Assessment Of The Impacts Of The St. Lucie Nuclear Generating Plant On Sea Turtle Species Found In The Nearshore Waters Of Florida

Prepared By:
Florida Power & Light Company
November, 1995

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1.0 SUMMARY AND CONCLUSIONS

This document provides a biological assessment on the impacts of continued operation of the Florida Power & Light Company (FPL) St. Lucie Nuclear Power Plant on five species of federally listed sea turtles as required by Section 7 of the Endangered Species Act (ESA) of 1973, as amended. The facility is located on south Hutchinson Island, Florida.

The turtle species encountered in decreasing numerical abundance are: loggerhead, green, Kemp's ridley, leatherback, and hawksbill. The scientific names and their level of endangerment are given in Table 1.

These five species of sea turtles enter the canal system of the St. Lucie Plant along with water that is drawn from the nearshore waters of the Atlantic Ocean for condenser cooling. The turtles cannot escape and must be removed from the canal system through a capture program. FPL has worked with federal and state agencies to promote sea turtle conservation efforts through stewardship efforts such as noting health, tagging, noting recapture incidents, obtaining morphometric data, rehabilitating injured individuals, nesting studies, conducting turtle walks, assisting with sea turtle stranding networks, and collaborating with research organizations.

The intake structures and velocity caps for St. Lucie Units 1 and 2 serve as an artificial reef, since the structures are the only significant physical feature in this nearshore environment. The turtles encounter this structure in their normal ranging activities and feed on organisms growing on the structure or seek the structures for shelter. Based on the water velocities in the intake structure, once a turtle passes the vertical plane of the velocity cap, it is swept into the intake pipeline and, after a 3-5 minute passage through the pipeline, it enters the intake canal.

To facilitate the capture of entrapped turtles and to restrict turtles from moving down the canal system towards the plant, a barrier net was erected in 1978. The rationale for the mesh size of this barrier net was based on the size frequency of 140 turtles captured in the intake canal before March, 1978. An 8 inch (20.3 cm) square mesh was chosen since it would exclude 95% of the turtles.

In the original evaluation of the environmental impact of St. Lucie Unit 1, turtle entrapment and impingement were not anticipated (U. S. Atomic Energy Commission, 1974). An initial biological assessment and ESA Section 7 consultation were completed in 1982 as part of the licensing of St. Lucie Unit 2. This assessment resulted in a no jeopardy opinion at the estimated level of entrapment, but had no provisions for mortality. This assessment was based on the entrapment history of the plant from 1976 through 1981, which averaged approximately 150 turtles a year. As part of this evaluation, the 8 inch (20.3 cm) square mesh barrier net was determined to be appropriate to exclude turtles from the plant's intake wells. Additionally, a research program to investigate methods to physically or behaviorally exclude turtles from the intake structures was conducted as part of the Environmental Protection Plan of St. Lucie Unit 2 during the initial years of operation. This study concluded that there was currently no practical method to exclude turtles from entering the intake structures in the nearshore environment (Florida Power & Light, 1985).

Since 1993, FPL has documented a significant increase in numbers of entrapped turtles, which now exceed 600 a year. A principal component of this increase is the number of juvenile green turtles (carapace width less than 12 inches (30 cm)). Over 400 juvenile green turtles have been captured in the time period of January 1, 1995 through June 30, 1995. This increase is believed to be indicative of an increase in population of green turtles present in the nearshore waters of the Atlantic Ocean.

With the increase in the number of turtles entrapped in the intake canal since 1991 and the decrease in size of the entrapped turtles, a certain percentage of green turtles have been able to penetrate the existing 8 inch (20.3 cm) mesh barrier net and pass down the canal to be impinged on the intake well structure of the plant. In the first six months of 1995, 23% of the turtles captured were removed from the intake wells of the plant.

To exclude turtles from the plant's intake wells, FPL is proposing to install a smaller mesh barrier net in the intake canal. The new net will exclude 100% of turtles in the size range encountered in 1995. This net will be 5 inch (12.7 cm) square mesh, or a diagonal measurement of 7 inches (18 cm). The size of the mesh is based on the size frequency distribution of 414 green turtles encountered in 1995.

As additional conservation measures for sea turtles, FPL is proposing to continue a summer turtle walk program where the public is taken on the beach at night to observe a nesting female. This activity, which handled approximately 1000 people in 1995, will increase public understanding and appreciation for sea turtles. FPL is also proposing to continue assistance to the Florida Department of Environmental Protection in their index beach nesting survey for sea turtles along the beaches of south Hutchinson Island. This long-term monitoring program will establish trends in sea turtle nesting populations in Florida, since the beaches of south Hutchinson Island are a key turtle nesting rookery. FPL is also proposing to continue to cooperate with the Florida Department of Environmental Protection in their sea turtle stranding network when dead or live turtles are washed up on the beach. Personnel examine dead turtles and record pertinent information to help understand the cause of death or transport live turtles to rehabilitation facilities for medical treatment.

With the new barrier net in place and the commitment to the conservation activities of the nesting survey, turtle walks, and participation in the stranding network, the continued operation of the St. Lucie Nuclear Generating Plant will not jeopardize the continued existence of sea turtles in Florida.

2.0 INTRODUCTION

2.1 Purpose

This biological assessment, for five species of sea turtle found at the Florida Power & Light Company (FPL) St. Lucie Nuclear Power Plant, is submitted to the National Marine Fisheries Service (NMFS) by the U.S. Nuclear Regulatory Commission (NRC) to comply with Section 7 of the Endangered Species Act of 1973, as amended and 50 CFR 402, Interagency Cooperation. Previously, an informal consultation with NMFS was conducted in 1982 (Bellmund et al., 1982).

This report provides the NRC's updated biological assessment, which predicts the impact from the continued operation of Units 1 and 2 of the St. Lucie Nuclear Power Plant on five species of sea turtles as listed in Table 1. This assessment is based on the monitoring data collected by FPL and its consultants and a review of pertinent literature.

2.2 Endangered Species Act

The purpose of the Endangered Species Act is: "... to provide for the conservation of endangered and threatened species of fish, wildlife, and plants, and for other purposes." One of the Act's principle features is contained in Section 7 of the Act, which provides for interagency cooperation in that, "... each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency ('agency action') does not jeopardize the continued existence of any endangered species or threatened species or result in destruction or adverse modification of habitat of such species...."

2.3 Jurisdiction of the National Marine Fisheries Service

The NMFS has jurisdiction over all species of sea turtles in the waters of the United States.

2.4 Jurisdiction of the U. S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS) has jurisdiction over all species of sea turtles in the terrestrial environment. Any time sea turtles venture from the water onto land, principally for nesting, and during the incubation and the hatching of young, the FWS has jurisdiction.

2.5 Chronology of Events Leading to this Assessment

In 1974, the Atomic Energy Commission in their Final Environmental Assessment for the Construction Permit for St. Lucie Unit 1, described various biological communities found in the nearshore Atlantic Ocean off the plant (USAEC, 1974). As a condition of FPL's license to operate Unit 1, FPL was required to conduct a monitoring program. This activity began in December 1975 and monitored biological communities in the vicinity of the plant. Several species of sea turtles where known to inhabit the waters adjacent to the plant and to nest on the beaches of Hutchinson Island. The results of the monitoring programs, including data on sea turtles, were summarized yearly and presented in annual environmental monitoring reports (Applied Biology, 1976, 1977a, 1978, 1979, 1980, 1981).

In 1981, the NRC requested an informal consultation with the NMFS and the FWS regarding the licensing of St. Lucie Unit 2. Five species of sea turtles were identified by the NMFS as inhabiting the Atlantic Ocean nearshore area of the St. Lucie Plant. In 1982, the NRC completed a biological assessment and concluded that the operation of the plant would not have an adverse impact on the continued existence of these turtle species (Bellmund et al., 1982). There were sea turtle monitoring requirements placed in the Environmental Protection Plan of Unit 2, which required relocation of turtle nests found within the beach construction zone during 1982, removal of entrapped sea turtles from the intake canal of the plant, a study to evaluate methods to reduce entrapment, a continuous evaluation of methods to capture entrapped turtles, and nesting surveys of Hutchinson Island for the time period 1982-1987.

These results were presented in yearly annual reports to the NRC (Applied Biology, 1982, 1983a, 1983b, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, Quantum, 1994).

3.0 SITE DESCRIPTION

3.1 Location

The St. Lucie Nuclear Power Plant is located on a 1129 acre (460 ha) site on South Hutchinson Island, St. Lucie County, FL (Figure 1). The plant is approximately 7 miles (11.3 km) south of Ft. Pierce, FL and approximately 7 miles (11.3 km) north of Stuart, FL.

3.2 Indian River Lagoon Environment

South Hutchinson Island is a typical barrier island of eastern Florida bounded on the east by the Atlantic Ocean and on the west by the Indian River Lagoon. The island is 23.3 miles (37.5 km) long and reaches its maximum width of 1.1 miles (1.7 km) at the plant site. This barrier island has a flat topography and is vegetated by mangroves, coastal hardwood hammocks, and salt tolerant beach species. At the site's ocean shore, the land rises slightly to a dune or ridge of approximately 19 feet (5.8 m) above mean sea level.

The Indian River Lagoon is a shallow embayment that is bounded on the west by the mainland peninsula of Florida and on the east by the narrow barrier islands located along the coast of Florida. The Indian River Lagoon originates in Brevard County in the Cape Canaveral area and terminates in the Stuart area. Several inlets along the coast connect the lagoon with the Atlantic Ocean. Many rivers and drainage canals empty into the entire stretch of the lagoon and greatly influence the salinity and nutrient levels of the water body. In many areas of the lagoon, extensive sea grass beds exist and support a wide diversity of fish biota (Gilmore 1977).

3.3 Atlantic Ocean Environment

Baseline and pre-operational studies of the St. Lucie Plant are reported in a series of publications entitled "Nearshore Marine Ecology at Hutchinson Island, Florida: 1971-1974" by the Marine Research Laboratory of the Florida Department of Natural Resources

(FDNR, 1977, 1979). These reports contain ten parts: 1) Introduction and Rationale; 2) Sediments; 3) Physical and Chemical Environment; 4)Lancelets and Fishes; 5) Arthropods; 6) Plankton Dynamics 1971-1973; 7) Phytoplankton 1971-1973; 8)Zooplankton 1971-1973; 9) Diel Plankton 1973-1974; 10)Benthic Algae Species List.

3.3.1 Salinity

The salinity of the ocean in the vicinity of the plant is influenced by two main water masses: the waters of the continental shelf, which receive fresh-water outflows from various inlets, and the Florida current, which is oceanic in nature. The salinity of the water adjacent to the plant is approximately 36 o/oo and varies plus or minus 2 o/oo. The variation is dependent on the extensive fresh-water outpourings under certain weather conditions from inlets located at Ft. Pierce and Stuart (Applied Biology, 1981). The Florida current sweeps within 12 miles (19 km) of the shoreline under certain conditions, but more typically is found 24 miles (39 km) offshore.

The salinity of the Indian River Lagoon varies widely from less than 20 o/oo during the rainy season when there are large fresh-water discharges to 34 o/oo during flood tide and low fresh-water discharges (Wilcox and Gilmore, 1976).

3.3.2 Temperature

Ambient water temperature of the Atlantic Ocean at the plant site ranges from a January minimum of 57 F (14 C) to a September maximum of 84 F (29 C)(Applied Biology, 1981). However under certain wind and upwelling conditions common during the summer months, the ambient water temperature of 78-81 F (25-27 C) can drop precipitously to 70-73 F (21-23 C) for several days (Applied Biology, 1993; Quantum, 1994).

3.3.3 Topography

The ocean bottom within 5 miles (8 km) of the plant consists entirely of sand and shell sediments with no reef or rock outcroppings, outside of the surf zone. The bottom relief slopes very gradually until about 14 miles (22 km) offshore, where the water depths are 120-150 feet (36-45 m), and then the continental slope begins. Water depths of 30-60 feet (9-18 m) are found up to 6 miles (9.6 km) offshore of the plant.

3.3.4 Wave Conditions and Turbidity

Wave conditions in the vicinity of the plant are extremely variable. Because of the location of the plant on the Atlantic Ocean, the area can be subject to hurricanes, northeasters, and distant storm systems, with associated wave and surf conditions that can exceed 16 feet (4.9 m). Under fair weather conditions, the ocean can be flat calm. The water clarity/turbidity in the plant's vicinity also varies with the wave conditions, the approximate distance to the Florida current, and fresh-water outpourings from the inlet (Applied Biology, 1981). Under heavy surf conditions, water clarity up to 1 mile (0.6 km) offshore is less than 1 foot (0.3 m); under calm conditions, water clarity can be 50 feet (15 m).

3.3.5 Reef System

Approximately 0.8 miles (1.3 km) south of the plant's intake structures, an extensive worm reef community is found along the shoreline and within the surf zone. This reef system provides extensive habitat for a wide variety of fish and invertebrate species (Applied Biology, 1977b). A coquinoid rock formation parallels much of island's ocean shoreline and provides suitable substratum for these worm reefs. The robustness of this worm reef is seasonally dependent and there is major accretion during the calm summer months. The worm reef has a smaller profile during the winter months due to the destructiveness of heavy surf action. There are no major reef systems outside of the surf zone within 6 miles (9.6 km) of the plant. However, there are several shoals composed of sand and shell hash 2-5 miles (3.2-8 km) from the plant. These shoals have a relief of about 10-15 feet (3-4.5 m) and are found 2-3 miles (3.2- 4.8 km) offshore in about 30-35 feet (9.1-10.7 m) of water.

4.0 ST. LUCIE NUCLEAR PLANT DESCRIPTION

4.1 General Description

The St. Lucie Plant consists of two Pressurized Water Reactors (Units 1 and 2), each rated at 839 MWe. Unit 1 began commercial operation in February, 1977 and Unit 2 began commercial operation in August, 1983. The location of the units in relationship to the site layout is shown in Figure 2. The reactor containment domes are the tallest structures on the plant site and are 225.5 feet (69 m) above mean low water.

The Atlantic Ocean provides cooling and receiving waters for each unit's condenser and auxiliary cooling systems. The units share a common intake and discharge canal and ocean piping system as shown in Figure 2. Major components of these canals and ocean piping systems are: 1) three ocean intake structures located approximately 1200 feet (365 m) from the shore line; 2) three buried intake pipelines to convey water from the intake structure to the intake canal (one pipeline is 16 feet (4.9 m)in diameter; two are 12 feet (3.65 m) in diameter); 3) a common intake canal to convey sea water to each unit's intake well structure; 4) individual unit intake well structures; 5) discharge structures for each unit; 6) a common discharge canal; 7) one discharge pipeline (12 feet (3.65 m) diameter) to convey water to a "Y" diffuser approximately 1200 feet (365 m) offshore and another pipeline (16 feet (4.9 m) diameter) to convey water to a multiport diffuser (solid pipeline from shoreline to approximately 1200 feet (365 m) offshore and then the multiport diffuser segment from approximately 1200 to 2400 feet (365-730 m) offshore) (Figure 2).

The design unit flow for Units 1 and 2 is 1150 cubic foot per second (32.6 cms) per unit with maximum and normal temperature rise across the condensers of 31 F and 25 F (17-13 C), respectively (Bellmund et al., 1982).

4.2 Circulating Water System

4.2.1 Intake Structures and Velocity Caps

Three intake structures and velocity caps are located approximately 1200 feet (365 m) offshore and about 2400 feet (731 m) south of the discharge structures. The intake structures have a vertical section to minimize sand intake, a velocity cap to minimize fish entrapment, but no screens or grates are used to deny organisms access to the intake pipes. The tops of the intake structures are approximately 7 feet (2.1 m) below the surface at mean low water. The velocity cap for the 16 foot (4.9 m) diameter pipe is 70 feet (6.5 m) square, is 5 feet (1.5 m) thick, and has a vertical opening of 6.25 feet (1.9 m). The velocity cap for the two 12 foot (3.65 m) diameter pipes is 52 feet (4.8 m) square, is 5 feet (1.5 m) thick, and has a vertical opening of 6.5 feet (2.0 m). In 1991-1992, all three velocity caps were rebuilt due to the failure of several panels comprising the caps. This failure was due to the stresses from the harsh ocean environment and wave action. The relative position of the three intake structures and velocity caps is shown in Figure 3.

The flow velocities at various locations of the velocity cap and intake structures have been calculated under various levels of biological fouling. The minimum and maximum horizontal intake velocities at the face of the ocean intake structures for the 12 foot (3.65 m) diameter pipe is calculated at 0.37-0.41 feet per second (11.2-12.6 cm/sec) and for the 16 foot (4.9 m) diameter pipe is calculated at 0.92-1.0 foot per second (28.3-30.5 cm/sec). As the water passes under the velocity cap, flow becomes vertical and the velocity increases to approximately 1.3 feet per second (40.2 cm/sec) for the 12 foot (3.65 m) diameter pipe and 6.2 feet per second (206 cm/sec) for the 16 foot (4.9 m) diameter pipe (Bellmund et al., 1982).

4.2.2 Intake Pipes

From the ocean intake structures, water flows through the three buried pipelines, approximately 1200 feet (365 m) in length, and empties into the open intake canal behind the dune line (Figure 2). The flow through these pipelines will vary from 4.2-6.8 feet per second (127-206 cm/sec) depending on the pipeline and the degree of fouling. Transit time for an object to travel this distance is approximately 180-300 seconds (3 to 5 minutes).

Due to the differences in the diameter of the pipelines and friction of the pipeline walls, the calculated volume through the two 12 foot (3.65 m) diameter lines is approximately 20% each and approximately 60% for the 16 foot (4.9 m) diameter pipeline (Bellmund et al., 1982).

4.2.3. Headwalls and Canal System

Approximately 450 feet (138 m) behind the primary dune line the intake pipes discharge their water at two head wall structures into the intake canal (Figure 2). The headwall structure for the two 12 foot (3.65 m) diameter pipes is a common vertical concrete wall. The head wall for the 16 foot (4.9 m) diameter pipe is a separate structure.

The 300 foot (91 m) wide intake canal has a maximum depth of approximately 25 feet (7.6 m) and carries the cooling water 5000 feet (1525 m) to the intake well structures. The flow rate in the canal varies from 0.9-1.1 feet per second (27-32 cm/sec), depending on tidal stage.

4.2.4 Highway Bridge and Underwater Intrusion System

The intake canal is crossed by two permanent structures (Figure 2). One is a bridge owned by the Florida Department of Transportation and is part of U.S. Highway A1A. The roadway is supported by a series of concrete pilings driven into the bottom of the intake canal. The other barrier is the underwater intrusion detection system (UIDS), which is required for security reasons. This system has a net with a 9 inch (23 cm) square mesh to prevent human intrusion into the secure area of the plant (Figure 4).

4.2.5 Intake Wells, Trash Racks, and Traveling Screens

Each unit has a separate intake well structure consisting of four bays. Each bay (Figure 5) contains trash racks ("grizzlies") that are vertical bars with approximately 3 inch (7.6 cm) spacings to catch large objects such as flotsam. Next are traveling screens with a 3/8 inch (1 cm) mesh to remove smaller debris, and finally a circulating water pump. Approach velocities to each bay are calculated to be less than 1 foot per second (30.5 cm/sec), but increase to approximately 5 feet per second (150 cm/sec) at the trash racks.

The trash racks are periodically cleaned by a mechanical rake that is lowered to the bottom of the rack. The teeth of the rake fit into the 3 inch (7.6 cm) vertical openings of the structure. This rake is pulled vertically up by a winch and cable and collects any debris that may have accumulated on the structures. This debris is emptied into a trough at the top of the intake bay for subsequent disposal. The debris that is collected on the traveling screens is washed from the screen by a series of spray jets. This debris is also emptied into the trough at the top of the intake bay for disposal.

After the water has passed through the trash racks, the traveling screens, and the circulating water pump, it travels through the condenser, which contains thousands of 7/8 inch (1 cm) diameter tubes. Condenser heat is transferred to this water, which is then expelled into the discharge canal.

In the Fall of 1995, FPL will install on Unit 2 a "Taprogge" cleaning system to maintain condenser tube cleanliness (Figure 6). This same system will be installed on Unit 1 in the spring of 1996.

The Taprogge system utilizes small sponge balls, some of which are coated with abrasive, and are approximately 7/8 inch (2.3 cm) in diameter. The balls are injected into the condenser inlet and pass through the condenser tubes with the condenser cooling water. This passage scours the condenser tubes and keeps them free of mineral scale and biological fouling. Upon emergence from the condenser outlet, the balls are recovered with a strainer and moved to the condenser inlet for another pass.

4.2.6 Discharge Systems

Each unit discharges its condenser cooling water into the discharge canal that is approximately 300 feet (91 m) wide and 2200 feet (670 m) long (Figure 2). The canal terminates at two headwall structures approximately 450 feet (137 m) behind the primary dune line. One structure supports a 12 foot (3.65 m) diameter pipeline that is buried under the ocean floor and runs approximately 1500 feet (460 m) offshore where it terminates into a two-port "Y" nozzle. The other structure supports a 16 foot (4.9 m) diameter pipeline that is buried under the ocean floor and runs approximately 3375 feet (1030 m) offshore. The last 1400 feet (425 m) of this pipeline contains a multiport diffuser segment with 58 discharge ports. To minimize plume interference, the ports are oriented in an offshore direction on alternating sides of the pipeline. The velocity of the water inside this pipeline averages about 5.7 feet per second (174 cm/sec) and the jet velocity of the discharge water at each port averages approximately 13 feet per second (400 cm/sec) to ensure quick dissipation of the thermal load (Bellmund et al., 1982).

4.2.7 Thermal Plume

FPL had the thermal plume modeled for two-unit operation. The results indicated that the maximum surface temperatures are strongly dependent on ambient ocean conditions. The maximum surface differential temperature is predicted to be less than 4.9 F (2.7 C) and the resulting 2 F (1.1 C) surface isotherm is estimated at 963 acres (390 ha) (Bellmund et al., 1982).

5.0 INFORMATION ON SEA TURTLE SPECIES

5.1 Loggerhead Sea Turtle (Caretta caretta)

5.1.1 Description

Caretta caretta, or the loggerhead sea turtle, is distinguished by a reddish-brown carapace and a dull brown to yellowish plastron. The carapace is composed of five pairs of costal scutes, eleven or twelve pairs of marginal scutes, and five vertebral scutes. The skull is broad and massive. Adult loggerheads in the southeastern United States have a mean straight carapace length of about 36 inches (92 cm) and a mean body weight of about 250 pounds (113 kg). Dodd (1988) provides a complete morphological description of the species.

5.1.2 Distribution

Loggerhead turtles are circumglobal in distribution but restricted to subtropical and tropical waters. They are found in estuarine waters and the coastal waters of the continental shelves and are uncommon far from mainland shores. Individuals have been found in latitudes as high as 50° in both the northern and southern hemispheres. Loggerheads are a widely dispersed species and hatchlings and small juveniles from southeastern U.S. beaches may spend 3-5 years circumnavigating the Atlantic in current gyres (Carr, 1986). Adults nesting on Florida east coast beaches are found in foraging areas throughout the Gulf of Mexico and Caribbean (Meylan et al., 1983). Adult females are seasonally more abundant in areas adjacent to nesting beaches during the summer season, but seasonal migration patterns for adult males and juvenile loggerheads are largely unknown.

5.1.3 Behavior

Loggerhead turtles are solitary, although they may form aggregations at sea or in the vicinity of nesting beaches. Nesting is also solitary and occurs at night. Loggerheads are active diurnal foragers and makes dives of moderate depth and duration.

The loggerhead mating system is polyandrous, without elaborate courtship.

5.1.4 Food Habits

Loggerhead turtles are primarily carnivorous, feeding on a wide variety of invertebrates, mollusks and crustaceans, although coelenterates and cephalopods predominate in the diets of juveniles (Dodd, 1988). At all ages, loggerheads commonly ingest non-food items such as plastics and tar.

5.1.5 Nesting

Loggerhead turtles favor high energy mainland beaches as nesting sites. Steeply sloping beaches with gradually sloped offshore approaches are preferred. Dodd (1988) gives a complete description of the nesting process.

The nesting behavior is stereotyped and there is very little individual variation. The nesting process may be interrupted at any point up to the actual deposition of the eggs, resulting in what is termed a "false crawl". Florida loggerheads nest from April until September, while farther north the nesting season is restricted to mid-summer. Mean clutch size varies from about 100 to 126 eggs. Loggerheads are known to nest from 1-6 times in a nesting season, with an internesting interval of about 14 days. Incubation time varies with temperature and is typically 50-60 days. Hatchlings emerge as a group at night and are oriented to the water by positive phototaxis of natural light reflecting off the water surface.

5.1.6 Numerical Abundance

Loggerheads are the most abundant species of sea turtle in U.S. coastal waters. The most widely cited population estimate for the southeastern U.S. population is given by Murphy and Hopkins (1984) at 14,150 adult females. This population number was endorsed by Ehrhart (1989) and is also cited in the 1991 NMFS/FWS recovery plan for the loggerhead turtle (National Marine Fishery Service and U.S. Fish and Wildlife Service, 1991). Data on adult males and subadults are not sufficient to estimate total population size, and there is no reliable estimate of the world population of loggerheads. From an analysis of trends in nesting data, the National Research Council (1990) concludes that there is evidence of a population decline for loggerheads in the northern portion of their range, while populations in Florida appear stable or possibly increasing.

5.1.7 Mortality Factors and Diseases

Mortality factors are commonly separated into two categories: natural mortality and human induced mortality. Causes of natural mortality include abiotic factors such as destruction of nests by beach erosion or accretion, tidal inundation of low-lying nests, hypothermia of juveniles and adults during sudden, severe cold spells, and biotic factors such as predation, parasitism, and disease.

Loggerhead eggs are preyed upon by raccoons, ghost crabs, hogs, foxes, ants, crows, vultures and other birds. Hatchlings fall prey to a wide variety of birds and predatory fish. Larger juveniles and adults are preyed upon by large coastal sharks, particularly the tiger shark.

Loggerhead mortalities may also be caused by vegetation. Sea oat and the beach morning glory root systems can invade turtle nests and cause egg mortality, and root systems can grow over a nest and block escape. Additionally, hatchlings and nesting females can become fatally entangled in vegetation.

Little is known about diseases in loggerhead turtles or the impact these diseases have on population levels. Stranded loggerheads have been found to be infested with blood flukes, which result in emaciation and anemia. Additionally, a variety of bacterial and fungal pathogens are believed to cause mortality of loggerhead embryos.

Human induced mortality factors have been extensively studied from both research and management perspectives. The National Research Council (1990) provides a detailed description and analysis of these various mortality factors.

Suitability of beaches for nesting can be compromised by beach armoring, which impedes access to nesting sites and promotes erosion of adjacent beaches. The widespread practice of beach renourishment can create changes in beach characteristics that make them less suitable for nesting (Nelson and Dickerson, 1984).

Artificial lighting on the beachfront both disorients hatchlings and deters nesting females from coming ashore (Witherington, 1990). High levels of human activity on the beach at night and use of recreational equipment on beaches can destroy nests, contribute to erosion, run over emergent hatchlings, cause hatchling disorientation and deter nesting females (National Research Council, 1990). Exotic vegetation, particularly the Australian pine, may reduce or impede access to nesting sites, affect incubation temperature by shading, and may occasionally trap nesting females in exposed root systems (Schmelz and Mezich, 1988).

The most important source of human induced mortality to juvenile and adult loggerheads is the shrimp fishery, which in recent years has accounted for the death of between 5,000 and 50,000 loggerhead turtles per year in U.S. waters (National Research Council, 1990). Other types of fishing gear such as gill nets, fish traps, and long lines collectively account for about 10% of the mortality associated with the shrimp fishery, constituting the second largest source of mortality to juveniles and adults.

Harbor, inlet and navigational channel dredging has been documented to cause significant turtle mortality. From 1980 to 1990, maintenance dredging of the Cape Canaveral and Kings Bay entrance channels killed 149 turtles, 90% of the total being loggerheads (National Research Council, 1990).

Boat collisions are also a significant source of mortality in Florida, with 6-9% of strandings, or an average of 150 turtles per year, showing evidence of boat collisions (National Research Council, 1990).

Directed take of eggs and adults by humans is a significant factor affecting turtle populations world wide, but is difficult to quantify. Although loggerhead meat is not highly prized, it is certainly eaten. Directed take is illegal in the United States and many Caribbean countries, and rates of illegal take are largely unknown.

Plastic debris and tar are commonly found in the digestive tracts of stranded turtles and ingestion of theses items causes intestinal blockage and releases toxic chemicals. In a Texas study, 26% of all stranded loggerheads had plastic debris or tar in the gut upon necropsy (Stanley et al., 1988). The exact role of ingested debris in the death of stranded turtles, however, is often unclear.

Entrapment in power plant intake pipes was mentioned in the National Research Council's report as a relatively minor source of turtle mortality. Adding the well-documented data from the St. Lucie Plant to estimates from other facilities from New York to Texas, the Council estimates that 57 loggerheads per year are killed by power plant entrapment (National Research Council, 1990).

5.2 Green Sea Turtle (Chelonia mydas)

5.2.1 Description

Chelonia mydas, or the green sea turtle, is the largest hard-shelled sea turtle, with Florida adults averaging 40 inches (101.5 cm) in carapace length and 300 pounds (136.2 kg) in weight. They are distinguished from the loggerhead by a much smaller, rounded head and a carapace with four pairs of costal scutes, and a single pair of frontal scales on the head. Pritchard (1979) gives a complete description and life history of the green.

5.2.2 Distribution

The green turtle is circumglobal in distribution, but restricted to the tropics. U.S. populations occur in the Virgin Islands and Puerto Rico, the Gulf of Mexico, and the eastern seaboard, occasionally as far north as Massachusetts. The primary habitat of adult green turtles is shallow, protected waters supporting growth of benthic algae and seagrasses. Their preferred nesting habitats are on high-energy island beaches, and at least one population of green turtles regularly migrates over 620 miles

(1000 km) between feeding and nesting habitats. Some green turtle nesting occurs in the continental U.S., mostly in Florida between Volusia and Broward counties. Populations of immature green turtles are found year round in the Indian River Lagoon, Florida Bay and Homosassa Bay areas of Florida.

5.2.3 Behavior

Like the loggerhead, the green turtle does not form social groups and is a solitary nocturnal nester. Green turtles are diurnal, feeding during the day and often returning to a particular ledge or coral head to sleep each night. The green turtle is more difficult to approach than the loggerhead and their mating behavior is similar to the loggerhead.

5.2.4 Food Habits

The adult green turtle is the only species of sea turtle which is primarily herbivorous. In the post hatchling, pelagic stage, green turtles have an omnivorous or carnivorous diet. Upon entering benthic feeding grounds (at about 8-10 inches (20-25 cm) length), they shift to a diet of algae and seagrasses. Green turtles are selective grazers, favoring growing shoots of seagrasses and a variety of algae, and as a consequence of eating a low protein, high fiber diet their growth is slow. The result of this low growth is that green sea turtles reach sexual maturity later, and have a smaller reproductive output than other sea turtles (Bjorndal, 1982).

5.2.5 Nesting

Major western hemisphere nesting beaches for green turtles are Ascension Island, Aves Island, Surinam, and Costa Rica. A range of 60 to 800 nests are recorded each year on the Atlantic coast of Florida south of Cape Canaveral. The nesting process is very similar to the loggerhead, except that the green turtle excavates a much deeper body pit and produces a higher nest mound. As a result, eggs are buried considerably deeper than in loggerhead nests. Mean clutch size is 110-115 eggs, and females deposit from one to seven (usually two or three) clutches per nesting season (Witherington and Ehrhart, 1989a).

5.2.6 Numerical Abundance

Sufficient data do not exist to accurately assess the current population or population trend of green turtles. Based on historical accounts of the 16th and 17th century, present day populations are certainly only a small fraction of historical levels. With 60 to 2,000 nests a year, Florida supports only a small percentage of the Caribbean and southeast Atlantic green turtle population, estimated by Carr (1978) at 69,000 adults. The National Research Council (1990) concluded that there was not sufficient information to assess trends in green turtle population, but noted that Hutchinson Island, Florida nesting levels have increased over the period 1971-1979. Data from 1979-1994 shows trends of modestly increasing nesting statewide by the green turtle and concludes that the Florida nesting aggregation of green turtles represent a significant contribution to the western Atlantic green turtle population (Meylan et al., 1995).

5.2.7 Mortality Factors and Disease

Mortality factors for the green turtle are similar to those discussed in Section 5.1.7 for the loggerhead, with a few major differences due to the species biological and distributional differences. Natural mortality factors impacting eggs and hatchlings are as described for the loggerhead, except that green turtle nests are less susceptible to raccoon and other small mammal predation due to the greater depth of the egg cavity. Green turtles are more vulnerable to cold stunning (hypothermia). In a series of cold stunning events in the Indian River Lagoon, Florida, green turtles were by far the most common species found affected, and mortality rates among green turtles were higher than loggerheads (Witherington and Ehrhart, 1989b).

Green turtles are subject to a largely species specific disease called fibropapillomatosis. The condition is thought to be viral in origin, although a specific pathogen is yet to be isolated. The condition is characterized by tumorous warts on the skin and inside the body cavity. These tumors restrict movement, cause blindness, promote parasite infestation, and increase the likelihood of entanglement.

Green turtles are not commonly taken in shrimp trawls, but are quite vulnerable to entanglement in other varieties of fishing gear such as gill nets. Directed take has historically been the greatest threat to green turtle populations, but present levels of directed take are difficult to quantify (National Research Council, 1990). Other human induced green turtle mortality factors are as described above in section 5.1.7.

5.3 Leatherback Sea Turtle (Dermochelys coriacea)

5.3.1 Description

The leatherback (Dermochelys coriacea) is distinguished by the absence of the keratinized scutes in the carapace, the lack of claws or scales in adults, and significant skeletal differences. The carapace is raised into seven longitudinal ridges and covered with thin black skin with numerous white spots. The leatherback is the largest living sea turtle, attaining a carapace length of 59-67 inches (150-170 cm) and a maximum weight of 1100-1980 pounds (500-900 kg) (Pritchard, 1979).

5.3.2 Distribution

The leatherback is found world wide, from the tropics to high latitudes. Although found in coastal waters, the leatherback is mainly pelagic, and is capable of traveling great distances between nesting and foraging grounds. Preferred feeding habitats are pelagic, temperate zone waters that support large populations of jellyfish, the leatherback's main prey item. Preferred nesting habitats are tropical mainland shores with a steep beach profile and deep water close to shore.

5.3.3 Behavior

As a consequence of their pelagic nature, little is known about leatherback behavior. Like other sea turtles, they are not highly social and are solitary, nocturnal nesters. In contrast to other species, which are benthic feeders, leatherbacks feed in the water column. They are capable of dives in excess of 3,000 feet (1,000 m) to reach food.

5.3.4 Food Habits

Jellyfish and other coelenterates are the major food item for leatherbacks and they have several adaptations for this highly specialized diet, such as a highly expandable oral cavity, scissor-like jaws and an esophagus lined with stiff spines that project backward to aid in holding and swallowing prey. Jellyfish are a low energy source and large quantities must be consumed to maintain this large turtle. The leatherback will move vertically through the water column in search of concentrations of jellyfish. Pritchard (1979) reported that young leatherbacks in captivity consumed twice their weight in jellyfish daily.

5.3.5 Nesting

Leatherback nesting is almost exclusively tropical. The largest nesting colonies are found in New Guinea, Indonesia, Central America, northeastern South America, and the southern Pacific coast of Mexico. Some nesting occurs outside the tropics, notably in South Africa and Florida. Florida records 38-188 leatherback nests annually. Leatherbacks nest every 2 or 3 years, with as many as ten nestings per season, and an internesting interval of about 10 days. Leatherback eggs are large, about 2.5 inches (6 cm) in diameter. Florida clutch size is from 60-90 eggs and includes a variable number of undersized yolkless eggs, typical of only leatherbacks. Incubation time is about 65 days, and hatching success from undisturbed nests is typically high (Pritchard, 1979).

5.3.6 Numerical Abundance

Estimates for total world population of nesting female leatherbacks range from 70,000 (Mrosovsky, 1983) to 115,000 (Pritchard, 1982). Fretey and Girondot (1990) report that previous estimates of about 15,000 nesting females from the French Guiana nesting colony may be an underestimate. The National Research Council (1990) concluded that although data are scarce, leatherback populations world wide appear to be stable.

5.3.7 Mortality Factors and Diseases

Like green turtles and in contrast to loggerhead nests, leatherback nests are resistant to predators because of the depth of the egg cavity, but the steep, high energy beaches they favor for nesting are very prone to storm erosion. The pelagic nature of the leatherback insulates it from many human caused sources of mortality like trawling, dredging, and boat collisions, but the leatherback is vulnerable to plastic ingestion, particularly polyethylene bags, which they mistake for jellyfish. Despite a widespread belief that leatherback meat is inedible, harvest of nesting females is common in Guyana, Trinidad, and Columbia. No specific disease pathogens are reported for leatherbacks.

5.4 Hawksbill Sea Turtle (Eretmochelys imbricata)

5.4.1 Description

The hawksbill (Eretmochelys imbricata) is characterized by thick, overlapping carapace scutes with bold streaks of brown and black on an amber background. The head is narrow, with a tapering, curved, "hawk's bill." The hawksbill is a relatively small sea turtle, with nesting females averaging 32 inches (81 cm) in carapace length. Witzell (1983) provides a synopsis of biological data on the hawksbill.

5.4.2 Distribution

Hawksbills are circumtropical in distribution, almost always in close association with coral reef habitats. Hawksbills are more sedentary than other species as adults, and in contrast to loggerheads, hawksbills do not disperse as hatchlings into the north Atlantic gyre (Witzell, 1983). Hawksbills nest on tropical islands and mainland shores of the tropics worldwide. Typical nesting beaches are low-energy narrow beaches often with vegetation growing almost to the water's edge. Nesting in the continental U.S. is extremely rare.

5.4.3 Behavior

Hawksbills maintain a foraging territory that shifts with age, moving to deeper water as the animal matures. The hawksbill is a benthic forager in shallow water out to 300 feet (100 m) (Meylan, 1989).

5.4.4 Food Habits

Although a wide variety of food items have been documented in feeding studies (Wiztell, 1983), hawksbills exhibit specialized feeding on a few genera of siliceous sponges. The sharp silicate spicules of this sponge are tolerated by the digestive system of the hawksbill (Meylan, 1988).

5.4.5 Numerical Abundance

Due to their remote, dispersed nesting habitats, no reliable population estimates exist for the hawksbill. Nesting surveys in Surinam over 15 years show a positive trend in increasing population size, but the sample size is very small (National Research Council, 1990).

5.4.6 Mortality Factors and Disease

The mortality factors discussed in section 5.1.7 on loggerheads also apply to the hawksbill. Because of their association with reef habitat where trawling is impractical, hawksbills are not often taken in shrimp trawls. The major threat to hawksbill populations is directed take for tortoise shell products and stuffed specimens. Between 1970 and 1986, an estimated 250,000 Caribbean hawksbill shells were imported by Japan alone (Donnelly, 1989). Local harvest and sales are harder to quantify than international trade, but there is little doubt the total take is a clear threat to the species survival.

5.5 Kemp's Ridley (Lepidochelys kempi)

5.5.1 Description

The Kemp's ridley (Lepidochelys kempi) is distinguished by an olive green carapace, often wider than long, with five pairs of costal scutes and five vertebral scutes. Adults measure 25 inches (62.70 cm) in average carapace length and weigh 77-100 pounds (35-45 kg). Pritchard (1979) gives a complete description and life history of the Kemp's ridley.

5.5.2 Distribution

Kemp's ridleys are largely confined to the Gulf of Mexico, with a few occurring along the U.S. eastern seaboard as far north as Long Island Sound. Within the Gulf of Mexico, juveniles are far more common in the northern Gulf, particularly in coastal waters from Texas to Florida. Foraging habitats for juveniles and adults are the coastal waters of the Gulf of Mexico, where they feed on a wide variety of crustacea and other invertebrates. Nesting habitat is almost exclusively confined to a single beach at Rancho Nuevo, Mexico at about latitude 23° North in the state of Tamaulipas.

5.5.3 Behavior

Kemp's ridley turtles show a high degree of social behavior. They aggregate offshore of the nesting beaches, sometimes for days, and then all emerge synchronously in an "arribada" to nest (i.e. group nesting), usually during daylight. In other behavioral aspects, they are similar to the loggerhead.

5.5.4 Food Habits

Kemp's ridleys consume a variety of prey, but their diet is dominated by the blue crab. The types of items found in the stomachs of stranded specimens suggest they may commonly feed on the unwanted fish and crabs dumped overboard by shrimp trawlers (Shoop and Ruckdeschel, 1982).

5.5.5 Numerical Abundance

Since the Kemp's ridley has a restricted distribution and, for the most part, nests on a single beach, population estimates are more accurate than for other species. Estimates of the total population of nesting females range from 350-620 (National Research Council, 1990). Based on a motion picture from 1947, in which an estimated 40,000 females nested in a single day at Rancho Nuevo, the current population is perhaps 1% of what it was less than 50 years ago.

5.5.6 Mortality Factors and Disease

Mortality factors affecting nests and hatchlings for the Kemp's ridley are similar to those discussed for the loggerhead in section 5.1.7. Human induced mortality factors for adult and juvenile Kemp's ridley's are also similar to those for the loggerhead. Shrimp trawling has been conclusively shown to be the most important threat to the survival of the Kemp's ridley (National Research Council, 1990). The small population and restricted distribution of the Kemp's ridley make it particularly vulnerable to catastrophic population declines, and shrimping effort is very heavy throughout its range. There are no specific pathogens reported for the Kemp's ridley, although bacterial and fungal infection are a major cause of egg mortality in the closely related olive ridley.

6.0 SEA TURTLE CONSERVATION ACTIVITIES

6.1 Sea Turtle Capture Program

The intake structures and velocity caps for St. Lucie Units 1 and 2, located in the nearshore waters of the Atlantic Ocean, serve as an artificial reef, since the structures are the only significant physical feature in this local environment. Five species of sea turtles inhabit this area for all or part of the year. The turtles encounter these structures in their normal ranging activities and feed on the organisms growing on the structure or seek the structures for shelter. Once a turtle passes the vertical plane of the velocity cap, it is swept into the intake pipeline by water being used for cooling by the St. Lucie Plant and, after a 3-5 minute ride through the pipeline, the turtle emerges in the intake canal and cannot escape on its own. This is called entrapment.

Loggerhead turtles were encountered as soon as Unit 1 became operational in 1977. Biological consultants performing monitoring work at the plant immediately began a capture program for turtles in the intake canal.

From its inception in 1977, the program has used large-mesh tangle nets that are rectangular in shape to capture turtles. These type of tangle nets have been used to capture turtles since the 1800's. The net is deployed into the water column and the turtles, in their free-ranging activities, swim into the net and become entangled. The turtles are removed by personnel monitoring the nets.

To facilitate the capture of entrapped turtles and to minimize turtles from moving down the canal system towards the plant, a large-mesh barrier net was erected in 1978. The rationale for the 8 inch (20.3 cm) mesh size of this barrier net was based on the size frequency of 140 turtles captured in the intake canal before March 1978. This mesh size would exclude 95% of the turtles encountered.

Since 1993, FPL has documented a significant increase in numbers of entrapped turtles, with catches exceeding 600 a year.

This increase is principally due to the number of juvenile green turtles encountered and is believed to be indicative of an increase in population of green turtles present in the nearshore waters of the Atlantic Ocean.

With this increase in the number of turtles entrapped in the intake canal since 1991 and the decrease in size of the turtles, a certain percentage of green turtles have been able to penetrate the existing 8 inch (20.3 cm) mesh barrier net and pass down the canal to be impinged on the intake well structures of the plant. In the first six months of 1995, approximately 25% of the turtles captured were removed from the intake wells of the plant.

To enhance the exclusion of turtles from the plant, FPL is proposing to install in 1995 a smaller mesh barrier net in the intake canal. The new net is expected to exclude 100% of turtles in the size range encountered in 1995.

The rationale for the sea turtle capture program at the St. Lucie Plant is to quickly remove entrapped turtles from the intake canal system once they have entered the system. FPL, in conjunction with Applied Biology, Inc, and Quantum Resources, Inc., former and current contractors for sea turtle conservation and monitoring activities, have developed procedures and methods for handling marine turtles entrapped or impinged (Applied Biology, 1993; Quantum, 1994).

Over the program's history, various size nets (length and depth), various floatation devices, differing weighting techniques of the net bottom, and various mesh sizes have been evaluated to achieve the most effective means of capturing turtles with the least amount of harm. Since 1990, personnel have also been able to capture a number of turtles by hand when they are snorkeling or SCUBA diving. This technique is only effective when there is sufficient water visibility to see the turtles, and this occurs only occasionally during the winter months and many times during the summer months when the sea is calm.

An intensive research program to investigate methods to physically or behaviorally exclude turtles from the intake structures was conducted as part of the Environmental Protection

Plan of Unit 2 and concluded that there was no practical method to accomplish this goal (Florida Power & Light, 1985).

6.1.1 Entrapment and Impingement of Turtles

Entrapment occurs when an organism enters a confined area and cannot escape. Therefore, turtles become entrapped when they enter the canal. Impingement occurs when an organism is carried by currents and pinned to a water intake well structure or barrier, and in the case of a power plant, the trash racks and/or the traveling screens system located in the intake wells. In the original evaluation of the environmental impact of St. Lucie Unit 1, turtle entrapment and impingement of turtles were not anticipated (U. S. Atomic Energy Commission, 1974).

The current thinking is that the intake structures and velocity caps serve as an artificial reef, since the structures are the only significant physical feature in this immediate nearshore environment. The turtles encounter these features in their normal ranging activities and feed on the organisms growing on the structures or seek the structures for shelter. Based on the intake velocities of the intake structures, once a turtle passes the vertical plane of a velocity cap, it is quickly swept into the intake pipeline. After a 3-5 minute ride through the pipeline, it emerges in the intake canal (see Sections 4.2.1 and 4.2.2).

The entrapment history of the St. Lucie Plant from 1976 - December 31, 1994 is given in Table 2. All five species of turtles present in the nearshore waters of Florida have been entrapped and total of 3199 turtles have been removed from the intake canal of the St. Lucie Plant. Loggerheads are the dominant turtle in numbers (n = 2394), greens are next (n = 751), followed by Kemp's ridley (n = 24), leatherback (n = 17), and hawksbill last (n = 13).

The entrapment history of the St. Lucie Plant from January 1, 1995 - June 30, 1995 is given in Table 3. A total of 609 turtles of four species have been handled. Greens and loggerheads are the dominant species encountered.

6.1.2 Barrier Nets

6.1.2.1 Past Configuration

To facilitate the capture of entrapped turtles and to minimize the number of turtles moving down the intake canal toward the plant, a large-mesh barrier net (8 inch (20.3 cm) square mesh) was erected at the A1A bridge in 1978 (Figure 2). The net was suspended across the canal and was anchored at the bottom with weights and supported at the top by cables and floats (Figure 7). The net was hung so that it had a 3:1 slope, with the bottom anchors being positioned upstream of the surface floats. This configuration prevents bowing of the net in the center and minimizes the risk of an injured or lethargic turtle from being pinned against the net by currents and drowning. By confining most turtles to the canal area east of the A1A bridge, the net capture of turtles in this part of the canal was enhanced. Any turtle with a carapace width of 11.3 inches (28.7 cm) or greater was excluded from passing through the net and moving down the canal towards the intake structures where it could be impinged.

The rationale for the barrier net to have an 8 inch (20.3 cm) square mesh, or a diagonal measure of 11.3 inches (28.7 cm), was based on the size frequency distribution of 140 turtles captured in the intake canal before March 1978. The 8 inch (20.3 cm) square mesh was chosen to exclude 95% of the turtles captured before that date (Figure 8).

The net has been rehung several times (e.g 1985, 1988, 1990) to maintain its 3:1 slope and to close gaps between the canal bottom and the canal sides. Because of the deterioration of this net over time, a new net with the same 8 inch (20.3 cm) mesh was installed in 1987.

6.1.2.2 Present Configuration

The barrier net presently in place was installed in 1987 according to the specifications given in Section 6.1.2.1 and has an 8 inch (20.3 cm) square mesh configuration (Figure 7). In 1990, the net head cable attached to the top of the net was given more

support by attaching a series of floatation rafts, which would keep the top of the net at or above the surface of the water under varying water levels. This configuration keeps turtles from swimming over the top of the net. Water level can change as a result of tides or operations of the generating units (e.g. if a unit is not operating, the water level in the canal rises about 4 feet (1.2 m)).

The net is inspected, approximately quarterly, to ensure its integrity throughout the water column, its sides, and its bottom. Repairs are made as necessary and if the foot of the net is buried by a build up of sediment, the material is removed.

6.1.2.3 Future Configuration

The entrapment rate for greens and loggerheads has increased in 1993 and 1994 (Quantum, 1994), and this trend is continuing in 1995 (see Figures 9 and 10). Due to unexpected increases in impingement rates and subsequent mortality at the intake wells of the plant (see Table 4), FPL is proposing to install a smaller mesh barrier net east of the present barrier net (see Figure 2). Due to potential fouling situations from jellyfish or seaweed, the top of the net will have the capability of being quickly released so that it can drop to the bottom of the canal. The mesh of this net will be 5 inches (12.7 cm) square, or a diagonal measurement of 7 inches (18 cm). According to a size frequency distribution of 414 green turtles entrapped in the intake canal during 1995, 100% of all turtles encountered should be excluded from moving down the canal towards the plant (Figure 12). The net will be inspected on a quarterly basis to ensure its integrity and to provide necessary cleaning and maintenance as required. Maintaining the integrity of the net will ensure that no turtles pass this barrier and, therefore, the numbers of sea turtles impinged on the intake well structures should approach zero.

Plans call for the present 8 inch (20.3 cm) mesh barrier net to be maintained in its existing place to serve as a back up in case there is a failure of the 5 inch (12.7 cm) mesh net or if the

5 inch (12.7 cm) net needs to be temporarily removed because of fouling from jellyfish, seaweed or flotsam.

6.1.3 Underwater Intrusion Detection System

In 1986 the underwater intrusion detection system (UIDS) was installed to prevent human entry to the plant via the canal system and to provide further security for the plant. This system also provides an additional barrier for turtles that have broached the barrier net at the A1A bridge. The barrier is located on the north-south arm of the canal (Figure 2) and consists of a rigid net with a 9 inch (22.9 cm) mesh (Figure 4). This net is hung at approximately a 0.9:1 slope with the bottom of the net downstream of the top. This net is inspected on an periodic basis by security personnel and several turtles, both live and dead, have been removed from this area in 1994 and 1995.

6.1.4. Intake Well Inspection and Removal

In December 1994 and to date in 1995, FPL has provided for the inspection of the intake wells at least once every three hours over a 24 hour period. This increase in surveillance was necessitated due to increased turtle presence and mortality in this area (Table 4).

Plant personnel, security personnel, and sea turtle biologists inspect the wells for any turtles that may be impinged or swimming in this area (Figure 5). Any plant or security personnel who see a turtle are instructed to notify a turtle biologist through a beeper system; the biologist responds within an hour. A sea turtle biologist then captures the turtle with a long-handle dip net and places it in a padded holding box for transport.

6.1.5 Netting Program

Sea turtles are removed from the intake canal by means of large-mesh entanglement nets fished between the intake headwall and the barrier net located at the A1A bridge (Figure 2). From 1976 through the present, this netting program has been constantly evaluated and continuously improved to minimize trauma to turtles and to maximize capture efficiency. Nets presently used are from 100-120 feet (30-37 m) long, 9-12 feet (2.7-3.7 m) deep, and composed of 16 inch (41 cm) stretch-mesh multifilament nylon. Large floats are attached to the top of the net to provide buoyancy and the bottom of the net is unweighted. Prior to April 1990, turtle nets were deployed on Monday mornings and retrieved on Friday afternoons. During periods of deployment, the nets were inspected for captures at least twice each day (e.g. mornings and afternoons). Additionally, plant personnel and security personnel checked the net periodically and biologists were notified if a capture had occurred. Sea turtle biologists were also on call 24 hours per day to retrieve turtles.

Beginning in April 1990, after consultation with NMFS, net deployment was scaled back to daylight hours only. Concurrently, surveillance of the intake canal and the nets was increased, with nets being continuously monitored by sea turtle biologists. This measure decreased response time for removal of entangled turtles from the nets and decreased mortalities from accidental drowning (Figure 13). The presence of a biologist also provided a daily assessment of turtle numbers in the canal and an indication as to when the turtle was first sighted. Biologists were then able to estimate the residence time, which is the number of days from the first observation to capture and release.

6.1.6 Hand Capture and Dip Netting

In addition to the use of tangle nets to capture turtles, dip nets and hand captures by snorkel and SCUBA divers are used (Table 4). Long-handle dip nets used from small boats and from the canal banks and headwalls are moderately effective in capturing turtles with carapace length of 12 inches (30.5 cm) or less. Hand nets have also been used to dip dead and floating small green turtles from various areas in the canal system and this fact accounts for the large mortality associated with this recovery system (Table 4).

Under good water visibility conditions, divers have proven to be very effective in capturing turtles of all sizes, particularly inactive turtles partially buried in the sediment in the vicinity of the barrier net or sleeping individuals throughout the canal. These hand captures have had a significant impact in reducing residence times for turtles in the canal (see Section 6.1.7).

6.1.7 Residence Time

Netting methodologies have been under continual review and refinement as net materials, configuration and placement have been varied in an effort to minimize sea turtle entrapment times. For the period for which residence time data are available (July 1 - December 31, 1994), about 76% of the turtles entering the canal were caught within 24 hours of first sighting (Quantum, 1994). Because of differences in size, loggerheads typically reside in the canal for shorter periods than the smaller green turtles.

In the July - December, 1994 period, 100% of all loggerheads were captured within one week of first sighting, with a mean residence time of 1.5 days. Over that same period, green turtles, which were smaller and less easily entangled in the large mesh nets, had a mean residence time of 2.0 days. For the green turtles, 96.9% were captured within one week of first sighting. Better utilization of currents and eddies, adjustments to tethering lines, multi-net deployment and increased efforts to hand capture turtles have contributed to reduced residence time during recent years (Quantum, 1994).

Residence times may be extended for turtles slipping past the A1A barrier net (Applied Biology, 1987). Because capture efforts west of the A1A barrier net were less effective than east of the barrier, most turtles that breach the barrier net were not caught until they entered the intake wells of Unit 1 or 2. Because of their relatively small size, virtually all of the turtles reaching the intake wells are green turtles. During 1994, 49 of the 194 green captures (25.2%) occurred at the intake wells (Quantum, 1994) and during the first six month of 1995, 23% (95 out of 414) of the captures occurred at the intake wells (Table 4).

During 1994, 84.2% of all turtles entrapped in the canal were captured east of the A1A barrier net, 253 by tangle net and 51 by hand or dip net capture. The effective confinement of most turtles east of the barrier net has been a major contributor to the high capture efficiency achieved during 1994 (Quantum, 1994).

6.1.8 Tagging and Health Assessment Activities

Regardless of capture method, all turtles removed from the St. Lucie Plant intake canal system are identified to species, measured, weighed, tagged, and examined for overall health and condition (wounds, abnormalities, parasites, missing appendages). Healthy turtles are released into the ocean north or south of the intake structure on the day of capture. See Section 6.1.9 for a discussion on rehabilitation of sick or injured turtles.

Beginning July 1, 1994, all turtles captured are photographed dorsally and ventrally prior to release, and the photographs retained for future reference. Tags supplied by the NMFS are applied to the proximal edge of the foreflipper; a monel or stainless-steel cattle ear tag is applied to one flipper and a rototag is applied to the other flipper. The tag numbers, the species, and morphometrics of each turtle are reported on a monthly basis to the Florida Department of Environmental Protection (DEP).

If a turtle has been previously tagged either at the St. Lucie facility or elsewhere, this is noted in the monthly data sheet and reported. These data are forwarded by DEP to the NMFS for inclusion in their data base. Over the period of turtle entrapment at the St. Lucie Plant (1976 - 1994), 177 recaptures (150 loggerhead and 27 green turtles) have occurred and a number of turtles have been recaptured more than once (Quantum, 1994). One loggerhead, in particular, has been recaptured 11 times. 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.

6.1.9 Necropsy and Rehabilitation Activities

If a turtle had recently died and conditions warrant, resuscitation techniques were used. Beginning in 1982, necropsies

were conducted on dead turtles found in fresh conditions; three necropsies were performed in 1994 by DEP personnel. Lethargic or slightly injured turtles are treated and occasionally held for observation prior to release; if further treatment is warranted, the DEP is notified and a decision is made as to which facility would provide additional veterinarian treatment.

6.2 Sea Turtle Nesting Programs

6.2.1 Jurisdiction of Fish and Wildlife Service/Department of Environmental Protection

The FWS has jurisdiction over all species of nesting sea turtles and their hatchlings and FPL has been conducting nesting studies as part of the St. Lucie Unit 1 and Unit 2 reporting requirements. In addition, FWS and DEP have started a long-term nesting index survey, and the data generated by FPL since 1971 are an integral part of this program.

6.2.2 Description of Program

FPL has been conducting sea turtle nesting programs on south Hutchinson Island since 1971 and reports have been summarized on a yearly basis (Applied Biology, 1976-1993; Quantum, 1994). Methodologies used during the 1994 nesting surveys on Hutchinson Island are described in the Annual Operating Report for St. Lucie Unit 2 (Quantum, 1994). Up through 1986, the turtle nesting program was a requirement of the Environmental Protection Plan of St. Lucie Unit 2, but after that date, FPL elected to voluntarily continue the nesting monitoring program through the present.

For the 1994 nesting season, nest surveys were conducted on a daily basis from April 15 - September 15. Biologists used small offroad motorcycles to survey the island early in the morning, generally completing the survey before 10 AM. New nests, non-nesting emergences (false crawls), and nests destroyed by predators are recorded for each of the 0.62 mile (1 km) survey areas (Figure 15). The 0.78 mile (1.25 km) long surveys established in earlier

studies were also monitored so comparisons could be made with previous studies.

The only significant change in nesting survey methods from previous years was that, beginning July 1, 1994 only areas A-S were surveyed by Quantum Resources biologists (Figure 14). Areas T-JJ were surveyed by biologist from Ecological Associates and these data are combined to provide 1994 whole island nesting totals.

6.3 Sea Turtle Stranding Program

In cooperation with DEP, Quantum Resource personnel are also on call 24 hours a day to handle live or dead turtle strandings (e.g. turtles that have washed up on the beach) on south Hutchinson Island or elsewhere, upon request. Standard data sheets are used, which record the date, location, species, size, condition of the turtle, injuries, and cause of death, if possible. These data are routinely provided to the DEP and NMFS through the Sea Turtle Stranding and Salvage Network.

If the turtle is severely decomposed, it is buried on the beach. If it is a small green, the carcass might be salvaged for further examination. If the turtle is alive, it is taken to the nearest rehabilitation center for medical treatment.

6.4 Turtle Walk Program

As a public service, FPL has been conducting turtle walk programs for the public to view nesting loggerhead sea turtles on the beaches of the St. Lucie Plant since 1982. The walks are conducted by permitted FPL and Quantum Resources personnel during the summer months of June and July when loggerhead nesting is at a peak. An orientation program is provided before the walk begins and this educates the participant (up to 50 people per walk) about sea turtle biology and conservation issues. A scout on a small offroad motorcycle runs the beach looking for a nesting turtle and radios the guide that it is appropriate to bring the participants on the beach and to observe the turtle nesting. In the summer of 1995, three walks per week were conducted over the 9 weeks of peak nesting. These walks have grown in popularity and attendance as shown in Table 5.

6.5 Assistance to Other Organizations

6.5.1 Description of Assistance

FPL, through its contractors Applied Biology, Inc. and Quantum Resources, Inc., provided assistance to a variety of federal, state, local, private and academic institutions on sea turtle issues. This assistance has consisted of such activities as: providing turtles affected with fibropapillomas to research centers for study and treatment; tagging turtles for capture and release programs; providing information on tag returns; providing adult and hatchling turtles for research purposes; providing tissue samples and blood for analysis; providing data on turtle abundance and nesting activities.

6.5.2 List of Organizations Assisted

Since the program began in 1976, data, specimens, and/or assistance have been given to the Florida Department of Environmental Protection, National Marine Fisheries Service, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Smithsonian Institution, South Carolina Wildlife and Marine Resources Division, the Archie Carr Center for Sea Turtle Research at the 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 Fisheries Management Council, Florida Marine Fisheries Commission, Harbor Branch Oceanographic Institution and the National Research Council.

7.0 ASSESSMENT OF PRESENT OPERATIONS

7.1 Direct and Indirect Impacts of the Continued Operation of the Circulating Water System of the St. Lucie Nuclear Generating Station on Sea Turtle Populations

7.1.1 Impacts Due to Entrapment and Entanglement Nets in the Canal System

Potential direct effects of entrapment and entanglement net capture in the canal system include: drowning in the intake pipes, injuries sustained in the pipes and the canal, injuries sustain during canal dredging (hydraulic and clam shell), loss of condition due to long entrapment, exposure to predators in the intake canal, injuries and stress sustained during capture, and drowning in fish gill nets and turtle capture nets. Potential indirect effects include: interruption of migration, loss of nesting opportunities for adult females, and loss of mating opportunities for adult males and females. Table 6 presents the numbers of mortalities and probable cause of death of sea turtles, by species, through the 1976 - June 30, 1995 operating history of the St. Lucie Plant. It is divided into the periods 1976 - 1990 when the capture nets were deployed but not tended continuously and 1990 - June 30, 1995, when the nets were deployed and continuously tended.

During conditions of low flow rates in the intake pipes, drowning in the intake pipes was identified as a probable mortality factor (Applied Biology, 1987). Low flow conditions were virtually eliminated when St. Lucie Unit 2 was brought on line in August, 1983, and transit times through the intake pipes (3-5 minutes) are such that drowning in the intake pipes is unlikely. Since Unit 2 started operation, no dead individuals have been recovered from the intake canal that are indicative of this type of mortality.

A small number of turtles captured show recent superficial scrapes, usually to the anterior carapace or plastron, which may be due to contact with encrusting organisms in the pipeline. In the last year of operation (July 1, 1994 - June 30, 1995), 14 of 361 turtles captured had significant injuries, most of which were old

and well healed (Quantum, 1994). One loggerhead was captured in 1994 with a fresh penetrating crack in the carapace. It is not known whether this injury was sustained in the intake pipes or before entrapment, possibly by boat collision.

Due to long residence times in the canal some turtles lack appropriate food and loose body weight. This loss of condition was identified by Bellmund et al. (1982) as a concern, but they concluded that residence times averaging 44 days had little detrimental effects on turtles. In 1994, residence times, calculated from visual observations, were estimated at 1.5 days for loggerheads and 2.0 days for green turtles and 100% of all loggerheads and 97% of all green turtles were captured within one week of first sighting (Quantum, 1994).

Bellmund et al. (1982) concluded that predation in the intake canal was not a significant mortality factor. Informal visual census of fish populations in the canal in recent years (1993-1995) reveal five to ten large (220+ pounds (100+ kg)) jewfish, not considered before in previous analysis, which may present a significant hazard to smaller turtles, especially greens. Other possible predators include numbers of great barracuda and occasionally blacktip and spinner sharks. There is no way to quantify the extent of this predation by fish species, but it does occur at a low level.

Injuries sustained during capture have all been superficial. Typically they involve small cuts from net strands and minor abrasions sustained during handling. None have ever required veterinary attention or rehabilitation. Stress is difficult to quantify, but efforts are made to minimize handling time (generally under one half hour to obtain biological information and to tag the animal) and to keep turtles shaded and cool prior to release.

Drowning in capture nets has occurred occasionally throughout the history of the St. Lucie Plant's capture program during the period 1976 - June 30, 1995. Since the program began 7 loggerheads (7 mortalities out of 2583 captures or 0.3%), 13 green turtles (13 mortalities out of 1165 captures or 1.1%), and 1 Kemp's ridley (1 mortality out of 29 captures or 3.5%) drowned in capture nets

(Tables 2, 3 and 6). Leatherback and hawksbill had no incidents of drowning.

Turtles can drown when they become tightly entangled, when the net becomes fouled on the bottom, or when a small turtle becomes tangled with a large turtle and is held underwater. Since April 1990, when the nets have been constantly tended during daylight hours, there have been zero loggerheads and 3 greens drowned in capture nets (Table 6).

Of the indirect effects, interruption of migration is the most difficult to evaluate, since the migratory habits at the life stages of the various species are poorly understood. As long as entrapment times in the canal are held to a minimum, no significant impact is expected.

Loss of nesting opportunities for adult females may be expected when entrapment time during nesting season exceeds the internesting interval. There have been several instances of turtles emerging from the canal and nesting on the canal bank. In at least one case, the nest was not discovered and hatchlings entered the canal, where most were killed because they were carried by currents to the plant (B. Peery, pers. comm., 1995). However, by minimizing residence time for adult turtles in the canal, this factor can be controlled.

Loss of mating opportunities can occur when an adult is trapped in the canal without access to the opposite sex in the mating season. The duration of the mating seasons for the various species is prior to the onset of nesting. Thus, by minimizing residence time in the canal, this factor can also be controlled.

Based on capture data, approximately 95% of turtles are in good relative condition based on weight, activity, parasite infestation, barnacle coverage, wounds, injuries and other abnormality (e.g. loss of an appendage) which might affect overall vitality. However the other 5% of the turtle population from the canal are in poor condition and probably entered the canal in that condition (Quantum, 1994). Some of the mortalities reported as unknown floating (Table 6) are put into this category because a cause of death could not be determined. However, the turtles condition is very poor based on visual observation (e.g the animal is underweight, is barnacle coverage, and lacks muscle tone).

7.1.1.1 Impacts to Loggerhead Turtles

Tables 2 and 3 show the total captures and total mortalities for loggerheads throughout the history of the canal capture operation. Figure 15 shows the decreasing mortality for loggerheads expressed as a percentage of captures, reflecting improvements in materials and methods employed in the canal capture program. Since the evaluation of low-flow conditions in 1984, and since the deployment of an effective barrier net in 1987, drowning in barrier net and unknown causes are the only significant identifiable sources of entrapment related mortalities for loggerheads (Table 6).

Injuries sustained by loggerheads in transit through the intake pipes and in the canal are minor and do not significantly impact loggerheads. In the period 1976 - 1990, there were 7 mortalities associated with hydraulic and clam shell dredging in the canal and 2 mortalities associated with fish gill netting required for a separate biological monitoring program (Table 6). The fish gill netting program has been discontinued so this will no longer be a source of mortality. With the recent hydraulic dredging of the intake canal in 1994 and the use of a temporary 4 inch (10.2 cm) barrier net to isolate the dredging area, there was no mortality associated with this program. Thus any future dredging program in the western part of the canal should not be a problem with the installation of the 5 inch (12.7 cm) net being planned by FPL.

Because of their size (subadult or adult), predation risk is also considered insignificant. Injury and stress during capture is also likely insignificant because of the effort to minimize handling time. Effects on the interruption of migration are unknown, but are minimized by the short residence times typical for loggerheads. Since 1983, an average of 25 adult female loggerheads per year have been captured in the canal. Their typically short residence times (mean residence time of 1.5 days; Section 6.1.7) renders loss of nesting and mating opportunities insignificant.

Current permit conditions call for increased capture effort to be employed whenever an adult turtle remains in the canal longer than 7 days. Under these conditions, nets are deployed 7 days a week up to 12 hours a day to minimize residence time for these adult animals.

No significant impact to loggerhead turtle populations is expected from the continued operation of the St. Lucie Plant.

7.1.1.2 Impact to Green Turtles

Tables 2, 3 and 4 shows the total captures and total mortalities for green turtles throughout the history of the canal capture operation. Figure 16 shows the trend in green turtle mortality expressed as a percentage of captures.

In contrast to the situation with the loggerhead, the deployment of barrier nets has not been effective in confining all green turtle to the portion of the canal east of A1A. Green turtles smaller than about 11.3 inches (28 cm) in width can pass through the barrier net, which can greatly increase residence times. Residence times for green turtles passing the A1A barrier are unknown and may be significant. Calculated residence times are based only on turtles sighted east of A1A, where observations are sufficiently rigorous. Turtles recovered west of A1A are more often underweight, which may reflect long residence times.

For the first six months in 1995, 95 or 23% of the greens captured in the intake canal passed through the existing 8 inch (20.3 cm) barrier net and were taken at the intake wells (Table 6). Based on this finding, FPL proposed using a smaller mesh net (5 inch or 12.7 cm) to prevent these smaller size turtles from moving down the intake canal towards the plant. Based on the size frequency distribution of 414 green turtles captured in 1995 (Figure 12), 100% of all green turtles should theoretically be prevented from reaching the intake wells.

Exposure to predators may be significantly affecting green turtles. The large jewfish observed in the canal have been documented to feed on small sea turtles (Randall, 1967). There is no way to quantify this predation by jewfish or other large predatory fish in the canal, but it does occur at a low level.

Drowning in capture nets has occurred throughout the history of the program (Section 7.1.1, 13 green turtle mortalities in the period 1976 - June 30, 1995; see Table 6), even after the present system of constantly tended nets was instituted in 1990. Mortality can be expected to continue at low levels.

Loss of nesting and mating opportunities for green turtles is not as significant as for loggerheads, since few adult greens are entrained (10 adults in 18 years). Drowning in the intake pipes, injuries sustained during passage in the intake pipes or from the capture program, and interruption of migration do not present significant impacts to green turtles under present operating conditions.

No significant impact to green turtle populations is expected from the continued operation of the St. Lucie Plant.

7.1.1.3 Impacts to Leatherback Turtles

Leatherback captures are infrequent at the St. Lucie Plant, with only 18 captured since monitoring began in 1976 (Tables 2 and 3). No leatherback mortalities have been recorded at the St. Lucie Plant (Tables 2, 3 and 6). Residence times for leatherbacks are extremely short, never more than a few hours from first sighting to capture. The only impacts to individual leatherbacks are injuries sustained in the intake pipes and in the canal, and injuries and stress sustained during capture. Due to their lack of a hard shell and their delicate skin, leatherbacks invariably sustain cuts from the capture nets and from contact with hard surfaces in the canal. All injuries were superficial, and none have required veterinary attention.

No significant impact to leatherback turtle populations is expected from the continued operation of the St. Lucie Plant.

7.1.1.4 Impacts to Hawksbill Turtles

Only 13 hawksbill turtles have been captured at the St. Lucie Plant in the period 1976 - June 30, 1995, and no mortalities have been recorded (Tables 2, 3 and 6).

No significant impact to hawksbill turtle populations is expected from the continued operation of the St. Lucie Plant.

7.1.1.5 Impacts to Kemp's Ridley Turtles

A total of 29 Kemp's ridley turtles have been captured at the St. Lucie Plant since 1976 (Tables 2 and 3), all but one of which were juveniles or sub-adults. There have been four Kemp's ridley mortalities (Tables 2, 3 and 6). Potential entrapment impacts to Kemp's ridleys include: loss of body condition due to long residence times, exposure to predators and drowning in capture nets. Interruption of migration for this species is unclear, but likely not significant. Loss of mating or nesting opportunities is not considered significant, since adults are extremely uncommon.

Due to their small average size, Kemp's ridleys have often been able to penetrate the barrier nets, contributing to longer residence times. Their small size also subjects them to a higher, but unknown, risk of predation. One Kemp's ridley was found to have drowned in a capture net in 1986. Modifications to capture procedures since then (e.g. the nets do not have lead lines and they are monitored whenever they are fished) have lessened the likelihood of this impact. The Kemp's ridley has the highest overall mortality rate of any species in the canal system at 13.8% (4 mortalities from 29 captures).

With the 5 inch (12.7 cm) mesh barrier net being proposed by FPL, all Kemp's ridleys should be prevented from moving down the canal system towards the plant.

No significant impact to the Kemp's ridley turtle populations is expected from the continued operation of the St. Lucie Plant.

7.1.2 Impacts Due to Impingement on Barrier Nets and the Intake Wells

Impacts due to impingement/entanglement on barrier nets and in the plant's intake wells cannot be easily characterized. Dead turtles in the canal that drift with the current will be recovered at these sites but, except for cases of obvious entanglement in barrier nets or mechanical injuries in the intake wells, the cause of death generally cannot be determined and is classified as unknown (Table 6).

Barrier net designs have improved markedly over the history of the St. Lucie Plant's operation, and have contributed to the overall reduction in mortality since 1990 (Table 6). Increased efforts to hand capture turtles are also effective in capturing sick, injured or otherwise inactive turtles that are at higher risk of impingement.

Mechanical injuries in the intake wells can occur when the rakes used to remove large debris from the intake wells strike or crush a turtle. Careful observation by equipment operators prior to lowering the rake minimizes this source of mortality. With the 5 inch (12.7 cm) mesh barrier net being proposed by FPL, all turtles should be prevented from moving down the canal system towards the plant and being exposed to this type of mechanical injury in the intake wells.

7.1.2.1 Impacts to Loggerhead Turtles

Since barrier net improvements were completed in 1990, one loggerhead has been found entangled in the barrier nets, and six loggerheads have been recovered floating at, but not entangled in, the barrier net (Table 6). No loggerhead has been captured at the intake wells since the barrier net improvements have been completed.

No significant impact to loggerhead turtle populations is expected from the continued operation of the St. Lucie Plant.

7.1.2.2 Impacts to Green Turtles

Small green turtles of carapace width smaller than 11.3 inches (28.7 cm) have been able to penetrate the current barrier net and able to reach the plant's intake wells. Daily checks of the intake wells instituted in January, 1995 are useful in removing turtles from these areas before they become exhausted swimming against the currents and impinged against the trash racks. This procedure has reduced but not eliminated mortalities altogether (Table 4).

Turtles that breach the A1A barrier net and are not strong enough to swim away from the UIDS barrier are impinged. The design of the UIDS barrier (see Sections 4.2.5 and 6.1.3) is such that it is more likely to result in drowning of an impinged turtle than the A1A barrier net. Barrier net improvements scheduled in 1995 should eliminate impingement at the intake wells and at the UIDS barrier.

No impact to green turtle populations is expected from the continued operation of the St. Lucie Plant.

7.1.2.3 Impacts to Leatherback Turtles

No impingement effects to leatherback turtles have been experienced or are expected, and therefore there is no significant impact to leatherback turtle populations from the continued operation of the St. Lucie Plant.

7.1.2.4 Impacts to Hawksbill Turtles

No significant impingement effects to hawksbill turtles have been experienced or are expected, and therefore there is no significant impact to hawksbill turtle populations from the continued operation of the St. Lucie Plant.

7.1.2.5 Impacts to Kemp's Ridley Turtles

Impingement impacts to Kemp's ridley turtles are essentially the same as those discussed above in section 7.1.2.2 for green turtles because of similar sizes. Barrier net improvements scheduled for 1995 will also be effective in reducing the potential for Kemp's ridley impingement mortality.

No significant impact to Kemp's ridley turtle populations is expected from the continued operation of the St. Lucie Plant.

7.2 Other Potential Station Impacts

7.2.1 Thermal Effects

Sea turtle nesting studies conducted since 1971 at the St. Lucie Plant have found no significant effects of the thermal discharge or other aspects of plant operation on sea turtle nesting on Hutchinson Island (Quantum, 1994). A study to assess the impact of thermal discharges on emerging hatchlings swimming near the discharge concluded that the St. Lucie Plant operation does not affect swimming performance (O'Hara, 1980).

No significant thermal impacts to sea turtles are anticipated from continued operation of the St. Lucie Plant.

7.2.2 Chlorination

Chlorination is used to control biofouling in the condenser tubes, heat exchangers, and other auxiliary equipment. In accordance with water-discharge permit requirements, total residual levels in the discharge canal do not exceed 0.1 mg/l. Given that chemical breakdown of sodium hypochlorite in seawater is rapid, and mixing with ambient seawater is thorough at the offshore discharge, chlorination is not anticipated to impact sea turtles. With the operation of the Taprogge cleaning system in both Units (Section 7.2.4), the use of chlorine for condenser cleanliness will be greatly reduced or eliminated.

No significant impacts to sea turtles as a result of chlorination are anticipated from continued operation of the St. Lucie Plant.

7.2.3 Lights

A vegetative light screen and shielding of security lighting is employed to eliminate direct lighting of the beach. The lack of documented hatchling disorientation incidents on company property indicate that these measures are effective. High rates of nesting at the plant site indicates that adult females are not deterred from using the plant site beaches.

No significant impacts to sea turtles on the beach or in the water as a result of plant lighting are anticipated from the continued operation of the St. Lucie Plant.

7.2.4 Taprogge Cleaning System

The Taprogge cleaning system will be installed on Unit 2 in the fall of 1995 and on Unit 1 in the spring of 1996. This system utilizes small sponge balls (approximately 7/8 inch (2.3 cm) in diameter). Some of the balls are abrasively coated. These balls are injected into the condenser inlet and pass through the condenser tubes to keep them free of mineral scale and biological fouling (Figure 6).

The system being installed at the St. Lucie Plant is an upgraded version and the design includes an inlet .20 inch (5 mm) debris filter and a .20 inch (5 mm) ball collection screen on the discharge side of the condenser. The screening system at the condenser outlet recovers the balls so that they can be reused. Because this upgraded system includes an inlet debris screen, it is expected that the outlet screen will not have to be cleaned as frequently as a system with only an outlet ball collection screen. The primary reason for ball loss is when the outlet ball collection screen is opened to flush debris that collects on the collection screen. Earlier versions of the system did not include the inlet debris screens.

The manufacturer, Taprogge America Corp. (pers. comm., 1995) indicated to the applicant, that design ball loss from the system is zero, but ball loss has been documented from other systems in Florida. Many coastal power plants employ similar type of cleaning system.

In that the balls are neutrally buoyant, any balls that escape the collection system in the condenser outlet may escape to the ocean. These sponge balls have been found in fish stomachs and it is possible that sea turtles could also mistake these objects as a food source. It appears, however, that no significant impact from ingestion from these sponge balls have been noted for sea turtles from the east coast of Florida where there is extensive sea turtle activity (DEP, pers. comm., 1995).

No significant impacts to sea turtles are anticipated from continued operation of the St. Lucie Plant using this cleaning system.

7.2.5 Dredging of the intake canal

With the installation of the 5 inch (12.7 cm) barrier net in the intake canal at the St. Lucie Plant, any impact to turtles west of this barrier net due to dredging operations will be minimal because the net should exclude all turtles. Any future dredging activity in the area west of A1A will incorporate the sea turtle monitoring staff at the plant. These personnel will be performing daily visual surveys of the canal between the 5 inch (12.7 cm) barrier net and the intake well structures. Additionally, the operating personnel of the dredge will also be trained to watch for sea turtles, and they will shut down any dredging if a sea turtle is seen in the vicinity of the work.

The installation of the 5 inch (12.7 cm) barrier net east of the A1A bridge in the fall of 1995 will require the relocation of approximately 1,500 to 2,000 cubic yards (1,150 - 1,530 cubic m) of sand. This work is necessary to restore the bottom contour to its original configuration so that the net can be anchored correctly and have no gaps along the bottom. FPL obtained an U. S. Army Corps of Engineers General Permit SAJ-17 #199506056 (GP-TM) to allow this dredging.

On October 25, 1995, FPL sent a letter to NMFS requesting an informal consultation on this permit regarding sea turtles and outlined measures to minimize impacts to sea turtles (Bouska, pers. comm., 1995). On October 26, 1995, the NMFS responded and concluded that the safeguards described in the Bouska letter were adequate and the actions were unlikely to adversely affect threatened or endangered sea turtles under the NMFS purview (Kemmerer, pers. comm., 1995).

Any future dredging east of the 5 inch (27.3 cm) barrier net or at this barrier net will require a separate endangered species consultation with the NMFS.

7.3 Cumulative Impact of the Continued Operation of the Circulating Water System of the St. Lucie Nuclear Generating Station on Sea Turtle Populations

The escalating catch rates for green sea turtles at the St. Lucie Plant experienced in 1994 and 1995 make future catch projections tenuous. Based on capture data from January through June 30, 1995, and factoring in historical data on seasonal patterns in catch rates of the different species, FPL estimates the 1995 total year catch at 400 loggerheads, 850 green turtles, 2 leatherback, 10 Kemp's ridleys, and 1 hawksbill. These catch rates are used in the calculations of anticipated lethal take presented below.

Minimum expected lethal take is calculated by multiplying the 1990 - June 30, 1995 mortality rate (Tables 2 and 3) for each species by the projected catch for that species. This time period was when deployed nets were constantly tended and, thus, the chances for turtle drowning was minimized. For loggerheads, at a mortality rate of 0.83% (7 mortalities out of 842 captures), this yields a minimum expected lethal take of three annually. For green turtles at a mortality rate of 2.6% (23 mortalities out of 879 captures), the minimum expected lethal take is 22 annually. Minimum expected lethal take for leatherbacks, Kemp's ridleys, and hawksbills is zero.

Maximum expected lethal take is calculated by multiplying the 1976 - June 30, 1995 mortality rate (Tables 2 and 3) for each species by the projected catch for that species. This time period was when deployed nets were not constantly tended (i.e. especially during the 1976 - 1990 time period) and, thus, the chances for turtle drowning was maximized. The maximum rate for loggerheads (5.1%; 131 mortalities out of 2583 captures) yields a maximum expected lethal take of 20 annually. The maximum rate for green turtles (3.4%; 40 mortalities out of 1165 captures) yields a maximum expected lethal take of 29 annually. The maximum rate for Kemp's ridley (13.8%; 4 mortalities out of 29 captures) yields a maximum expected lethal take of one annually. Maximum expected lethal takes for leatherbacks and hawksbills are zero, but realistically should be set at one.

In the absence of reliable data on the populations and population trends of sea turtle species, an analysis of the effects of the above levels of take on sea turtle populations is problematical, but take associated with operation of the St. Lucie Plant is unlikely to significantly affect sea turtle populations. The various sub-lethal impacts discussed in section 7 above are also believed to pose no significant impact to sea turtle populations.

7.4 Overall Assessment

The refinements to the sea turtle capture program over its history at the St. Lucie Plant have significantly reduced mortality rates for entrapped sea turtles. With the installation of the 5 inch (12.7 cm) barrier net in the intake canal (Figure 2), the overall impact to sea turtles from entrapment and impingement will be diminished even further.

Stewardship programs being conducted by FPL, such as turtle walks, assistance with DEP index beach nesting surveys, and assistance with the DEP sea turtle standing network, are conservation measures that will help to recover the sea turtle populations of southeastern United States.

It is concluded that the continued operation of the St. Lucie Nuclear Generating Plant will have no significant impact on sea turtle species found in the nearshore waters of Florida.

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REPTILES

Latin Name	Common Name	Status
Caretta caretta	loggerhead turtle	T
Chelonia mydas	green turtle	E*
Dermochelys coriacea	leatherback turtle	E
Eretmochelys imbricata	hawksbill turtle	E
Lepidochelys kempi	Kemp's ridley turtle	E

T = threatened
E = endangered
E* = endangered, Florida population only

Table 1. A list of threatened or endangered species entrapped at the St. Lucie Nuclear Power Plant.

YEAR	Species: 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)
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	1.3 (0.2)	175.9 (9.0)

* Excludes 1976 (partial year of plant operation).

Table 2. Total number of sea turtle captures and number of dead turtles (numbers in parenthesis) removed from the St. Lucie Intake Canal, 1976 - 1994

Month	Loggerhead	Green	Kemp's ridley	Hawksbill	Leatherback	Total
January	28	59 (2)	1		1	89
February	19	64 (3)				83
March	25	83 (4)				108
April	44	64 (2)	2			110
May	39 (1)	92 (1)	2			133
June	34	52				86
Total	189 (1)	414 (12)	5	0	1	609

Table 3. Sea turtles captured from the St. Lucie Plant intake canal for the first 6 months of 1995, tabulated by species and month. Numbers in parenthesis are mortalities.

Method of Capture	Number of Turtles
Capture Nets	263 (1)
* Hand Captures	36 (1)
* Dip Net	20 (4)
Intake Wells	95 (6)
Total	414 (12)

* These capture methods are occasionally employed to recover dead turtles and did not cause the associated mortalities.

Table 4. Green turtle capture summary at the St. Lucie Plant, 1/1/95 - 6/30/95. Numbers in parenthesis are mortalities.

Year	Number of Walks	People Attending
1982	6	245
1983	5	225
1984	8	346
1985	14	684
1986	15	702
1987	13	824
1988	14	801
1989	12	600
1990	14	780
1991	15	789
1992	20	883
1993	21	975
1994	27	1184
1995	27	1030
Total	211	10,068

Table 5. Turtle walks conducted by FPL during the time period 1982 -1995.

YEAR	SPECIES	DROWNING CAPTURE NETS	DROWNING BARRIER NETS	DROWNING GILL NETS	DREDGE INJURY	INTAKE WELL INJURY	UNKNOWN FLOATING	UNKNOWN INTAKE WELLS	UNKNOWN OTHER
1976 through 1989	Loggerhead	7	3	2	7	2	80	15	10
	Green	10				2	6	2	
	Kemp's ridley	1					2	1	
	Leatherback								
	Hawksbill								
1990 through June 30 1995	Loggerhead		1				5		1
	Green	3				3	5	12	
	Kemp's ridley								
	Leatherback								
	Hawksbill								

Table 6. Sea turtle mortalities in the St. Lucie intake canal system tabulated by species and probable cause of death. Data are given for the periods 1976 - 1989 and 1990 - June 30, 1995.

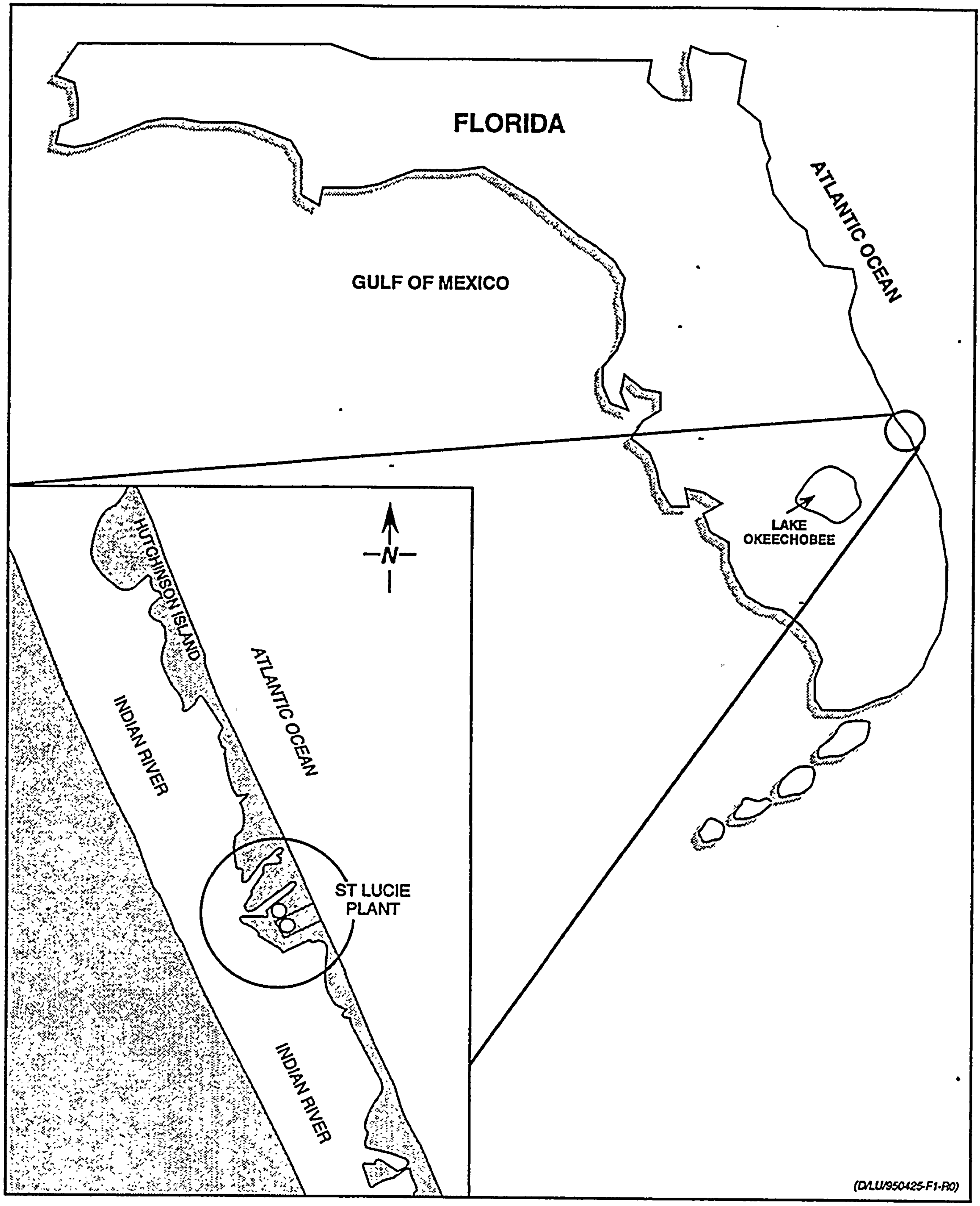

Figure 1. Location of the St. Lucie Plant on the east coast of Florida. The plant is located on South Hutchinson Island, a barrier island, and is about 7 miles (11.3 km) south of Ft. Pierce and about 7 miles (11.3 km) north of Stuart.

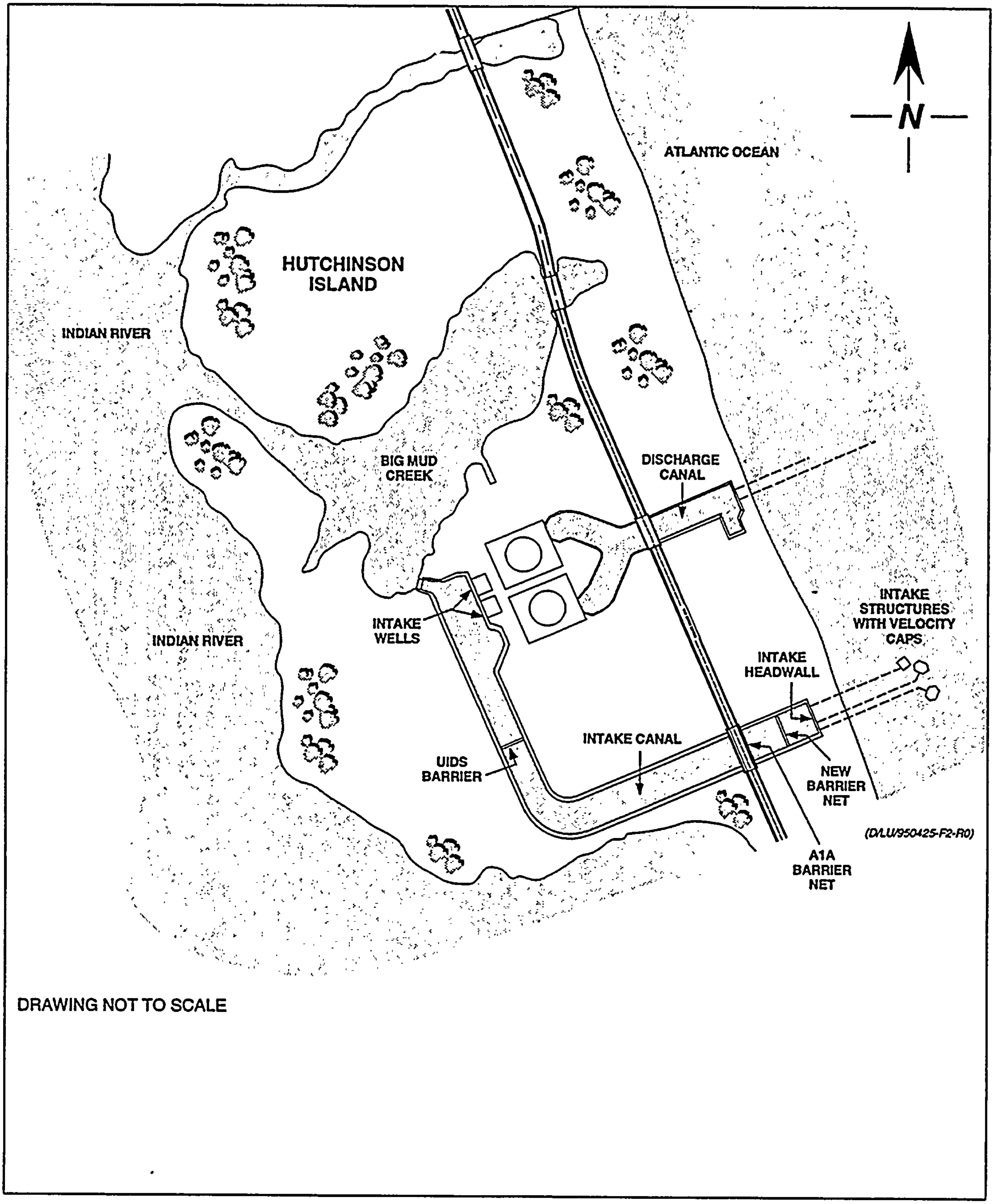

Figure 2. Design of the St. Lucie Plant showing the relationship between Units 1 and 2 and the configuration of the cooling water intake and discharge system with key features labeled.

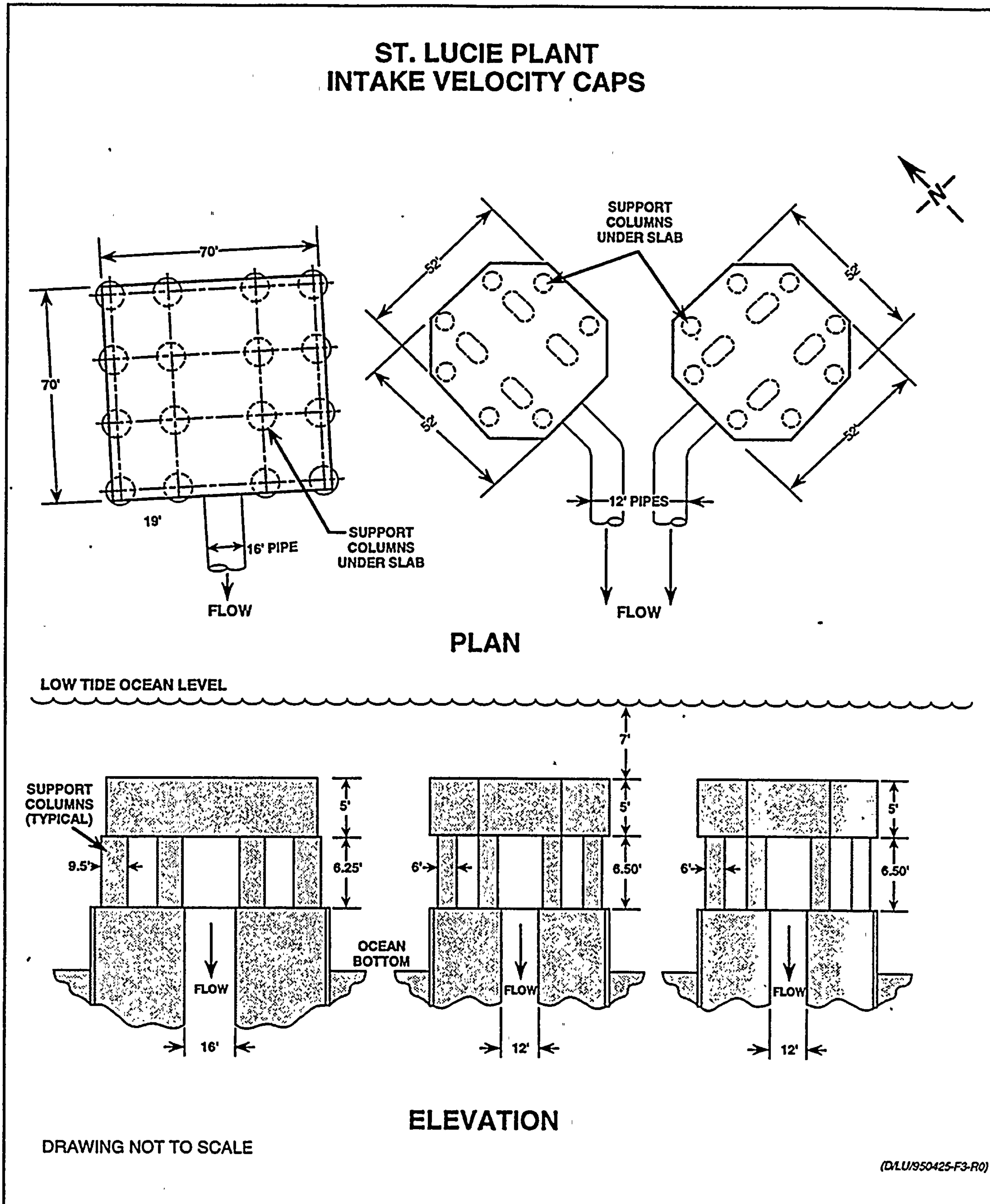

Figure 3. Diagram of the intake structures located 1200 feet (365 m) offshore of the shoreline at the St. Lucie Plant.

ST. LUCIE PLANT UNDERWATER INTRUSION DETECTION SYSTEM (TYPICAL SECTION)

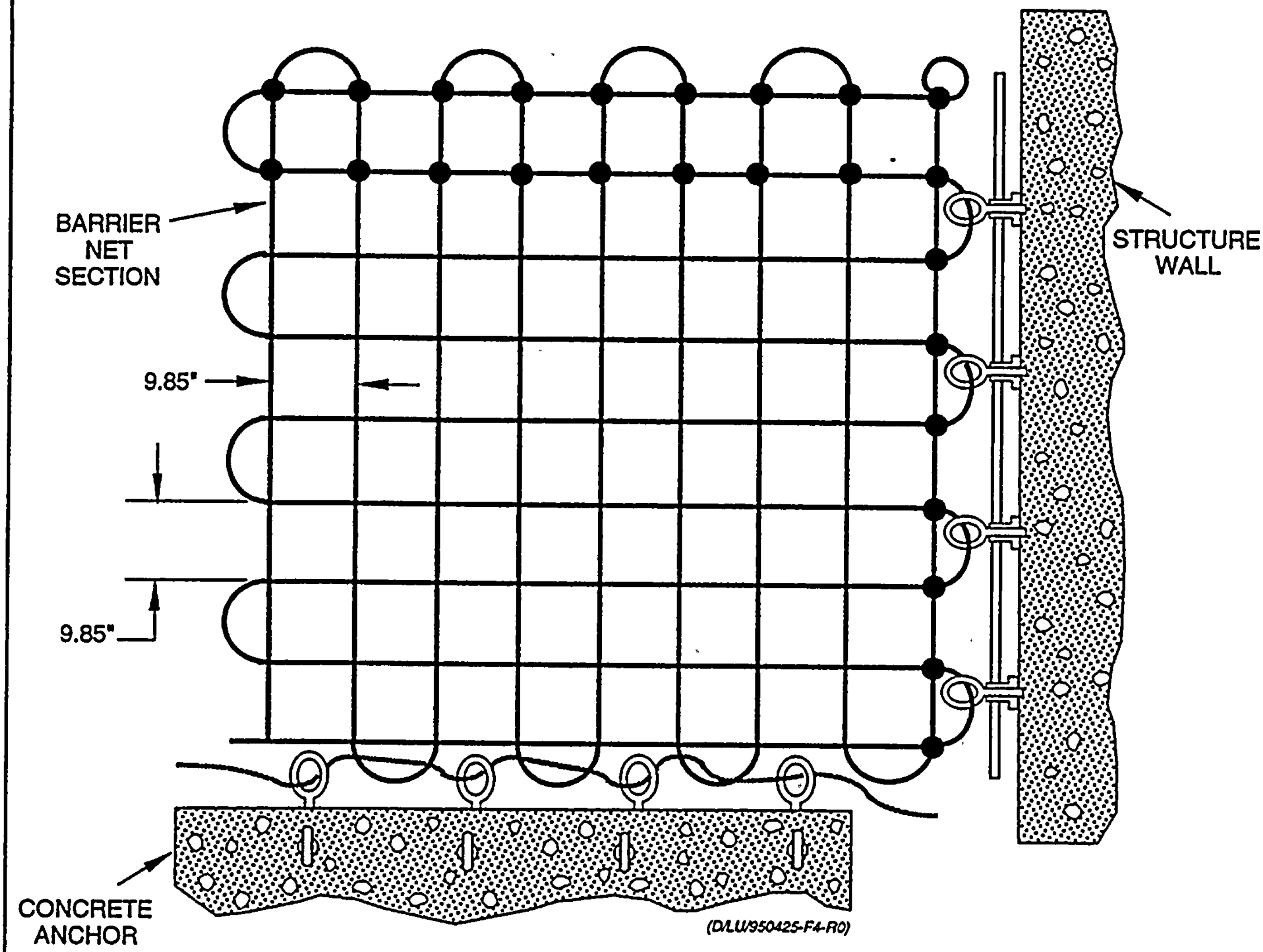

Figure 4. Diagram of the Underwater Intrusion Detection System at the St. Lucie Plant.

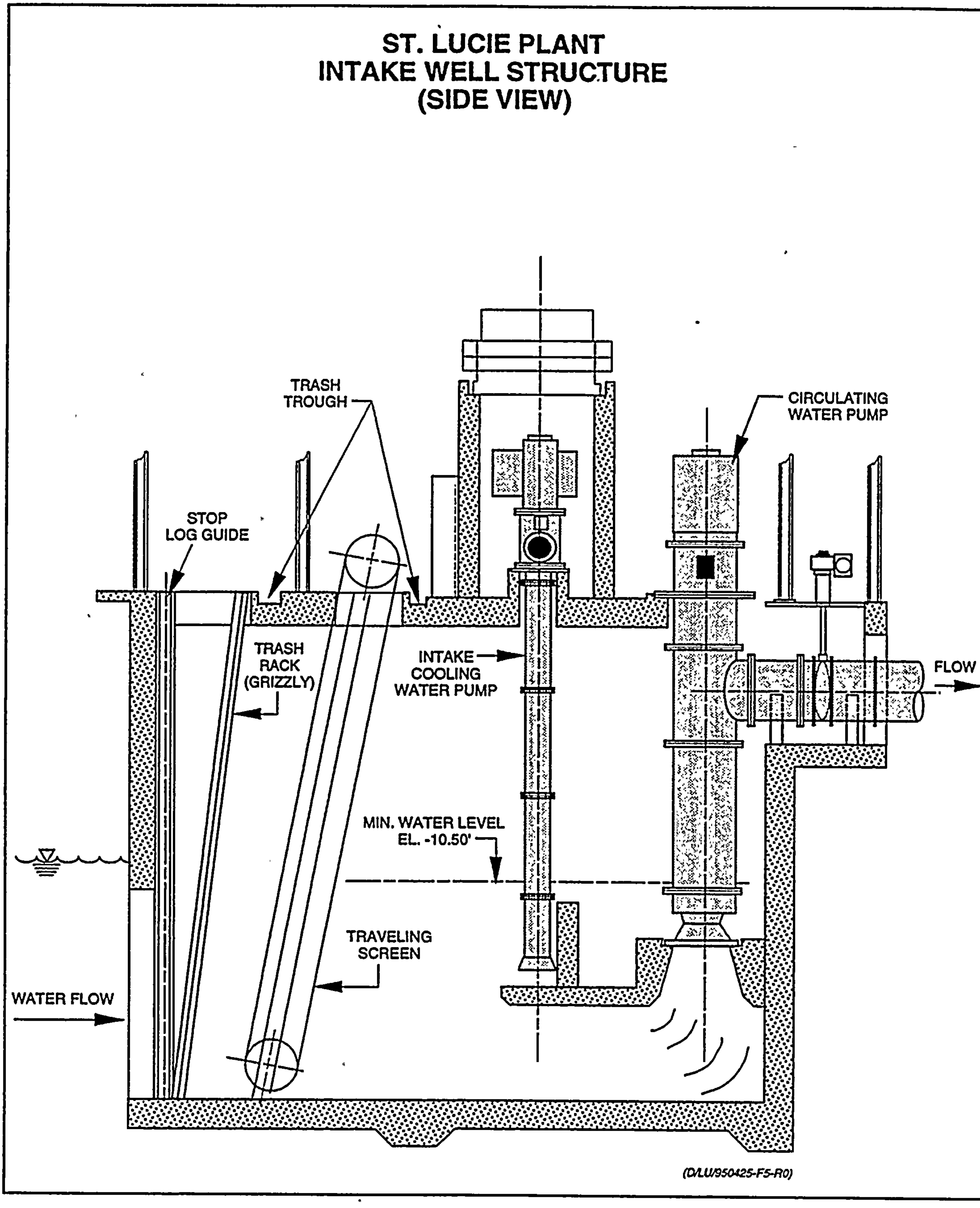

Figure 5. Diagram of an intake well at the St. Lucie Plant.

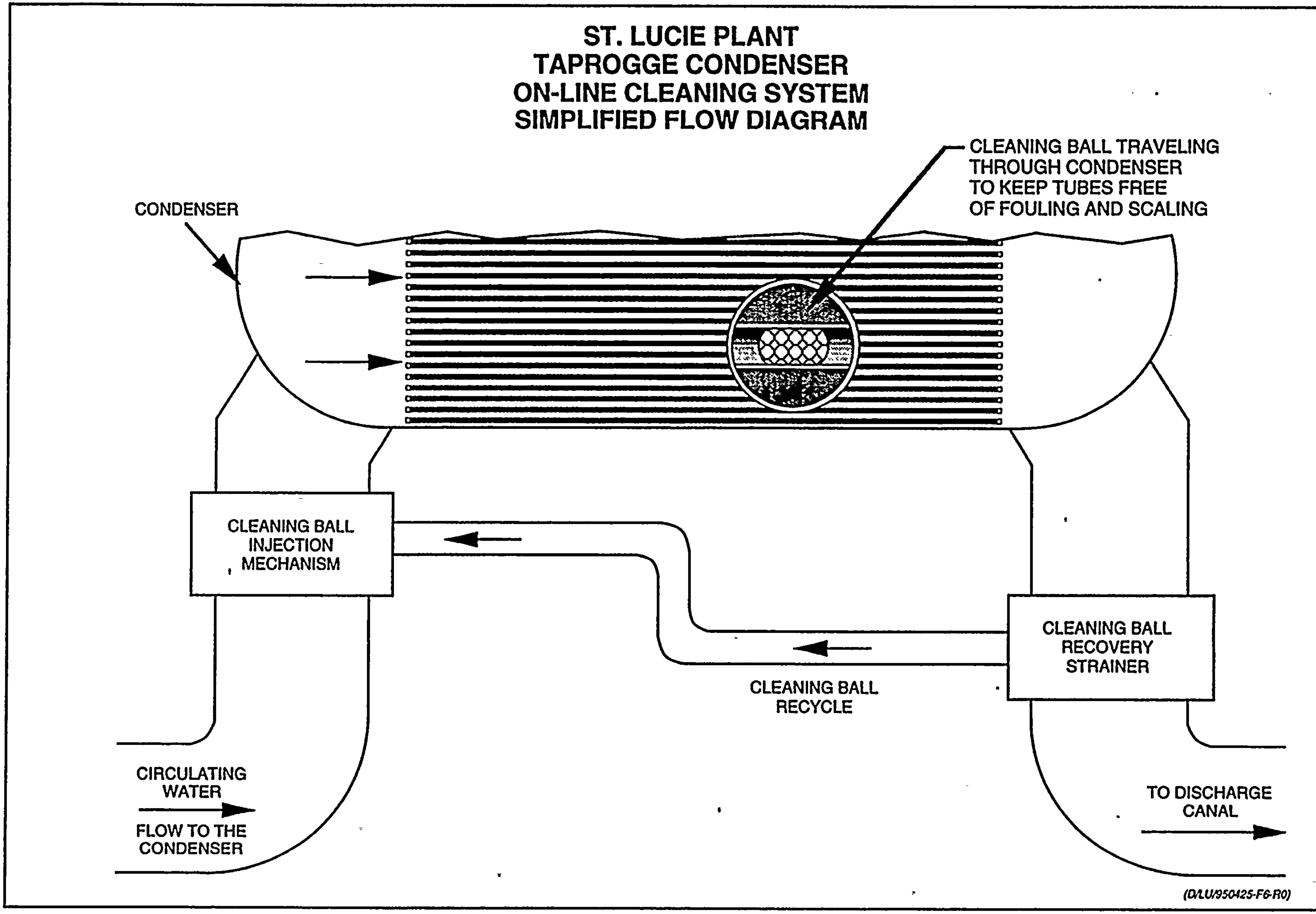

Figure 6. Diagram of the Taprogge system for maintaining condenser cleanliness.

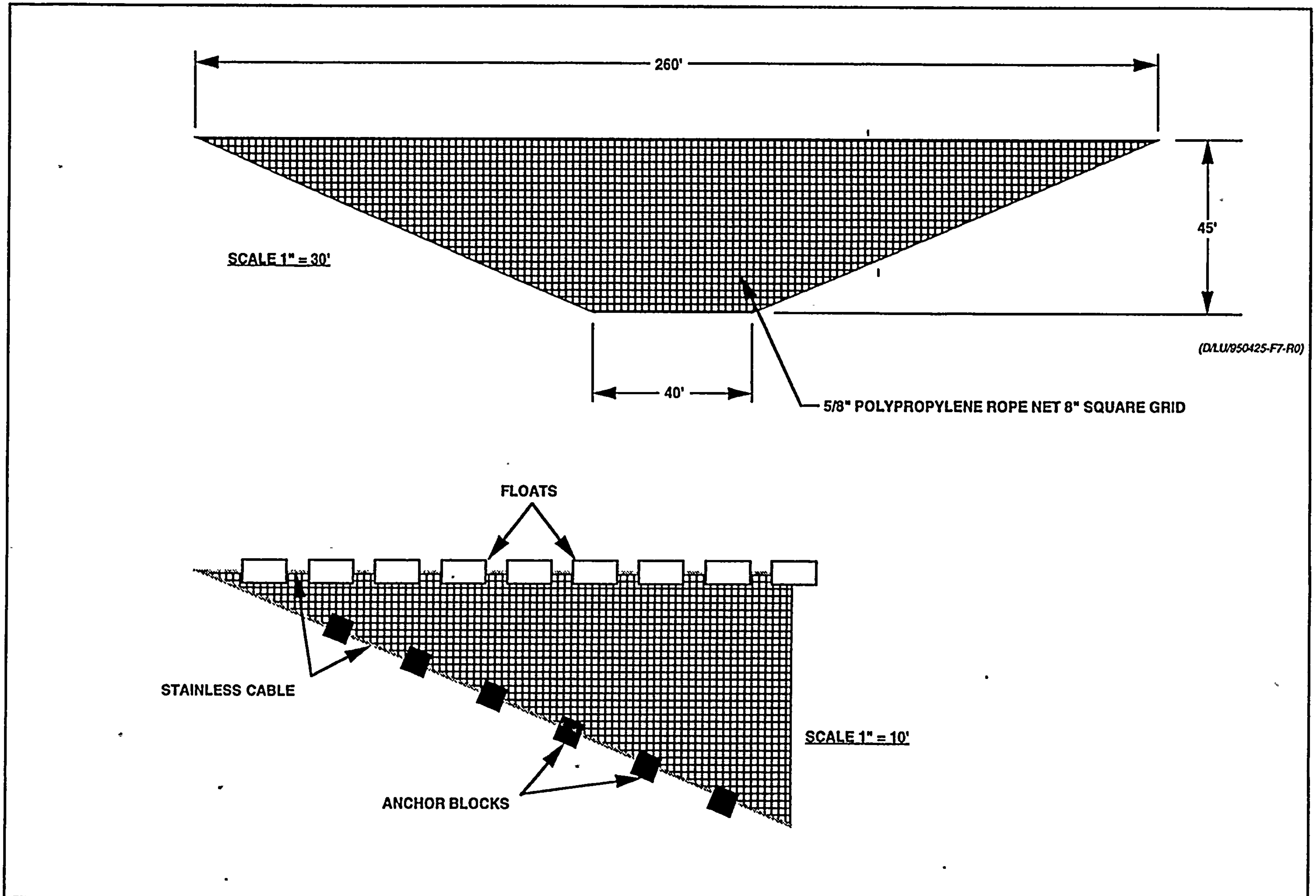

Figure 7. Diagram of the turtle barrier net used in the intake canal of the St. Lucie Plant. This net is located at the A1A bridge (see Figure 2)

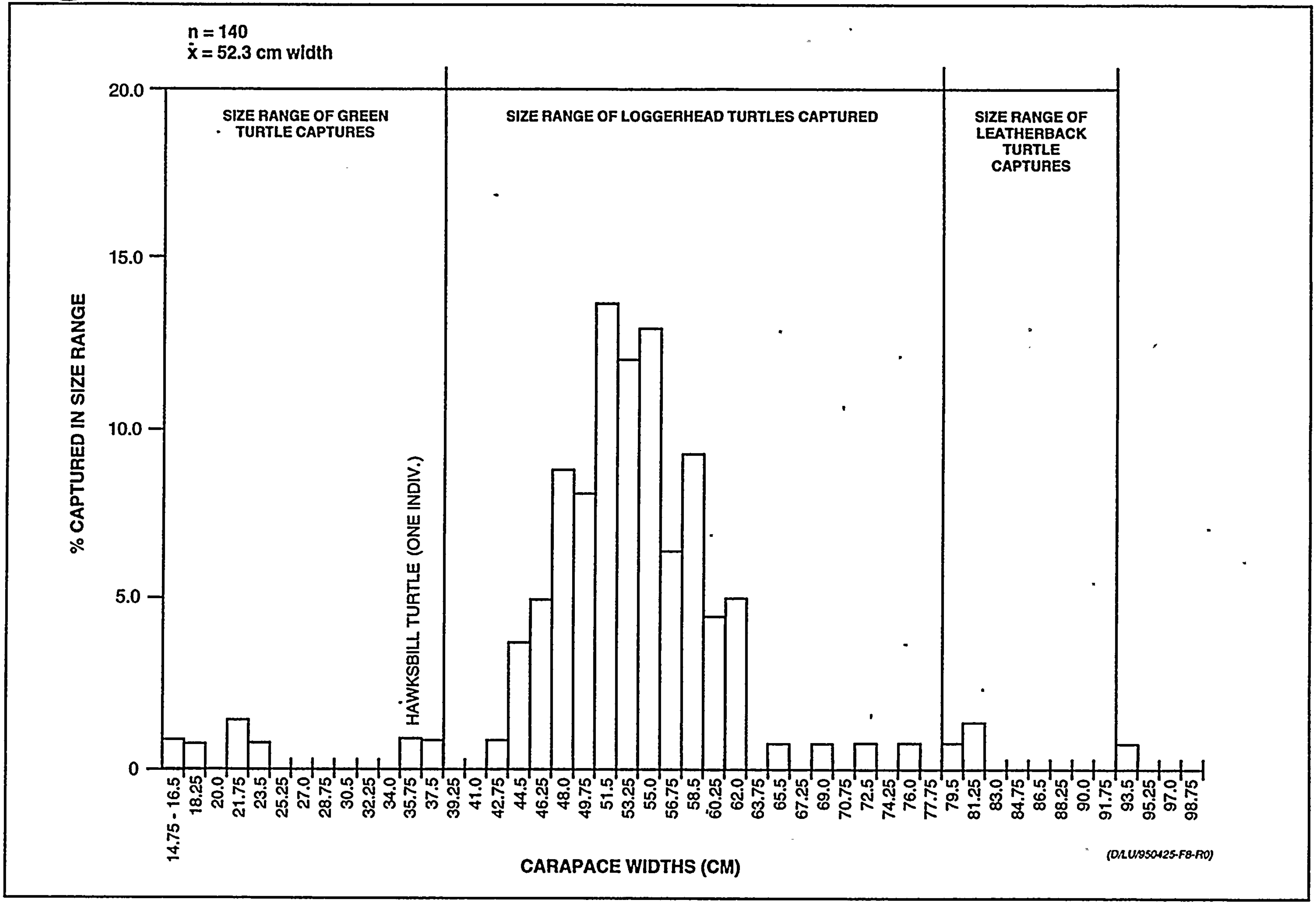

Figure 8. Size freequency distribution of 140 turtles captured in the intake canal of the St. Lucie Plant in 1976 - 1978. A mesh size of 8 inch (20.3 cm) square mesh would exclude 95% of the entrapped turtles form passing through this size barrier net.

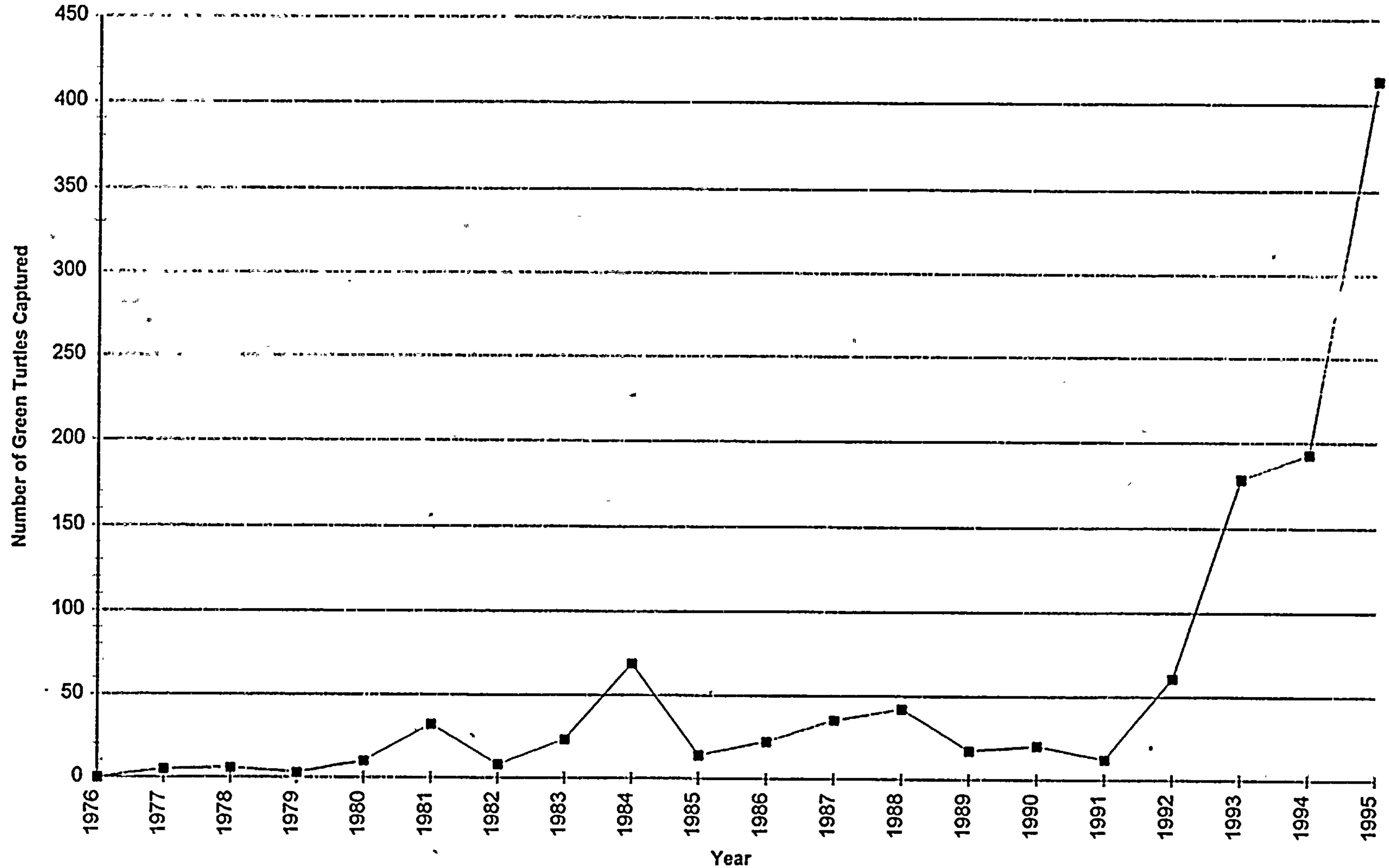

Figure 9. Green turtles captured from 1976 - 1995 (through June 30, 1995) for the St. Lucie Plant.

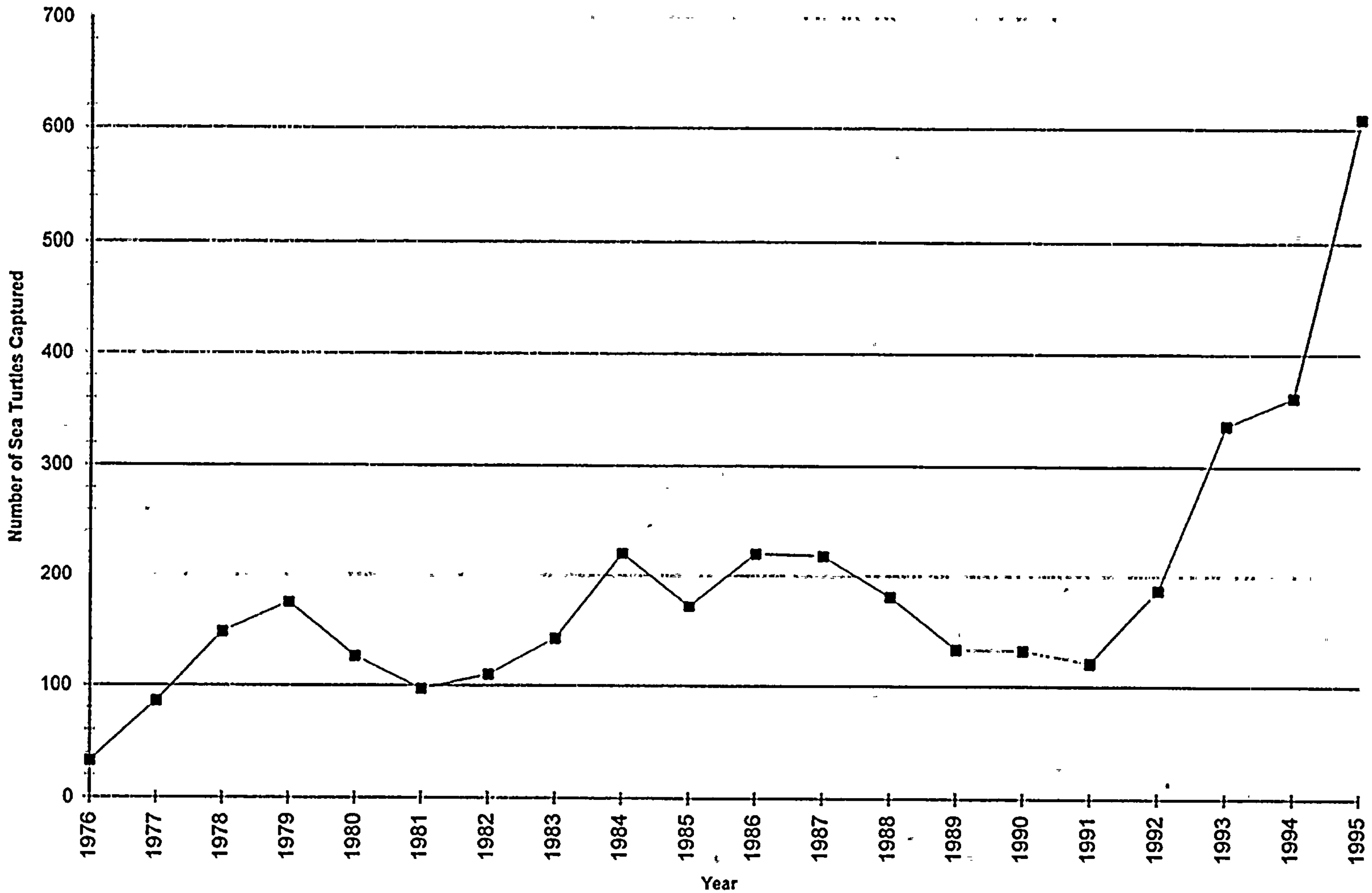

Figure 10. All species of turtles captured from 1976 - 1995 (through June 30, 1995) for the St. Lucie Plant.

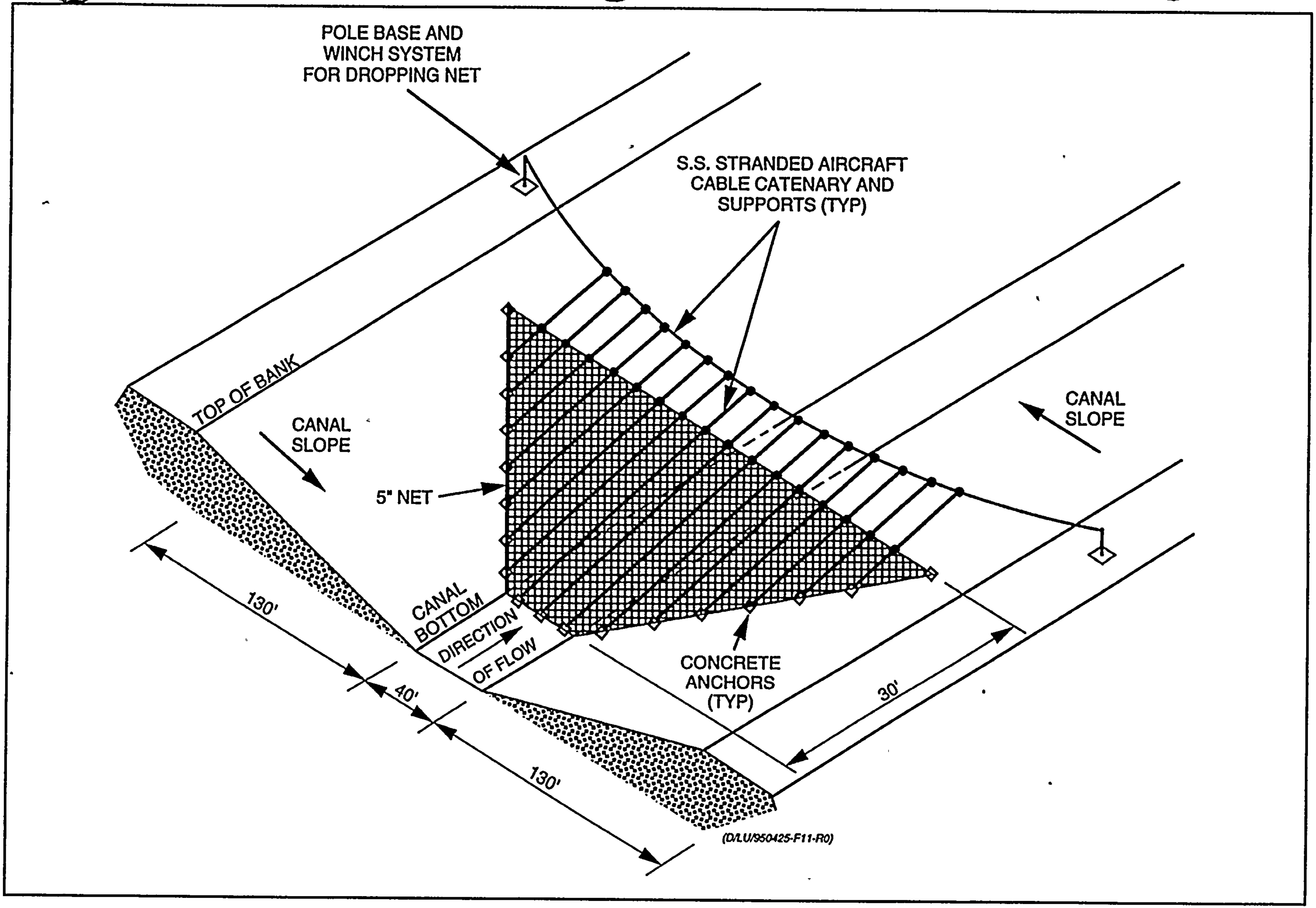

Figure 11. Conceptual design for a 5 inch (12.7 cm) square mesh barrier net to be installed in the intake canal of the St. Lucie Plant.

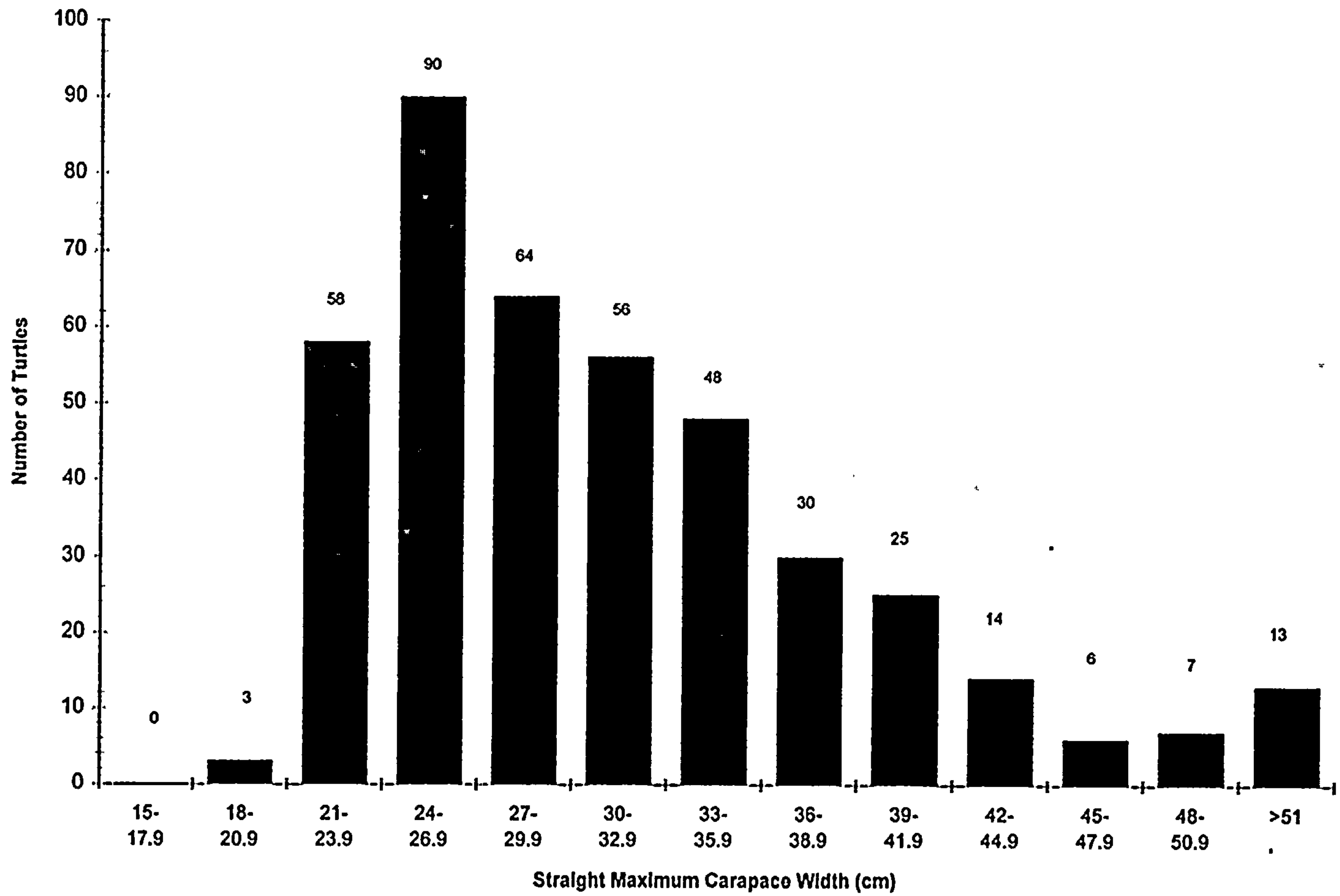

Figure 12. Size distribution of green sea turtles (n = 414) captured in the St. Lucie Plant intake canal during the first six months of 1995. A barrier net of 5 inches (12.7 cm) square mesh or 7 inches (18 cm) stretch mesh would exclude 100% of the turtles from passing through this net.

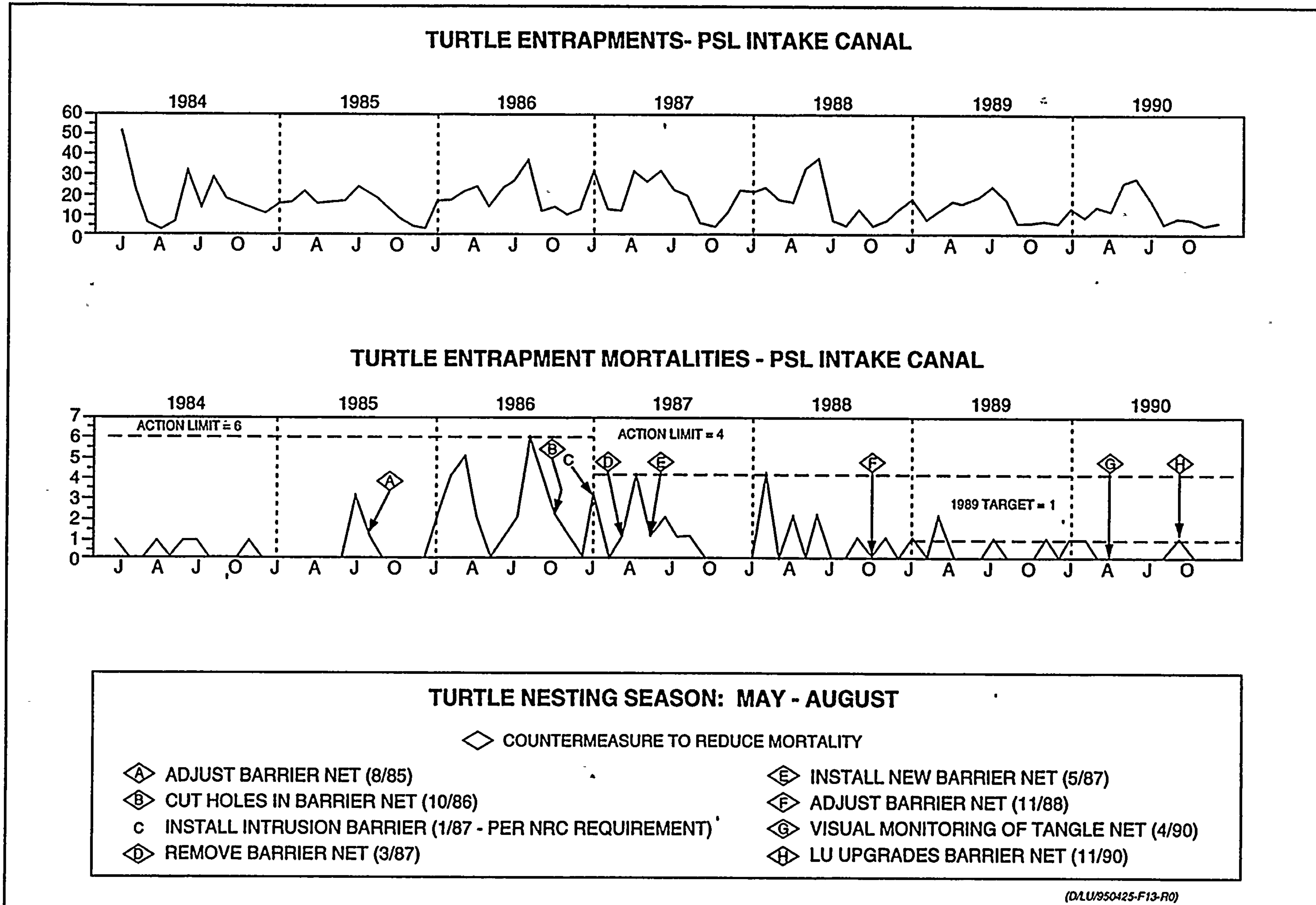

Figure 13. Turtle entrapment, mortality, and countermeasures taken to reduce turtle mortality in the St. Lucie Plant intake canal during the period 1984 - 1990.

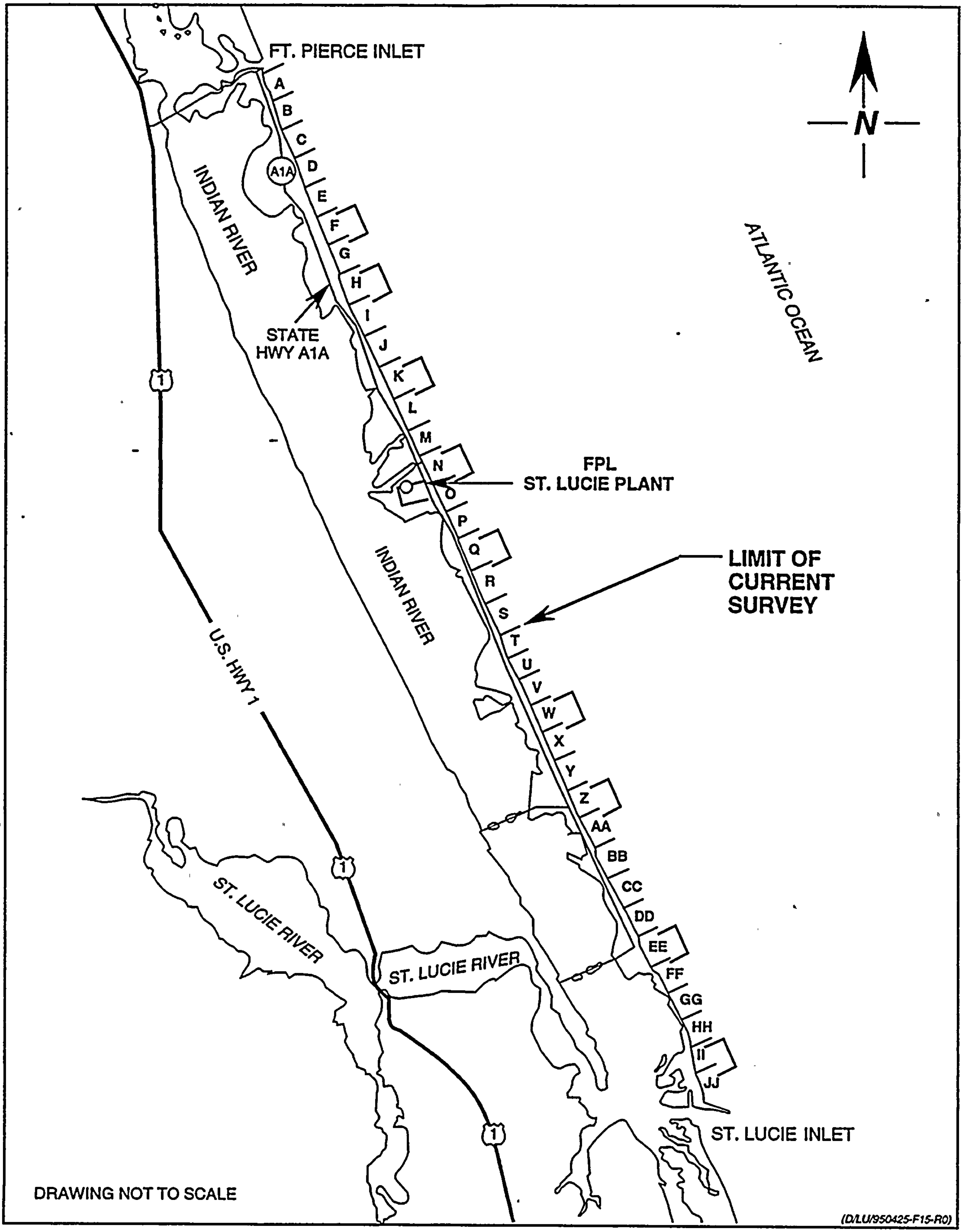

Figure 14. Designation and location of nine 1.25-km segments and 36 1-km segments surveyed for sea turtle nesting, south Hutchinson Island 1971 - 1994.

Figure 15. Loggerhead mortality in the St. Lucie Plant intake canal system, expressed as a percentage of captures, 1976 - 1994.

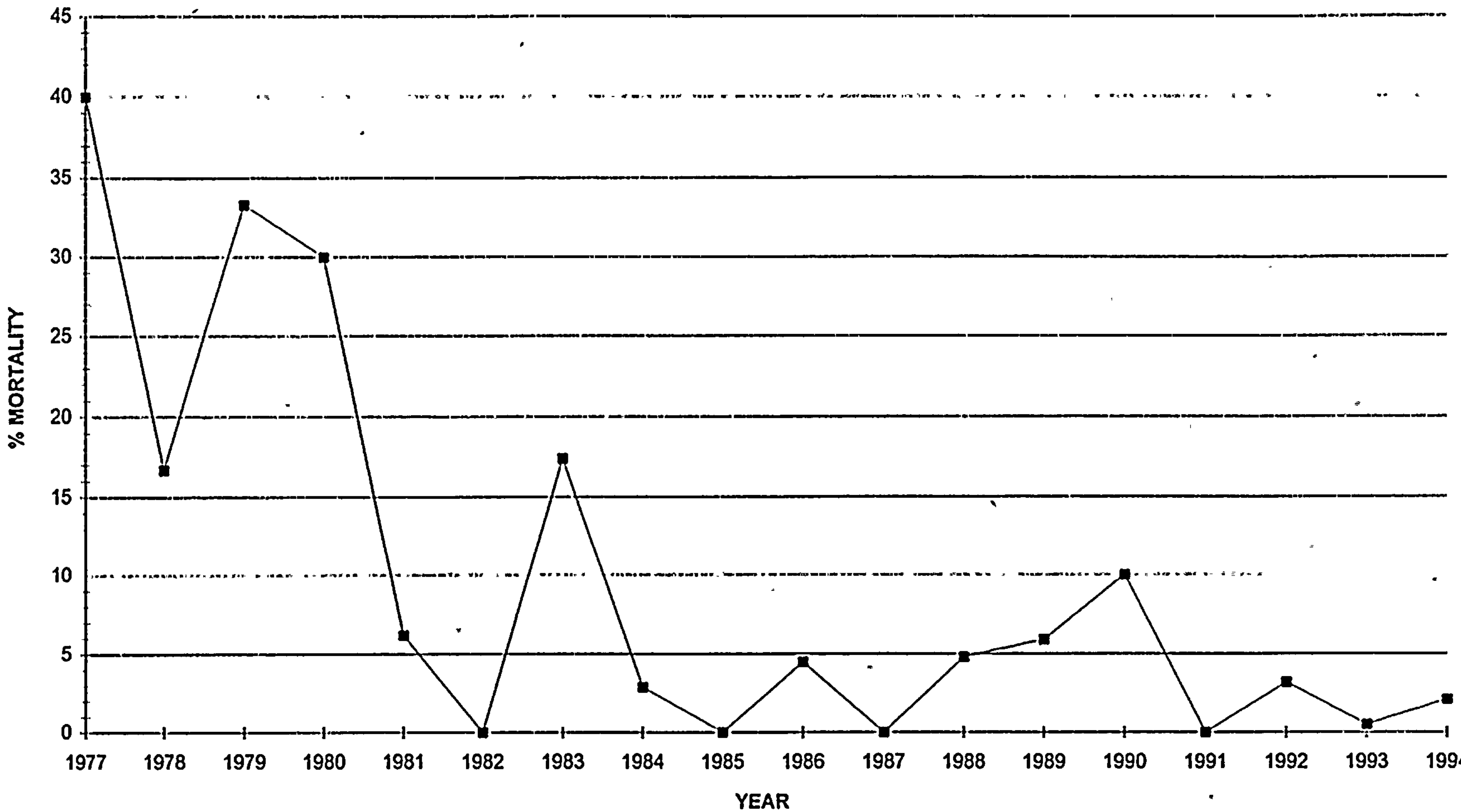

Figure 16. Green turtle mortality in the St. Lucie Power Plant intake canal system, expressed as a percentage of captures, 1977 - 1994. No green turtles were captured in 1976.