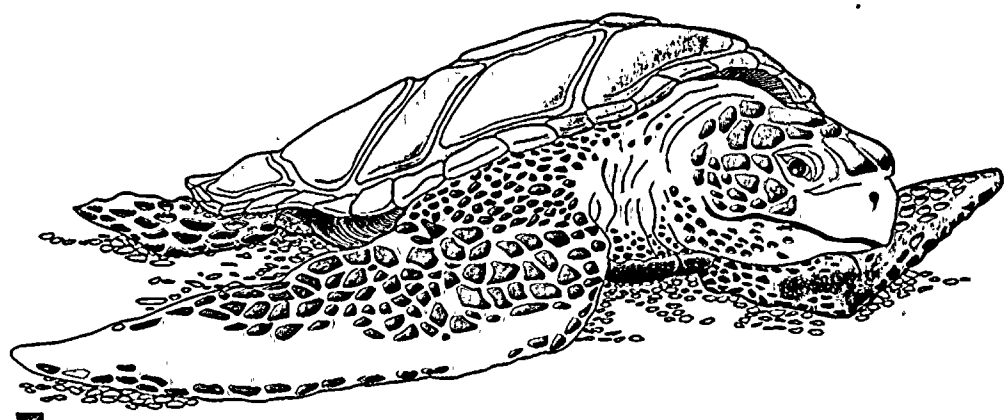
Florida Power & Light Company St. Lucie Plant Unit 2



FPL

St. Lucie Nuclear Plant
Sea Turtle Refuge

Annual Environmental Operating Report 1994 - Volume I

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FLORIDA POWER & LIGHT COMPANY

ST. LUCIE UNIT 2

ANNUAL ENVIRONMENTAL

OPERATING REPORT

1994

VOLUME 1

FLORIDA POWER AND LIGHT COMPANY
JUNO BEACH, FLORIDA

QUANTUM RESOURCES, INC.
PALM BEACH GARDENS, FLORIDA

ENVIRONMENTAL OPERATING REPORT

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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 839-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 2 Annual Environmental Operating Report".

TURTLE NESTING SURVEY

Since monitoring began in 1971, there have been considerable year-to-year fluctuations in sea turtle nesting activity on Hutchinson Island. However, data collected through 1994 have shown no long-term reductions in nesting on the island. Relatively high nesting during recent years may actually reflect an increase in the number of nesting females in the study area. On a smaller scale, power plant operation has had no significant effect on nesting near the plant. Low nesting activity in 1975 and again in 1981 - 1983 in the vicinity of the plant was attributed to nighttime construction activities associated with installation of plant intake and discharge structures. Nesting returned to normal or above normal levels following both periods of construction . During 1991, daytime construction activities associated with velocity cap repairs had no apparent effect on nesting. Formal requirements to conduct nesting surveys expired in 1986 but this program was voluntarily continued through 1994 with agreement from federal and state agencies.

INTAKE CANAL MONITORING

Since plant operation began in 1976, 3199 sea turtles (including recaptures) representing five different species have been removed from the intake canal. Of these 74.8 percent were loggerheads. Differences in the numbers of turtles found during different months and years have been attributed primarily to natural variation in the occurrences of turtles in the vicinity of the plant, rather than to operational influences of the plant itself. The majority of turtles removed from the intake canal (about 94 percent) were captured alive and released back into the ocean. Ongoing evaluations and improvements to the canal capture program have substantially reduced mortalities of entrapped sea turtles during recent years. Turtles confined between the A1A barrier net and intake headwalls typically reside in the canal for a relatively short period prior to capture, and most are in good to excellent condition when caught.

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.

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. 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 with sea turtle studies are contained in eleven annual environmental operating reports covering the period from 1983 through 1993 (ABI 1994). This report describes the 1994 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 the east side by the Atlantic Ocean and on the 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.

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 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 839-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. 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.

TURTLES

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. All three species are protected by state and federal statutes. The federal government has 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. 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 nighttime 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 1994, 36 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.

During 1991, another major offshore construction project was undertaken to replace damaged velocity caps on the three intake structures. A large elevated platform, from which repair activities were conducted, was erected around the three structures. Construction occurred throughout the nesting season. However, in contrast to previous offshore projects, work was restricted almost entirely to daylight hours, nighttime lighting of the work area was minimal, and no equipment or materials were used on the beach. A sea turtle protection plan implemented in support of the project included caging of nests along a 1,500 m section of beach west of the platform and release of hatchlings to unaffected areas to the north and south. This plan was intended to mitigate any negative effects potentially resulting from required safety and navigational lighting on and near the platform.

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 1994 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 (See ABI, 1994). Results of studies to assess the effects of thermal discharges on hatchling swimming speed have also been reported (ABI, 1978). In July of 1994, responsibility for sea turtle research and conservation activities was transferred from Applied Biology, Inc. to Quantum Resources, Inc. Methodologies employed in both the nesting surveys and canal capture operations remained essentially unchanged so that data collected in 1994 and future years are directly comparable to previous years data. The purpose of this report is to 1) present 1994 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 1994 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 in earlier reports (ABI 1994). Methods used during the 1994 survey were designed to allow comparisons with these previous studies.

The only significant change in nesting survey methods for 1994 was that, beginning July 1, only areas A - S were surveyed by Quantum Resources biologists (Figure 3). Data reported herein includes the full nesting season data for areas A - S and data for areas T - JJ through June 30. Data supplied by Ecological Associates, Inc. are used to provide whole island nesting totals in Figures 8, 11, and 12.

On 11 April 1994, a preliminary nest survey was conducted along Hutchinson Island from the Ft. Pierce Inlet south to the St. Lucie Inlet. Four leatherback turtle nests were found on Hutchinson Island prior to the beginning of formal nesting surveys. From 15 April through 15 September, nest surveys were conducted on a daily basis. The last nest recorded in area A - S was on 7 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 1-km-long survey areas (Figure 3). The 1.25-km-long survey areas established in earlier studies also were monitored so comparisons could be made with previous studies.

Data collected from beach nesting surveys were reported to the Florida Department of Environmental Protection (DEP) as part of the DEP Index Beach Nesting Survey. In a cooperative effort, data from stranded turtles found during beach surveys

were routinely provided to the Florida Department of Environmental Protection and the National Marine Fisheries Service (NMFS) 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 1994 were from 30 to 40 m in length, 3 to 4 m deep and composed of 40 cm stretch mesh multifilament nylon. 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. Since its inception in 1976, the canal capture program has been under continual review and refinement in an attempt to minimize both entrapment times and injuries/mortalities to entrapped sea turtles. Prior to April 1990, turtle nets were usually deployed on Monday mornings and retrieved on Friday afternoons. During periods of deployment, the nets were inspected for captures at least twice each day (mornings and afternoons). Additionally, St. Lucie Plant personnel checked the nets periodically, and biologists were notified immediately if a capture was observed. Sea turtle specialists were on call 24 hours a day to retrieve captured turtles from the plant.

Beginning April 1990, after consultation with NMFS, net deployment was scaled back to daylight hours only. Concurrently, surveillance of the intake canal was increased and biologists remained on site for the duration of each day's netting activities. This measure decreased response time for removal of entangled turtles from nets and provided an opportunity to improve daily assessments of turtle levels within

the canal. Records of daily canal observations were compared with capture data to assess capture efficiencies.

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 20.3 cm x 20.3 cm. A cable and series of large floats are 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 underwater by strong currents.

In the past, the integrity of the barrier net was occasionally compromised, and turtles were able to move west of A1A. These turtles were further constrained downstream by an underwater intrusion detection system (UIDS) consisting, in part, of a large barrier positioned perpendicular to the north-south arm of the canal (Figure 2). The UIDS security barrier also consists of 20.3 cm x 20.3 cm mesh. Prior to completion of the UIDS 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 UIDS barrier, all but the smallest individuals were unable to reach the intake wells. Thus, as required, tangle nets were also deployed west of A1A. Improvements made to the A1A barrier net during 1990 have effectively confined all turtles larger than 32.5 cm carapace length (28.7 cm carapace width) to the eastern end of the canal.

Formal daily inspections of the intake canal were made to determine the numbers, locations and species of turtles present. Surface observations were augmented with periodic underwater inspections using SCUBA, particularly in and around the A1A barrier net.

In addition to the use of tangle nets, dip nets and hand captures by snorkel and SCUBA divers are also employed to capture turtles. Long handled dip nets, employed from small boats and from the canal banks and headwall structures, are moderately effective in capturing turtles with carapace lengths of about 30 cm or less. Divers are employed to hand capture turtles whenever underwater visibility permits, and this technique has proven highly effective in the capture of turtles of all sizes, particularly less active individuals often found partially buried in the sediment in the vicinity of the A1A barrier net. Hand capture efforts have had a significant impact in reducing entrapment times for turtles in the intake canal.

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.). Beginning in July 1994, all turtles captured have been photographed prior to release, and the photographs retained for future reference. Healthy turtles were released 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 permitted veterinarians. 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; three such necropsies were performed during 1994.

Florida Power & Light Company, Applied Biology, Inc., and Quantum Resources, Inc., continued to assist other sea turtle researchers in 1994. Since the program began, data, specimens and/or assistance have been given to the Florida Department of Environmental Protection, 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), Florida Atlantic University, University of Central Florida, Texas A & M University, University of Rhode Island, University of South Carolina, University of Illinois, University of Georgia, Virginia Institute of Marine Science, Western Atlantic Turtle Symposium, South Atlantic Fishery Management Council, Florida Marine Fisheries Commission, Harbor Branch Oceanographic Institution and the National Research Council.

RESULTS AND DISCUSSION

Nesting Survey

1994 Loggerhead Nesting Summary

In 1994, 6607 Loggerhead turtle nests were recorded in the 36 1-km segments comprising Hutchinson Island (Figures 4 and 5). This total is in accordance with a general increase in loggerhead turtle nesting on Hutchinson Island since surveys began in 1971, although significant year to year fluctuations are evident.

Spatial Distribution of Loggerhead Turtle Nests

From 1981 through 1994, 36 1-km long segments comprising the island's coastline have been surveyed. The distribution of nests among these 36 survey areas has shown an increase in nesting from north to south along the northern half of the island (ABI, 1987, 1994). Along the southern half of the island there has either been no gradient or a gradient of decreasing nesting from north to south. Though beach dynamics may sometimes affect the selection of nesting sites by loggerhead turtles, 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. 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 (Figures 6 and 7).

Historically, the pattern of loggerhead emergences on the island has generally paralleled the distribution of nests (ABI, 1987, 1994). In contrast, nesting success by loggerheads along the island has typically lacked gradients (ABI, 1987, 1994). Thus, the relatively high numbers of loggerhead nests observed in certain areas are usually a result of more turtles coming ashore in those areas rather than of more preferable nesting conditions being encountered by the turtles after they emerged. A variety of environmental factors (i.e., offshore bottom contours, distribution of reefs, type and extent of dune vegetation, and human activity on the beach at night) may affect loggerhead turtle emergence patterns and several have been reported to affect emergence patterns on Hutchinson Island (ABI, 1988, 1989). Undoubtedly, a combination of factors account for the overall distribution of emergences and therefore the overall nesting pattern on the island.

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 (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. During 1991 when offshore construction was restricted almost entirely to daylight hours, nests were more abundant at the plant site than at the control site. Data collected through 1994 have shown that power plant operation exclusive of nighttime intake/discharge construction has had no apparent effect on nesting.

Long-Term Trends in Loggerhead Turtle Nesting

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 (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 1993 the total number of nests in the nine areas varied from 32.5 to 35.6 percent of the total number of nests on the island . 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 thirteen-year mean of 33.81 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 2.958. This technique, when applied to the nine survey areas during the thirteen years in which the entire island was surveyed, produced whole-island estimates within 5.3 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 thirteen 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 (Figure 8). Annual variations in nest densities also are common at other rookeries, and may result from non-annual reproductive behavior. Nonetheless, data collected through 1994 suggest an overall increase in nesting on Hutchinson Island since surveys began in 1971. Total nesting activity was greatest during 1991 when 6,812 loggerhead nests were recorded. 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.

Seasonal Patterns of Loggerhead Turtle Nesting

The loggerhead turtle nesting season usually begins between mid-April and early May, attains a maximum during June or July, and ends by mid-September (ABI, 1987). Nesting activity during 1994 followed this same pattern.

Cool water intrusions frequently occur over the continental shelf of southeast Florida during the summer (Smith, 1982). These intrusions may have been responsible for the temporary declines in loggerhead turtle nesting activity previously observed on Hutchinson Island (ABI 1994). 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 has been a 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 (Hopkins et al., 1979). 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 may be attributable to trapping programs, construction activities, habitat loss or disease.

During 1994, 9.4 percent (286) of the loggerhead nests (n= 3035) in areas A - S were depredated by raccoons. As in previous years (ABI, 1994), predation of turtle nests was primarily restricted to the most undeveloped portion of the island (Figures 9 and 10).

Ghost crabs have been reported by numerous researchers as important predators of sea turtle nests (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 0.1 to 2.1 percent from 1983 - 1993 (ABI, 1994). During 1994, 0.5 percent (14) of the loggerhead nests (n=3035) in areas A - S were depredated by ghost crabs (Figure 9). 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 1994, 4.7 percent (143 nests) were destroyed by either ghost crabs or a combination of ghost crabs and raccoons.

1994 Green and Leatherback Nesting Summary

In 1994, 195 green turtle and 52 leatherback turtle nests were recorded in the 36 1-km-segments comprising Hutchinson Island. Both these figures represent an all-time high since nesting surveys were initiated in 1971 (Figures 11 and 12) and may reflect an increase in the numbers of nesting females in the Hutchinson Island area.

Trends in 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 1993, only 2.6 percent (7) of the leatherback nests (n=266) and only 1.4 percent (12) of the green turtle nests (n=831) 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 probably were 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 1994, the number of nests observed on the island ranged from 5 to 146 for green turtles and from 1 to 44 for leatherbacks (Figures 11 and 12). 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. Leatherback turtles usually begin nesting in March or April and continue to nest through early to mid-July. Considerable fluctuations in green turtle nesting on the island have occurred among survey years (Figure 11). 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, data collected through 1994 suggest an overall increase in nesting since 1971 and may reflect an increase in the number of nesting females in the Hutchinson Island area. During 1994, 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 1994, 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). The velocity caps supported above the openings to each intake pipe eliminate vertical water entrainment and substantially reduce current velocities near the structures by spreading horizontal draw over a wider area. 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.

1994 Canal Capture Summary

In 1994, a record 361 sea turtles were captured in the intake canal of the St. Lucie Plant. Captures included 164 loggerheads, 193 green turtles, 2 Kemp's ridleys, and 2 leatherbacks. (Table 1)

Relative Abundance and Temporal Distribution

Since intake canal monitoring began in May 1976, 2394 loggerhead (including 150 recaptures), 751 green (including 27 recaptures), 17 leatherback, 24 Kemp's ridley and 13 hawksbill captures have taken place at the St. Lucie Plant. Annual catches for all species combined ranged from a low of 33 in 1976 (partial year of plant operation and monitoring) to 361 in 1994.

Except for 1993 and 1994, when the green turtle was the most abundant species in the canal, loggerheads have dominated annual captures. Since 1977, the first full year of plant operation, the number of loggerheads captured each year ranged from 62 in 1981 to 195 in 1986 (Figure 13). Numbers have exhibited considerable year-to-year fluctuations with no persistent trends evident.

The number of green turtles captured each year since 1977 have ranged from 3 in 1979 to a record high of 193 in 1994 (Figure 13). Increasing numbers of captures over the last three years may reflect an increase in the number of turtles inhabiting the nearshore coastal area near the plant or may simply represent natural variation. Another possibility relates to changes in the physical characteristics of the intake structures. As a result of a major reconstruction project undertaken in 1991, the structures may now be more attractive to green turtles, thereby increasing their probability of entrainment. Additional years of capture data will be required before any long-term population trends can be established.

During 1994, the monthly catch of loggerheads ranged from 5 (March) to 33 (July), with a monthly mean of 13.6 (Table 2). Over the entire monitoring period, monthly catches have ranged from 0 to 39, with the greatest number of captures occurring during January 1983.

During 1994, the monthly catch of green turtles ranged from 1 (June and September) to 68 (December) with a monthly mean of 16.1 (Table 3). The December 1994 catch of 68 green turtles is the largest number of captures for this species for any month on record. Seasonal abundance patterns of green turtles have been much more pronounced than for loggerheads, with over 50 percent of all captures occurring between January and March.

Catches of leatherbacks, hawksbills and Kemp's ridleys have been infrequent and scattered throughout the 19 year study period. Each species has shown rather pronounced seasonal occurrences; over 60 percent of all leatherbacks were captured in March and April, over 60 percent of the hawksbills were collected between July and September, and almost 90 percent of the Kemp's ridleys were caught between December and April.

Size-Class Distributions

The size-class distribution for loggerheads removed from the intake canal in 1994 is presented in Figure 14. The size-class distribution for green turtles removed from the intake canal in 1994 is presented in Figure 15. ABI (1994) presents size-class data for turtles removed from the intake canal from 1976-1993.

Sex Ratios

Of the 164 loggerheads captured in 1994, 112 were juveniles with a straight line carapace length (SLCL) less than or equal to 70 cm, 36 were adults (SLCL > 85 cm) and 16 were transitional (SLCL 71-85 cm). (Hirth 1980) The latter group probably includes both mature and immature individuals. Of the 36 individuals classified as adults, 29 were females and 7 were males, with females predominating by a ratio of 4.1:1.

Of the 194 green turtles captured in 1994 all were juveniles or sub-adults (SLCL < 83 cm) (Witherington and Ehrhart 1989). The 2 leatherbacks captured in 1994 were both adult females (SLCL > 121 cm) (Hirth 1980). One juvenile Kemp's ridley and one adult female Kemp's ridley (SLCL > 60 cm) (Hirth 1980) were captured in 1994. ABI (1994) discusses sex ratio data for previous years.

Capture Efficiencies

Netting methodologies have been under continual review and refinement as net materials, configurations and placement have been varied in an effort to minimize sea turtle entrapment times. Additionally, alternative capture techniques have been evaluated, and potential deterrent systems tested in the laboratory. Current capture procedures have proven to provide a safe, efficient and cost-effective program for removing entrapped turtles from the intake canal.

Formal daily inspections of the intake canal are conducted every day that capture nets are deployed (usually five days each week), and the number, location, and relative size of entrapped turtles are recorded on field observation forms. For the period for which residence time data is available (July 1 to December 31, 1994), about 76 percent of the turtles entering the canal were caught within 24 hours of first sighting. Because of differences in mean size, loggerheads typically resided in the canal for shorter periods than the smaller green turtles.

In July - December 1994, 100 percent of all loggerheads were captured within one week of first sighting, with a mean entrapment period of 1.47 days. Over that same period, green turtles, which are less easily entangled in the large mesh nets, had a mean entrapment time of 2.00 days. 96.9 percent of all green turtles were captured within one week of first sighting. Better utilization of currents and eddies, adjustments to tethering lines, multi-net deployments and increased efforts to hand capture turtles have contributed to reduced entrapment time during recent years.

Entrapment times may be extended for turtles swimming past the A1A barrier net (ABI, 1987). Because capture efforts west of the A1A bridge were generally 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. Because of their relatively small sizes, virtually all the turtles reaching the intake wells are green turtles. During 1994, 49 of the 194 green turtle captures (25.2 percent) occurred at the intake wells.

During 1994, 84.2 percent of all turtles entrapped in the canal were captured east of the A1A bridge, 253 by tangle nets and 51 by hand or dipnet capture. The effective confinement of turtles east of A1A has been a major contributor to the high capture efficiency achieved during recent years.

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 vitality. During 1994, 95.1 percent (156) of all loggerheads found in the canal were alive and in good condition. Only 4.9 percent (8) of loggerhead captures involved individuals in fair or poor condition. Of the 194 green turtles removed from the intake canal during 1994, 174 (89.7 percent) were in good condition, 16 (8.2 percent) were in fair or poor condition, and 4 (2.1 percent) were dead. One of the 2 Kemp's ridleys captured in 1994 was in fair condition and the other was in good condition.Both of the leatherbacks captured in 1994 were in good condition.

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. A rating of good indicates 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 boat collision or fisheries gear entanglement injuries, obviously were sustained prior to entrainment.

During 1994, 14 of the 361 turtles captured (3.9 percent) had noticeable injuries, such as missing appendages, broken or missing pieces of carapace or deep lacerations. Most of these were old, well-healed wounds, and did not require medical attention.

Of the 357 live removals during 1994, 343 were released into the ocean the day of capture. Six small green turtles which were very lethargic at the time of removal were held overnight for observation. Relatively low water and air temperatures at the time of capture were thought to be responsible for this condition. One of these turtles died overnight while being held for observation. The other five were released the following day. Six turtles (3 loggerheads and 3 green turtles) in obvious ill health or suffering serious injuries were transported to Sea World of Florida for treatment and rehabilitation. One of the loggerheads had a penetrating crack in the carapace. The remaining two loggerheads were noticeably underweight, lethargic and heavily infested with barnacles and leeches, a condition referred to as "diseased turtle syndrome." This condition has been reported elsewhere (Ehrhart 1987), and is unrelated to entrapment in the canal. X-rays of one of these loggerheads also revealed significant intestinal blockage. Three small green turtles recovered from the intake wells in lethargic and underweight to emaciated condition were transported to Sea World. One of these turtles died during transport, one died in rehabilitation, and the other is recovering. Four green turtles with fibropapilloma were removed from the canal in 1994. Two turtles with extensive tumors were transferred to the Florida DEP for transportation to a

rehabilitation facility. Two turtles with minor tumors were tagged and released. Few turtles with fibropapillomas have been captured in the past at the St. Lucie Plant.

Mortalities

Sea turtle mortalities have been closely monitored throughout the life of the canal capture program in an attempt to assign probable causes and take appropriate remedial action to minimize future occurrences. Previous analyses of capture data identified drowning in nets (A1A barrier net, UIDS barrier, and tangle 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 has probably accounted for a portion of observed mortalities.

Over the entire 19 year monitoring period, 130 (5.4 percent) of the 2,394 loggerheads and 28 (3.7 percent) of the 751 green turtles entrapped in the canal were found dead. Mortalities spanned the range of size classes for loggerheads (SLCL = 47.5-103 cm), while all green turtle mortalities involved juveniles less than 42 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 dead leatherback or hawksbill turtles have been recovered at the St. Lucie Plant.

Modifications to capture procedures, improvements to the A1A barrier net and virtual elimination of low flow conditions within the canal have resulted in a substantial reduction in sea turtle mortalities over the life of the canal capture program. Mortality

rate, expressed as the percentage of total captures involving dead animals, declined from 7.8 percent during the period 1976-1984 to 3.5 percent since 1984 (Table 1).

In 1994, four turtles were removed dead from the intake canal, for an overall mortality rate of 1.1%. All of the mortalities occurred in December 1994, and all involved small green turtles removed from the plant intake wells. Three of the dead turtles were recovered in fresh condition, and were transferred to DEP for necropsy. All three were underweight or emaciated at time of death. An additional green turtle was severely decomposed when recovered, and no necropsy was performed.

The mortalities coincided with an unprecedented influx of green turtles in December. Their small size allowed them to pass through the barrier net and UIDS barrier. At the time the present barrier was designed, calculations indicated it would confine 95% of all turtles to the easternmost portion of the intake canal. The large increases in green turtle levels in recent years has significantly reduced the mean size of turtles captured in the canal, due to the much smaller average size of green turtles occurring in the intake canal as compared to loggerheads. Thus, the barrier net is not as effective in confining the majority of turtles to the east of A1A. Consultations are underway for barrier net design improvements to correct this situation.

Recapture Incidents

Since the St. Lucie Plant capture program began, most turtles removed 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 19 year history of turtle entrapment at the St. Lucie Plant, 177 recaptures (150 loggerheads and 27 green turtles) have occurred, and a number

of turtles have been recaptured more than once. Several other turtles with tag scars have also been recovered, indicating that the actual number of recaptures may be higher. Occasionally, turtles are captured that have been tagged by other researchers. One such capture occurred in 1994, a female leatherback with tags from French Guiana.

SUMMARY

A gradient of increasing loggerhead turtle nest densities from north to south along the northern half of Hutchinson Island has been shown during most 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 nighttime construction activities associated with installation of power plant intake and discharge structures. Nesting returned to normal or above normal levels following both periods of construction. During 1991, daytime construction activities associated with velocity cap repairs had no apparent effect on nesting. Statistical analyses indicate that power plant operation, exclusive of nighttime construction, has had no significant effect on nest densities near the plant.

In 1994, 6607 loggerhead turtle nests were recorded on Hutchinson Island. There have been considerable year-to-year fluctuations in loggerhead nesting activity on Hutchinson Island from 1971 through 1994. Fluctuations are common at other rookeries and may result from non-annual reproductive behavior. Despite these fluctuations, loggerhead nesting activity has remained high during recent years and may reflect an overall increase in the number of nesting females in the Hutchinson Island

area. No relationship between total nesting on the island and power plant operation or intake/discharge construction was indicated.

Temporal nesting patterns of the Hutchinson Island population may be influenced by natural, large scale fluctuations in water temperature, such as those produced by the cool water intrusions that frequently occur over the continental shelf of southeast Florida during the nesting season. However, localized fluctuations in water temperature associated with power plant operation have had no apparent effect on nesting.

Since nesting surveys began in 1971, raccoon predation is 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. Ghost crab predation on turtle nests may be more significant than previously documented but remains relatively minor compared to raccoon predation.

During 1994, 195 green turtle and 52 leatherback turtle nests were recorded on Hutchinson Island, a new record for both species. Nesting activity by these two species has exhibited considerable annual fluctuations, as has been recorded at other rookeries, but has remained relatively high during recent years. This may reflect an overall increase in the number of nesting green and leatherback turtles in the Hutchinson Island area.

During 1994, 164 loggerheads, 193 green turtles, 2 leatherbacks, and 2 Kemps ridleys were removed from the St. Lucie Plant intake canal. Since monitoring began in May 1976, 2394 loggerhead, 751 green, 17 leatherback, 13 hawksbill and 24 Kemps 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 194 in 1994. Differences in the number of turtles entrapped during different years and months are attributed primarily to natural variation in the occurrence of turtles in the vicinity of the offshore intake structures, rather than to plant operating characteristics.

Size-class distributions of loggerhead turtles removed each year from the canal have consistently been predominated by juveniles between 50 and 70 cm in straight line carapace length. Over 75 percent of all green turtles entrapped in the canal 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 loggerheads caught in the canal continued to be biased towards females.

During 1994, about 95 and 88 percent, respectively, of all loggerheads and green turtles removed from the canal were categorized by physical appearance as being in good condition.

About 4 percent of the turtles removed form the intake canal during 1994 had substantial injuries, and most of those were apparently sustained prior to entrapment. Once in the canal, turtles confined east of A1A typically had very brief residency times. Thus the relative condition of most turtles was not affected by their entrapment.

During 1994, 4 green turtle mortalities were recorded in the intake canal. Program modifications, including continual surveillance of tangle nets during periods of deployment, improvements to the integrity of the A1A barrier net and greater effort to hand capture turtles have contributed to a substantial decline in sea turtle mortalities during recent years.

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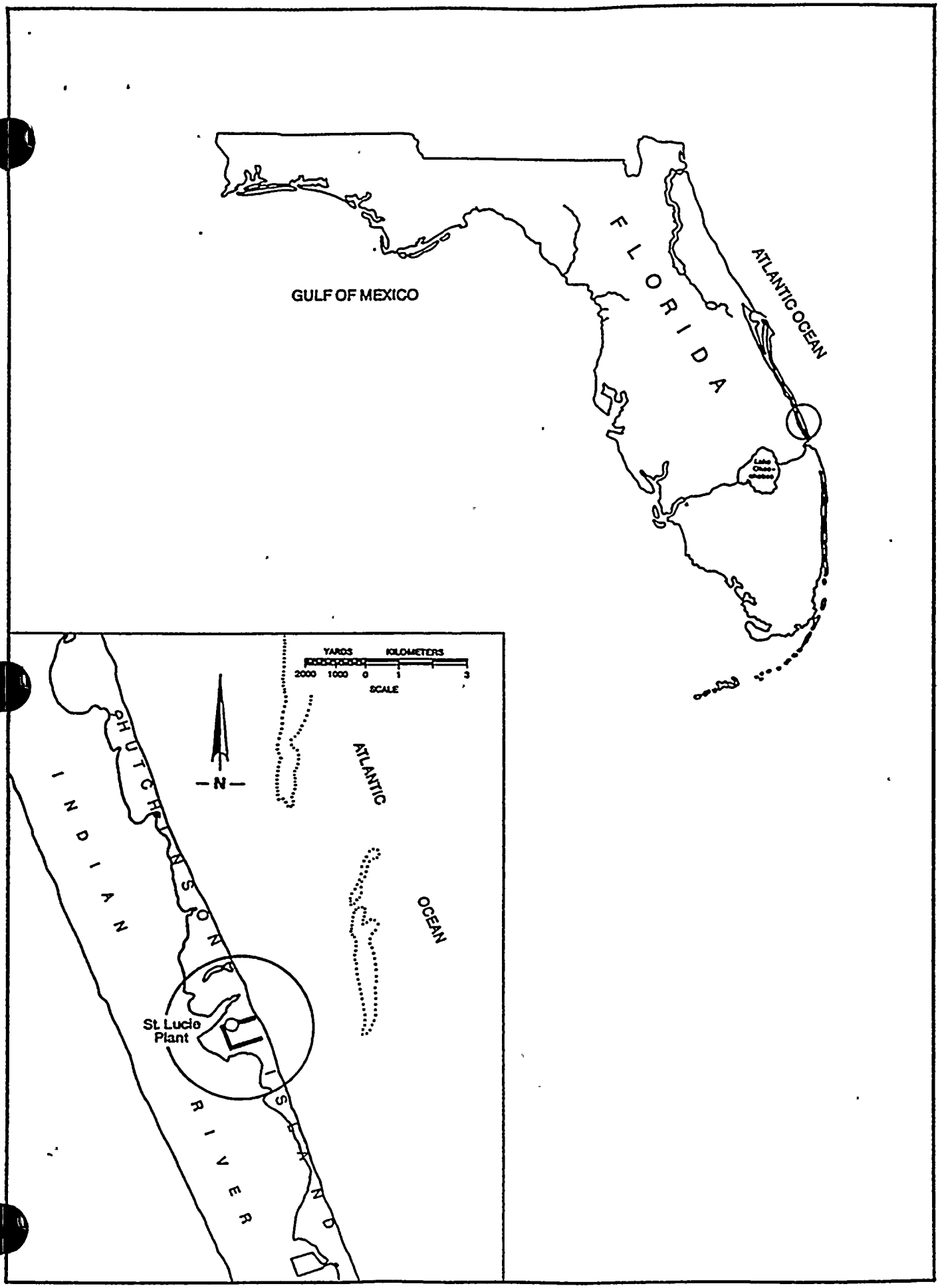

Figure 1. Location of the St. Lucie Plant.

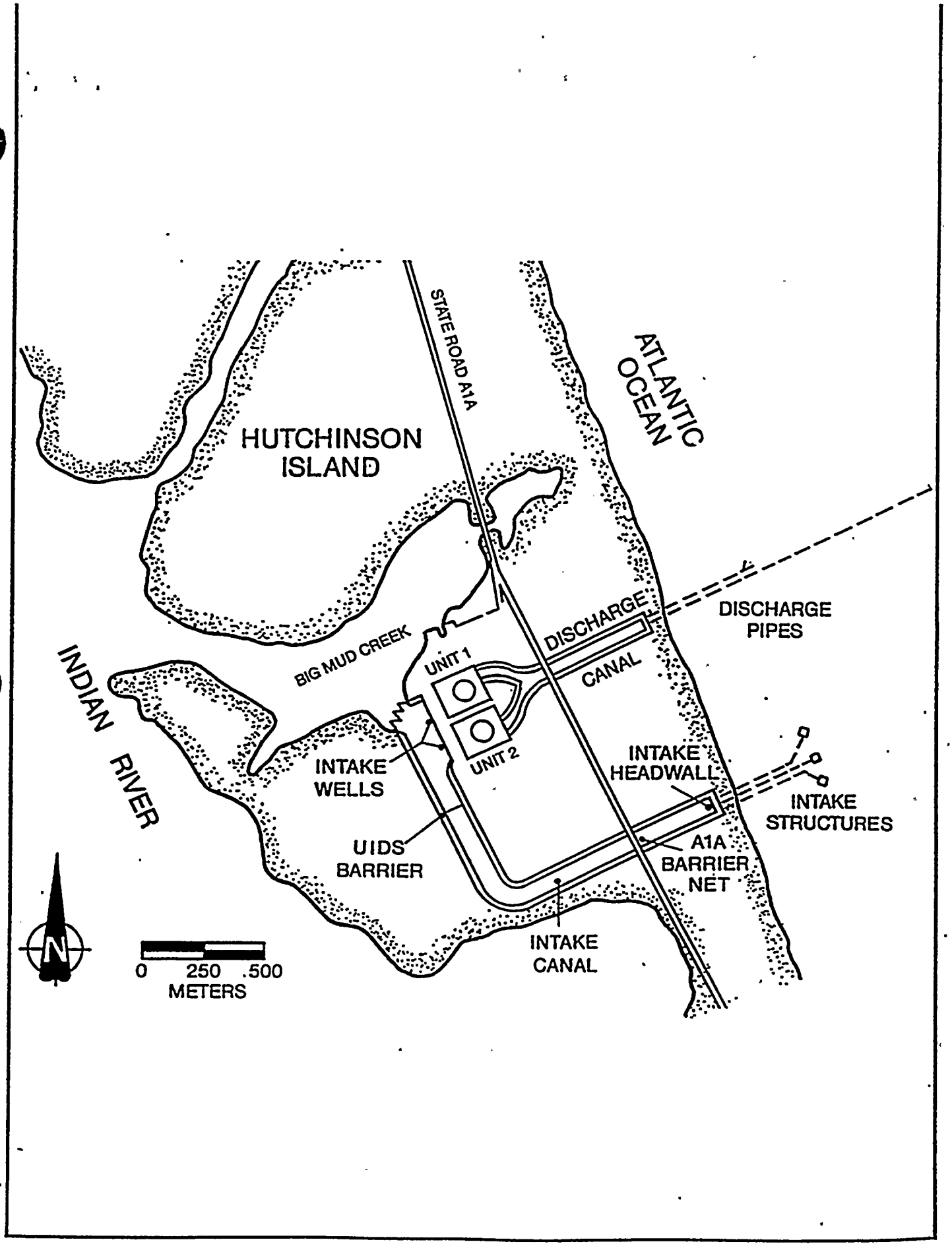

Figure 2. St. Lucie Plant cooling water intake and discharge system.

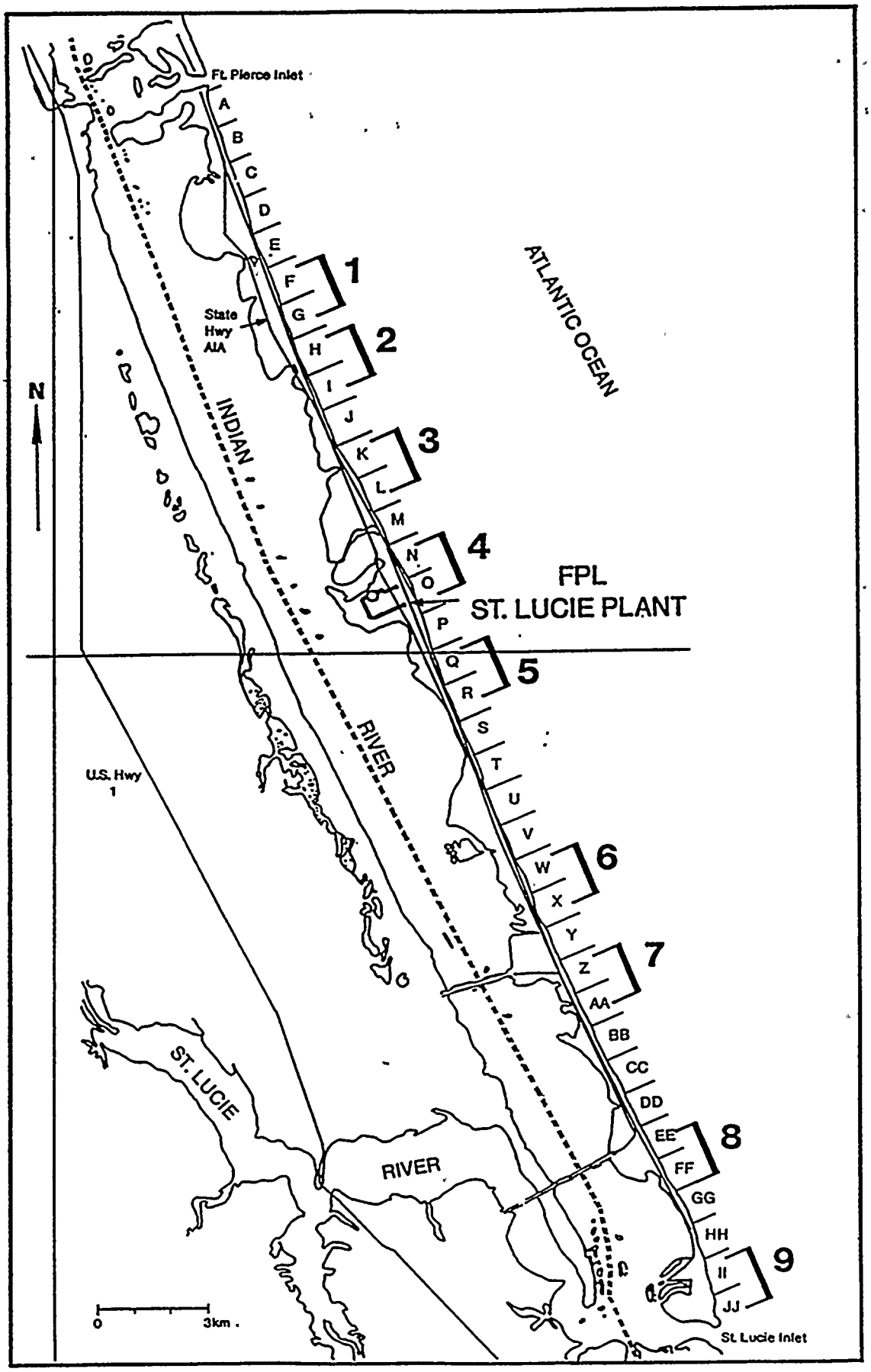

Figure 3. Designation and location of nine 1.25-km segments and thirty-six 1-km segments surveyed for sea turtle nesting, Hutchinson Island, 1971-1992.

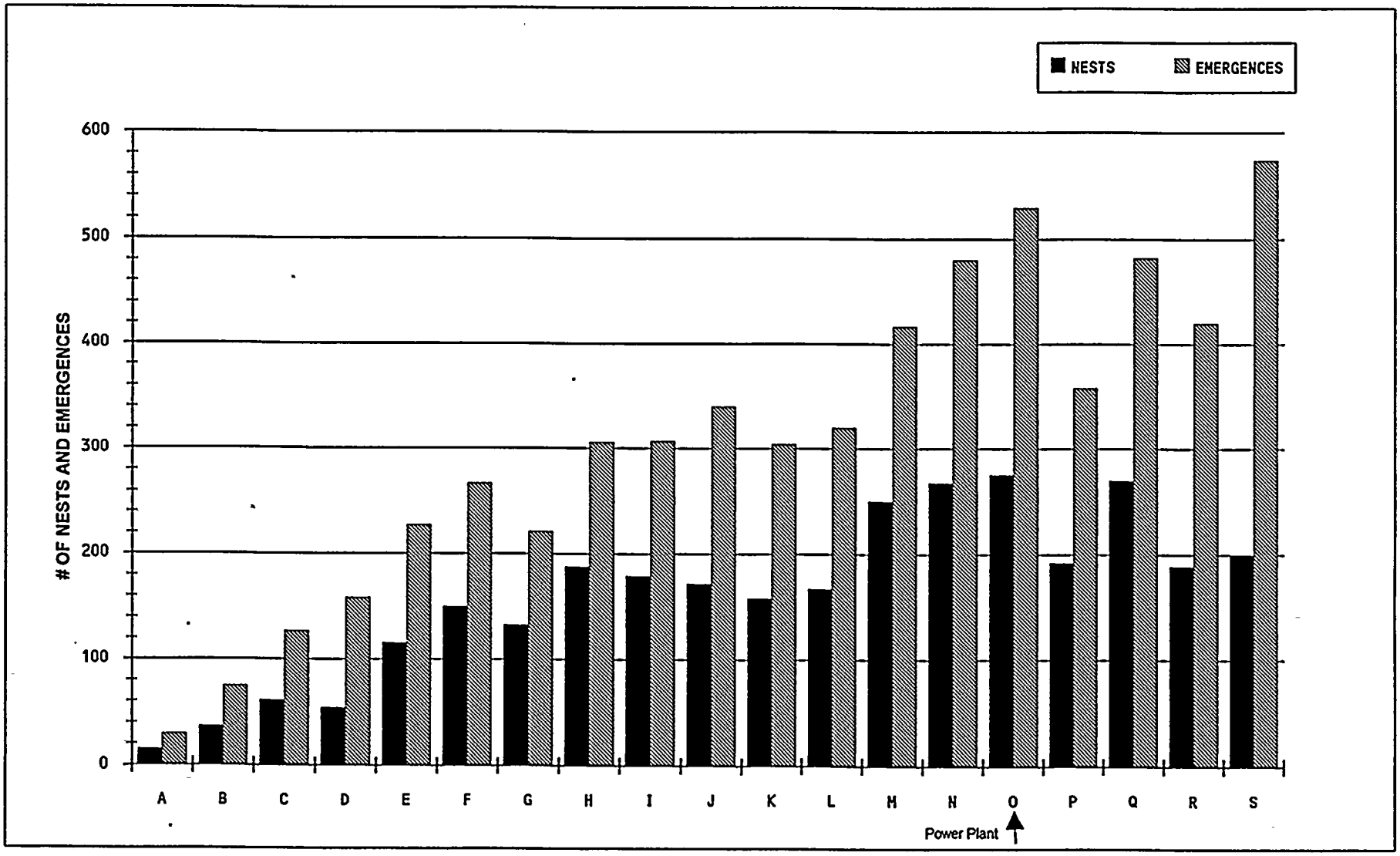

Figure 4. Number of loggerhead turtle nests and emergences for areas A through S, Hutchinson Island, April through September 1994.

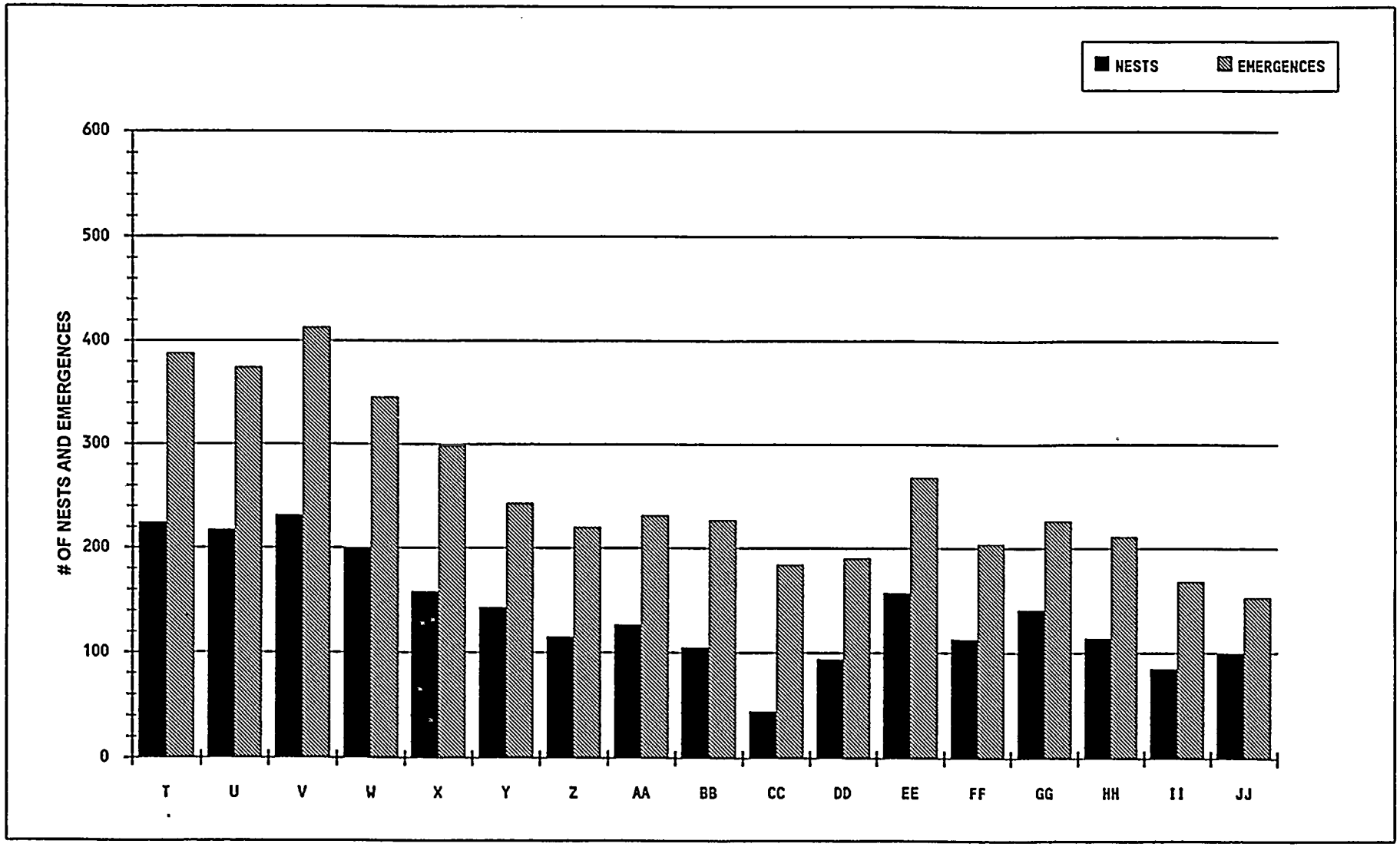

Figure 5. Number of loggerhead turtle nests and emergences for areas T through JJ, Hutchinson Island, April through June 1994.

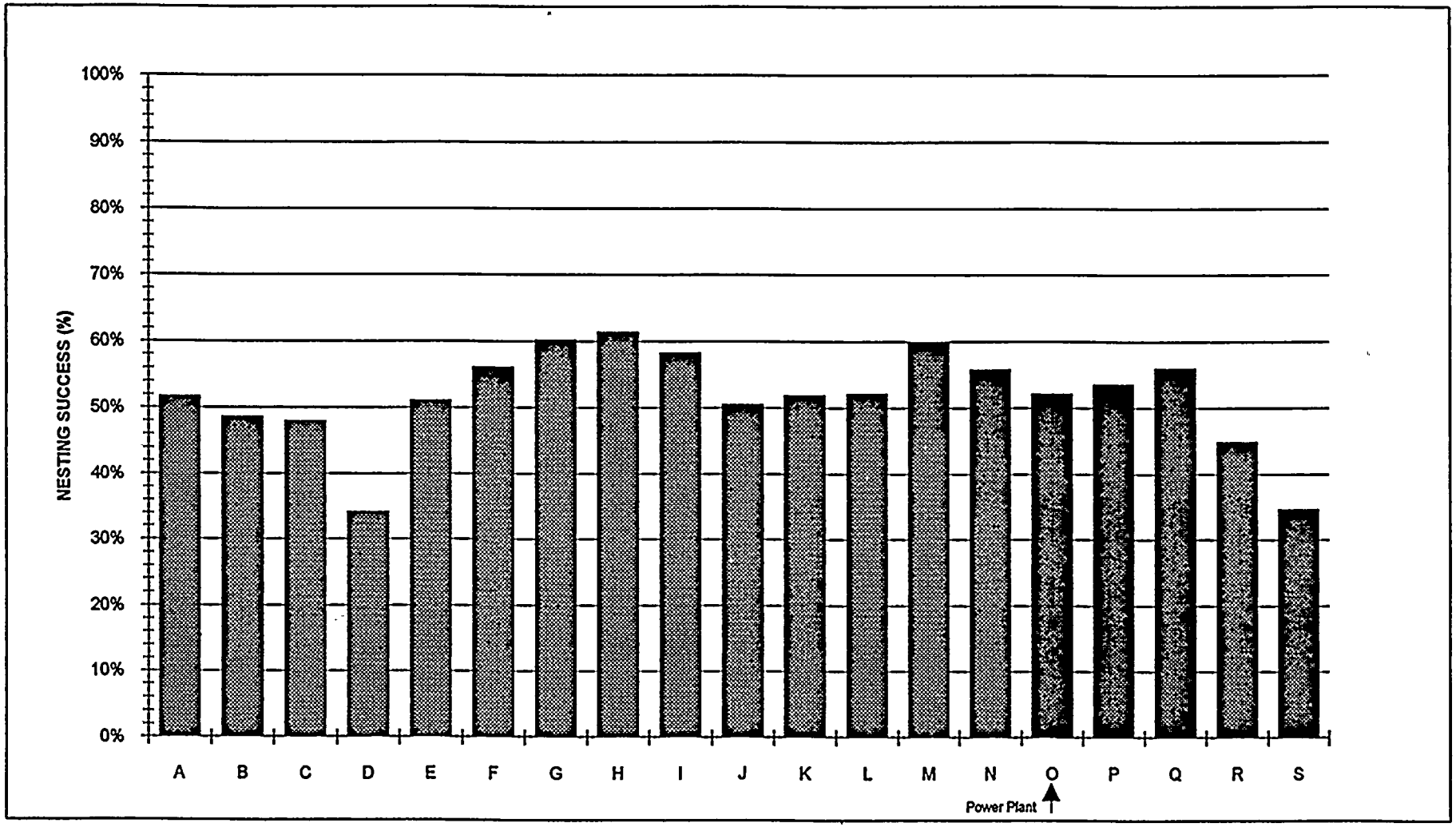

Figure 6. Loggerhead turtle nesting success (percentage of emergences resulting in nests) for areas A through S, Hutchinson Island, April through September 1994

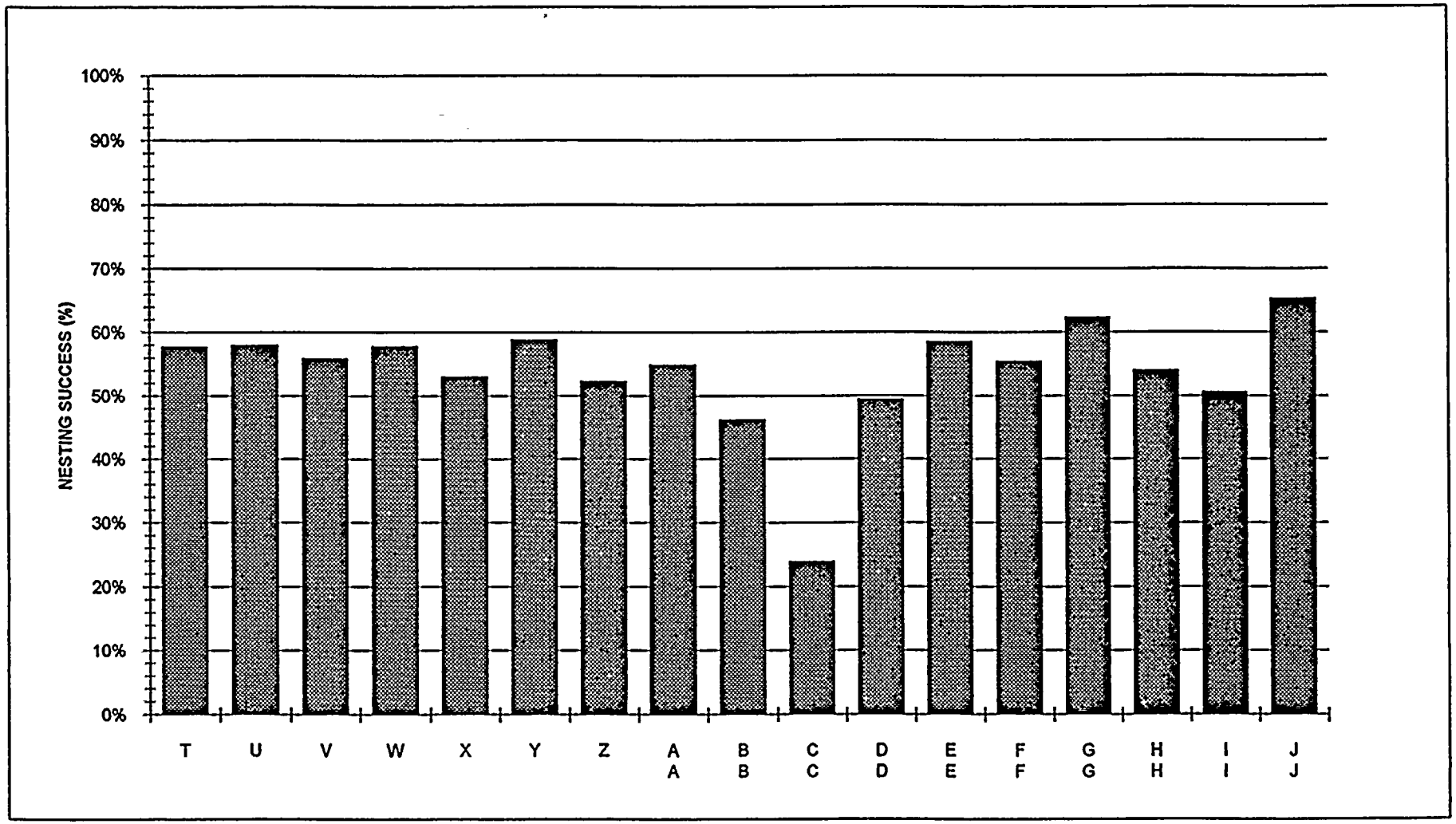

Figure 7. Loggerhead turtle nesting success (percentage of emergences resulting in nests) for areas T through JJ, Hutchinson Island, April through June 1994.

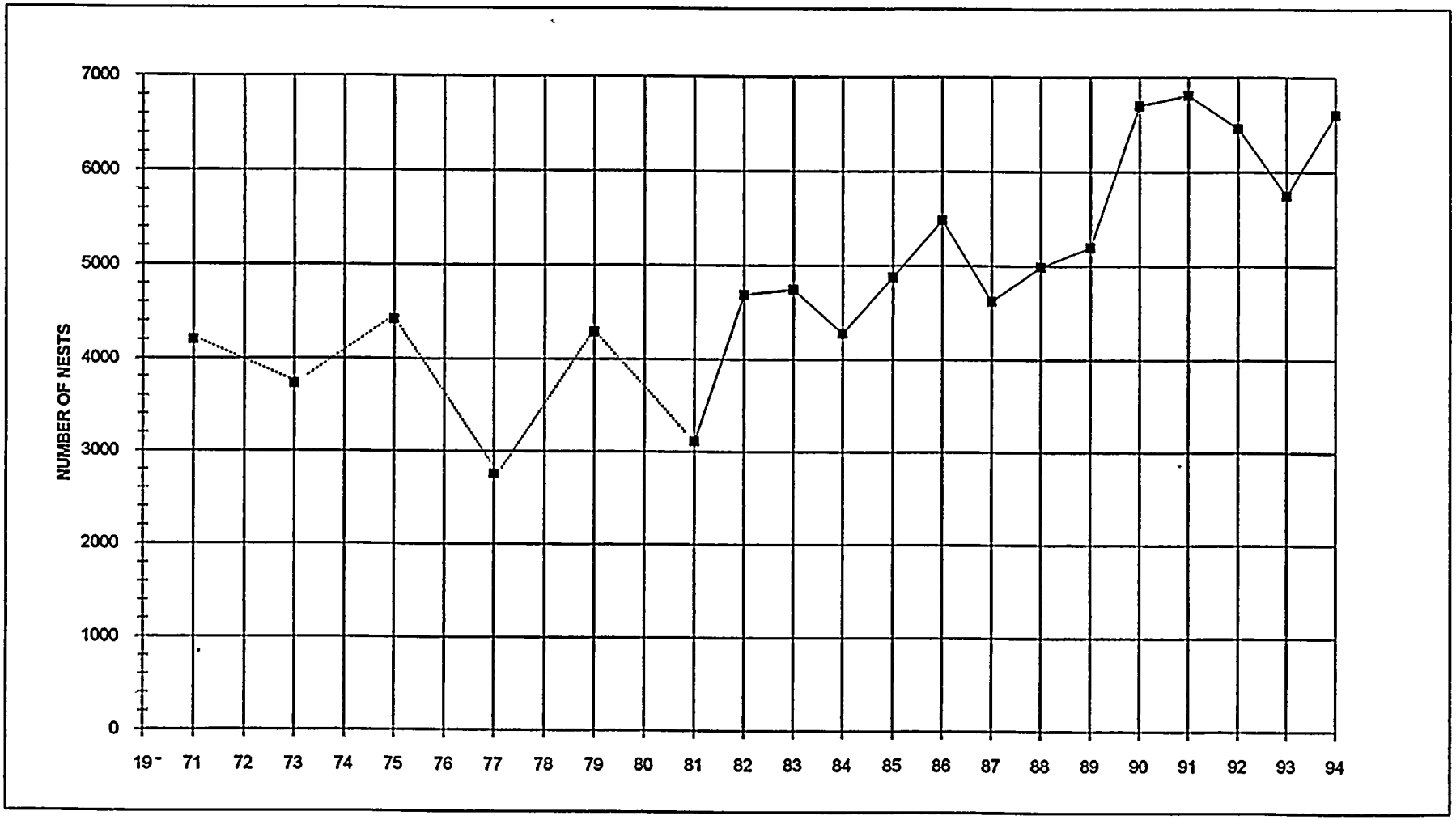

Figure 8. Number of loggerhead turtle nests, Hutchinson Island 1971 through 1994. Values for 1971 through 1979 are estimates (see text), values for 1981 through 1994 are from whole island surveys.

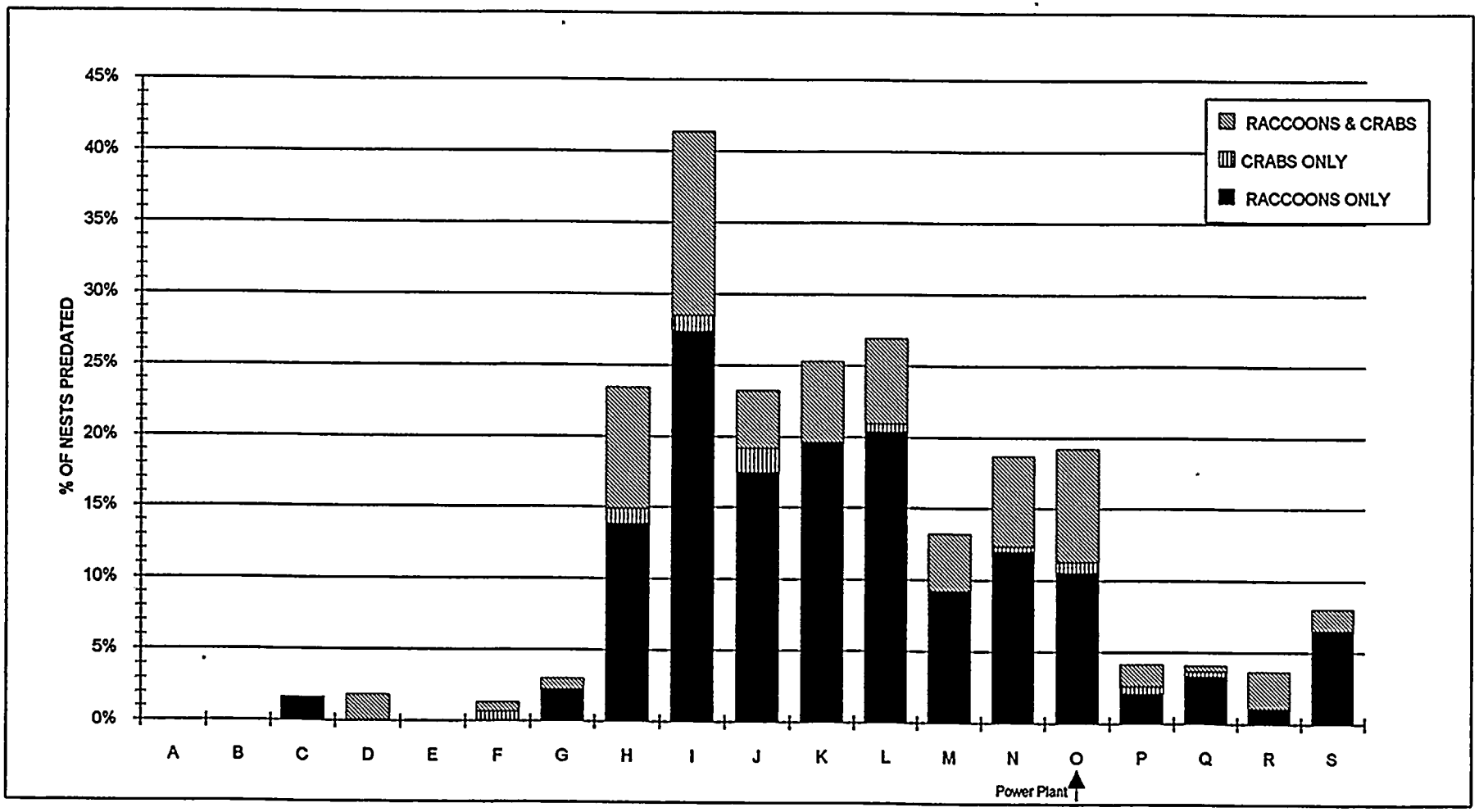

Figure 9. Percentage of loggerhead turtle nests predated by raccoons and/or ghost crabs in areas A through S, Hutchinson Island, April through September 19

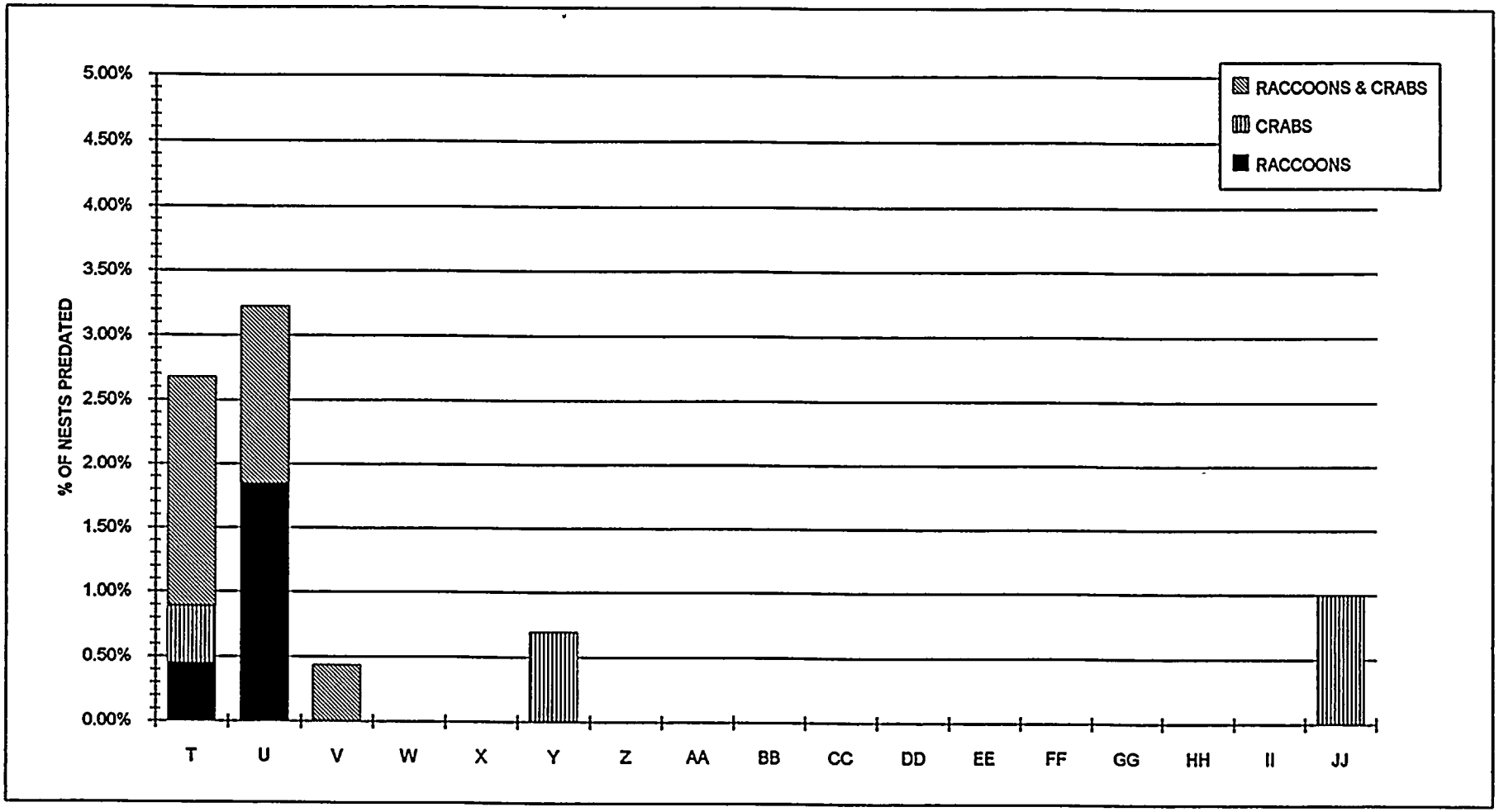

Figure 10. Percentage of loggerhead turtle nests predated by raccoons and/or ghost crabs in areas T through JJ, Hutchinson Island, April through June 1994.

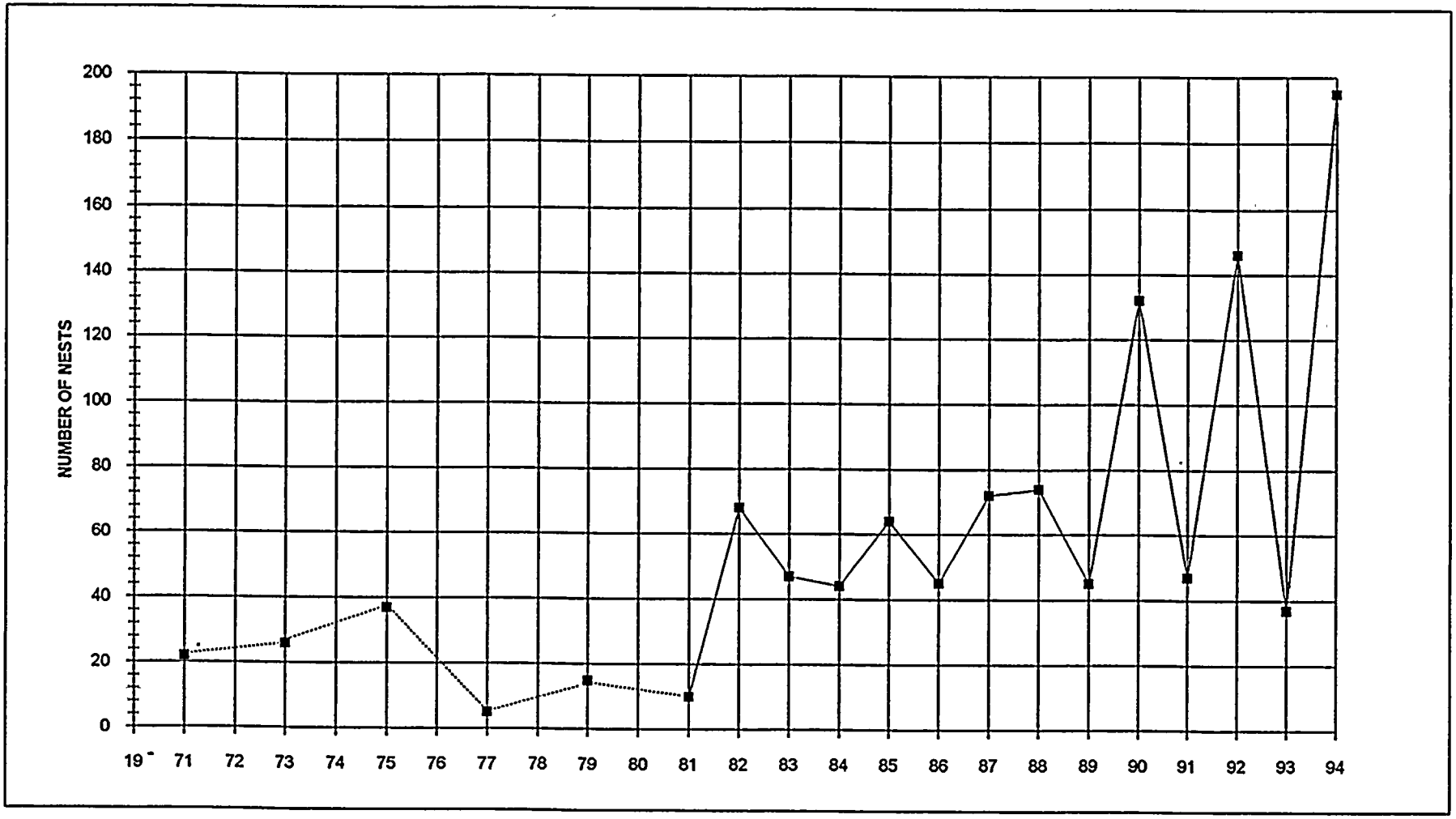

Figure 11. Number of green turtle nests, Hutchinson Island,1971 through 1994. Values for 1971 through 1979 are estimates (see text). Values for 1981 through 1994 are from whole island surveys.

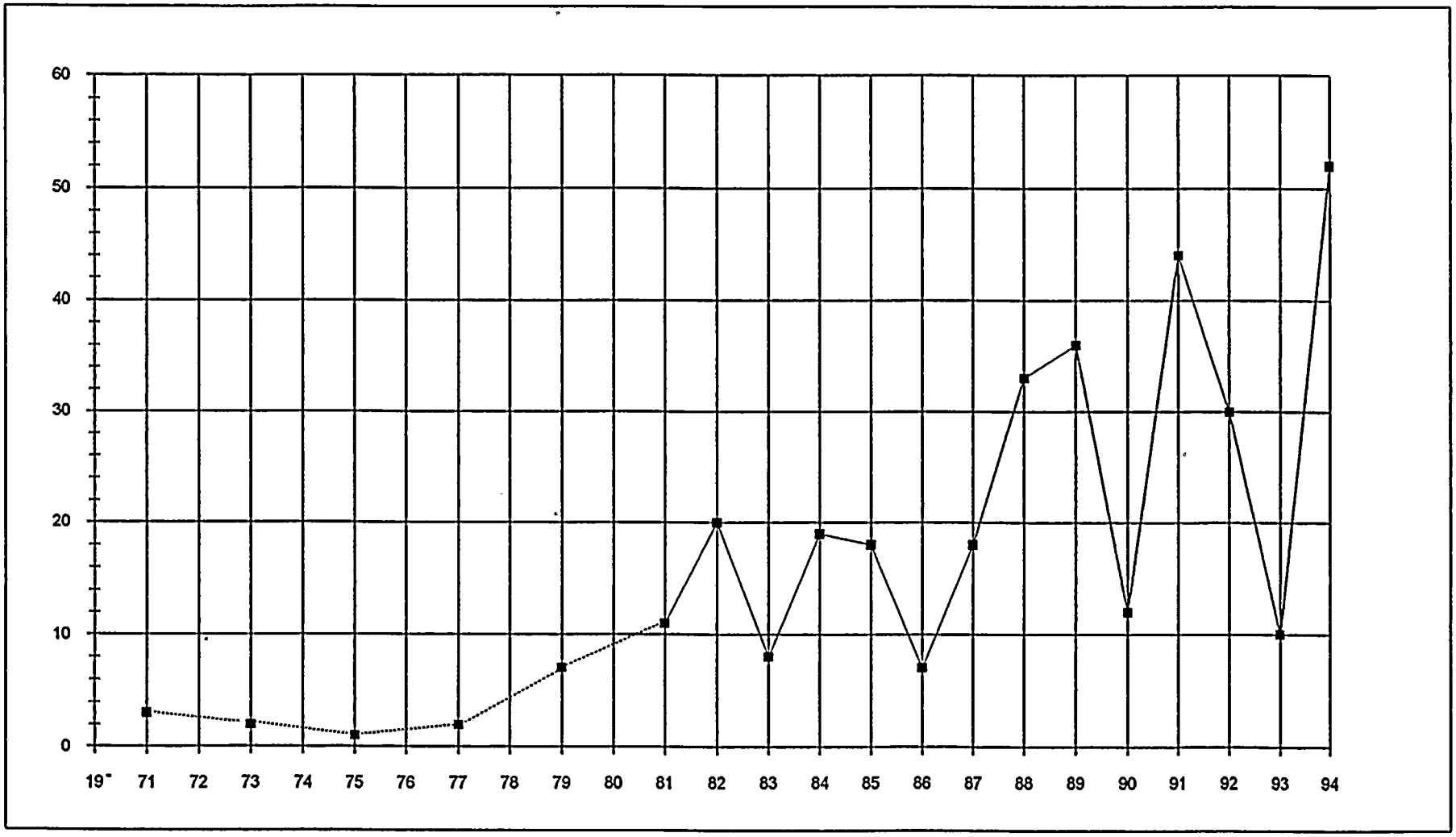

Figure 12. Number of leatherback turtle nests, Hutchinson Island, 1971 through 1994. Values for 1971 through 1979 are estimates (see text). Values for 1981 through 1994 are from whole island surveys.

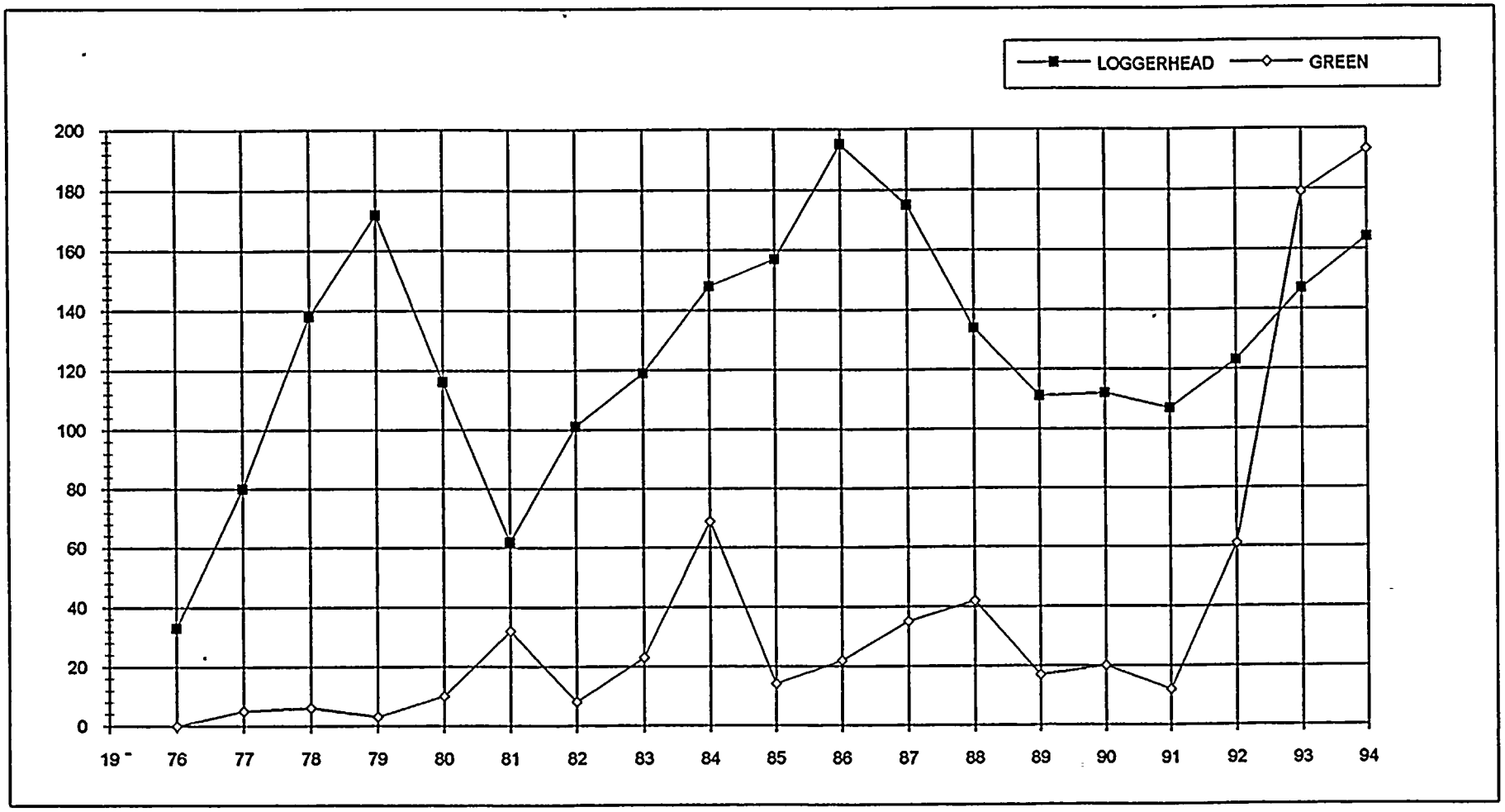

Figure 13. Number of loggerhead and green turtles removed each year from the intake canal, St. Lucie Plant, 1976 through 1994.

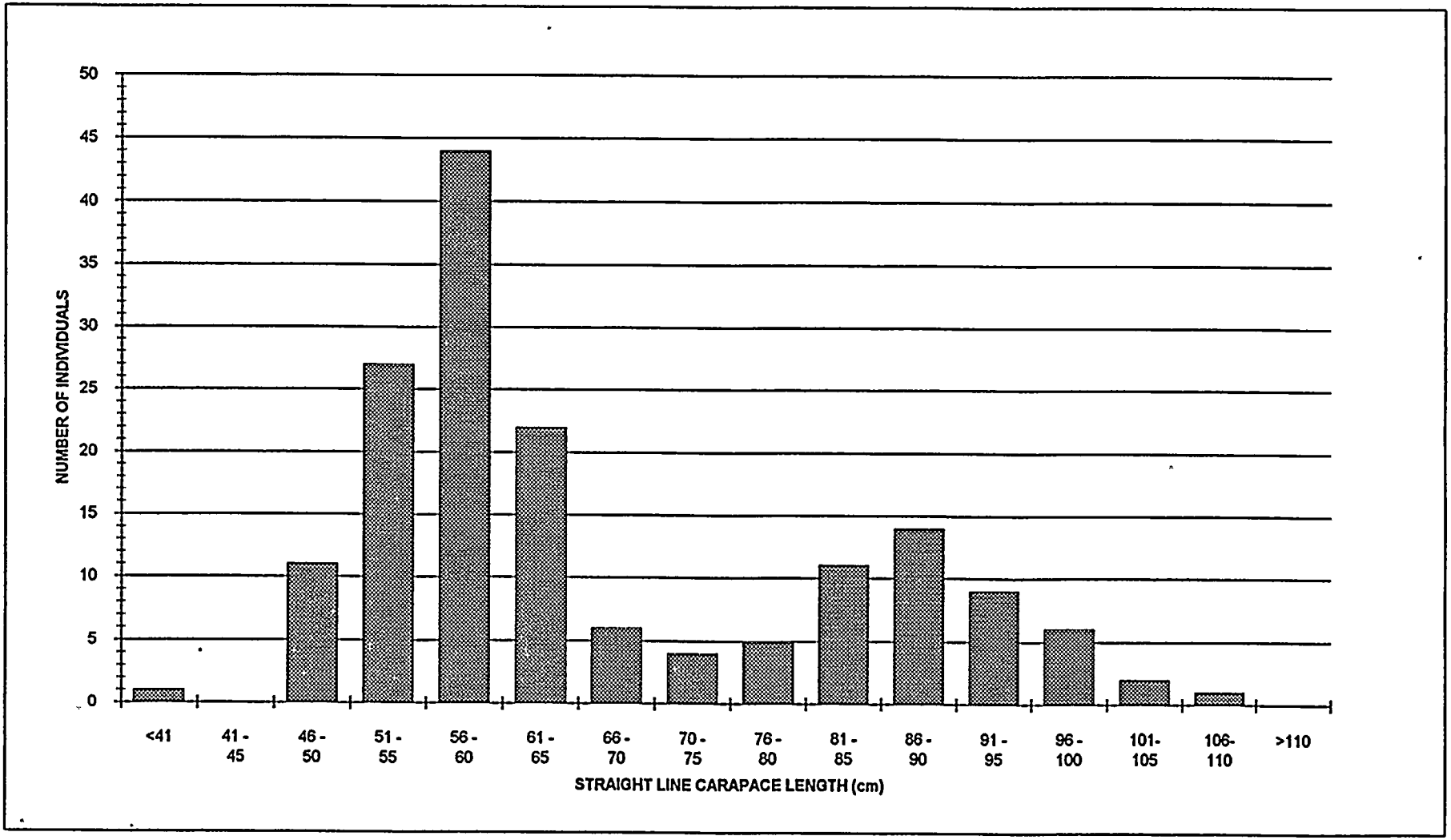

Figure 14. Length distribution (SLCL) of loggerhead turtles (N = 163) removed from the intake canal, St. Lucie Plant, 1994.

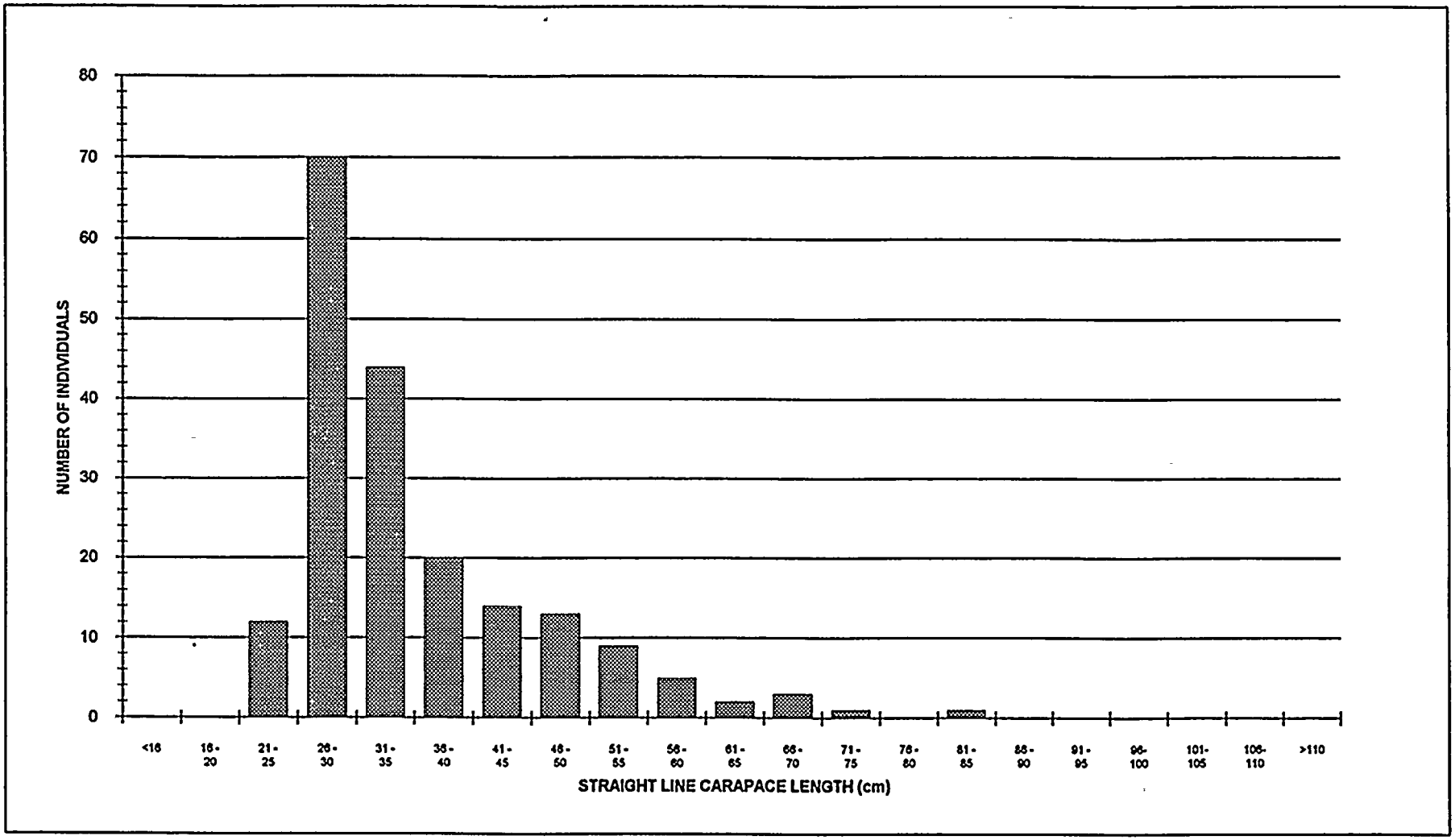

Figure 15. Length distribution (SLCL) of green turtles (N = 194) removed from the intake canal, St. Lucie Plant, 1994.

TABLE 1

TOTAL NUMBER OF SEA TURTLE CAPTURES AND {NUMBER OF DEAD} TURTLES REMOVED FROM THE INTAKE CANAL

ST. LUCIE PLANT, 1976 - 1994

YEAR	Species					Total
	loggerhead	green	leatherback	hawksbill	kemp's ridley	
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}
1990	112 {1}	20 {2}				132 {3}
1991	107 {1}	12		1	1	121 {1}
1992	123 {2}	61 {2}	1	2		187 {4}
1993	147	179 {1}	5	2	4	337 {1}
1994	164	193 {4}	2		2	361 {4}
Total	2394 {130}	751 {28}	17	13	24 {4}	3199 {162}
Annual Mean*	131.2 {7.2}	41.7 {1.6}	0.9	0.7	1.33 {0.2}	175.89 {9.0}

* Excludes 1976 (partial year of plant operation).

TABLE 2

TOTAL NUMBER OF LOGGERHEAD TURTLES REMOVED EACH MONTH FROM THE INTAKE CANAL

ST. LUCIE PLANT, 1977* - 1994

	1977 Through 1994						
Month	Number of Captures	Percent of All Captures	Minimum	Maximum	Mean	Standard Deviation	1994
January	304	12.9%	6	39	16.9	9	20
February	222	9.4%	5	29	12.3	5.5	9
March	195	8.3%	1	27	10.8	6.8	5
April	211	8.9%		24	11.7	6.8	13
May	200	8.5%		28	11.1	8.4	17
June	254	10.8%	3	30	14.1	8.9	8
July	235	10.0%		33	13.1	10	33
August	219	9.3%	2	34	12.2	9.2	24
September	149	6.3%	1	19	8.3	5.3	7
October	146	6.2%		17	8.1	5.3	14
November	104	4.4%		15	5.8	3.8	6
December	122	5.2%	1	13	6.8	4.1	8
Total	2361			39			164
Mean	196.8				10.9		13.7
Std. Deviation	57.7				7.7		8.5

* First full year of plant operation. An additional 33 loggerheads were captured during 1976.

TABLE 3

TOTAL NUMBER OF GREEN TURTLES REMOVED EACH MONTH FROM THE INTAKE CANAL

ST. LUCIE PLANT, 1977* - 1994

	1977 Through 1994						
Month	Number of Captures	Percent of All Captures	Minimum	Maximum	Mean	Standard Deviation	1994
January	143	19.0%	0	37	7.9	10.3	25
February	109	14.5%	0	28	6.1	7.8	23
March	94	12.5%	0	55	5.2	12.6	4
April	48	6.4%	0	23	2.7	5.2	3
May	26	3.5%	0	8	1.4	2.5	8
June	23	3.1%	0	6	1.3	1.7	1
July	17	2.3%	0	6	0.9	1.6	6
August	19	2.5%	0	4	1.1	1.3	4
September	14	1.9%	0	6	0.8	1.4	1
October	59	7.9%	0	21	3.3	6.2	21
November	76	10.1%	0	29	4.2	7.4	29
December	123	16.4%	0	68	6.8	16.1	68
Total	751		0	68			193
Mean	62.6				3.5		16.1
Std. Deviation	45.6				7.9		19.3

* First full year of plant operation.