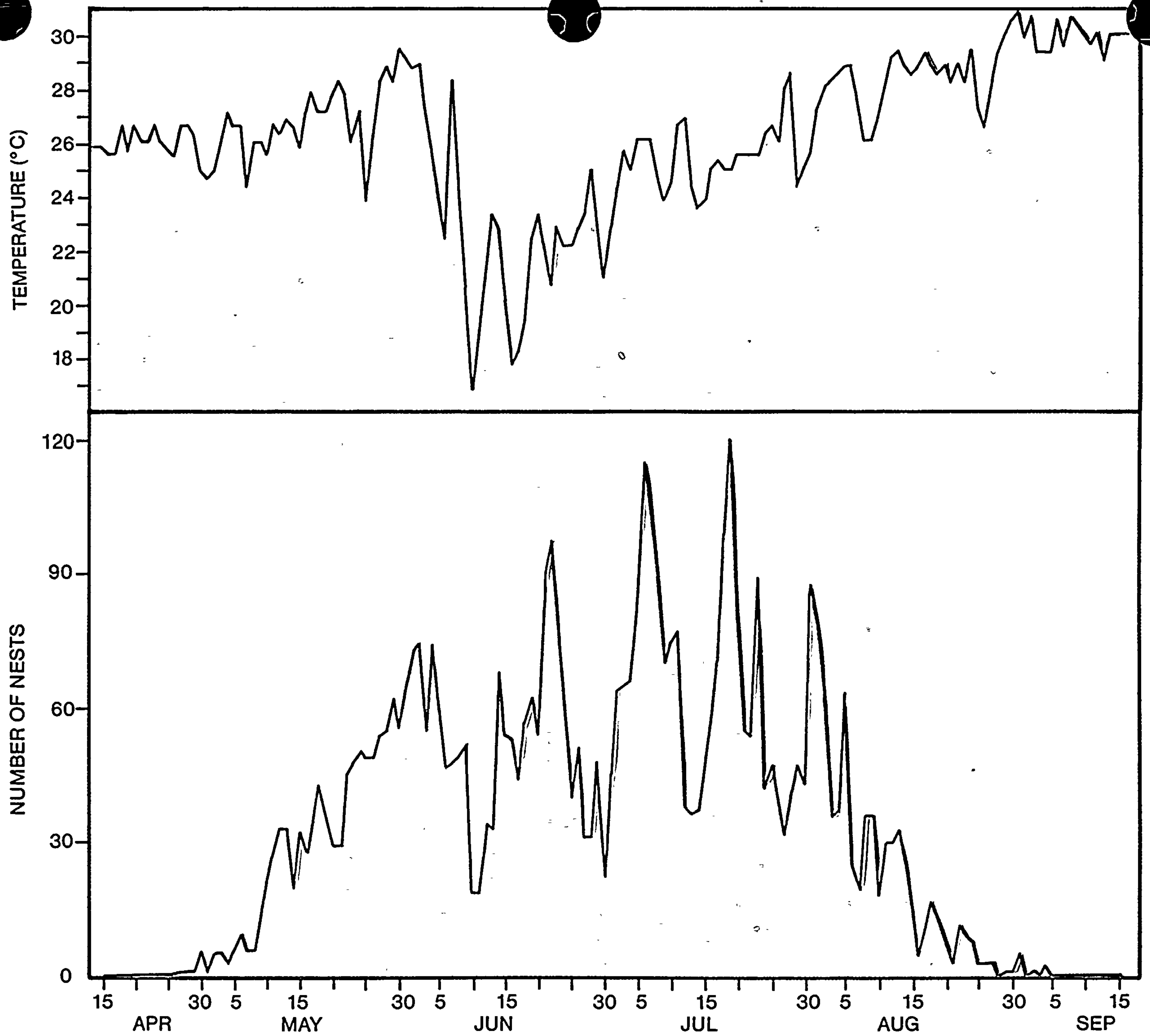

Figure 10. Daily loggerhead turtle nesting activity and water temperature, Hutchinson Island, 1989.

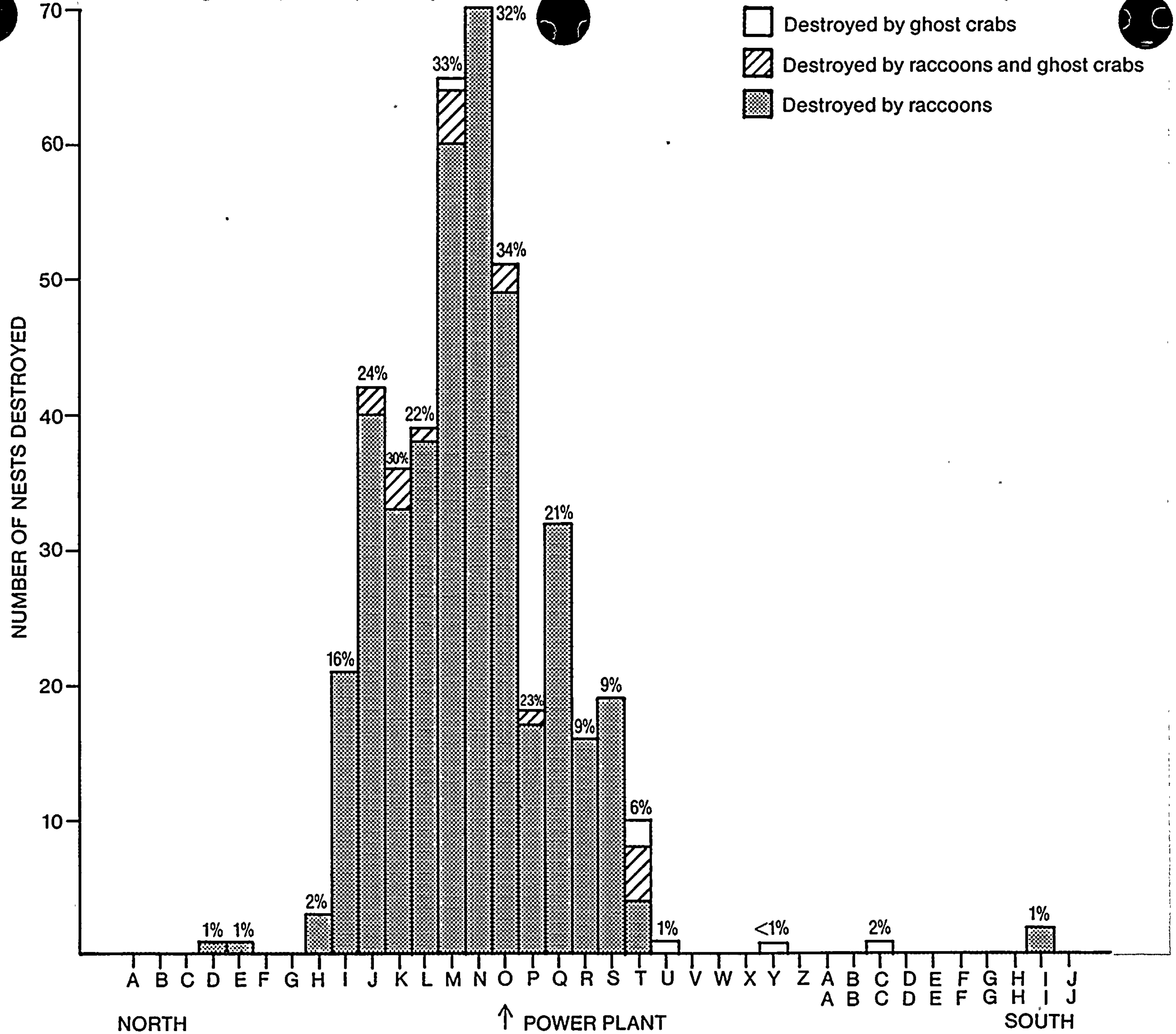

Figure 11. Number of loggerhead turtle nests destroyed by raccoons and ghost crabs and percentage of nests destroyed in each 1-km-long survey area, Hutchinson Island, 1989.

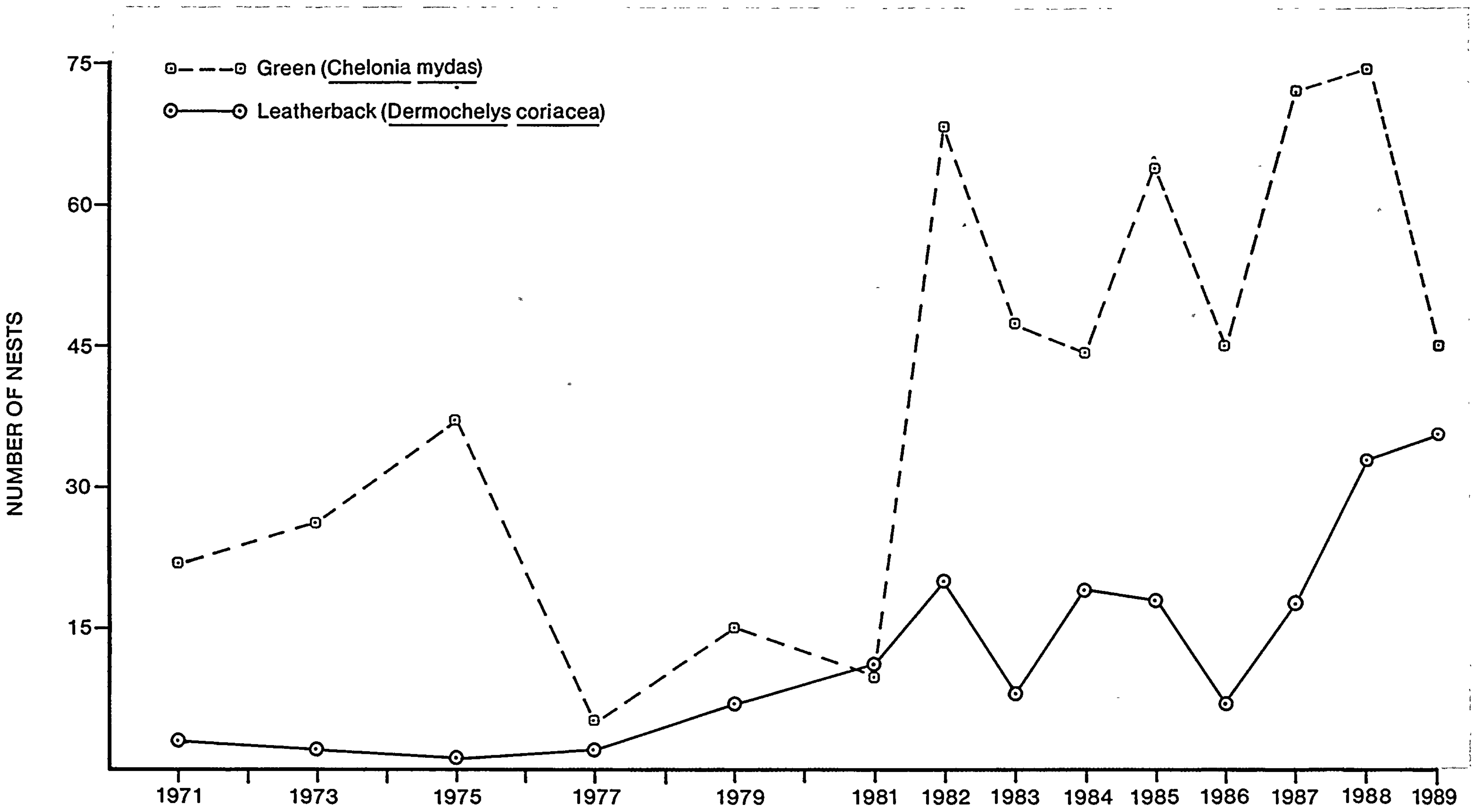

Figure 12. Annual numbers of green turtle and leatherback turtle nests, Hutchinson Island, 1971-1989.

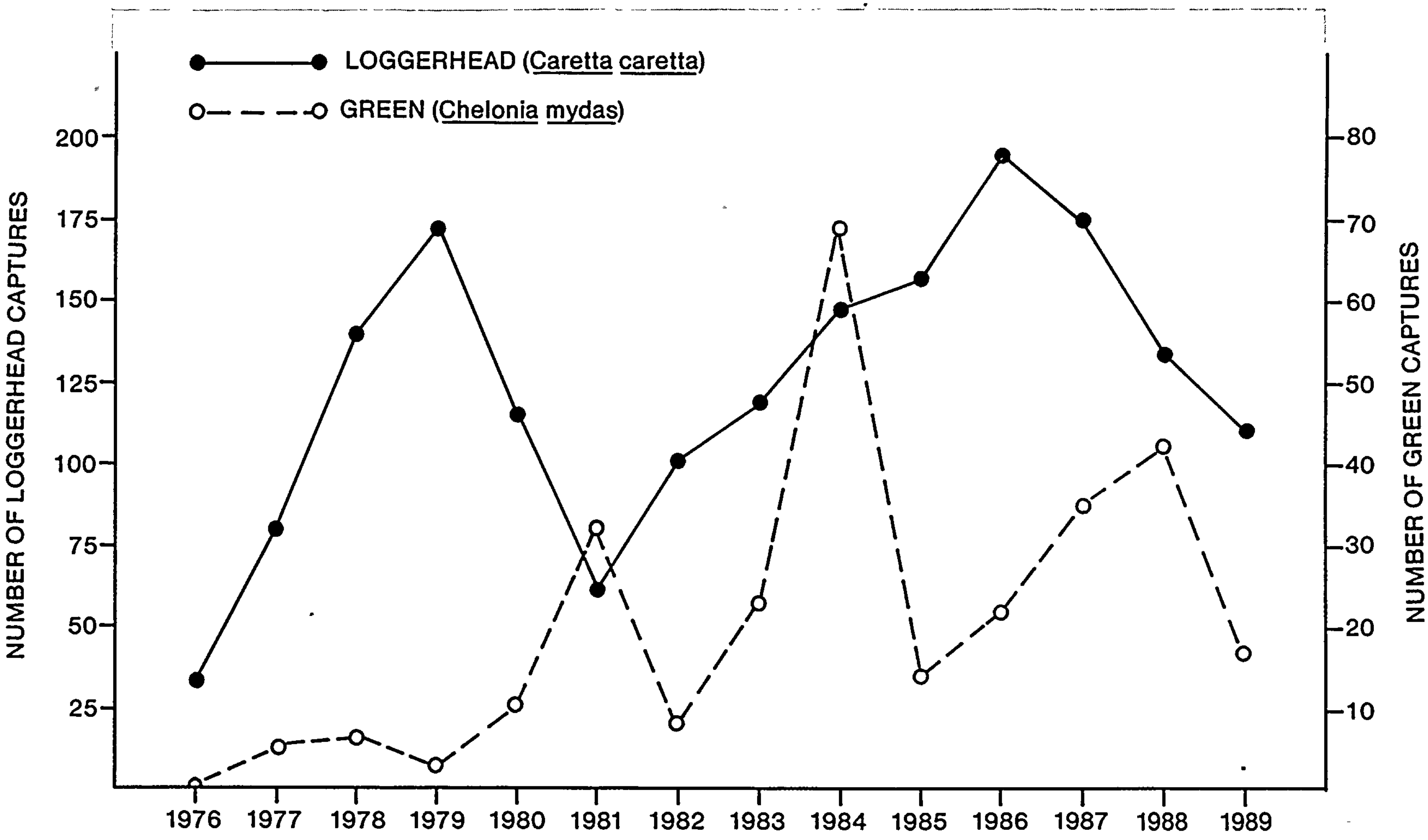

Figure 13. Number of loggerhead and green turtles removed each year from the intake canal, St. Lucie Plant, 1976-1989.

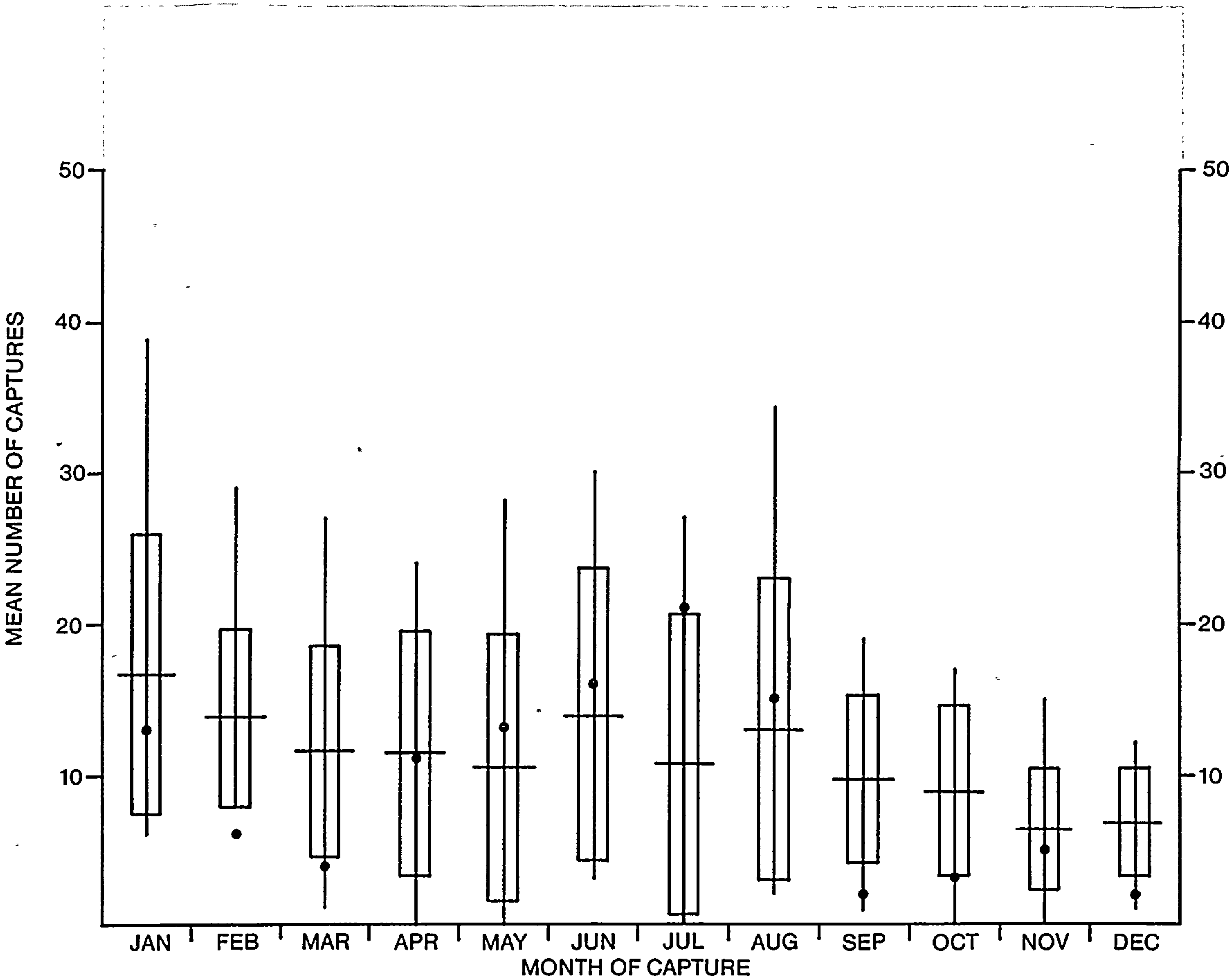

Figure 14. Mean number of loggerheads captured each month, St. Lucie Plant intake canal, 1977-1988, compared with number of monthly captures during 1989. Horizontal lines are means, boxes enclose plus or minus one standard deviation, vertical lines are ranges, and closed circles are 1989 values.

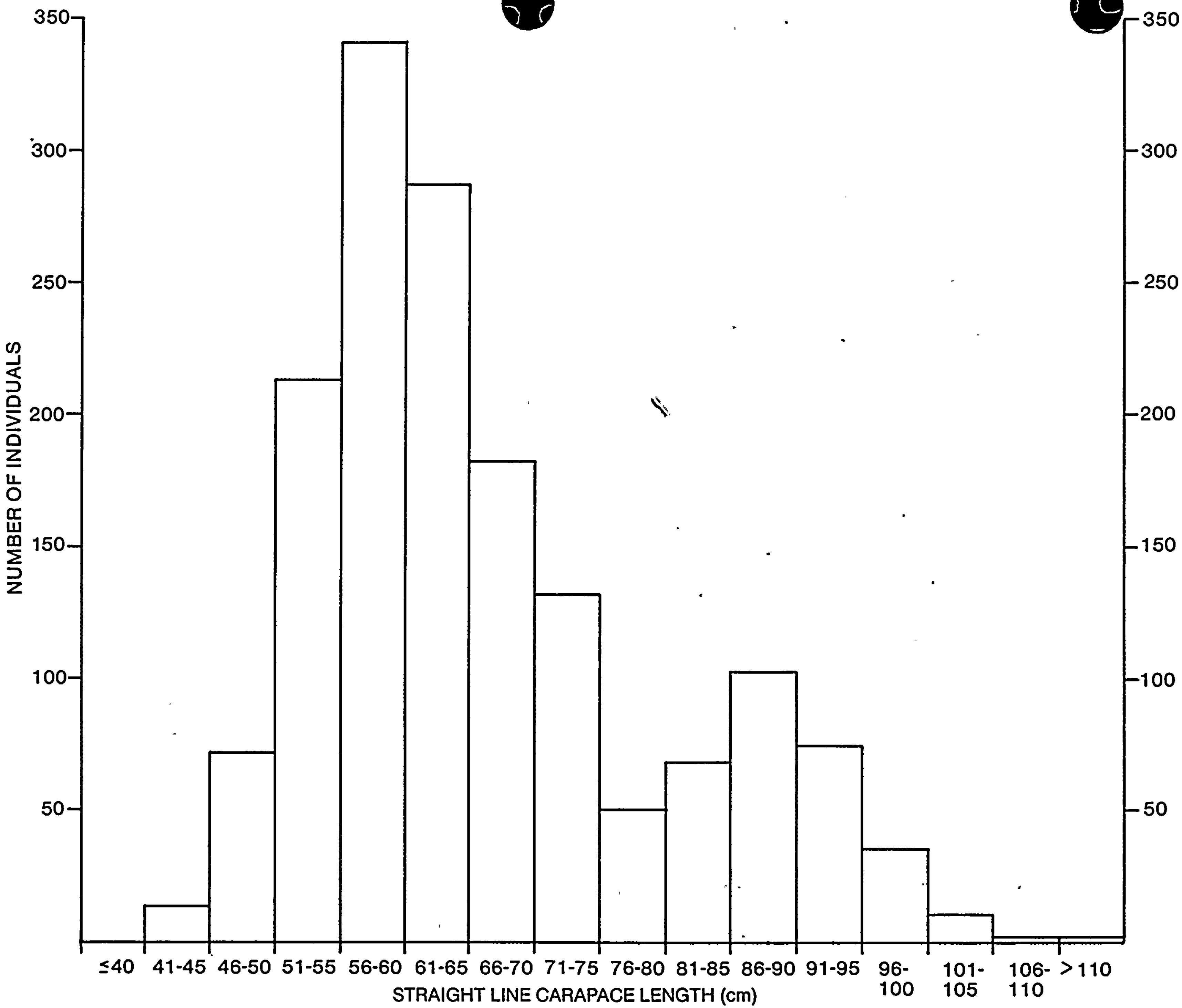

Figure 15. Length distribution (SLCL) of loggerhead sea turtles (N=1,580) removed for the first time from the intake canal, St. Lucie Plant, 1976-1989. No data collected for 72 individuals.

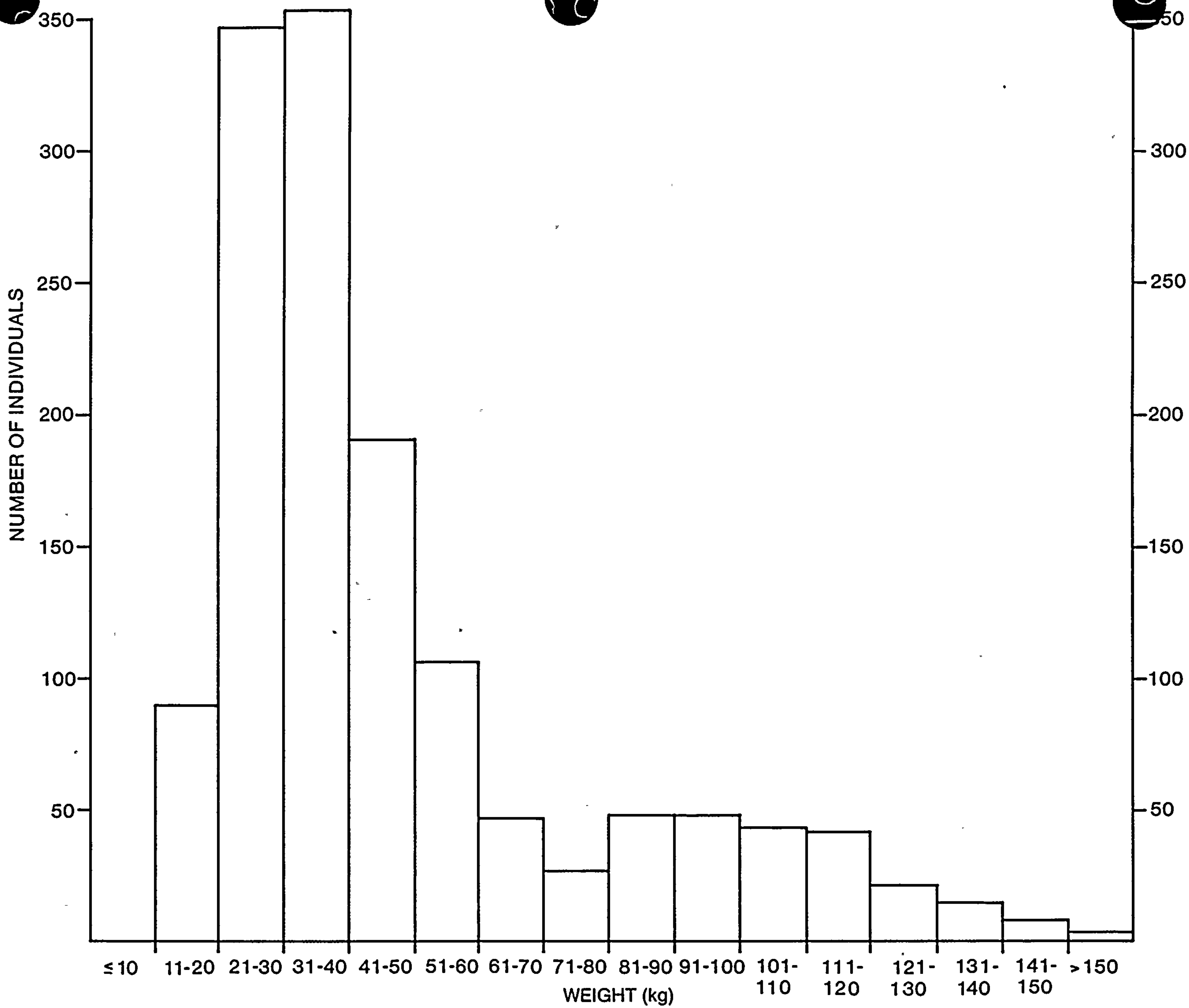

Figure 16. Weight distribution of live loggerhead sea turtles (N=1,387) removed for the first time from the intake canal, St. Lucie Plant, 1976-1989. No data available for 265 individuals.

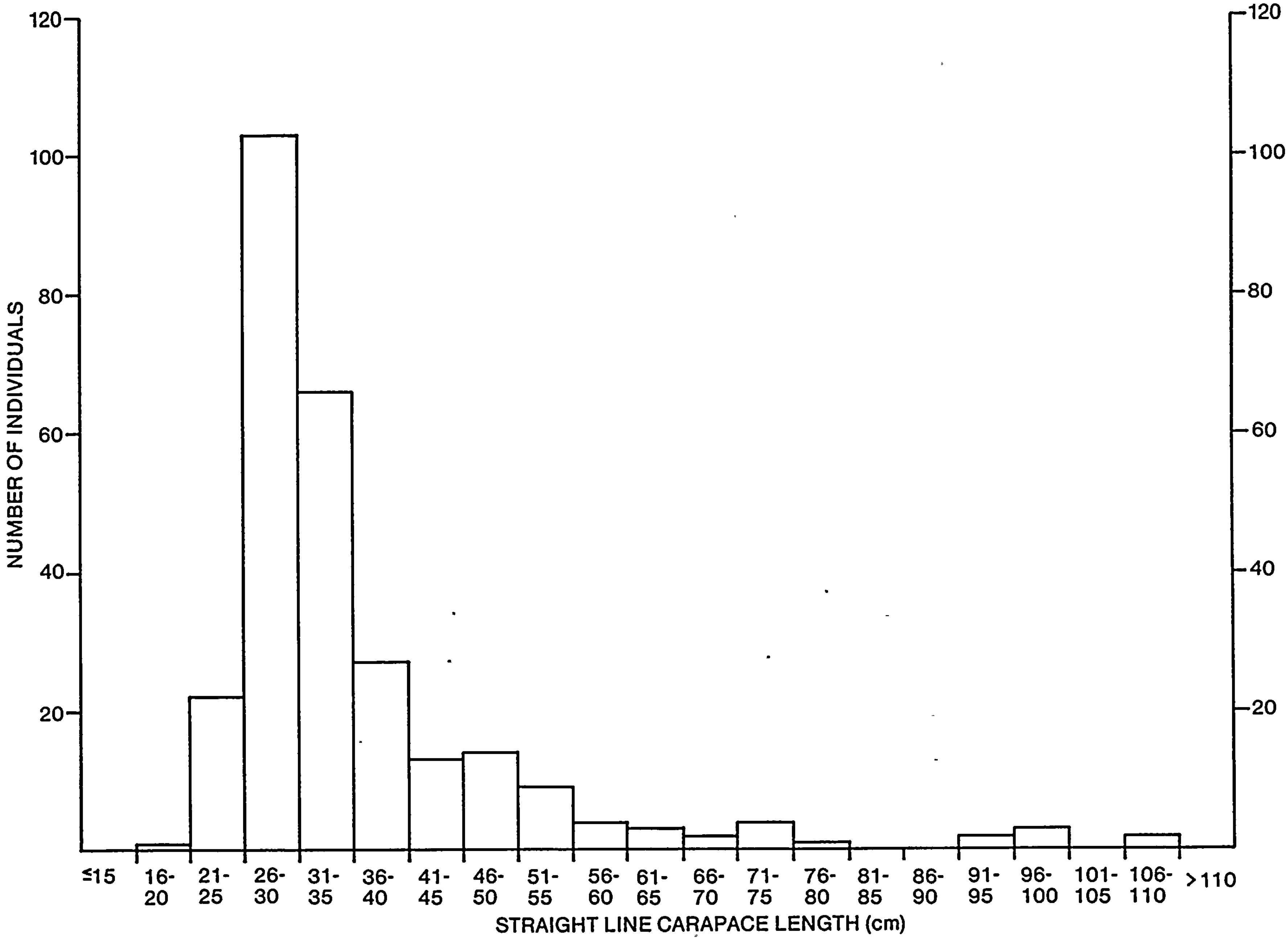

Figure 17. Length distribution (SLCL) of green turtles (N=276) removed for the first time from the intake canal, St. Lucie Plant, 1976-1989. No data collected for 9 individuals.

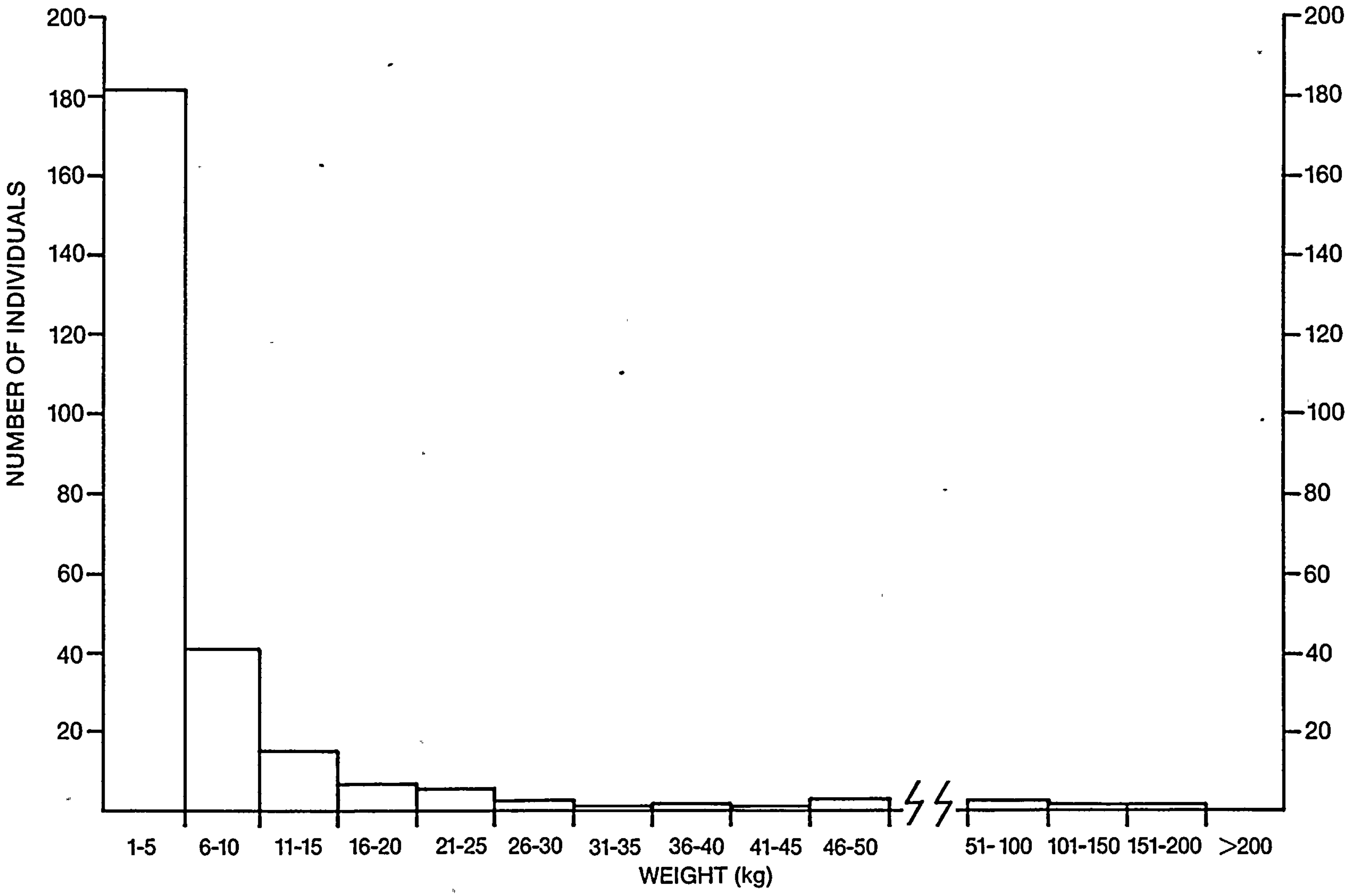

Figure 18. Weight distribution of green turtles (N=271) removed for the first time from the intake canal, St. Lucie Plant, 1976-1989. No data collected for 14 individuals.

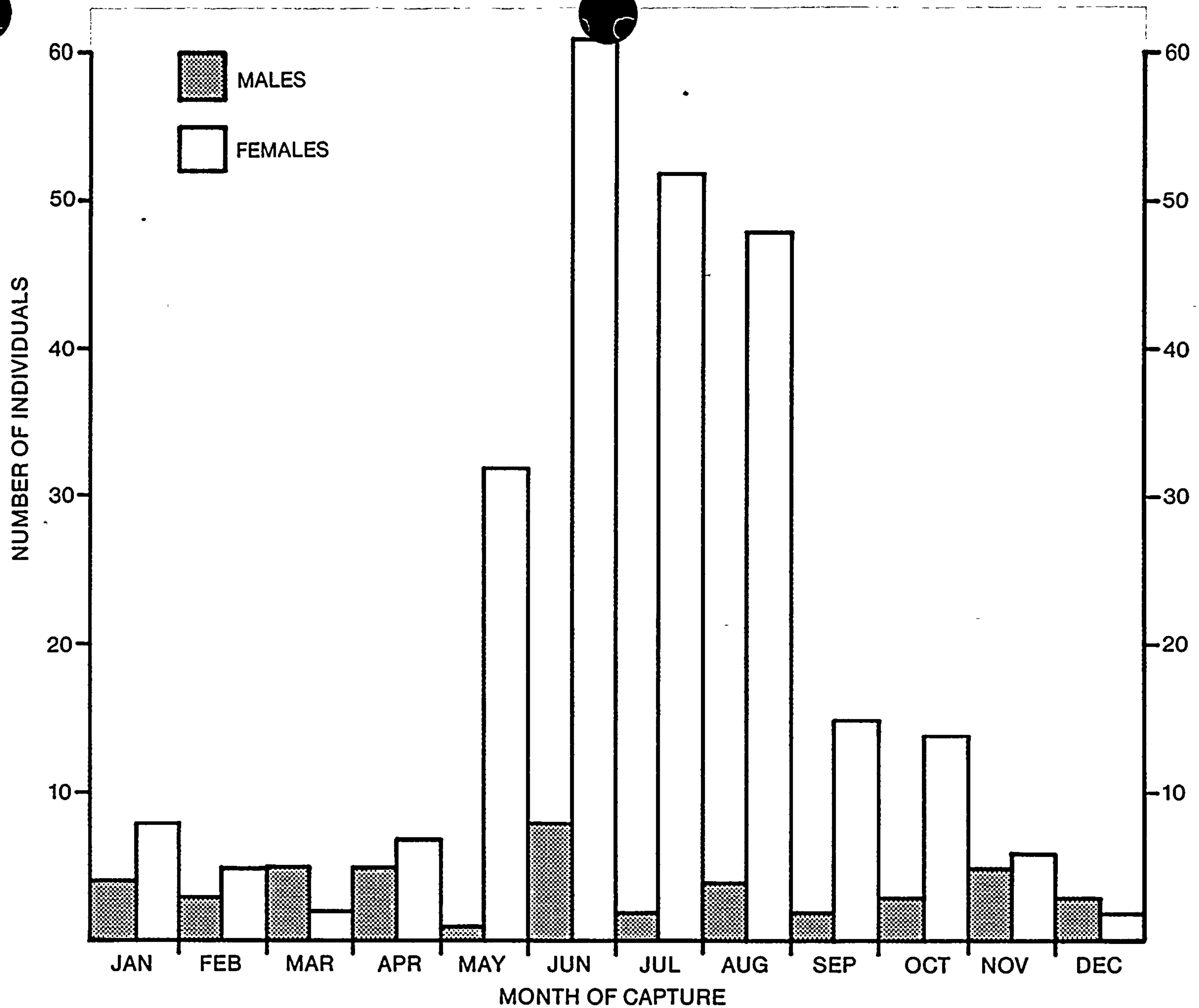

Figure 19. Numbers of adult loggerheads (SLCL $\geq$ 80.0 cm), including recaptures, removed each month from the intake canal, St. Lucie Plant, 1976-1989. (N=297)

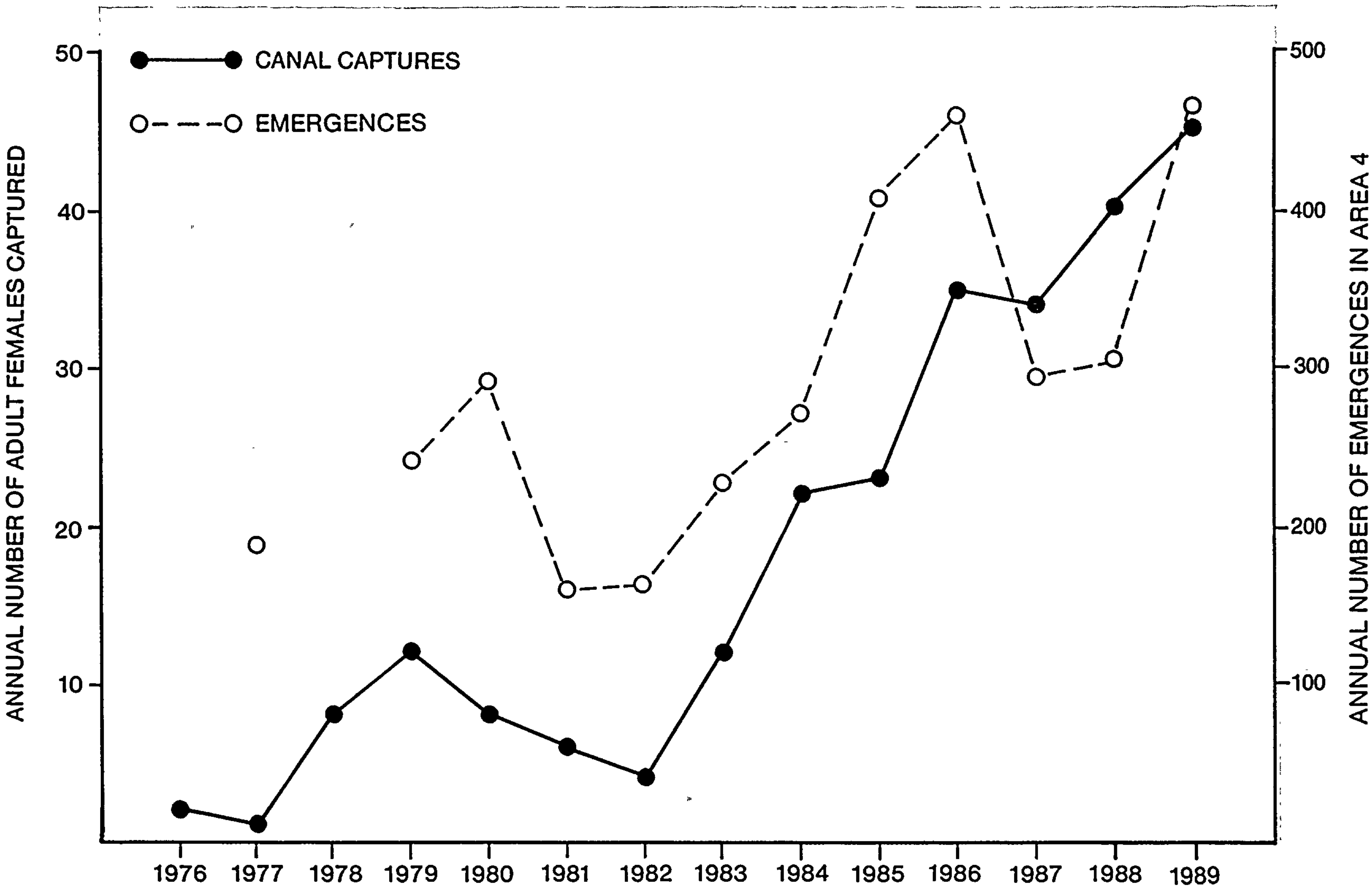

Figure 20. Comparison of captures of adult female loggerheads in the intake canal, St. Lucie Plant, 1976-1989, and numbers of loggerhead emergences in area 4 adjacent to the plant. Nesting activity was not monitored in 1976 and 1978.

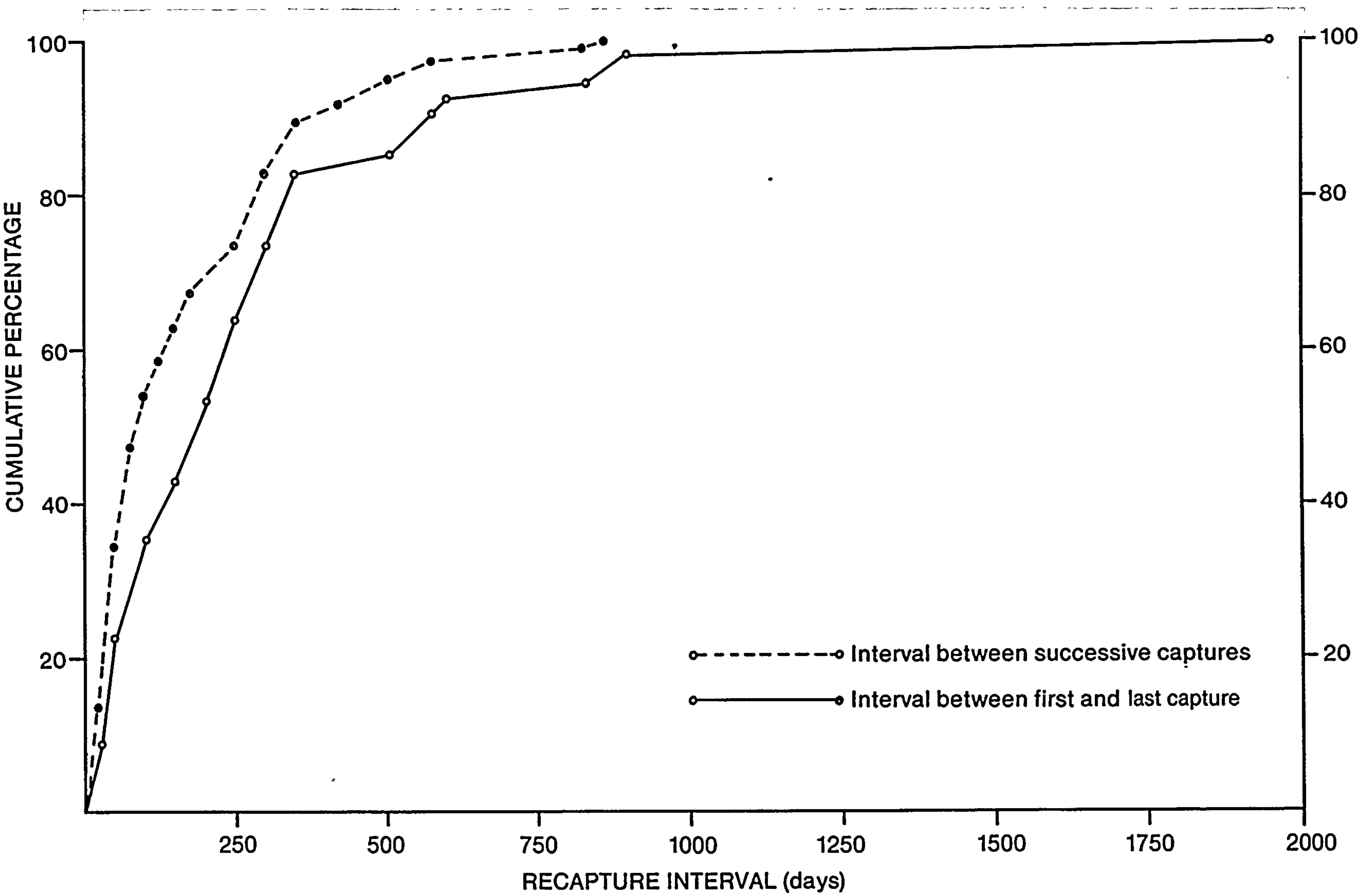

Figure 21. Cumulative percentage of all loggerhead recaptures occurring within various time intervals between successive captures (N=87) and first and last capture (N=53), St. Lucie Plant intake canal 1976-1989.

TABLE 1

ESTIMATES OF THE NUMBERS OF LOGGERHEAD TURTLE NESTS ON HUTCHINSON ISLAND BASED ON SURVEYS OF NINE 1.25-KM-LONG SURVEY AREAS, 1971-1989, COMPARED TO THE ACTUAL NUMBER OF NESTS ON THE ISLAND, 1981-1989

	Year													
	1971	1973	1975	1977	1979	1981	1982	1983	1984	1985	1986	1987	1988	1989
Number of nests in the nine 1.25-km-long survey areas	1420	1260	1493	932	1449	1031	1634	1592	1439	1623	1839	1645	1701	1774
Extrapolation from the nine survey areas to the entire island (see text)	4175	3704	4389	2740	4260	3031	4804	4680	4231	4772	5407	4836	5001	5216
Actual number of nests on the entire island	-	-	-	-	-	3115	4690	4743	4277	4877	5483	4623	4990	5193

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TOTAL NUMBER OF SEA TURTLE CAPTURES AND (NUMBER OF DEAD)
TURTLES REMOVED FROM THE INTAKE CANAL
ST. LUCIE PLANT
1976 - 1989

	Species					
Year	loggerhead	green	leatherback	hawksbill	Kemp's ridley	Total
1976	33(4)					33(4)
1977	80(5)	5(2)	1			86(7)
1978	138(19)	6(1)	3	1		148(20)
1979	172(13)	3(1)				175(14)
1980	116(5)	10(3)				126(8)
1981	62(5)	32(2)	2		1	97(7)
1982	101(16)	8	1			110(16)
1983	119(4)	23(4)				142(8)
1984	148(3)	69(2)		1	2	220(5)
1985	157(4)	14		1		172(4)
1986	195(27)	22(1)	1	1	1	220(28)
1987	175(11)	35		2	6(2)	218(13)
1988	134(6)	42(2)			5(2)	181(10)
1989	111(4)	17(1)	1	2	2	133(5)
Total	1741(126)	286(19)	9(0)	8(0)	17(4)	2061(149)
Annual Mean[a]	131.4	22.0	0.7	0.6	1.3	156.0

[a]Excludes 1976 (partial year of plant operation).

TABLE 3

TOTAL NUMBER AND (NUMBER OF DEAD) LOGGERHEAD TURTLES
REMOVED EACH MONTH FROM THE INTAKE CANAL
ST. LUCIE PLANT
1976 - 1989

Month	1976	1977	1978	1979	1980	1981	1982	1983
January	-	13	19	24(3)	16	11(1)	6(2)	39
February	-	8(1)	11(2)	29(1)	21(2)	11(3)	11	13(1)
March	-	7	27(2)	11	14	6	14	1
April	-	5(2)	19(5)	17	0	10	14	0
May	2	1	3(1)	0	7	6	17(4)	4
June	0	5	10	3(1)	8(3)	6	7	7(1)
July	7(1)	4	0	27(2)	0	1	7	7
August	2	3	12	16(2)	12	6	2(1)	6
September	1	15(1)	1	8(1)	19	2(1)	9(1)	8(2)
October	7	9(1)	17(2)	15(3)	7	0	9(5)	17
November	5(3)	5	15(7)	12	4	0	4(2)	5
December	9	5	4	10	8	3	1(1)	12
Total	33(4)	80(5)	138(19)	172(13)	116(5)	62(5)	101(16)	119(4)

TABLE 3
(continued)
TOTAL NUMBER AND (NUMBER OF DEAD) LOGGERHEAD TURTLES
REMOVED EACH MONTH FROM THE INTAKE CANAL
ST. LUCIE PLANT
1976 - 1989

Month	1984	1985	1986	1987	1988	1989	Total	Monthly Mean	Percent of Total Catch[a]
January	13	11	15(2)	26(3)	7	13	213(11)	16.4	12.5
February	11	15	16(4)	11	10(3)	6	173(17)	13.3	10.1
March	6	20	14(4)	8(1)	11	4(2)	143(9)	11.0	8.4
April	2(1)	13	20(2)	24(3)	13(2)	11	148(15)	11.4	8.7
May	7	16	12	23(1)	28	13	139(6)	9.9	8.0
June	28(1)	17	20(1)	26(1)	30	16	183(8)	13.1	10.7
July	12(1)	20(3)	26(2)	19(1)	5	21(1)	156(11)	11.1	8.7
August	26	19(1)	34(6)	17(1)	3	15	173(11)	12.4	10.0
September	16	14	9(4)	4	11(1)	2	119(11)	8.5	6.9
October	10	7	11(2)	3	2	3	117(13)	8.4	6.4
November	9	3	8	5	5	5(1)	85(13)	6.1	4.7
December	8	2	10	9	9	2	92(1)	6.6	4.9
Total	148(3)	157(4)	195(27)	175(11)	134(6)	111(4)	1741(126)	-	-

[a]Excludes 1976 (partial year of plant operation).

TABLE 4

TOTAL NUMBER AND (NUMBER OF DEAD) GREEN TURTLES
REMOVED EACH MONTH FROM THE INTAKE CANAL
ST. LUCIE PLANT
1976 - 1989

Month	1976	1977	1978	1979	1980	1981	1982	1983
January	-	2	1	0	0	20(1)	1	8(1)
February	-	2(1)	2	1	5(1)	7	0	4
March	-	0	2	0	4(1)	1	0	3(2)
April	-	1(1)	0	1(1)	0	1	1	0
May	0	0	1(1)	0	0	0	0	0
June	0	0	0	1	1(1)	0	0	1
July	0	0	0	0	0	0	0	1
August	0	0	0	0	0	2(1)	2	0
September	0	0	0	0	0	0	0	1
October	0	0	0	0	0	0	0	1
November	0	0	0	0	0	0	3	4(1)
December	0	0	0	0	0	1	1	0
Total	0	5(2)	6(1)	3(1)	10(3)	32(2)	8	23(4)

TABLE 4
(continued)
TOTAL NUMBER AND (NUMBER OF DEAD) GREEN TURTLES
REMOVED EACH MONTH FROM THE INTAKE CANAL
ST. LUCIE PLANT
1976 - 1989

Month	1984	1985	1986	1987	1988	1989	Total	Monthly Mean	Percent of Total Catch
January	37(1)	4	1	4	12	3(1)	93(4)	7.2	32.5
February	10	1	1	1	11	0	45(2)	3.5	15.7
March	0	1	6(1)	3	4	6	30(4)	2.3	10.5
April	1	2	3	3	2	3	18(2)	1.4	6.3
May	0	0	1	2	3	1	8(1)	0.6	2.8
June	3	0	1	3	6(2)	1	17(3)	1.2	5.9
July	2	2	1	1	1	0	8	0.6	2.8
August	2	1	1	1	0	0	9(1)	0.6	3.1
September	1	0	2	1	0	0	5	0.4	1.7
October	6	1	2	0	1	1	12	0.9	4.2
November	4(1)	1	1	5	0	0	18(2)	1.3	6.3
December	3	1	2	11	2	2	23	1.6	8.0
Total	69(2)	14	22(1)	35	42(2)	17(1)	286(19)	-	-

TABLE 5

NUMBER OF MONTHLY CAPTURES BY SIZE CLASS FOR LOGGERHEAD TURTLES REMOVED FROM THE INTAKE CANAL
ST. LUCIE PLANT
1977 - 1989[a]

	Size classes (SLCL in cm)[b]											
	Juveniles/Sub-Adults					Transition		Adults				
Month	41-50	51-60	61-70	Total	Percentage	71-80	Percentage	81-90	91-100	>100	Total	Percentage
January	16	83	73	172	14.8	23	12.2	10	2	0	12	4.1
February	11	72	54	137	11.8	17	9.0	6	1	0	7	2.4
March	8	57	48	113	9.7	16	8.5	2	6	0	8	2.7
April	12	44	49	105	9.0	19	10.1	8	4	0	12	4.1
May	10	48	32	90	7.7	11	5.8	16	17	0	33	11.3
June	9	46	43	98	8.4	13	6.9	41	20	3	64	21.9
July	4	43	34	81	7.0	12	6.4	27	25	3	55	18.8
August	6	42	48	96	8.3	20	10.6	33	17	1	51	17.4
September	3	45	37	85	7.3	12	6.4	7	9	2	18	6.1
October	7	35	30	72	6.2	18	9.6	14	1	1	16	5.5
November	4	20	24	48	4.1	18	9.6	5	4	1	10	3.4
December	5	33	26	64	5.5	9	4.8	3	4	0	7	2.4
Total	95	568	498	1161		188		172	110	11	293	
% of Total					70.7		11.4					17.8

[a]Excludes 1976 (partial year of data)

[b]No data were collected for 66 individuals.

TABLE 6

RELATIVE CONDITION OF SEA TURTLES REMOVED
FROM THE INTAKE CANAL
ST. LUCIE PLANT
1976 - 1989

Relative condition	Loggerheads		Greens		Leatherbacks		Kemp's ridleys		Hawksbills		All species	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
1	344	19.8	99	34.6	1	11.1	2	11.8	6	75.0	452	21.9
2	436	25.0	49	17.1	1	11.1	3	17.6	2	25.0	491	23.8
3	479	27.5	78	27.3	6	66.7	3	17.6			566	27.5
4	265	15.2	29	10.1	1	11.1	3	17.6			298	14.5
5	81	4.7	7	2.4			2	11.8			90	4.4
6	126	7.2	19	6.6			4	23.5			149	7.2
7	10	0.6	5	1.7							15	0.7
TOTAL	1741		286		9		17		8		2061	

1 Excellent - normal or above normal weight, active, very few or no barnacles or leeches, no wounds.

2 Very good - intermediate good to excellent.

3 Good - normal weight, active, light to medium coverage of barnacles and/or leeches, wounds absent, healed or do not appear to debilitate the animal.

4 Fair - intermediate poor to good.

5 Poor - emaciated, slow or inactive, heavy barnacle coverage and/or leech infestation, debilitating wounds or missing appendages.

6 Dead

7 Alive but otherwise condition not recorded.

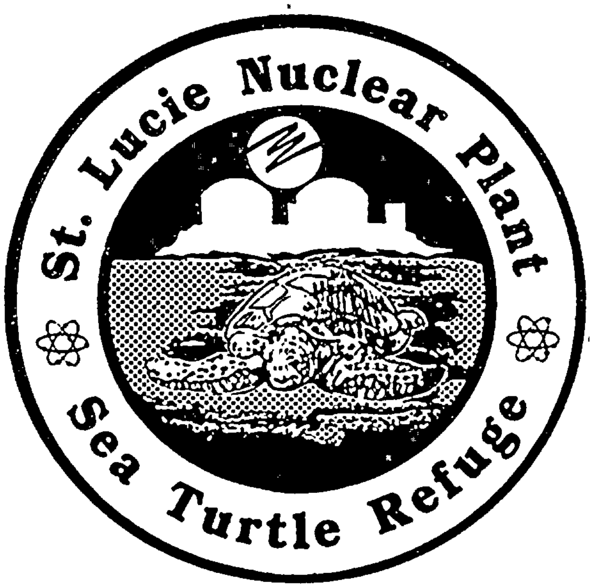
FLORIDA POWER & LIGHT COMPANY

ST. LUCIE UNIT NO. 2

ANNUAL ENVIRONMENTAL OPERATING REPORT (FPL-89)

APRIL 1990

VOLUME II



ANNUAL ENVIRONMENTAL OPERATING REPORT

I. Introduction

The St. Lucie Unit 2 Environmental Protection Plan (EPP) requires the submittal of an annual report for various activities at the plant site including the reporting on sea turtle monitoring programs, and other matters related to Federal and State environmental permits and certifications. This report and Volume II described below fulfill these reporting requirements.

II. Sea Turtle Monitoring and Associated Activities

A report on aquatic and terrestrial sea turtle monitoring programs to satisfy Sections 4.2.1 (Beach Nesting Surveys), 4.2.3 (Studies to Evaluate and/or Mitigate Intake Canal Mortality) and 4.2.5 (Capture and Release Program) is concurrently submitted in a separate report (AB-603, Vol. II) prepared by Applied Biology, Inc. of Jensen Beach, Florida and Atlanta, Georgia.

Studies to evaluate and/or mitigate intake entrapment required by Section 4.2.2 of the EPP have been previously performed. A final report was submitted to the Office of Nuclear Reactor Regulation on April 18, 1985. With submittal of that report, the EPP requirement was fulfilled and will not be readdressed in this or future reports.

Surveillance and maintenance of the light screen to minimize sea turtle disorientation as required by Section 4.2.4 of the EPP is ongoing. The Australian Pine light screen, located on the beach dune between the power plant and the ocean, is routinely surveyed to

determine its overall vitality. The tree line is surveyed for any gaps occurring from tree mortality, which would result in unacceptable light levels on the beach. Trees are replaced as necessary to maintain the overall integrity of the light screen.

III. Other Routine Reports

The following items for which reporting is required are listed by section number from the plant's Environmental Protection Plan (EPP):

5.4.1.(a) EPP NONCOMPLIANCES AND CORRECTIVE ACTIONS TAKEN

No noncompliances under EPP Section 5.4.1(a) were determined to have occurred during 1989.

5.4.1.(b) STATION DESIGN AND OPERATION CHANGES, TESTS, AND EXPERIMENTS AFFECTING THE ENVIRONMENT

No plant site activities were determined to be reportable under Section 5.4.1(b) during 1989.

5.4.1.(c) NONROUTINE REPORTS SUBMITTED TO THE NRC FOR THE YEAR 1989 IN ACCORDANCE WITH EPP SUBSECTION 5.4.2:

1. Submittal of an NPDES Permit modification request to EPA; sumitted to the NRC on April 13, 1989.

2. Report concerning an exceedance of the NPDES Permit limitation for pH from the Unit 1 Sewage Treatment Plant effluent; reported to the NRC on May 11, 1989.

3. Report concerning an exceedance of the NPDES Permit limitation for free available oxidants in the once through cooling water discharge; reported to the NRC on June 7, 1989.

4. Report concerning an exceedance of the NPDES Permit limitation for iron from the radwaste system effluent; reported to the NRC on July 17, 1989.

5. Report concerning an exceedance of the NPDES Permit limitation for maximum once through cooling water discharge temperature (discharge canal terminus); reported to the NRC on October 16, 1989.

The following reports were submitted to the NRC for the year 1989 for informational purposes although not required under provisions of EPP subsection 5.4.2:

1. Sea turtle activities report dated April 24, 1989 for the first quarter 1989.

2. Sea turtle activities report dated August 2, 1989 for the second quarter 1989.

3. Sea turtle activities report dated November 2, 1989 for the third quarter 1989.

4. Sea turtle activities report dated January 23, 1990 for the fourth quarter 1989.