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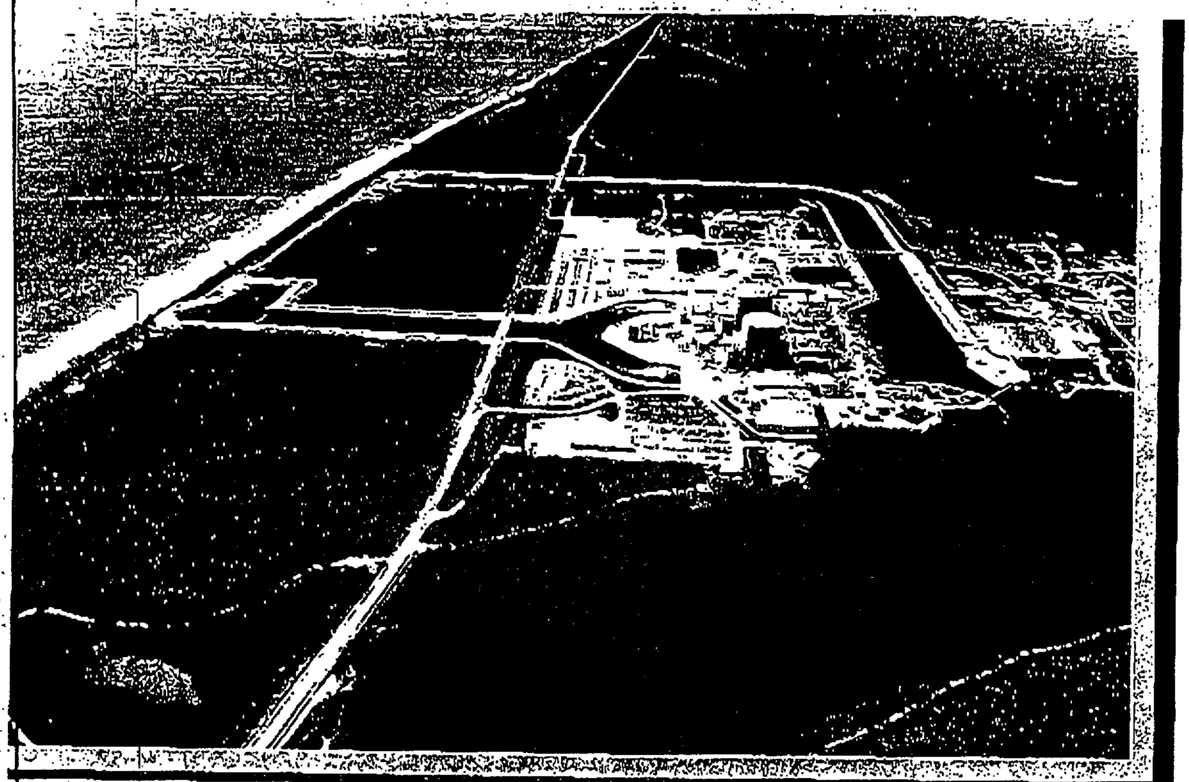
SURVEY OF AQUATIC ENVIRONMENTS POTENTIALLY AFFECTED BY THE OPERATION OF THE ST. LUCIE POWER PLANT, HUTCHINSON ISLAND, FLORIDA



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April 2001

SURVEY OF AQUATIC ENVIRONMENTS POTENTIALLY AFFECTED BY THE OPERATION OF THE ST. LUCIE POWER PLANT HUTCHINSON ISLAND, FLORIDA

AN ASSESSMENT PERFORMED IN SUPPORT OF LICENSE RENEWAL FOR ST. LUCIE PLANT UNITS 1 & 2

Prepared for:

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April 2001

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EXECUTIVE SUMMARY

Florida Power & Light Company (FPL) operates two nuclear-powered electric generating units on Hutchinson Island in St. Lucie County, Florida, both of which are licensed and permitted by the Nuclear Regulatory Commission (NRC). In support of its license renewal application, FPL commissioned a survey of aquatic environments in the vicinity of the St. Lucie Plant to identify any significant environmental changes that may have occurred over the 25-year period that Units 1 and 2 have been in operation. The results of the aquatic survey are presented in this document.

The St. Lucie Plant is sited on a barrier island bordered on the west by the Indian River Lagoon and on the east by the Atlantic Ocean. Recognizing the important environmental attributes of the surrounding aquatic environment, FPL designed and constructed the St. Lucie Plant to minimize the potential for environmental impacts generic to most coastal power facilities utilizing a once-through cooling water system. To avoid entrainment of larval and juvenile stages of the many species of recreationally and/or commercially important finfish and shellfish that utilize the Indian River Lagoon as nursery habitat, the St. Lucie Plant was designed to draw its cooling water from the Atlantic Ocean. Thermal effluents are also discharged back into the Atlantic Ocean. The discharge pipes terminate in a series of diffusers, which jet water into the surrounding environment. This enhances mixing with ambient water and results in rapid dissipation of heat. Both intake and discharge structures were sited in an offshore area devoid of hardbottom and attached macrophytes. The area's isolation from major spawning grounds of resident and migratory fish reduced the potential for entrainment of fish eggs and larvae. To reduce the potential for impacts associated with the entrainment and impingement of larger, motile marine organisms, ocean intake structures were fitted with velocity caps. These large flat plates, elevated above the intake pipes by a series of concrete posts, reduce intake current velocities by drawing water laterally over an arc of 360°.

Numerous scientific studies have been conducted over the life of the St. Lucie Plant to document the effects of Unit 1 and 2 operations on adjacent aquatic habitats. Prior to placing Unit 1 on-line, FPL funded environmental baseline studies in the vicinity of ocean intake and discharge structures. These studies documented ambient water quality and sediments and characterized existing plankton, macrophyte, benthic macroinvertebrate, fish, and worm reef communities. The extent to which local barrier island beaches were utilized for nesting by marine turtles was also documented. Results of these studies served as the comparative basis for assessing impacts related to the operation of Units 1 and 2.

Due largely to the design and siting of ocean intake and discharge structures, permit compliance monitoring demonstrated that power plant operation had no substantial, persistent, or widespread effect on water quality in the receiving water body.

Infrared mapping of the thermal plume during a period when both Units 1 and 2 were operating at near full capacity confirmed earlier model predictions of a spatially limited thermal plume. Consequently, thermal effluents had no demonstrable effects on resident plankton, macroinvertebrate or fish communities. Furthermore, the studies concluded that the plume did not act as an attractant to commercially important finfish, such as Spanish mackerel and bluefish, nor did it disrupt the migratory movements of those species.

Baseline and operational studies produced remarkable databases for regional sediments, hydrology, and bottom dwelling organisms. Collectively, sediment, water quality, and biological data showed that combined operations of Units 1 and 2 had little impact on benthic environments in the vicinity of the plant, with the exception that those communities closest to the discharge pipes underwent a gradual restructuring due to sediment instability caused by the high velocity discharge of thermal effluents. Based on the paucity of shrimp, crabs and scallops collected during ocean sampling, the nearshore environment in the vicinity of the St. Lucie Plant does not appear to provide suitable or preferred habitat for commercially important species of shellfish.

Overall, entrainment studies indicated some impacts to fish eggs and larvae related to plant operation. Numbers of fish eggs and larvae were consistently lower in the discharge canal than in the intake canal, reflecting mortality from passage through the plant. However, calculations of entrainment mortality showed that on an annual basis, power plant operations removed less than one percent of the pool of fish eggs and larvae in the vicinity of the offshore intake structures. More importantly, occurrences of larvae of sport and commercial species were infrequent and insignificant in the canal system.

Operational monitoring showed considerable year-to-year variations in the number of fish inhabiting nearshore waters adjacent to the St. Lucie Plant, but there were no discernable patterns that could be attributed to plant operation. Comparison of data from the intake canal and stations in the vicinity of the offshore intake structures indicated that the entrainment of fish and large motile crustaceans was relatively low, and there did not appear to be any major accumulations of these species within the canal. Catches of commercially important migratory species within the intake canal were very small.

Three species of marine turtles regularly nest on Hutchinson Island: loggerhead, leatherback and green turtles. Comparison of data from baseline studies and operational monitoring indicated that nesting by all three species has increased over the period that the St. Lucie Plant has been in operation. Although construction activities associated with the installation of Unit 2 intake and discharge pipes caused a temporary reduction in nesting near the plant, the long-term trend of increasing nest densities indicates that thermal effluents and other aspects of plant operation have not had a negative effect on nesting behavior.

Over the three-year period from 1976 through 1978, FPL conducted monitoring of the traveling screens at the St. Lucie Plant intake wells to determine the types and abundance of fish and crustaceans being removed from water used to cool Unit 1's generating equipment. Samples consisted mainly of small fish and a few crustaceans. Impingement of recreationally and/or commercially important species was negligible, and losses were not considered to have any significant impact on offshore populations. This low impingement rate, particularly of commercial species, was largely attributed to the effectiveness of the velocity caps in minimizing entrainment.

Although siting and design features of the cooling water system reduce the potential for entrainment and impingement, some larger, motile organisms do, nevertheless, enter the intake structures and are carried with cooling water into the St. Lucie Plant canal system where they become entrapped. Some of these species are listed as threatened or endangered and are protected by state and federal regulations. Consequently, FPL has developed and implemented programs to ensure their safe and timely removal from the canal.

Biologists using tangle nets and a variety of other methods capture sea turtles entrapped in the intake canal of the St. Lucie Plant. Through 1999, a total of 6,581 sea turtles, representing all five species inhabiting Florida's coastal waters, were removed from the canal. Juvenile loggerhead and green turtles accounted for 99 percent of all captures. Entrapment rates have increased dramatically during recent years, the likely result of increases in the number of juvenile turtles utilizing the nearshore environment adjacent to the St. Lucie Plant.

FPL has worked diligently to identify and remedy sources of sea turtle mortality at the St. Lucie Plant. As a result of these efforts, the number of mortalities has been reduced substantially during recent years. During the period from 1990 through 1999, overall mortalities for all species combined averaged only about 1.06 percent of all turtles entrapped. During the previous 10-year period, overall mortality was 6.42 percent. Thus, while the average number of turtles entrapped each year in the intake canal nearly tripled between the 1980s and 1990s, improvements to FPL's sea turtle capture program resulted in an 83.5 percent reduction in the frequency of mortalities. FPL has mitigated the take of turtles at the St. Lucie Plant through a variety of scientific programs, environmental education, and public awareness initiatives.

There have been five occasions when manatees have entered the offshore intake structures and become entrapped in the intake canal. FPL coordinates the capture and evaluation of entrapped manatees with the Florida Fish and Wildlife Conservation Commission. None of the manatees entrapped in the intake canal has suffered injuries as the result of its entrainment or entrapment.

Thermal, entrainment, and impingement impacts to aquatic organisms resulting from St. Lucie Plant operation have been shown to be minor. Although FPL has not been required to monitor water quality or biological communities in the receiving water body since 1984, there have been no changes in the design or operating characteristics of the plant that could reasonably be expected to alter conditions previously documented. The only element of plant operation requiring continued surveillance is the entrapment of larger, motile vertebrates and invertebrates within the intake canal. FPL is committed to minimizing mortalities and residency times of entrapped sea turtles and is bound by regulatory protocol for dealing with these and other listed species. Collectively, these findings indicate that continued operation of the St. Lucie Plant is unlikely to have any unexpected or unacceptable adverse impacts on adjacent aquatic environments.

SURVEY OF AQUATIC ENVIRONMENTS POTENTIALLY AFFECTED BY THE OPERATION OF THE ST. LUCIE POWER PLANT HUTCHINSON ISLAND, FLORIDA

AN ASSESSMENT PERFORMED IN SUPPORT OF LICENSE RENEWAL FOR ST. LUCIE PLANT UNITS 1 & 2

INTRODUCTION

In 1970, the United States Atomic Energy Commission, now the Nuclear Regulatory Commission (NRC), issued construction Permit No. CPPR-74 to the Florida Power & Light Company (FPL). This permit allowed construction of Unit No. 1 of the St. Lucie Plant, an 850-MW nuclear-powered electric generating station on Hutchinson Island in St. Lucie County, Florida. Unit No. 1 was placed on-line in March 1976. In May 1977, FPL was issued Permit No. CPPR-144 by the NRC for the construction of a second 850-MW nuclear-powered unit. Unit 2 was placed on-line in May 1983 and began commercial operation in August of that year. As used throughout this report, the St. Lucie Plant shall refer to Units 1 and 2 collectively, as well as the associated grounds and support facilities.

In support of its license renewal application, FPL commissioned a survey of aquatic environments in the vicinity of the St. Lucie Plant to identify any significant environmental changes that may have occurred during the period that Units 1 and 2 have been in operation. This document characterizes the existing marine environment surrounding the plant site, summarizes results of previous environmental studies conducted in compliance with operating permits, assesses the extent to which plant operations have impacted aquatic biological communities, and projects future impacts from continued plant operation.

Area Description

Units 1 and 2 of the St. Lucie Plant are sited on a 457-ha (1130-acre) tract near the geographical center of Hutchinson Island (27°21'N; 80°14'W), a long (37.5 km; 23 mi) narrow barrier island stretching from the Ft. Pierce Inlet to the St. Lucie Inlet along the southeast coast of Florida (Figure 1). The island is separated from the mainland on its western side by the Indian River Lagoon and bordered on the east by the Atlantic Ocean.

The St. Lucie Plant was built at the widest section of the island (1.8 km; 1.1 mi) in an area previously degraded by mosquito control projects. The most prominent topographic feature of the site is the grade for State Road A1A, which passes through the eastern portion of FPL's property (Figure 2). East of A1A, a relatively broad sandy beach is backed by a ridge of dunes that reach a maximum elevation of about 5 m (16 ft)

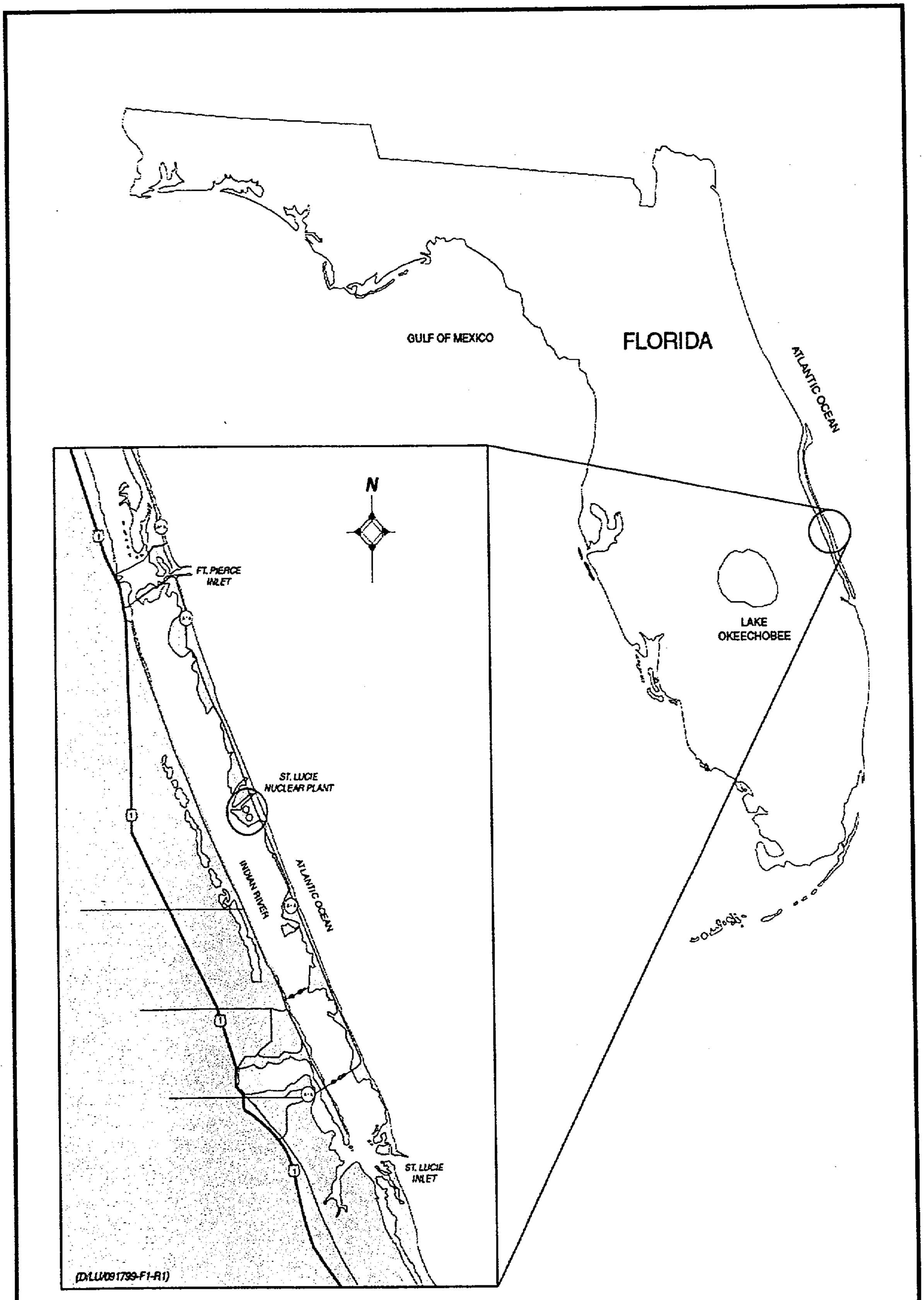

Figure 1. Location of St. Lucie Plant, Hutchinson Island, Florida.

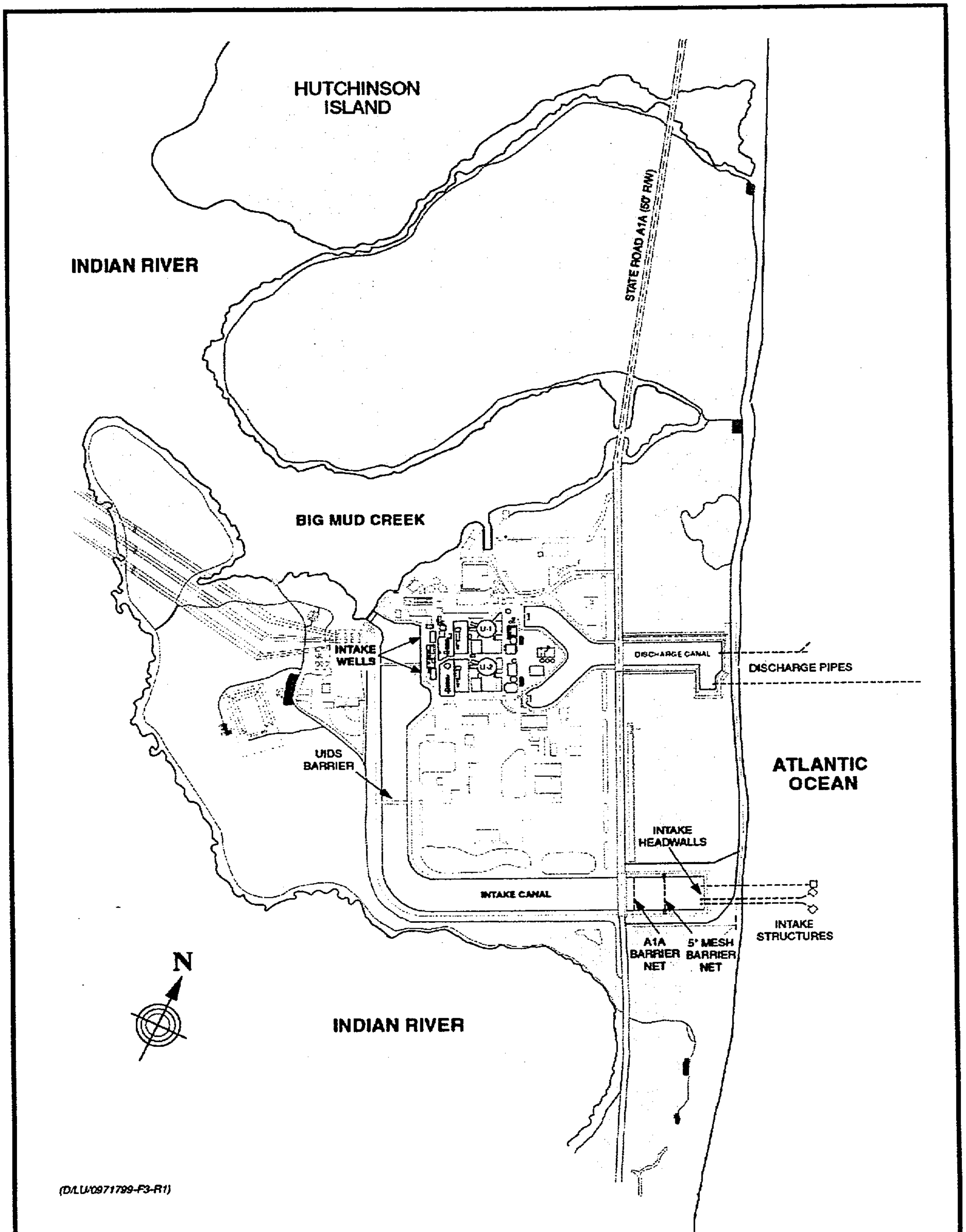

Figure 2. St. Lucie Plant facility layout showing cooling water intake and discharge system.

above mean low water. Between the dunes and A1A, the principal feature is a series of mangrove-dominated mosquito impoundments interspersed with islands of natural coastal strand vegetation. Units 1 and 2 are located on the west side of A1A in a relatively flat, sheltered area of the island. West of the facility, the land gradually slopes downward to a mangrove fringe bordering the intertidal shoreline of the Indian River Lagoon.

The Indian River Lagoon is a long (251 km; 156 mi), shallow (< 3 m; 10 ft) tidally-influenced estuary stretching along Florida's central east coast from Ponce Inlet in Volusia County to Jupiter Inlet in Palm Beach County. Its geographic location along the transition zone between warm-temperate and subtropical climates combined with its large size and diverse physical characteristics make it an estuary of extremely high biological productivity. Although not well documented at the time of initial licensing for the St. Lucie Plant, the Indian River Lagoon is now characterized as having one of, if not *the*, most diverse assemblages of plants and animals of any estuarine system in North America. Mangrove shorelines, expansive beds of seagrasses and attached and drift algae afford nursery habitat for a variety of fish and shellfish, many of which are important components of local sport and commercial fisheries. Nearly 400 species of fish have been recorded from the lagoon system (Gilmore, 1995). Because of its biological significance, the Indian River Lagoon has been designated as an Aquatic Preserve by the State of Florida and as an "estuary of national significance" by the U.S. Environmental Protection Agency. It is now part of the National Estuary Program.

The Indian River Lagoon receives an influx of ocean water through the inlets that separate the barrier islands along the east coast of Florida. Fresh water enters the lagoon from the mainland via canals, tidal creeks and land runoff. Tides and winds are the two major factors affecting water circulation in the estuary. Salinity and other physical parameters vary considerably depending on location, season and prevailing weather patterns.

Over the last two decades, the Indian River Lagoon has been increasingly threatened by residential and commercial development, industry, agriculture and other human activities. At its website, the South Florida Water Management District (http://www.sfwmd.gov) reports that "the combined effects of waste and stormwater runoff, drainage, navigation, loss of essential marshland and agricultural and urban development have severely impacted the lagoon's water, sediment and habitat quality." The watershed of the lagoon has been substantially enlarged due to the construction of extensive agricultural and urban drainage projects. These upland changes have caused significant alterations in the timing, distribution, quality and quantity of freshwater entering the lagoon. A predictable and relatively stable gradient of salinity is the cornerstone of an estuary's productivity. Consequently, alterations to normal patterns of freshwater input have placed severe stress on the entire Indian River Lagoon ecosystem and contributed to major changes in the structure of the biological communities inhabiting the estuary. This is evidenced by major reductions in the abundance and distribution of seagrasses and oysters, two major indicators of the lagoon's health.

Big Mud Creek, a backwater cove of the Indian River Lagoon, is located on the north side of the St. Lucie Plant (Figure 2). During plant construction, the cove was dredged to a maximum depth of 14 m (46 ft) to provide deep-water access for barge service between the St. Lucie Plant and the nearby Intra-Coastal Waterway (ICW) in the Indian River Lagoon. The St. Lucie Plant is considerably distant to both the Ft. Pierce and St. Luice Inlets. Consequently, tidal influence in the vicinity of the plant is negligible, and there is only minimal water exchange between Big Mud Creek and the adjacent Indian River Lagoon. As a result of its depth and poor circulation, Big Mud Creek typically experiences water stratification during the summer, with bottom conditions being cooler and more saline than surface waters (ABI, 1979d). This typically results in anoxic conditions on the bottom. During winter months, as surface waters cool, turnover often occurs causing a mixing of surface and bottom water masses.

A notable beach frontage feature at the St. Lucie Plant is the intertidal coquina-rock formation that protrudes through the sand at Walton Rocks, just south of the plant's intake canal. This hard substrate provides attachment sites for encrusting, tube-building polychaete worms, which form extensive colonies. The "worm rock" communities support a rich and diverse association of other invertebrates, algae, and fishes.

Seaward of the worm rock formations, the ocean floor consists solely of unconsolidated sediments composed of quartz and calcareous sands, broken shell fragments, and negligible admixtures of silts and clays. Although submerged coquinoid rock formations parallel much of Hutchinson Island, the nearshore area potentially affected by plant operations is devoid of reef structures, grass beds, and rock outcroppings (Gallagher and Hollinger, 1977). The marine terrain includes a narrow beach terrace zone that gently slopes into a trough that reaches a maximum depth of about 12 m (39 ft). On the eastern side of the trough about 3 km (2 mi) from shore, the bottom rises to form Pierce Shoal.

At the location of the St. Lucie Plant on Hutchinson Island, the edge of the continental shelf is located about 33 km (21 mi) offshore. The Florida Current (northern extension of the Gulf Stream) flows north approximately parallel to the shelf margin but closer to shore, and a weak counter current is usually present near shore. During the summer, the Florida Current periodically meanders over the inner shelf causing water temperatures near shore to decrease dramatically below seasonal norms. Tidal range in the vicinity of the plant is about 0.8 m (3 ft).

The estuarine and oceanic environments surrounding Hutchinson Island are in an ecological transition zone, or ecotone, that exhibits characteristics of both sub-tropical and tropical conditions. Due to the overlap between adjacent environments, ecotones frequently contain plant and animal assemblages characterized by unusually high diversity and abundance. This is especially true in transitional areas that contain a large variety of habitats and diverse physical characteristics. The St. Lucie Plant is located in just such an area.

General Design of the St. Lucie Plant

The St. Lucie Plant uses a once-through condenser cooling water system. Cooling water is drawn from the Atlantic Ocean through three intake structures located 365 m (1,200 ft) offshore in approximately 7 m (23 ft) of water (Figure 2). Each structure consists of a large concrete housing, with a vertical shaft in the center (Figures 3 and 4). The large diameter pipes that transport water to the plant enter the structures at the base of the shaft. Two of the structures house intake pipes with inside diameters of 3.7 m (12 ft). They were constructed to support operation of Unit 1. A third and larger structure, was installed during construction of Unit 2. It houses an intake pipe with an inside diameter of 4.9 m (16 ft).

The intake pipes pass shoreward beneath the sea floor, beach and dunes and terminate within two headwalls at the end of a 1500 m-long (4, 920 ft) by 90 m-wide (295 ft), L-shaped canal that transports water to the plant (Figure 2). At the plant, cooling water is drawn from the bottom of eight separate intake wells (four for each unit). Incoming seawater then flows through a two-screen filtration process to remove debris and marine life before the water passes through the plant's condenser cooling system (Figure 5). The first is a fixed grate designed to capture large objects. This structure is monitored both visually and electronically and accumulations of debris and marine organisms (e.g., seaweed and jellyfish) are removed to guard against possible flow disruptions. The second filtering device is a 9.5 mm^2-mesh (3/8 in^2) traveling screen that removes remaining debris and macro-organisms.

After passing through the condenser system, heated cooling water is discharged into a 670 m-long (2,200 ft) by 60 m-wide (200 ft) discharge canal (Figure 2). At the eastern terminus of the canal, the water enters two parallel, 3.7 m (12 ft) inside diameter buried pipelines that pass beneath the beach/dune system and emerge on the sea floor offshore the plant. The terminal sections of these lines are of unequal length and release water differently. The shorter one, built first to service St. Lucie Unit No. 1, terminates about 365-m.offshore (1,200 ft). It is fitted with a Y-shaped structure that directs discharges at high velocity through divergent nozzles; one is horizontal and the other directed upward at an angle of 45 degrees. The longer line was added later to share the increased discharge load produced by construction of Unit No. 2. It terminates about 856 m (2,810 ft) from shore in water depths of between 10 and 12 m (33 – 40 ft). The seaward portion of this pipe consists of a manifold and 48 alternate, side-to-side, equally spaced ports, that jet discharges upward at an angle of 23 degrees.

Potential Impacts from Power Plant Operation

All power generating facilities that utilize a once-through condenser cooling water system have the potential to impact surrounding water bodies. Impacts generally fall into one of two categories: entrainment/impingement and thermal. Organisms that are drawn with cooling water to the plant are either removed by a mechanical filtration system or pass through the plant's condensers. Those captured (impinged) by the screens at the St. Lucie Plant are washed into a trough and discarded. Smaller sea-life (e.g., plankton) that

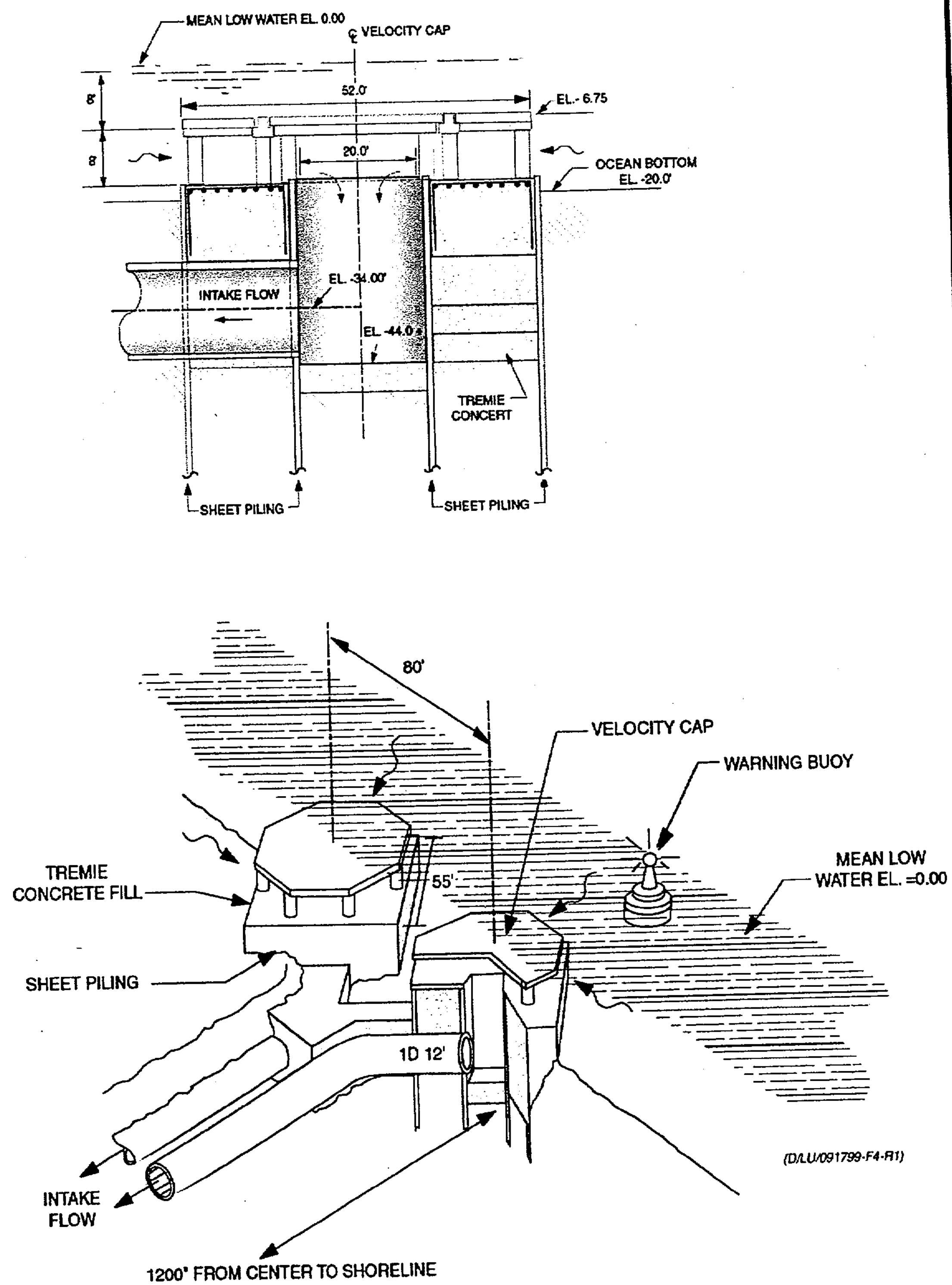

Figure 3. Configuration of the two 3.7 meter-diameter intake structures, St. Lucie Plant, Hutchinson Island, Florida.

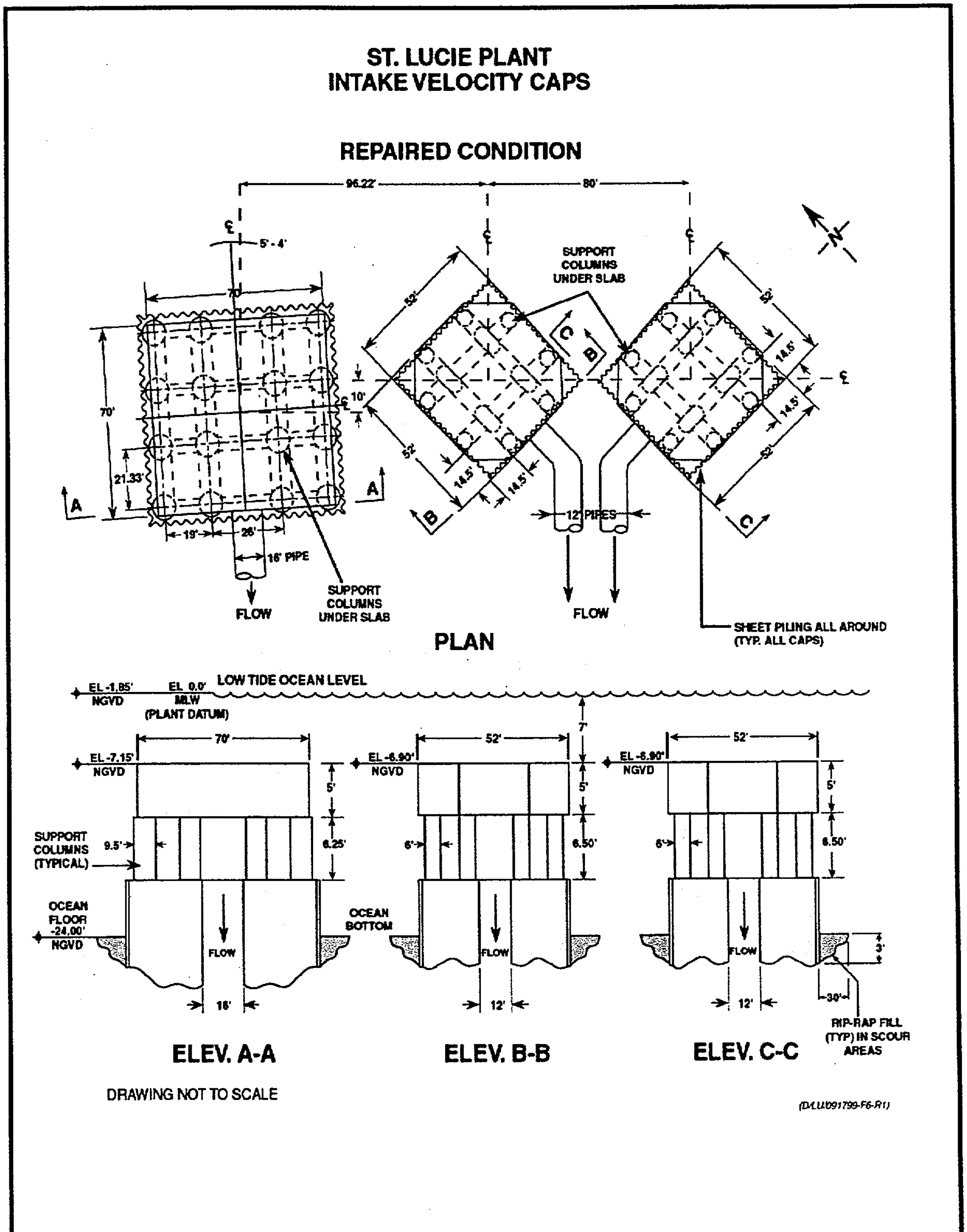

Figure 4. Diagram of the three intake structures located 1200 feet (365 m) offshore the St. Lucie Plant, Hutchinson Island, Florida. Dimensions represent conditions after velocity cap repairs were completed in February 1992.

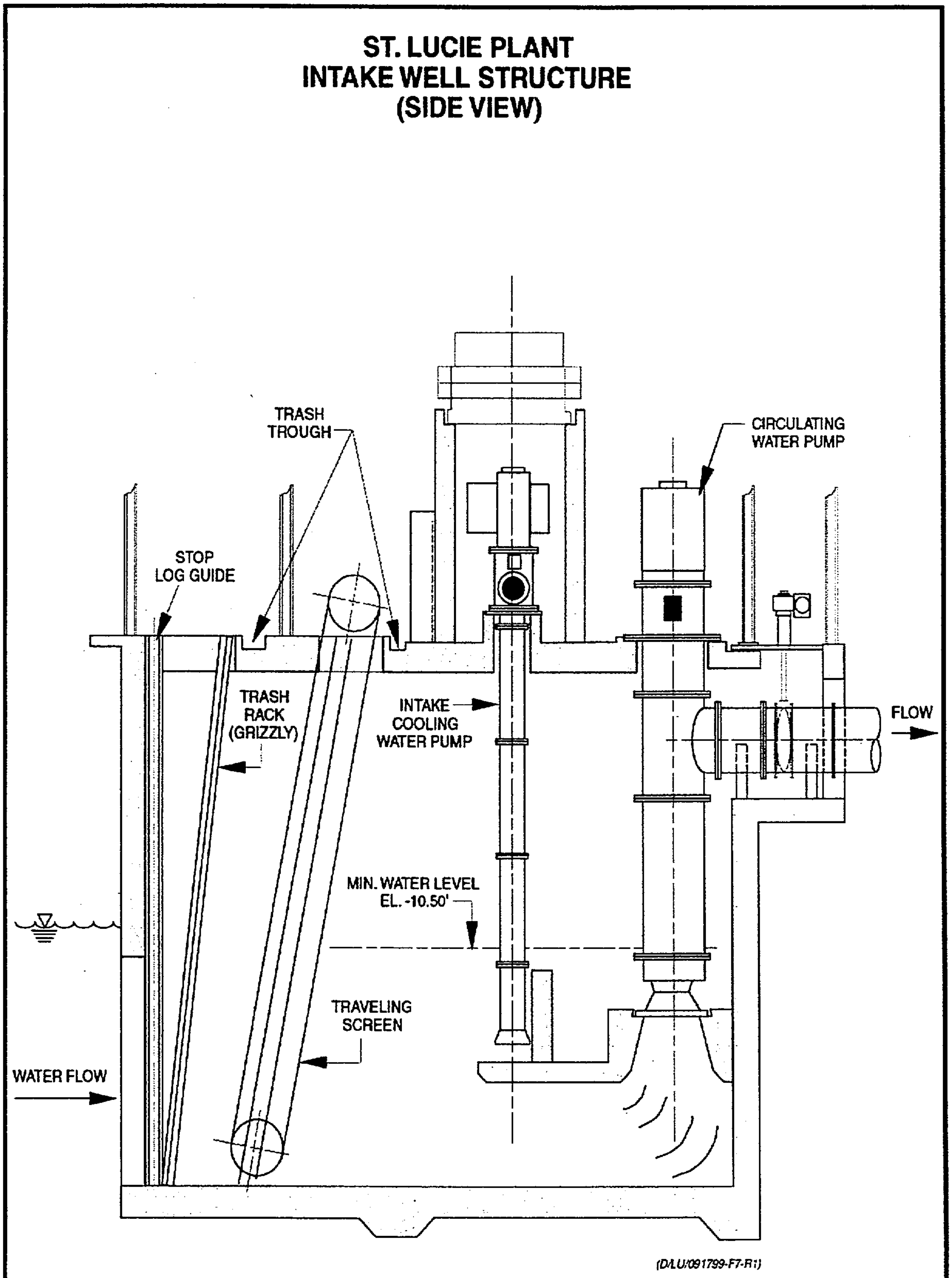

Figure 5. Diagram of an intake well at the St. Lucie Plant, Hutchinson Island, Florida.

escape the finer mesh traveling screens similarly suffer high rates of mortality due to turbulence and heat as they pass through the plant's condenser cooling water system. Consequently, the impingement and entrainment of marine life is a major issue considered during the licensing and permitting of coastal power facilities.

In addition to the loss of marine life associated with entrainment and impingement, the enclosed cooling water system at the St. Lucie Plant can also entrap organisms. Not all organisms entrained with cooling water are impinged. Some, particularly larger motile forms, such as fish and sea turtles, may reside in the intake canal for extended periods. Water velocities within the intake pipes prevent their escape unless both units are operating at very low capacity, which is a rare occurrence. Although entrapped organisms may suffer a low rate of mortality, they are nevertheless lost to their respective populations unless there is a system in place for capturing and returning them to the ocean.

Big Mud Creek has been designated as a pool for emergency cooling water for the St. Lucie Plant should there be disruptions to ocean intake systems. FPL tests this system several times a year to ensure that it is operational. These tests last only a few minutes and draw less than 100,000 gallons from the creek. During these tests, dissolved oxygen levels are monitored in accordance with the facility's Site Certification to ensure that water withdraw does not impair water quality within Big Mud Creek or the offshore environment.

Water that leaves the plant is heated considerably above ambient temperatures. This thermal effluent has the potential to impair water quality in the receiving water body. Very high temperatures may cause stress or mortality of sedentary organisms (e.g., attached vegetation and benthic macroinvertebrates) and/or may cause motile organisms (nekton) to seek refuge in areas outside the influence of the warm water. The extent to which thermal effluents impact aquatic communities is determined by the absolute temperatures at the point of discharge in the receiving water body and the capacity of the receiving water body to dissipate heat. Deep water bodies with turbulence and good circulation will dissipate heat much more rapidly than shallow, calm, water bodies with poor circulation.

Power plant discharges may also affect other water quality parameters, such as salinity, dissolved oxygen, turbidity, and nutrient loads. The extent to which plant operations affect these variables is largely determined by differences in ambient physicochemical conditions between intake and receiving water bodies and the amount of mixing that occurs at the point of discharge.

Engineering For Environmental Protection

Recognizing the important environmental attributes of the surrounding aquatic environment, FPL designed and constructed the once-through cooling water system at the St. Lucie Plant to minimize the impacts identified above. Given the proximity of both the Indian River Lagoon and the Atlantic Ocean to the plant site, various combinations of intake and discharge configurations were considered. Early research and planning for Unit No. 1 indicated that the Indian River Lagoon would support an abundant and diverse assemblage of marine life. By contrast, data from the Atlantic side of Hutchinson Island were less remarkable, and particularly so within the offshore, mid-island region inside Pierce Shoal. Hydrographic conditions there were much less variable, attached macrophytes and hardbottom were generally absent, and the area appeared to be largely isolated from major spawning grounds of most species of finfish and shellfish taken in local recreational and commercial fisheries. Consequently, the most significant design feature of the St. Lucie Plant is a system that draws cooling water from the ocean rather than the lagoon. Persistent withdrawal of cooling water from the Indian River Lagoon undoubtedly would have resulted in high rates of entrainment and impingement for larval and juvenile phases of many species of recreationally and/or commercially important finfish and shellfish that use the lagoon as nursery habitat (ABI, 1979c).

To further reduce the potential for impacts associated with the entrainment and impingement of marine organisms, additional siting and design features were incorporated into construction plans. First, the intake pipes were sited seaward of nearshore worm reefs in an area devoid of hardbottom. Second, and more importantly, the intake structures were fitted with velocity caps. These devices are large flat plates elevated about 2 m (6 ft) above the vertical shaft of the intake structure by a series of concrete posts (Figures 3 and 4). The tops of the caps come to within 2 m (6 ft) of the surface at mean low water. Water flows beneath the caps into the intake structure. By drawing laterally over an arc of 360°, in-flowing water currents are reduced to rates of 30 cm/sec (1 ft/sec) or less. Fish have been observed to actively swim beneath the caps and across the openings of the vertical shafts without being involuntarily entrained into the intake pipes. It is only within the shaft itself that velocities increase to such an extent that active entrainment is affected. When both Units 1 and 2 are in operation, design velocities within the smaller pipes range from 127 to 142 cm/sec (4.2 to 4.7 ft/sec) and in the larger pipe from 180 to 206 cm/sec (5.9 to 6.8 ft/sec). In addition to eliminating the vortex that might otherwise form in the absence of the caps, cooling water is drawn from mid-depth rather than from the surface or bottom of the water column. Many fish eggs and larvae are buoyant and drift with the currents near the surface. Most invertebrates and many species of fish live on the bottom. Consequently, water withdrawal at mid depth reduces the potential for the entrainment of these organisms.

As for the withdrawal of cooling water, it was decided to discharge thermal effluents into the ocean rather than the lagoon. Because of nearshore turbulence, long-shore currents and relatively deep water, the ocean serves as an enormous heat sink. The Y-port diffuser constructed for Unit 1 and the multi-port diffuser installed for Unit 2 further serve to dissipate heat by jetting water into the surrounding sea. This enhances mixing with ambient water. Consequently there is rapid dissipation of heat as discharge currents rise to the surface and spread as a thermal plume. The discharge structures were sited sufficiently far away from the intake structures to prevent the entrainment of heated effluents.

Review of meteorological data and studies of currents in the nearshore area of Hutchinson Island enabled modelers to predict thermal plume configuration and dispersal from Unit 1 operation (EBASCO, 1971). Plumes associated with thermal effluents from the St. Luice Plant will usually take the shape of a long oval. Predominant flow direction within these plumes is easterly, but at any specific time, both plume shape and direction may be influenced by prevailing wind and current conditions. Because of the effectiveness of the Y-port and multi-port diffusers in mixing effluents with ocean water, a relatively small surface area of the ocean is affected by plant discharges. Models predicted that the highest Δt (difference between discharge and ambient water temperatures), 5.5°F (3.1°C), would affect an area of only 0.1 acres or less. Temperatures between 1.5°F (0.8°C) and 3°F (1.7°C) above background are generally limited to a plume of around 25 acres. Temperatures less than 1.5°F (0.8°C) above ambient will affect an area of approximately 400 acres down to a depth of about 2.5 m. Thus, temperature increases associated with plant operation are relatively small in terms of both absolute value and spatial scale and are limited to surface waters.

As for thermal effects, the potential for altering water chemistry is reduced by withdrawing and discharging cooling water into the same water body. Turnover of water within the intake and discharge canals is relatively rapid, and thus with the exception of temperature, water leaving the discharge canal is not substantially different from water in the ocean at the point of discharge.

Through construction and operational design, FPL substantially reduced the potential for environmental impacts at the St. Lucie Plant. The principal environmental issue associated with present-day operation of the plant is the entrapment of aquatic organisms in the intake canal, including rare and endangered species. However, as discussed below, FPL has been proactive in developing programs to minimize and mitigate these impacts.

ENVIRONMENTAL CONDITIONS AT THE ST. LUCIE PLANT

Minimization of environmental impacts has been of primary concern to FPL throughout the planning, design, construction, and operation of the St. Lucie Plant. A multitude of scientific studies have been conducted throughout the life of the facility to document the effect of Unit 1 and 2 operations on adjacent aquatic habitats and to explore alternative methods for further improving the plant's environmental performance.

Baseline Studies

Relatively little was known about the physical and biological characteristics of the aquatic environments in the vicinity of the St. Lucie Plant at the time of initial permitting for Unit 1. Consequently, in 1971 FPL funded environmental baseline studies of Atlantic Ocean receiving water bodies and nearby beaches. These studies were conducted between 1971 and 1974 by the Florida Department of Natural Resources Marine

Research Laboratory (now Florida Fish and Wildlife Conservation Commission Florida Marine Research Institute). The following environmental components were monitored: salinity, temperature, dissolved oxygen (DO), turbidity, chlorophyll *a*, total suspended solids, nutrients, total organic carbon, sediments, phytoplankton, zooplankton, macrophytes, infaunal and epifaunal macrobenthos, worm reef communities, fish, and sea turtle nesting. Gallagher and Hollinger (1977) presented a physical description of the area, background information and general methodology for the studies. Results of much of the monitoring were presented in a series of reports published by the Marine Research Laboratory (Table 1).

Table 1. Published Results of Baseline Studies

Environmental Component	Reference
Sediments	Gallagher (1977)
Physical and Chemical Environment	Worth and Hollinger (1977)
Lancelets and Fishes	Futch and Dwinell (1977)
Arthropods	Camp, Whiting and Martin (1977)
Plankton	Walker and Steidinger (1979); Tester and Steidinger (1979); Walker et al. (1979); Walker (1979)
Benthic Algae	Moffler and Van Breedveld (1979)
Mollusks	Lyons (1989)
Sea Turtles	Gallagher et al. (1972); Worth and Smith (1976)

During baseline monitoring, researchers found physical and chemical conditions within nearshore waters adjacent to the St. Lucie Plant to be relatively homogenous (Worth & Hollinger, 1977). No significant diel (day/night) patterns were evident, nor was there any appreciable or persistent stratification within the water column. The only exception was during occasional summer intrusions of Florida Current water onto the continental shelf which caused relatively large surface to bottom variations in both temperature and salinity. The greatest source of variation in physicochemical temporal and spatial patterns resulted from tidal exchange between estuarine (Indian River Lagoon) and coastal water masses.

Baseline monitoring established that there were three sub-tidal microhabitats offshore the St. Lucie Plant: shallow beach terrace, offshore shoal, and a deeper trough in between the two. Sediment composition differed among these zones. The beach terrace consisted of fine to very fine, moderately well sorted, gray non-biogenic sand. Medium grained, well-sorted sandy shell was present on the offshore shoal. The trough consisted of coarse to very coarse, poorly sorted, sandy shell-hash. The biological composition of macroinvertebrate communities was largely influenced by sediment composition. Because of sediment heterogeneity, the trough supported the most abundant fauna. It was characterized by high diversity and relatively rapid turnover of less abundant and transient species. In the intertidal zone, the worm reef community provided yet another distinct habitat for macroinvertebrates.

Patterns of fish abundance and diversity were also largely aligned along microhabitat boundaries. In addition to the four habitats identified above, the surf zone harbored yet another distinct assemblage of fishes.

Baseline monitoring confirmed that Hutchinson Island was an important rookery for loggerhead sea turtles and documented the presence of both green and leatherback turtles nesting on beaches in the vicinity of the St. Lucie Plant (Gallagher et al., 1972 and Worth and Smith, 1976). Studies of the intertidal worm reef communities at Walton Rocks found that this habitat supported a variety of attached algae and numerous species of macroinvertebrates, many of which were found nowhere else within the study area.

Unit 1 and 2 Operational Studies

Operational monitoring for Unit 1 and pre-operational monitoring for Unit 2 were designed to assess aquatic impacts associated with operation of the St. Lucie Plant. They included water quality, phytoplankton, zooplankton, aquatic macrophytes, periphyton, macroinvertebrates, fish, and sea turtles.

Water Quality

Post-construction field studies considered climate, rainfall, currents, tides, and thermal effluents as factors potentially influencing water quality in the vicinity of the St. Lucie Plant. Water sampling was conducted to document temperature, salinity, dissolved oxygen, turbidity, light transmittance and nutrients at six offshore stations within the three microhabitats identified during baseline studies. Monitoring commenced in 1976 coincident with Unit 1 start up. Monitoring requirements were deleted from the plant's Environmental Technical Specifications in May 1982 after it was demonstrated that Unit 1 operations were not having a substantial, persistent or widespread effect on water quality in the receiving water body.

Temperature – Seasonal seawater temperatures near Hutchinson Island are highest in late summer/early fall and lowest in mid- to late-winter. This summer/winter pattern of heating and cooling is largely controlled by air temperatures, and tends to lag behind changes in air temperature by about two months. In this humid, sub-tropical climate, it is not surprising that maximum ocean water temperatures in September may exceed 30.5°C (87°F) and fall to minimum values in January as low 18.3°C (65°F). However, due to water depths, currents, and the moderating influence of the nearby Gulf Stream, seasonal fluctuations in ocean temperature are much less dramatic than those in the adjacent Indian River Lagoon, where shallow depths permit more rapid heat exchange between the air and water.

No distinct thermocline has ever been recorded in the vicinity of the plant, but through a gradual change within the water column, it is not unusual for water near the bottom to be cooler by several degrees than surface water. From August to December, and again between April and May, these offshore waters are normally isothermal. This scenario may undergo small, temporary changes due to intrusions by adjacent water masses. These include estuarine waters from the Indian River Lagoon, Gulf Stream waters, and waters that originate north of Cape Canaveral.

Infrared mapping of the thermal plume conducted in 1984 during a period when both Units 1 and 2 were operating at near full capacity confirmed model predictions of the limited spatial extent of thermal effluents (Intera, 1984). At the time of the aerial surveys, temperatures in the discharge canal were around 40°C (104°F). However, maximum plume temperatures did not exceed 32°C (90°F). The maximum difference between plume and ambient surface water temperatures observed during two separate overflights was 4.5°C (8.1°F).

Salinity – Salinities within the nearshore waters adjacent to the St. Lucie Plant are typical of oceanic conditions, generally fluctuating between 34 and 36 ppt (ABI, 1983). Except for precipitation, the only freshwater inputs are from the two inlets at either end of Hutchinson Island, both considerably distant to the plant site. During the rainy summer months (June-September), freshwater runoff entering the Atlantic Ocean from the inlets may influence salinity regimes near the plant, provided long-shore currents are favorable. However, these deviations rarely persist for more than a few days (Worth and Hollinger, 1977).

A halocline has never been reported in local hydrographic studies, but small salinity differences between surface and bottom waters are quite common. There is no evidence that power plant operations have had any measurable effect on local salinity patterns.

Dissolved Oxygen – In contrast to records for water temperature and salinity, highest values for dissolved oxygen have been recorded mostly in winter. This is as would be expected since oxygen solubility is inversely related to temperature. Overall, DO values at ocean stations generally fell within the range of 4 to 8 mg/liter (ABI, 1983), and samples were found to be 100% saturated in at least 70% of analyses performed. There were no significant differences between day and night oxygen records, and no departures from background values in the vicinity of thermal discharges. Concentrations at all stations exceeded the minimum requirements of indigenous aquatic biota. Based on available data, plant operations have had no discernible affect on levels of dissolved oxygen in the vicinity of the St. Lucie Plant.

Turbidity – Turbidity is a measure of water clarity and reflects the amount of suspended inorganic and organic material present in the water column. It can be affected by waves and currents that agitate bottom sediments and by input from upland runoff.

Suspended particulates may limit light penetration, and thus high turbidities may affect the growth and reproduction of phytoplankton and attached macrophytes.

The physical environment in the vicinity of the St. Lucie Plant is extremely dynamic. As expected, turbidity was generally greater at the bottom, where currents and waves suspend sediments, than at the surface. Similarly, turbidities were greater at the sand terrace stations where wave action is more prevalent than at the deeper trough and shoal stations (ABI, 1983). Turbidity values were generally similar between stations in the immediate vicinity of the discharge pipes and comparable control stations, indicating that plant operations had little influence on water clarity.

Light Transmittance – There was considerable variability in light transmittance within the nearshore waters adjacent to the St. Lucie Plant. Light penetration varied in relation to turbidity, wave action, cloud cover, time of day, season, and water depth (ABI, 1983). Penetration was generally lowest at stations on the beach terrace where wave action and turbidity was greatest. However, based on absolute values, researchers concluded that due to relatively shallow water depths, it would be unlikely that poor light transmittance would ever exclude photosynthetic processes in the vicinity of the plant. There were no consistent patterns in light transmittance at ocean stations and no indications that plant operation was influencing observed patterns.

Nutrients – This category includes monitoring records for ammonia, nitrate, and nitrite nitrogen, silicate, inorganic phosphorus and both dissolved and suspended organic carbon (total organic carbon). Data for waters offshore Hutchinson Island shows that values for all of these variables are within normal limits consistent with ecologically balanced, moderately productive, sub-tropical waters. All three nitrogen categories had concentrations that averaged 1 ppm or less (ABI, 1983). Higher values were generally found in spring, summer, and fall and may be associated with rainfall, land drainage, and transport to the plant area via the St. Lucie Inlet and northbound currents. Nutrients were typically dispersed homogeneously among stations, and there was no indication that plant operations were having any measurable influence on the concentrations of these variables.

Plankton

Plankton densities and composition in the vicinity of the St. Lucie Plant were monitored monthly at six ocean stations and at one station each within the intake and discharge canals. Monitoring commenced in 1976 coincident with Unit 1 start up. Monitoring requirements were deleted from the plant's Environmental Technical Specifications in May 1982 after it was demonstrated that Unit 1 operations were not having a substantial, persistent or widespread effect on phytoplankton or zooplankton densities and community composition with the receiving water body.

Phytoplankton – The phytoplankton community was composed primarily of diatoms and phytoflagellates. Cryptophytes and dinoflagellates occurred infrequently as major groups. The composition of the phytoplankton communities was typical of those described for other nearshore areas along the eastern seaboard of the United States (ABI, 1983).

Phytoplankton densities were typically higher in the intake canal than in the discharge canal due to entrainment mortality (ABI, 1983). However, the disparity between the two canals appeared to decrease over the term of monitoring.

Despite high entrainment mortality, phytoplankton densities and chlorophyll *a* concentrations were typically much higher in both the intake and discharge canals than in the ocean (ABI, 1983). Similarity in densities and chlorophyll *a* concentrations between the ocean discharge station and a comparable nearshore control station indicated that natural environmental factors common to the beach terrace were the predominant influences on phytoplankton abundance. Comparisons of operational and baseline data among stations and study years provided no evidence of long-term or widespread adverse impacts of plant operation on the ocean phytoplankton community. The most probable net effect of plant operation was phytoplankton enrichment in the immediate vicinity of the ocean discharge.

Zooplankton – The ocean zooplankton community was characterized primarily by neritic holoplanktonic species (species that spend their entire life cycle in the water column); copepods were the dominant group (ABI, 1983). Holoplanktonic urochordates were the second most important zooplankton group. Meroplankton, benthic macroinvertebrate larvae that are temporary members of the plankton community, were major contributors to the zooplankton only during brief periods. This group included barnacle, crustacean, polychaete, mollusk, and echinoderm larvae.

As for phytoplankton, zooplankton densities in the intake canal were typically greater than those in the discharge canal. This was attributed in part to the loss of organisms upon passage through the plant. Similarities in zooplankton composition and density between ocean discharge and comparable control stations indicated that thermal effluents were not having a measurable affect on nearshore zooplankton populations.

Aquatic Macrophytes

Quarterly sampling was conducted at six ocean stations to determine if operation of the St. Lucie Plant was affecting the abundance or composition of macrophytes in nearshore waters. Over the course of monitoring it became apparent that the absence of stable hard substrate in the vicinity of the plant limited the occurrence of benthic macrophytes. Attached algae consisted primarily of small plants or fragments on pieces of unconsolidated shell and rock (ABI, 1983). During the summer, algae became more abundant, primarily due to the influx of drift algae from distant locations. During that period, macrophyte abundance was greatest at beach terrace stations, because that is where drift algae tended to accumulate. It was concluded that algae played a minor role in primary productivity within the study area and that plant operation had no measurable effect on this marine community. Consequently, macrophyte monitoring requirements were deleted from the plant's Environmental Technical Specifications in May 1982.

Periphyton

In its broadest sense, periphyton refers to organisms that attach by various means to submerged substrates but do not penetrate into them. The periphyton community includes not only bacteria, yeasts, molds, protozoa, and algae, but also colonial organisms, such as bryzoans, and a variety of free-living organisms (e.g., crustaceans and polychaetes) that inhabit the mat of attached forms. This community has been widely used to monitor water quality.

An investigation of the periphyton community was undertaken at the St. Lucie Plant between May 1976 and January 1977 (ABI, 1977). Sampling was conducted by submerging arrays of microscope slides (diatometers) for intervals of two to three weeks at discharge and intake (control) stations. Analyses of scrapings from exposed slides showed that during summer months when water temperatures were greatest, reductions in diversity, abundance, and biomass of the periphyton community occurred within the discharge canal. However, thermal effluents did not significantly alter the species composition of these communities. Intermittent plant operation precluded meaningful comparisons of overall productivity between intake and discharge periphyton communities on an annualized basis.

Macroinvertebrates

Macroinvertebrates are animals that, as adults, primarily live at the bottom of the sea associated with unconsolidated sediments or hard surfaces such as rocks, reefs, and artificial structures. Major groups include polychaete worms, mollusks, arthropods, and echinoderms. Members of this community are important components of the marine food web, many figuring prominently in the diet of recreationally or commercially important species of fish. Others, such as lobster, shrimp, crabs, and scallops, are themselves targeted for commercial exploitation.

In marine environmental monitoring studies, benthic macroinvertebrates are eminently useful and important for several reasons. First, within a framework of normal reproductive patterns and seasonal phenomena, these organisms become organized in characteristic communities based on substrate type, hydrological conditions, and food supply. Furthermore, most component species are essentially non-migratory and establish more or less stationary communities that typically exhibit relatively long-term stability. Because each individual bottom community is ecologically structured by its surroundings, any persistent environmental alteration(s) invariably results in marked community restructuring involving changes in species diversity, abundance, and overall community structure. Consequently, these communities serve as useful indicators of environmental impact.

Sub-Tidal Communities – During baseline studies from 1971-1973 three major benthic habitats, each characterized by different substrates, hydrological conditions, and biological assemblages, were identified in the vicinity of the St. Lucie Plant: beach terrace, offshore trough, and offshore shoal. Among the invertebrates, 127 species of arthropods and nearly 300 species of mollusks were identified and analyzed in respect to frequency of occurrence, abundance, numbers per unit area, and seasonality. The diverse makeup of these groups, and to some extent their seasonal variability was attributed to the transitional temperate, sub-tropical, and tropical mix of climate and water masses in the general vicinity of Hutchinson Island. Some estuarine affinities were also noted and attributed to water mass intrusions from the Indian River Lagoon by way of the St. Lucie Inlet and prevailing northerly coastal currents. Among species of direct commercial value, the Calico scallop was the only mollusk recorded. Arthropods of potential commercial value included penaeid shrimp and the blue crab. However, these species were generally collected in small numbers and infrequently.

Between 1976 and 1982 studies were conducted to determine if Unit 1 operation was impacting benthic macroinvertebrate assemblages. Methodology drew largely on baseline work, with the exception that an additional southern control station was added to better assess the effects of Unit 1 thermal discharges. During quarterly sampling at each of the six stations, sediment and water quality data (temperature, salinity, dissolved oxygen, and turbidity) were collected.

During the seven years of evaluations for Unit No. 1, some small-scale, year-to-year changes were noted in biological and water quality parameters, but with only a few exceptions, there were no significant deviations from pre-operational baseline conditions. The exceptions, all of which occurred adjacent to the Y-port diffuser, included a slight rise (about 1°C; 1,8°F) in bottom water temperature, a slight increase in turbidity measurements during 1981, and increases in the diversity and abundance of invertebrates taken in trawl samples during 1981. The observed rise in water temperature was attributed to discharges from Unit No. 1, and was deemed insignificant because there was no concomitant effect on the benthic infaunal community nearest the Y-port diffuser. Throughout the period of monitoring, bottom temperatures in the general vicinity of the discharge never rose above 30°C (86°F). The cause and significance of turbidity and faunistic irregularities recorded at the diffuser station during 1981 proved less clear. However, these deviations were only observed during a single year, which happened to corresponded to the placement of the discharge pipeline for Unit 2. Thus, it seemed most likely that they were inconsequential and related to construction activities.

The benthic monitoring program shifted in 1982 to evaluate the hydrological and benthic impacts of Unit 2 as well as the combined operational impacts of Units 1 and 2. Station locations were modified to better assess thermal impacts from the new multi-port diffuser. A total of seven stations were monitored quarterly until mid-1984. A new control station was established in the offshore trough well to the north and outside anticipated boundaries of the enlarged thermal plume.

Over the monitored period of combined Unit 1 and 2 operations, results for water quality measurements showed that bottom water temperatures at all discharge stations averaged less than 1°C (1.8°F) higher than background seawater and never exceeded

1.7°C (3.1°F) above background. Thermal effluents never caused a surface increase in water temperature of more than 2.2°C (4.0°F). Measurements of salinity and dissolved oxygen followed normal seasonal patterns at all stations and were within the ranges of long-term records. Turbidity measurements diminished after 1981, but remained slightly above control station values at both the Y- and multi-port diffuser stations. Even so, turbidity values at the discharge stations rarely exceeded 5 Jackson Turbidity Units above background levels and always remained within the range of normal seasonal turbidity fluctuations.

As in previous studies, two unique faunal assemblages were documented adjacent to the two discharge pipelines, one on the beach terrace and another in the trough (ABI, 1985). Populations of benthic macroinvertebrates were persistent over the study period, although both assemblages exhibited considerable seasonal and annual variability. Few species exhibited systematic long-term increases or decreases in abundance. Variation in density and species richness was not strongly correlated with changes in ambient temperature, salinity, turbidity, or DO. Most of the dominant taxa collected on the beach terrace exhibited irruptive life histories characterized by unpredictable, large-magnitude changes in abundance. In contrast, the densities of taxa that dominated shell hash habitats were relatively stable over time.

Sediment data indicated that higher than normal amounts of fine-grained particles periodically accumulated in the vicinity of both diffusers. However, such accumulations proved to be temporary, and were regularly dispersed by waves and currents during stormy weather. At those stations immediately adjacent to the multi-port diffuser, values for both macroinvertebrate diversity and abundance showed a gradual and regular decline from 1982 until the end of benthic investigations in 1984, even though one of these stations was upcurrent of the prevailing plume dispersal (ABI, 1985). The most plausible explanation for this finding involves an association between benthic community structure, and temporal changes in sediment stability. Due to high discharge volumes and velocities, considerable turbulence and scour occurs in the vicinity of the discharge pipes. A relatively high degree of sediment instability may prevent the establishment of the diverse and abundant assemblages found elsewhere within the shell-hash sediments of the offshore trough.

In summary, the extension of benthic studies from 1971 through 1984 produced remarkable databases for regional sediments, hydrology, and bottom dwelling organisms. A total of 934 taxa of benthic macroinvertebrates, many species new to science, were identified over the period of monitoring. Collectively, sediment, water quality, and biological data show that combined operations of Units 1 and 2 at the St. Lucie Plant had little impact on benthic environments in the vicinity of the discharge diffusers and within the boundaries of the thermal plume. The one possible exception had to do with observations that showed a gradual restructuring of benthic communities on both sides of the multi-port diffuser due to sediment instability. However, this effect was spatially limited.

Worm Reef Communities – Quarterly worm-rock studies were conducted at two sites at Walton Rocks between April 1976 and April 1979. Macroalgae and major invertebrate groups (mollusks, echinoderms, and arthropods) were sampled at both locations and photographs were taken upon each visit to document the appearance of the *Phragmatopoma lapidosa* colonies that covered the coquinoid rock formations.

The macroinvertebrate community inhabiting the worm rock formations was highly transitory in nature, increasing in size during the calmer summer months and then deteriorating during the winter (ABI, 1979b). As sea conditions increased during the fall and winter, portions of the worm reef would become buried by sand and other parts destroyed by pounding waves. The density of individuals, number of species, and faunal diversity of worm reef fauna corresponded to these changes. Two crabs, *Menippe nodifrons* and *Pachycheles monolifer*, dominated the fauna throughout the period of monitoring. No collections contained juveniles or adults of species taken in regional fisheries.

Community characteristics of the worm reefs during 1976, a year of intermittent plant operation, and between 1977 and 1979, a period of sustained plant operation, were compared with results of studies performed by the Smithsonian Institution in 1974 and 1975 prior to commencement of plant operations (Gore et al., 1978). There were no significant changes in the density, number of species, or dominance patterns of the associated worm reef fauna among any of the three periods. Thus, the St. Lucie Plant did not appear to have any measurable effect on the macroinvertebrate community inhabiting the Walton Rocks worm reefs.

Commercially Important Shellfish – An evaluation of the impacts of plant operation on populations of commercially important mollusks and crustaceans was undertaken in conjunction with fish studies. Collectively, gill net, trawl and beach seine studies were designed to show the normal, inshore-offshore distribution and relative abundance of fish and large epibenthic crustaceans. Offshore stations were positioned near intake and discharge structures and within the boundaries of the thermal plume to detect deviations from normal catch patterns that could be attributed to plant operation.

The crustacean catch resulting from trawling was limited to very small numbers of brown shrimp (*Penaeus aztecus*), pink shrimp (*Penaeus duorarum*), rock shrimp (*Sicyonia brevirostris*), blue crabs (*Callinectes sapidus*), and the calico scallop (*Argopecten gibbus*). Only a single stone crab (*Menippe mercenaria*) and no spiny lobsters (*Panulirus argus*) were taken. Because there were such small numbers collected, no spatial patterns could be discerned; specimens of all species occurred at both intake and discharge stations. The nearshore area in the vicinity of the St. Lucie Plant does not appear to provide suitable or preferred habitat for these species. Consequently requirements for trawl and seine monitoring were deleted from the plant's Environmental Technical Specifications in May 1982.

Fish

Studies of regional fishes and fish eggs and larvae were integral elements of operational monitoring at the St. Lucie Plant. The need for this work was based on two critically important factors. First, recreational and commercial fisheries of the Florida East Coast represent extremely valuable economic resources. And secondly, predictable environmental impacts of the facility's cooling water system would unavoidably cause some level of mortality among local and migratory fish populations through entrainment and impingement of eggs and larvae. Additionally, there was concern about whether fish, particularly migratory species, might congregate in the vicinity of thermal discharges.

The fish communities offshore the St. Lucie Plant are transitional assemblages of temperate and tropical forms. Compilation of fish records for the Indian River Lagoon and adjacent waters indicated that there are about 560 species of fish inhabiting neritic, surf zone/sand shell, open benthic, and reef habitats on the continental shelf of the Atlantic Ocean in the general vicinity of the St. Lucie Plant (Gilmore and Herrema, 1981).

Understanding that oceanic icthyofauna are most diverse and abundant near reefs and other hardbottom areas, FPL sited intake and discharge structures for Units 1 and 2 in areas devoid of these habitats. During baseline studies conducted between 1971 and 1973, a total of 75 species of fishes were collected offshore the St. Lucie Plant (Futch and Dwinell, 1977). However, only 30 of these species were taken from depths in which intake and discharge lines now terminate (i.e. trough habitat). Perhaps most importantly, all pre-operational studies showed that the three most valuable fish in local ocean fisheries occur farther offshore and are only seasonally abundant during migrations in spring and fall. These include Spanish mackerel, king mackerel, and bluefish.

Operational studies for Unit 1 began in March 1976 and ended eight years later in 1982. The purposes of these studies were to 1) sample the intake canal to determine species and abundance of entrained fishes, and determine if there was evidence of fish accumulations: 2) sample intake and discharge canals and offshore habitats for fish eggs and larvae to determine their diversity and abundance, and estimate losses due to entrainment through the condenser cooling system: 3) sample at beach and offshore stations to census fish species and abundance to document spatial patterns potentially related to the presence of intake and discharge structures and/or thermal discharges.

In these sampling programs paired plankton nets (Bongo Nets) were used to collect ichthyoplankton, while fish were sampled using beach seines, gill nets, and trawls. Samples were collected within both the intake and discharge canals and from nine offshore stations.

Analysis of ocean ichthyoplankton samples revealed no influences due to power plant operations (ABI, 1983). Fish eggs were somewhat more abundant at offshore stations than inshore stations, while larvae proved to be equally abundant in both areas. In most samples herrings and anchovies were the dominant fishes. These are primarily forage species, which are abundant in the area of the St. Lucie Plant. Seasonally, more eggs and larvae were consistently collected in spring and summer than at other times. Among sport and game species, mackerel larvae were occasionally taken, but no bluefish larvae were ever recorded.

Overall, the entrainment studies of fish eggs and larvae indicated some impacts related to plant operation (ABI, 1983). As expected, numbers of fish eggs and larvae were consistently lower in the discharge canal than in the intake canal, reflecting mortality from passage through the plant. However, calculations of entrainment mortality showed that on an annual basis, power plant operations removed less than one percent of the pool of fish eggs and larvae in the vicinity of the offshore intake structures. More importantly, occurrences of larvae of sport and commercial species were infrequent and insignificant in the canal system. Based on these findings, researchers did not consider the effect of plant operation on fish eggs and larvae to be a significant environmental concern. A major factor contributing to the low entrainment was the design of the intake structures. Cooling water is drawn from well below the surface of the ocean. This layer consistently contains far fewer fish eggs and larvae than surface water.

Although catch records by gear and station showed considerable year-to-year variations in the number of fish inhabiting nearshore waters adjacent to the St. Lucie Plant, an overall analysis of the data showed no significant variation(s) that could be attributed to Unit 1 operation (ABI, 1983). Notable species in the offshore catches included Atlantic bumper, Spanish and king mackerels, bluefish, Atlantic croaker, spot, cobia, weakfish, sheepshead, snook, pigfish, pompano, jacks, menhaden, sardines, anchovies, and herring.

Results of gill netting in the intake canal showed that relative to the number of fish collected in the vicinity of the offshore intake structures, the number collected in the intake canal was low (ABI, 1983). Again, this finding attests to the effectiveness of the velocity caps in minimizing entrainment impacts.

On an annual basis total counts of fish and large motile crustaceans (e.g., blue crabs, lobster and stone crabs) netted from the intake canal amounted to only about 1,500 and, 60, respectively (ABI, 1983). Data indicated that there was no major accumulation of fish or crustaceans within the canal, probably due to mortality, predation and scavenging. Throughout Unit 1 operational monitoring, catches of commercially important migratory species were very small. For example, only 15 Spanish mackerel and 37 bluefish were recorded over an 8-year period. Although numerous species of sport and commercial importance, such as snappers, sheepshead, drum, and mullet, were entrained with cooling water, losses to their respective populations was negligible considering the low numbers encountered.

Due to the lack of significant impacts from the entrainment of fish, icthyoplankton monitoring and offshore trawl and seine studies were deleted from the St. Lucie Plant's Environmental Technical Specifications in May 1982. Concurrently, increased effort was placed on offshore gill netting to determine if thermal effluents from the combined operation of Units 1 and 2 was disrupting the normal migratory behavior of commercial species. Additional offshore stations were added and semi-monthly collections were made during the periods when these species were present in the area.

During the intensified ocean gill netting program, there were no statistically significant differences in the numbers of fish collected among stations (ABI, 1985). Studies showed that fish concentrations in intake and discharge areas varied seasonally, indicating that fish did not permanently congregate around the structures, but rather moved on. This finding had important implications, because it showed that the intake and discharge structures and thermal effluents were not important enough attractants to interfere with the natural migratory movements of commercial species, such as Spanish mackerel and bluefish. Changes in year-to-year abundances in the vicinity of the plant were related to natural variation. Because there were no indications of any significant or widespread effects of St. Lucie Plant operation on local fish populations, monitoring for fish was terminated in 1984.

Sea Turtle Nesting

For thousands of years, sea turtles have used the narrow, shelf-depth waters off Hutchinson Island as a migratory corridor, and the beach as a favored nesting habitat. All five Atlantic species of marine turtles occur in waters off Hutchinson Island. These include the loggerhead (*Caretta caretta*), green turtle (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and Kemp's ridley (*Lepidochelys kempii*). However, nesting on the barrier island beaches is limited to loggerhead, leatherback and green turtles.

FPL has monitored sea turtle nesting on Hutchinson Island since 1971, first for baseline purposes and then later to determine if plant operations were affecting nesting patterns. These studies are on-going, making the Hutchinson Island program one of the longest running nesting surveys in the country.

The loggerhead turtle is responsible for the majority of nesting on Hutchinson Island. Each year between 3,000 and 8,000 nests are deposited along the 36 km length of the barrier island (FPL and Quantum Resources, Inc., 2000). Green turtles are the next most prolific nesters, each year constructing between 10 and 250 nests. Unlike the other two species, green turtles exhibit a distinct biannual nesting pattern; over the past decade, highest numbers of nests were recorded during odd-numbered years. Leatherbacks typically account for between 10 and 150 nests per year.

Nesting on Hutchinson Island by all three species has been increasing over the last two decades (FPL & Quantum Resources, Inc., 2000). During recent years, record numbers of nests have been recorded for all three species. This increase is also evident on the beaches adjacent to the St. Lucie Plant (Figures 6 and 7). For loggerheads the increase is statistically significant. Although construction activities associated with the installation of Unit 2 intake and discharge pipes caused a temporary reduction in nesting

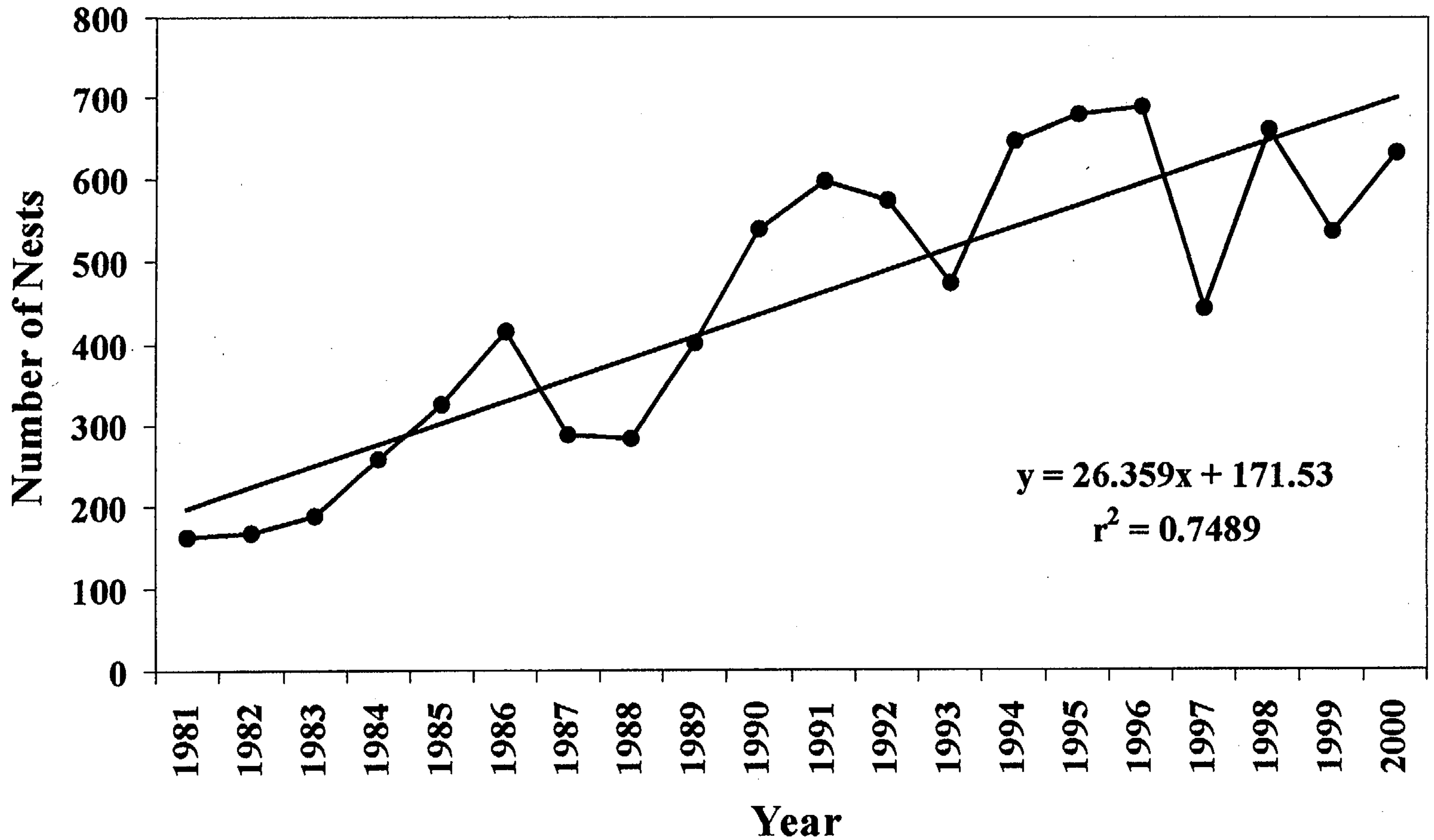

Figure 6. Annual nesting by loggerhead turtles within a 2-km section of beach adjacent to the St. Lucie Plant, Hutchinson Island, Florida, 1981-2000.

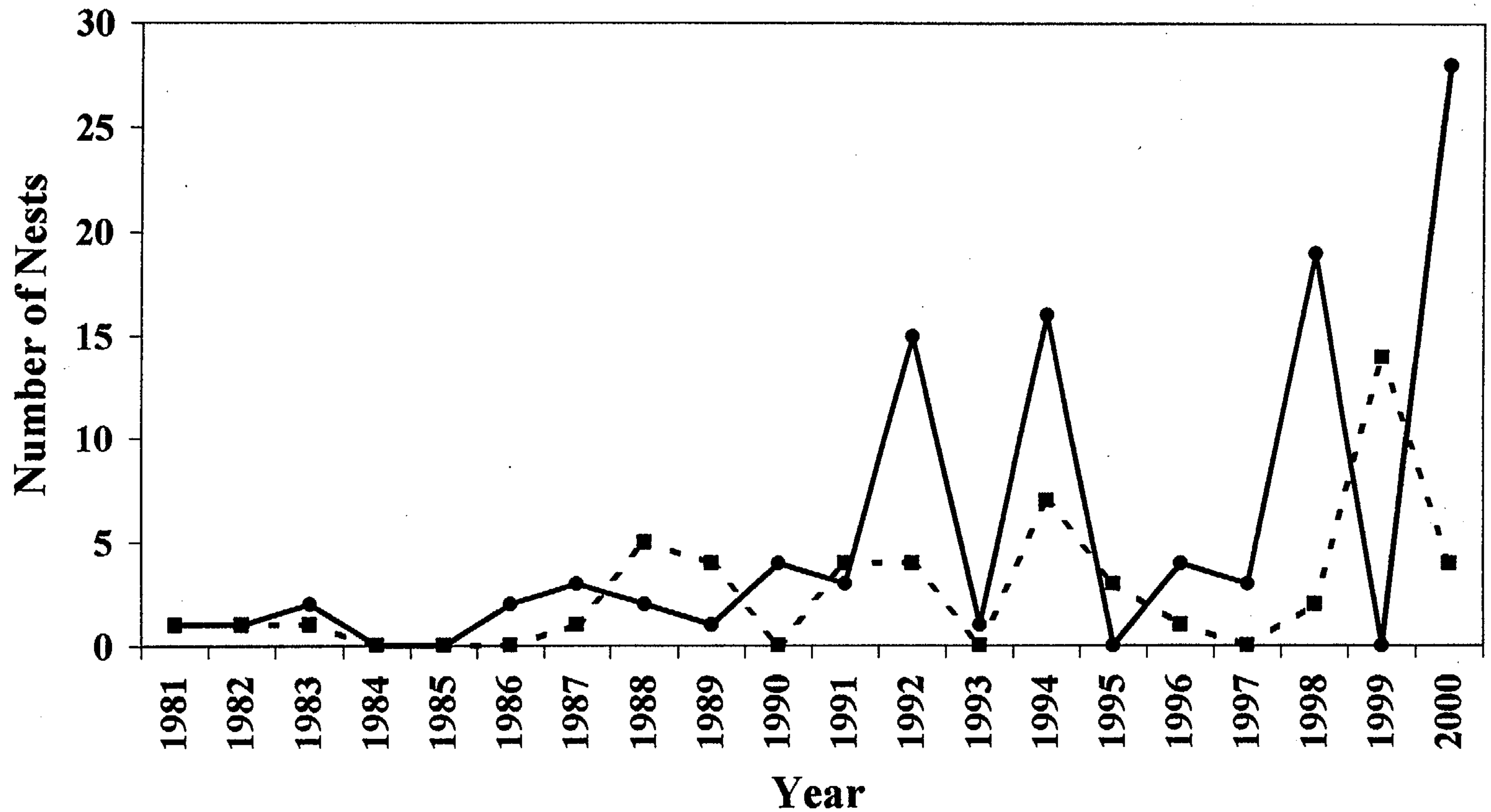

Figure 7. Annual nesting by leatherback and green turtles within a 2-km section of beach adjacent to the St. Lucie Plant, Hutchinson Island, Florida, 1981-2000.

near the plant, the long-term trend of increasing nest densities indicates that thermal effluents and other aspects of plant operation are not having a negative effect on nesting behavior.

FPL has instituted programs at various times throughout the history of the plant to reduce predation and protect nests from construction-related impacts. A light screen is presently maintained along the eastern perimeter of the property and other light management measures have been undertaken to prevent artificial lights on FPL property from shining onto the beach where it might disorient emerging hatchlings.

During 1977, the year after Unit 1 began operation, FPL commissioned a study to determine if hatchlings swimming offshore after leaving their nests might be affected by elevated water temperatures within the thermal plume. Results indicated that brief encounters (50 minutes or less) with temperatures above 30°C (86°F) may reduce swimming speeds, but that normal activity resumed when temperatures returned to ambient (O'Hara, 1980). Temperatures in excess of 33°C (91.4°F) could potentially reduce survivorship by causing heat stress and interfering with orientation mechanisms. However, the maximum temperature recorded in the thermal plume during the summer with both units operating at high capacity is only 32°C (89.6°F; Intera, 1984). Furthermore, the area affected by thermal effluents is relatively small. Consequently, thermal discharges from the St. Lucie Plant probably pose a minor risk to hatchlings during their offshore migrations.

IMPINGEMENT

Over a three-year period from 1976 through 1978, FPL conducted monitoring of the traveling screens at the St. Lucie Plant intake wells to determine the types and abundance of fish and crustaceans being removed from water used to cool Unit 1's generating equipment. Sampling was conducted over a 24-hour period twice a week. Organisms filtered from cooling water by the traveling screens were washed into a fine-mesh basket, identified, counted, and weighed.

Samples consisted mainly of small fish and a few crustaceans. The most commonly found fishes were anchovies, jacks, croakers, and mojarras (ABI, 1979a). Jacks constituted the majority of biomass. Other fish of interest because of their recreational and commercial importance were silver seatrout, weakfish, spot, southern kingfish, black drum, flounder, sheepshead, lane and yellowtail snapper, menhaden, and cobia. Data for 1978 were extrapolated to estimate the total number and weight of fish that would have been impinged if Unit 1 were to operate at full capacity every day throughout the year. This estimate was 33,696 individuals and 453.5 kg (999 lbs). By comparison, the commercial landing of finfish in St. Lucie and Martin Counties in 1976, the latest year for which data were available, was 26.7 million kg (12.1 million lbs). Thus, impingement of fish at the St. Lucie Plant was considered negligible.

In order of abundance, commercially important crustaceans in impingement samples included penaeid shrimp (e.g., pink shrimp), blue crab, stone crab, and spiny lobster (ABI, 1979a). Annualized data extrapolated from 1978 impingement data equaled 212 pounds for shrimp, 178 pounds for blue crabs, 22 pounds for stone crabs and insignificant poundage for the spiny lobster (only 8 individuals collected). Again, these numbers were inconsequential in relation to comparable commercial landing data.

Compared to commercial landings, which indicate the relative abundances of fish and shellfish off Hutchinson Island, the biomass of impinged fish and shellfish was low, and losses were not considered to have any significant impact on offshore populations. This low impingement rate, particularly of commercial species, was largely attributed to the effectiveness of the velocity caps (ABI, 1979a). Due to the minor impacts associated with impingement of aquatic organisms, requirements to monitor the traveling screens were deleted from the St. Lucie Plant's Environmental Technical Specification in January 1979.

ENTRAPMENT

Although siting and design features of the cooling water system reduce the potential for entrainment, some larger, motile organisms do, nevertheless, enter the intake structures and are carried with cooling water into the St. Lucie Plant canal system where they become entrapped. Many of the species entrained with cooling water apparently utilize the intake structures as shelter and/or feed on the attached algae and invertebrates that colonize them. On the otherwise barren sand/shell bottom offshore the plant, the vertical relief offered by the structures in all appearances resembles a reef, complete with dark undercut ledges. Not surprisingly, many species of fish that are associated with hardbottom communities, such as grouper, snapper, and grunts, as well as sea turtles, are attracted to the structures. Presumably, the majority of animals entrained with cooling water willfully enter the intake housing rather than being drawn in by currents.

Sea Turtles

The entrainment of sea turtles at the St. Lucie Plant was an unforeseen environmental impact during permitting of Unit 1. However, as soon as the plant began operation in March of 1976, it became apparent that a program was needed to return entrapped turtles to the ocean. That program, which is on-going today and part of the facility's Environmental Protection Plan, has steadily evolved over the life of the plant.

As soon as entrapment of turtles was recognized as a persistent phenomenon, FPL initiated a series of experimental studies to identify feasible and effective methods for deterring turtles from entering the intake structures. These involved static light and bubble screens (ABI, 1981), weak electric impulses (O'Hara and Kania, 1981), seismic profiling/pneumatic air guns (O'Hara and Wilcox, 1983), and strobe lights (Raesly et al., 1984). In some of the tests, combinations of these devices were used. Additionally, FPL assessed the practicality of utilizing physical barriers at the structures. Although some of the deterrents showed promise, none could be demonstrated to be both highly effective and practical. Given the dynamic nature of the physical environment in the area of the intake structures and the corrosive nature of seawater, maintenance of these systems would undoubtedly be high. Additionally, there would be considerable engineering costs and capital outlay to transfer technology from the lab to the field. In the final analysis, FPL concluded that "upon careful evaluation of the practicality, reliability, and costs of the various deterrent systems, . . . the present netting technique is the most practical and cost effective technique for removing entrapped turtles from the intake canal at the St. Lucie Plant" (FPL, 1984). Simultaneously, FPL made a commitment to ensure that turtles were removed from the canal in the safest and most expedient manner reasonably possible.

The recovery and release of entrapped turtles is predicated on a paradigm of effective turtle retention, rapid detection, benign capture, and timely return to the sea. In operation, entrained turtles are confined and concentrated by two barrier nets installed to block off and partition the intake canal segment east of Highway A1A where capture techniques are most effective (Figure 2). Turtle capture is optimized by the use of buoyed tangle nets. Under normal conditions, these nets are deployed 7 days per week and fished over a period of between 8 and 12 hours per day. The netting technique is supplemented with capture by hand (divers) and dip net. Biologists are on call for emergency rescue operation on a 24-hour basis.

Through 1999, a total of 6,581 sea turtles have been removed from the canal (FPL and Quantum Resources, Inc., 2000). About 59 and 40 percent, respectively, of all captures involved loggerhead and green turtles. The remaining one percent was divided fairly evenly among leatherbacks, hawksbills and Kemp's ridleys. The vast majority of turtles captured in the canal were juveniles. About 97 percent of all entrapped sea turtles were removed alive and released safely back into the environment.

Although most of the sea turtles entrapped in the intake canal are safely returned to the ocean, some mortality does occur. FPL has worked diligently to identify and remedy sources of mortality. Barrier nets used to confine turtles to the eastern portion of the intake canal have been repositioned and reconfigured to reduce residency times. Additionally, capture efforts have intensified and more efficient methods of capture developed. As a result of these efforts, FPL has substantially reduced the frequency of mortalities during recent years. Over the last decade only 1.06 percent of all captures have resulted in mortality.

Because of the incidental take of turtles that has occurred at the St. Lucie Plant, FPL was required to prepare a biological assessment of impacts associated with plant operation. This assessment was part of a Section 7 Consultation (a requirement of the Endangered Species Act of 1973, as amended) between the National Marine Fisheries Service (NMFS) and the NRC. As a result of the assessment, the NMFS developed a series of measures needed to reduce and mitigate take at the St. Lucie Plant. These requirements were then incorporated into the facility's Environmental Protection Plan.

Over the life of the plant, the annual number of sea turtle captures appears to be rising, with unprecedented capture rates being documented beginning about 1993. One of the requirements stemming from the Section 7 Consultation was an analysis of sea turtle entrapment data to assess the extent to which changes in capture rates were related to plant operating characteristics and/or extraneous environmental conditions (Martin and Ernest, 2000). The assessment considered changes in operating capacity, the addition of Unit 2, weather, and water temperature. The number of adult turtles entrapped in the canal most closely corresponded to nesting trends on adjacent beaches, suggesting that the turtles were using the structures as inter-nesting resting habitat. Although there were weak correlations between the number of juvenile loggerhead and green turtles entrapped in the intake canal and several of the plant operating conditions/environmental factors analyzed, none provided a convincing explanation for the dramatic increase in captures since the mid 1990s. Similar unprecedented increases in captures of juvenile turtles in natural water bodies have been documented for other areas of south central Florida. Consequently, the authors concluded that the most logical explanation for increases at the St. Lucie Plant was a growing local population.

FPL has mitigated the take of turtles at the St. Lucie Plant through a variety of scientific programs and environmental education initiatives. Informative booklets and brochures regarding sea turtle biology and conservation have been developed and distributed to FPL's customers. Nighttime "turtle walks" are offered each summer free of charge to the general public to increase public awareness of marine turtle conservation issues. These extremely popular educational programs allow the public to view nesting turtles in an organized and unobtrusive manner.

As indicated earlier, FPL continues to monitor and document nesting trends on Hutchinson Island and has implemented an effective light management program to reduce the potential for hatchling disorientations on FPL property. FPL also participates in the Florida Fish and Wildlife Conservation Commission's (FWC's) Sea Turtle Stranding and Salvage Network, a state-wide network of volunteer scientists who respond to reports of dead, ill and injured turtles that wash ashore on local beaches and inland waterways. Ill and injured turtles are transported to state-approved facilities for treatment and rehabilitation. Important scientific information (e.g., size, species, cause of death, etc.) is collected from dead animals to assist FWC in identifying persistent sources of human-related mortality so appropriate conservation measures can be developed and implemented.

A variety of data are collected from each captured turtle. In essence the St. Lucie Plant serves as a static trap and provides scientists access to life history stages that are difficult to access and study in the wild. Measurements and weights are taken, blood is drawn for sexing and genetic profiling, and tags are applied to track movements. Collectively, data collected over the life of the plant has provided a wealth of scientific information on the demographics of local sea turtle populations. Much of this work has been published in reports and scientific journals and/or presented at scientific meetings.

Manatees

There have been five occasions when manatees have entered the offshore intake structures and become entrapped in the intake canal. The first event occurred in 1991. FPL coordinated its capture with the USFWS and Florida Department of Environmental Protection (presently FWC). Because of the novelty of the event, a passive capture technique was attempted. This involved luring the animal with food and water into a partially submerged cage. After considerable time passed without success, a more aggressive netting effort ensued. Ultimately the animal was captured after 32 days in the intake canal. After evaluation and rehabilitation it was released back to the wild.

During subsequent events FPL improved its capture techniques. During the last four events, the animals have been removed within a day of their first sighting in the canal. Although two other animals have been taken to marine mammal care and rehabilitation facilities prior to their release, none suffered from their entrainment or brief residency in the intake canal. One animal had to be treated for deep prop wounds that it incurred prior to entering the canal. The other appeared to be a small calf separated from its mother. Current procedures call for FPL to coordinate the capture and evaluation of entrapped manatees with FWC. As required, FPL assists FWC in transporting ill or injured animals to approved rehab facilities and/or releasing entrapped animals back into the wild. No manatees have died as a result of their entrapment.

Fish and Lobster

Comparison of impingement data to intake canal gill net data indicated that certain fishes might become entrapped in the intake canal without necessarily being impinged. The numbers and biomass of entrapped fish were reported to be low and impacts resulting from entrainment and subsequent entrapment were considered to be insignificant (ABI, 1979a). Nevertheless, in 1993, FPL voluntarily initiated measures to remove entrapped fish and juvenile lobster from the intake canal.

Fish are routinely captured by hook and line and with submerged traps. This effort has been extremely successful. Through 2000, nearly 6,500 individuals representing 100 species have been caught and removed from the canal. The majority of these have been released back into the ocean, Indian River Lagoon, and Big Mud Creek.

Many of the fish that have been removed from the canal are of sport or commercial importance. These include grouper, snapper, snook and tarpon. Numerically, sheepshead, lane snapper and pork fish make up about half of all individuals captured. In order of abundance, mangrove snapper, black margate, jack crevalle, sailors choice, spadefish and common snook make up an additional 30 percent. Thus 9 species account for 80 percent of all catches. The most frequently entrained species are those typically associated with reef and hardbottom systems. Because of behavioral traits and/or habitat preferences other important sport and commercial species are rare or absent from the canal. For example, during the period that the fish removal program has been in place, only 3 cobia, 2 bluefish, 1 pompano, 1 kingfish, 2 flounder, and 1 seatrout have been caught. No Spanish mackerel, dolphin (mahi mahi), or billfish have been captured.

About 57 percent of all fish removed from the canal are tagged prior to release to obtain information on their movements. Twenty-four (24) percent, mostly smaller individuals, are released untagged. About 1,250 specimens taken from the canal have been given to national aquaria, research facilities, non-profit environmental organizations, or are maintained in FPL's touch tank for display and public education.

In addition to capturing fish, FPL began deploying specially designed collectors to remove post-larvae (puerulus stage) lobsters from the intake canal. Larvae entrained with cooling water settle out on the collectors and are removed and released. Over a 10-year period in the 1990s, approximately 6,800 juvenile lobsters were removed from the collectors, most of which were released back into appropriate aquatic habitats. Post-larval abundance was greatest during the winter and lowest during the summer.

STATE AND FEDERALLY LISTED SPECIES

Three species of fish, seven reptiles, six marine mammals, and one species of aquatic plant listed as threatened, endangered, or as a species of special concern inhabit or may occur in the aquatic environments surrounding the St. Lucie Plant (Table 2).

Fish

None of the fish species are federally listed, but all are designated as Species of Special Concern by the State of Florida. The Atlantic sturgeon (*Acipenser oxyrhynchus*) inhabits salt or brackish water and may move into fresh water to spawn (Gilbert, 1992). It has been collected along the Atlantic coast of Hutchinson Island and is listed as an occasional inhabitant of the neritic and surf zone over sand and shell bottoms (Gilmore and Herrema, 1981). No records could be found to indicate that this species was ever collected in the intake canal or during operational monitoring offshore the St. Lucie Plant.

The mangrove rivulus (*Rivulus marmoratus*) is listed as a rare inhabitant of mangroves, freshwater tributaries, canals, and mosquito impoundments (Gilmore and Herrema, 1981). However, it is unlikely that it occurs much farther south than Indian River County (Gilbert, 1992). Because of the types of habitat it prefers, it is unlikely that it would be found in aquatic environments in the vicinity of the plant and therefore would not be affected by plant operation.

Table 2.

Plants and Animals Listed as Endangered, Threatened, or Species of Special Concern[1] Inhabiting Aquatic Environments In and Around the St. Lucie Plant, Hutchinson Island, Florida.

Group	Scientific Name	Common Name	Federal Status[2]	State Status*
Fish	*Acipenser oxyrhynchus*	Atlantic sturgeon		SSC
	Centropomus undicimalis	Common snook		SSC
	Rivulus marmoratus	Mangrove rivulus		SSC
Reptiles	*Alligator mississippiensis*	American alligator	T(S/A)	SSC
	Caretta caretta	Atlantic loggerhead turtle	T	T
	Chelonia mydas mydas	Atlantic green turtle	E	E
	Dermochelys coriacea	Leatherback turtle	E	E
	Eretmochelys imbricata imbricata	Atlantic hawksbill turtle	E	E
	Lepidochelys kempi	Atlantic ridley turtle	E	E
	Nerodia fasciata taeniata	Atlantic salt marsh snake	T	T
Mammals	*Balaenoptera borealis*	Sei whale	E	E
	Balaenoptera physalus	Finback whale	E	E
	Eualaena glacialis	Right whale	E	E
	Megaptera novaeangliae	Humpback whale	E	E
	Physeter catodon	Sperm whale	E	E
	Trichechus manatus latirostris	West Indian (= Florida) manatee	E	E
Plants	*Halophila johnsonii*[3]	Johnson's seagrass	T	T

[1] Source: Florida's Endangered Species, Threatened Species and Species of Special Concern, Official Lists, August 1, 1997. Florida Fish and Wildlife Conservation Commission.

[2] Code: E = Endangered
T = Threatened
T(S/A) = Threatened/Similarity of Appearance
SSC = Species of Special Concern

[3] Recently listed by the U.S. Fish & Wildlife Service.

The common snook (*Centropomus undicimalis*) is a highly prized recreational species common to the Indian River Lagoon and nearshore ocean waters adjacent to the St. Lucie Plant. Fishing for this species is highly regulated by the State of Florida. Closed seasons permit snook to migrate and spawn without substantial impacts to the population. During open seasons, regulations regarding the number and size of individuals that can be kept are strictly enforced.

A number of snook were taken in offshore trawls during Unit 1 and 2 operational studies and they are regularly entrained with cooling water. Consequently, there are some impacts to this species. However, as described in the Entrapment Section of this report, FPL has implemented a systematic program to remove snook from the intake canal and return them to the ocean, thereby reducing the extent of impacts.

Reptiles

All five species of sea turtles occurring in the Atlantic Ocean occur regularly in nearshore waters adjacent to the plant, and three regularly nest on FPL property. All five species are occasionally entrained with cooling water and are subsequently entrapped in the intake canal. As described in the Entrapment Section of this report, FPL has implemented a systematic program to efficiently remove these animals from the intake canal and return them safely to the ocean. Although mortalities have occurred over the life of the facility, FPL has continued to implement new and refine existing measures to minimize impacts. During the period from 1990 through 1999, overall mortalities for all species combined averaged only about 1.06 percent of all turtles entrapped in the canal (FPL and Quantum Resources, Inc., 2000). During the previous 10-year period, overall mortality was 6.42 percent. Thus, while the average number of turtles entrapped each year in the intake canal nearly tripled between the 1980s and 1990s, improvements to FPL's sea turtle capture program resulted in an 83.5 percent reduction in the frequency of mortalities. The most recent improvement occurred in 1996 when a new turtle barrier net was added to the intake canal. This net further restricts the movements of turtles within the canal, thereby facilitating their capture and release. Since its deployment (1996-1999), the mortality rate of all turtles entrapped has declined to 0.78 percent.

The American alligator (*Alligator mississippiensis*) is a freshwater species inhabiting lakes, rivers, ponds, and other freshwater systems. It is listed as a Species of Special Concern by the State of Florida and as a threatened species because of similarity of appearance with the endangered American crocodile. Occasionally, alligators are flushed out of freshwater areas during periods of heavy rainfall. They can then be carried into the Indian River Lagoon and even out the inlets into the Atlantic Ocean. Thus, although alligators do not inhabit the aquatic environments in the vicinity of the St. Lucie Plant, they may rarely occur on FPL property. There has been at least one documented incident of an alligator showing up at the St. Lucie Plant. The animal was captured and returned to the wild.

The Atlantic salt marsh snake (*Nerodia fasciata taeniata*) is listed as threatened by both the state and federal government. It inhabits salt marshes, tidal creeks, ditches and pools in black mangroves on the east coast of Florida. Although historical accounts show this species occurring as far south as neighboring Indian River County, it is believed that it is presently confined to estuarine marshes in Volusia County (USFWS, 1999). Consequently, it is unlikely to occur in the vicinity of the St. Lucie Plant.

Marine Mammals

Four species of whales, all listed as endangered, may occur in ocean waters off Hutchinson Island (Table 2). Both humpback (*Megaptera novaeangliae*) and North Atlantic right whales (*Eubalaena glacialis*) have been observed in relatively close proximity to shore off Hutchinson Island, some in the immediate vicinity of the St. Lucie Plant. These sightings occur between January and March. Waters of the southeastern United States are considered wintering and calving grounds for right whales (Waring, et al., 1999). Thus, when this species is spotted, both a mother and calf are usually present. Humpback whales seen in the area are probably returning to northern waters after wintering in the West Indies.

In addition to the sightings of live animals, numerous species of marine mammals have stranded (washed ashore dead or dying) on ocean beaches of Hutchinson Island. However, the only one protected under the Endangered Species Act is the sperm whale (*Physeter catodon*). In the most significant event five individuals stranded in St. Lucie County north of the St. Lucie Plant in 1990.

Because of their large sizes and habits, whales could not be entrained with cooling water. Similarly, they do not appear to be attracted to the thermal discharges. The only incident involving a whale at the St. Lucie Plant occurred in March 1982, when a right whale became entangled in gill nets used to monitor offshore fish populations. The whale was untangled and released unharmed.

The Florida or West Indian manatee (*Trichechus manatus latirostris*) inhabits the Indian River Lagoon and Atlantic coastal waters off Hutchinson Island. Although preferred habitats are in the Indian River Lagoon and other inland waterways, where food sources are abundant, they do occasionally travel up and down the coast near shore. On five separate occasions since 1991, manatees have entered the intake structures and been entrapped in the intake canal. As discussed in the Entrapment Section of this report, FPL coordinates the removal and assessment of these animals with the appropriate wildlife agencies and assists in the recovery effort. To date none of the manatees entrapped in the intake canal has suffered injuries as the result of its entrainment and entrapment.

Manatees are known to congregate in the warm water effluents of power plants during winter months. However, there are typically abundant food resources near the facilities where they congregate. Considering that there is little attached vegetation in the nearshore environment adjacent to the St. Lucie Plant and that some of the captures have occurred during summer months, there seems to be no compelling evidence to infer that manatees congregate at, or are attracted to, the warm water discharges of the St. Lucie Plant.

Aquatic Plants

The only listed species of aquatic vegetation found in the vicinity of the St. Lucie Plant is Johnson's seagrass. This diminutive species is found in the Indian River Lagoon, most often near inlets. Major threats include loss of habitat through dredge/fill activities and degradation of water clarity. Due to turbulence and sediment instability, it is unlikely that Johnson's seagrass could inhabit the nearshore waters off Hutchinson Island. Water depths and anoxic bottom conditions probably preclude its presence in the dredged channel of Big Mud Creek. Consequently, the species is not likely to suffer thermal or other impacts associated with St. Lucie Plant operation.

UNUSUAL OCCURRENCES

Occasionally, large quantities of drift algae and blooms of jellyfish occur in the nearshore waters off Hutchinson Island. Although these events are rare, when the organisms involved are entrained into the intake canal with cooling water they can overwhelm the plant's cooling water system. In large quantities, jellyfish and seaweed accumulate on nets used to capture sea turtles causing temporary cessation of netting operations. They also accumulate on the barrier nets used to confine turtles to the eastern portion of the intake canal, causing damage and/or requiring the nets to be lowered to prevent damage. At the plant, nuisance organisms may clog the intake screens, thereby restricting intake water flow and/or causing damage to the traveling screens. In a worst-case scenario, they may cause the plant to trip (i.e. go off line) or operate at reduced power. Typically, these disruptions only last for a few days.

FPL's Environmental Protection Plan for the St. Lucie Plant was developed to address environmental issues identified in plant operating permits. Under the Plan, FPL is required to notify the Nuclear Regulatory Commission (NRC) of non-routine events that substantially affect plant operations or impact the environment. There have been three periods since the St. Lucie Plant has been operational when jellyfish have caused sufficient disruption to plant operations that reports have been filed with the NRC: September 1984, September 1993 (2 events), and September 1998 (2 events). Lesser events have occurred over the life of the plant, but they did not affect plant operations.

Although entrainment of drift algae is a routine summer occurrence, it rarely causes disruptions to plant operation. However, during August 2000, the quantity of seaweed reaching the intake screens was so great that the plant was forced to operate at reduced capacity. A report was filed with the NRC.

ENVIRONMENTAL IMPACTS ASSOCIATED WITH CONTINUED OPERATION OF THE ST. LUCIE PLANT

Permit compliance monitoring, planning studies, and voluntary sampling performed by FPL at the St. Lucie Plant during the period from 1976 through 2000 clearly demonstrate that Unit 1 and 2 operation has had a minor and spatially limited effect on local aquatic environments. Thermal effects are essentially non-existent. There are no attached macrophytes of consequence or meaningful populations of

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