FPL

Florida Power & Light Company, 6501 S. Ocean Drive, Jensen Beach, FL 34957

March 18, 2011

L-2011-108
10 CFR 50.4
EPP 3.2.2

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Re: St. Lucie Units 1 and 2
Docket Nos. 50-335 and 50-389
Environmental Protection Plan Report
316(b) Related Documentation

Pursuant to section 3.2.2 of the St. Lucie Environmental Protection Plan, FPL is forwarding the attached copy of 316(b) related documentation. The matter pertains to the proposed St. Lucie Biological Plan of Study required by the revised St. Lucie Plant Industrial Wastewater Facility (IWWF) Permit No. FL0002208 and Condition 20 of the Administrative Order (AO) AO022TL.

Please contact Vince Munne at (772) 467-7453 if there are any questions on this matter.

Sincerely,

Eric S. Katzman
Licensing Manager
St. Lucie Plant

ESK/KWF

Attachments – 1. Tranmittal Letter to FDEP
2. Florida Power & Light St. Lucie Plant Biological Plan of Study
3. Survey of Aquatic Environments Potentially Affected by the Operation of the St. Lucie Power Plant, Hutchinson Island, Florida

IE25
NRR

Transmittal Letter to FDEP

FPL

Florida Power & Light Company, 6501 S. Ocean Drive, Jensen Beach, FL 34957

March 18, 2011

Marc Harris, P.E.
Supervisor, Power Plant NPDES Permitting
Industrial Wastewater Section
Florida Department of Environmental Protection
2600 Blair Stone Road, MS 3545
Tallahassee, Florida 32399-2400

RE: FPL - St. Lucie Plant
State IWW Permit No. FL0002208 (Rev. F)
Administrative Order AO022TL
Condition 20 - Submittal of Biological Plan of Study

Dear Mr. Harris:

Please find four (4) enclosed copies of FPL's Biological Plan of Study (BPOS), as required by the revised St. Lucie Plant Industrial Wastewater Facility (IWWF) Permit No. FL0002208 and Condition 20 of Administrative Order (AO) AO022TL. This study was required to be submitted no later than March 23, 2011 (90 days after the effective date of the AO). Please review the BPOS and contact us with any questions or concerns as it is imperative that we begin the study as soon as possible in order to allow us adequate time to collect baseline information prior to the completion of the Extended Power Uprate for Unit 1 (currently estimated as February 2012).

Please contact Ron Hix at (561) 691-7641 if you have any questions on this matter.

Sincerely,

Richard L. Anderson
Site Vice President
St. Lucie Plant

LIC-PSL-2011-017

Enclosures
cc:
FDEP – SE District – Linda Brien
FDEP – PSL Office – Terry Davis
FDEP – Tallahassee - Siting Office – Mike Halpin

Florida Power & Light
St. Lucie Plant
Biological Plan of Study

FLORIDA POWER & LIGHT COMPANY
ST. LUCIE PLANT
BIOLOGICAL PLAN OF STUDY

This document has been prepared in support of Florida Power and Light Company's (FPL's) permit modification (NPDES Permit No. FL0002208) for the extended power uprate (EPU) for both Units 1 and 2 at the St. Lucie Plant on Hutchinson Island, St. Lucie County, Florida. It provides a detailed description of sampling activities and milestones.

Section 4.0 of the Interagency 316(a) Guidance Manual (EPA, 1977) defines Representative Important Species (RIS) as having one or more of the following traits: commercially or recreationally valuable; threatened or endangered; critical to the structure and function of the ecosystem; and/or a necessary component of the food chain for the preceding species. The Guidance Manual recommends that not more than 15 species be designated as RIS. Based upon the rationale contained in Appendix A to this Biological Plan of Study (Biological POS) and analysis of data generated during prior 316(a) demonstration studies at the St. Lucie Plant, the RIS listed below will be the focus of the study. The following species meet one or more of the criteria listed above and are representative of different levels of the water column from surface to bottom (Table 1).

<u>Representative Important Species</u>

1. Atlantic croaker (*Micropogonias undulatus*) – This bottom associated species was one of the most abundant species captured in both gill nets and trawls during prior studies at the plant. It spawns offshore and gravid females have been found throughout the year.

2. Sheepshead (*Archosargus probatocephalus*) – This bottom associated species is an important recreational species and spawns offshore. It regularly occurs in the vicinity of the plant, and gravid females have been collected during winter and spring.

3. Snook (*Centropomus* spp.) – Several species of snook are found in the vicinity of the plant. The largest of these, the common snook (*Centropomus undecimalis*), is one of the most highly prized recreational species in Florida. It is often found near shore. Several of the smaller snook species spawn in the ocean during the winter, whereas the common snook spawns during the summer and fall (Gilmore, et. al., 1983). All snook found in the study area are bottom associated species.

4. Seatrout (*Cynoscion* spp.) – Several species of seatrout, including the sand seatrout (*Cynosicion arenarius*) and the silver seatrout (*Cynoscion nothus*), are found in the vicinity of the plant. The larger of the two, the sand seatrout, is an important recreational species. Both were relatively common in gill net and trawl collections during prior studies at the plant. These bottom

associated species spawn offshore, and gravid females have been found throughout the year.

5. Snapper (Lutjanidae) – A variety of snapper in the family of Lutjanidae are found along the southeast coast of Florida. The gray or mangrove snapper (*L. griseus*) and the lane snapper (*L. synagris*) are two of the more important species in recreational fisheries, and both have been captured during previous studies at the plant. They are present year round and spawning occurs in the ocean during spring and summer.

6. Kingfish/Whiting (*Menticirrhus* spp.) – These species occur in coastal waters over sandy bottom and were routinely captured in ocean gill nets during previous studies at the plant. They are bottom associated species that forage primarily on benthic organisms. Members of this group spawn in the ocean during spring, summer and fall.

7. Florida pompano (*Trachinotus carolinus*) – This species is a commercially important and recreationally popular coastal species often found in small to large schools along sandy beaches. Florida pompano were often captured with gill nets during previous studies at the plant. This species primarily spawns in the spring and summer.

8. Spanish mackerel (*Scomberomorus maculatus*) – This schooling coastal species is both commercially and recreationally important in eastern Florida waters and was one of the most frequently caught species in gill netting operations conducted during previous studies at the plant. Although it occurs throughout much of the year, largest concentrations occur during the fall and winter, with gravid females being present primarily during the spring and summer. Spanish mackerel feed on a variety of clupeiform fish (herrings and sardines) which are extremely abundant in the nearshore waters off Hutchinson Island.

9. Bluefish (*Pomatomus saltatrix*) – As for Spanish mackerel, this recreationally important schooling predator regularly occurs in coastal waters of east Florida, although it is present in greatest numbers during the fall and winter. It was captured in large numbers by gill net during prior studies at the plant. Gravid females were present throughout the year.

10. Clupeiformes – This group includes a variety of anchovies, herrings and sardines, the primary source of food for most of the commercially important piscivorous fish species that migrate through the area. Clupeiformes were numerically prevalent in trawl and gill net sampling previously conducted at the plant.

11. Mullet (*Mugil* spp.) – There are two species of mullet, the striped, *Mugil cephalus*, and the white, *M. cumea*, that are very important to fisheries along

the southeastern coast of the United States, and both are found in the vicinity of the St. Lucie Plant. They are not only landed in commercial fisheries but are also a principal food source for a variety of commercial and sport fishes. Both species leave the estuaries and migrate offshore in large schools to spawn, the striped mullet in fall and winter, and the white mullet in spring. After spawning, larvae and pre-juveniles then migrate to inshore nursery areas within the Indian River Lagoon.

12. Sea robin (*Prionotus* spp.) – The sea robin is a benthic oriented fish that is common over sandy substrates. Several species were commonly captured in trawl sampling during previous studies at the plant. Individuals in spawning condition were captured in winter and spring.

13. Green sea turtle (*Chelonia mydas*) – The green sea turtle is federally listed as endangered. Juveniles are found in inland estuaries where they occupy and feed on submerged aquatic vegetation. They are also regularly found in the ocean where they feed on algae that colonize exposed hardbottom and worm reef. Large numbers of juvenile green turtles occur in the ocean in the vicinity of the St. Lucie Plant, as evidenced by their routine entrapment in the plant's cooling water intake system.

General Approach to Monitoring RIS

Prior 316(a) demonstration studies at the St. Lucie Plant involved extensive gill netting, trawling, and beach seines (see Appendix A, Table 1). In the process, thousands of individuals, including many of recreational and commercial importance were captured. Many died during capture or subsequent taxonomic identification and data collection. Although at the time these traditional methods were necessary to provide the accurate taxonomic and numeric data needed to effectively assess plant effects on the fish community, in today's environmental climate, they may no longer be appropriate. For example, in 1995 the State of Florida implemented a comprehensive net ban in waters of the state out to three miles from shore. Thus, a large-scale gill netting program might raise public concern resulting in unnecessary criticism of the study. Furthermore, traditional methods can be selective in the size and types of fish collected and may not always provide an accurate picture of the ichthyofaunal community. Thus, data regarding both relative abundances and size class structure may vary in relation to the type of gear used. Fortunately, new and much more sophisticated techniques now exist that allow for the identification and quantification of RIS. Although the technology may not always allow identification of fish to the species level, it is sufficiently robust to identify major species groups (e.g., mullet, snook, croaker, etc.). Providing that these species groups have similar life history traits, the occasional lack of species-level identifications should not substantively preclude evaluation of plant effects on the RIS.

The innovative technology to be used in the Biological POS will involve sidescan sonar, high-frequency imaging sonar, and bio-acoustic transects. Additionally, traditional methods will be used to collect and quantify ichthyoplankton. Each of these techniques will be applied to three separate sites within the study area, each measuring approximately 1.9 mi (3,000 m) on a side and encompassing an area of approximately 2,224 acres (900 hectares; Figure 1). Within the near and far field area surrounding the St. Lucie Plant's discharge structures, the first site will extend 9,842 ft (3,000 m) offshore along the axis of the Unit 2 multi-port diffuser. The western boundary will be set at about the 10 ft (3.0 m) depth contour. The north and south boundaries of the discharge site will each be located 4,921 ft (1,500 m) from the discharge structure and will parallel the center line. Within this bounded area, three unique habitat types are present, each with a unique benthic and fish fauna: the beach terrace (shallow sandy areas near shore in depths less than about 20 ft (6.1 m), an offshore trough (a relatively homogenous shell hash substrate in 35-40 ft (11-12 m), and an offshore shoal (sandy substrate that rises to a depth of approximately 20 ft (6.1 m; EAI, 2001).

Two additional sites of equivalent size to the discharge site and positioned similarly will serve as reference sites to document background conditions in areas unaffected by thermal discharges. One of these will be located approximately midway between the discharge site and the Ft. Pierce Inlet and the other midway between the discharge site and the St. Lucie Inlet. The exact size and location of all sites will be finalized during a reconnaissance (recon) trip performed during initiation of baseline monitoring. During this reconnaissance, sidescan sonar will be used to characterize bottom conditions within each of the three study sites to ensure comparability of bottom types among sites. Either a boat-mounted or towfish type of instrument with an integrated Global Positioning System (GPS) will be used to produce continuous two-dimensional imaging of bottom topography. During the recon trip, the sidescan sonar will also be used to map areas of exposed nearshore hardbottom and worm reef as candidate sites for monitoring utilization by juvenile green sea turtles.

Baseline monitoring will commence as soon as practical after FDEP approval of the Biological POS and will continue until the EPU of Unit 1 has been completed (projected for fall of 2011). Two years of post-operational monitoring will commence once the Unit 2 EPU has been completed in the spring/summer of 2012. Depending on the results of baseline monitoring, and at the discretion of FPL, additional data collection may continue during the interim period between completion of the EPU for the two units. Data collected during the study will be compared among study sites and years to discern any potential impacts related to the St. Lucie Plant EPU.

Monitored Variables for RIS

Relative Abundances and Seasonality of Juvenile and Adult Fish

RIS identification and enumeration will be performed using multi-frequency imaging sonar having a minimum operating frequency of 1.5 MHz for initial detection and 2.3 MHz or higher for species-level identifications. It shall also have a beam width of at least 30° and have the capacity to pan and tilt using remote controls. The system may be either mounted to a pole suspended from a boat or attached to a remotely operated vehicle (ROV).

Each study site will be divided into a grid of 100 cells each 984 X 984 ft (300 X 300 m) on a side. Prior to the recon trip, at least four cells each on the beach terrace and offshore shoal will be randomly selected for monitoring. An additional 17 cells will be randomly selected in the offshore trough. This design will yield a total of 25 monitored cells. Upon confirmation that bottom types within each cell are relatively uniform, these same cells will be used for all subsequent monitoring. Sub-meter GPS will be used to mark the exact location of the 25 selected cells.

High-frequency imaging sonar monitoring for RIS will be performed monthly from July through September when water temperatures are highest, and quarterly throughout the remainder of the year for a total of six sampling events. During each event, monitoring will take place during both daytime and nighttime periods. Daytime monitoring will be conducted during the period from one hour after sunrise to one hour before sunset. Nighttime monitoring will be performed during the period from one hour after sunset to one hour before sunrise. Both daytime and nighttime sampling will be done within the same 24-hour period, weather and other factors permitting. If one photoperiod is completed and the other has to be cancelled, it will be performed at the next earliest opportunity. However, if more than two weeks pass before the second half of the paired diel sampling is completed, the entire sampling event will be repeated.

At each of the 25 randomly selected cells, the sonar unit will be deployed and observations made at a minimum of two depths (1/3 and 2/3 distance from surface to bottom). Additional sampling depths may be required to ensure complete coverage of the entire water column from the seafloor to the ocean's surface. At each depth, the instrument will be slowly rotated for a minimum of two minutes. Recorded data will be post-processed and RIS enumerated and identified to species/species group. Data will be reported as the average number of individuals/species (or species group)/cell for each study site and sampling event. This data will also be segregated by daytime and nighttime sampling periods.

The level of taxonomic precision that can be achieved during the study will be based in large part on the size and shape of the fish observed. Species of similar shape may not be distinguishable at the species level, as the high-frequency sonar has no color rendition. However, snook for example, are clearly distinguishable from sheepshead, mullet and other RIS. The level of taxonomic refinement for RIS listed in Table 1 reflects the anticipated level of detail that can be achieved by this non-lethal monitoring technology.

Although the RIS are the primary focus of the Biological POS, other fish species will also be identified to the lowest taxonomic level practicable and quantified. This data will be summarized in a manner consistent with that described above for the RIS.

Fish Spawning Locations and Periods

Over 200 species of fish in the study area produce diagnostic spawning calls, typically at night and during evening crepuscular periods (Mok and Gilmore, 1983; Rountree et al., 2006; Gilmore, 2002 and 2003; Gilmore et al, 2003). Sonic techniques have been used for over 30 years to isolate spawning populations and sites of inshore fish. Fish species that produce diagnostic calls and chorusing behavior off South Hutchinson Island include a variety of valuable fishery species: red drum, sand seatrout (weakfish), black drum, common snook, sheepshead, porgy, and striped croaker (listed as a "Species of Concern" by National Marine Fisheries Service). Other likely species to spawn on the continental shelf, but whose spawning calls have not yet been documented there, include the pigfish grunt, sailor's choice grunt, mutton snapper, lane snapper, gray snapper, and red porgy. All of these species are known to produce sound (Fish and Mowbray, 1970).

In an effort to isolate spawning locations and identify those species producing sounds, an active hydrophone monitoring program will be employed. Within each study site, three shore-perpendicular transects will be established, each 9,842 ft (3,000 m) in length. The exact locations of all transects will be established during the recon trip and then these same locations will be maintained for the duration of the study.

The hydrophones used in the study will have a frequency response of 10 to 30 KHz and will be connected to a digital recording device. At 1,968 ft (600 m) intervals along each transect, the hydrophone will be lowered to mid depth from a boat powered down and silently adrift and the recorder activated for a minimum of two minutes. Monitoring will occur during the same six months used for monitoring fish abundance and will be conducted during the period from one-half hour before to two hours after sunset. This crepuscular period is when sound production is greatest. Due to the narrow window for hydrophone monitoring, several consecutive nights may be required to sample all sites. The order in which the three sites are monitored will be randomly selected prior to each sampling event. The intervals between stations may be adjusted based on results obtained during the recon trip.

Hydrophone recordings will be analyzed and compared to known species calls in existing sound libraries to allow species identifications. Data will be reported as total sound pressure in decibels (1 dB re to 1 μPa) and average number of spawning calls/species/minute of recording time for each study site and sampling event.

Relative Abundances and Seasonality of Fish Eggs and Larvae

As a means of confirming spawning activity and for assessing plant effects on larval fish, ichthyoplankton samples will be collected six times a year at each study site. Sampling will be conducted using paired bongo nets (20 cm diameter) having a 500 micron mesh. Each net will be equipped with flow meters to allow determination of volume of water sampled. Nighttime sub-surface tows will be made along two shore-perpendicular transects within each study site. This activity will be paired with the fish spawning monitoring, the tows being conducted at each site after the acoustic work has been completed. The tows will begin at a point 820 ft (250 m) seaward of the 18 ft depth contour and will continue seaward 1,640 ft (500 m). The exact location of transects will be determined during the recon trip, and then the same locations will be maintained for the duration of the study. Once the nets are retrieved aboard the vessel, the contents from both cod ends of the bongos will be combined into a single sample and preserved in 5% buffered formalin for laboratory identification. Thus, there will be two samples per study site per sampling event.

Fish eggs and larvae will be enumerated and identified to the lowest practicable taxonomic level. Data will be reported as the average number of individuals/taxon/per unit volume of water filtered for each study site. To the extent possible sound intensity of spawning fish will be correlated with the number of eggs and larvae in the water column.

Relative Abundance and Seasonal Utilization of Worm Reef and Hardbottom Habitat by Juvenile Green Sea Turtles

Sea turtle utilization of nearshore hardbottom and worm reef habitat will be assessed monthly within each of the three study sites during the period when turtle abundance is typically greatest (January through March) and quarterly for the remainder of the year. During the recon trip, suitable habitat will be mapped and a 0.6-mi (1-km) transect established within each study site. If insufficient habitat exists to allow a continuous 1-km transect, two or more smaller transects may be used to provide an equivalent length. Once established, these transects will be used for all subsequent monitoring.

Surveys will be performed from a boat equipped with an elevated platform capable of holding two observers. As the boat traverses the transect at a slow and constant speed (4.0 knots or less), one observer will look to port side and the other to starboard side. Observers will record and identify to species, when possible, any turtle observed surfacing along the transect. Each transect will be traversed a minimum of two times during each sampling event with at least a 30 minute separation between the two passes. Monitoring days will be selected for optimal viewing capabilities (e.g., sunny with calm seas). The order in which the three study sites are monitored will be randomly selected prior to each monitoring event. Data will be reported as the number of turtles sighted, by species, per minute of observation or linear distance.

Ancillary Water Quality

During each type of sampling event at a study site, water quality will be measured at the surface, mid-depth and bottom at three equally spaced points along central transect used to monitor for fish spawning locations. Monitored variables will include temperature, salinity, dissolved oxygen, conductivity, and pH. All in-situ instrumentation used for this monitoring will be calibrated and maintained in accordance with FDEP standard operating procedures (FDEP, 2004).

Data Analysis and Reporting

Data collected each year will be tabulated and graphically presented, as applicable. Appropriate statistical tests will be used to determine if significant differences exist among study sites and years for any of the monitored variables. A final interpretive Biological Report evaluating all years of monitoring will be submitted to the Department for review and approval no later than 60 days after the approved Biological POS completion date, as scheduled below. Utilization of reference and discharge (impact) sites in concert with baseline and post-operational data will optimize the ability to draw inferences regarding the presence/absence of significant plant EPU effect(s) on monitored biological variables.

Adjustments to Plan of Study

Following completion of baseline monitoring, FPL will review the data to determine if adjustments to the Biological POS are warranted. Any needed changes to methods, station locations, sampling frequency, or other aspects of the program, as summarized in Table 2, will be made in consultation with the FDEP prior to initiation of post-construction monitoring.

Schedule

The following schedule for initiation and completion of monitoring milestones is based on anticipated completion dates for the EPU of each unit at the St. Lucie Plant. Any change in completion dates shall be reflected in the schedule accordingly:

Activity	Start Date	Completion Date
Approval of Biological POS	March 23, 2011	April 22, 2011
Contractor Mobilization	May 15, 2011	July 1, 2011
Recon Trip and Initiation of Baseline Monitoring	July 1, 2011	March 2012
Initiation of Post-construction Monitoring[1]	July 2012	June 2014[2]
Delivery of Biological Report[1]	June 2014	September 2014[3]

[1]Dates are dependent upon uprate completion date.
[2]AO requirement is to continue monitoring for no less than 24 months after completion of the uprate.
[3]AO requirement is to submit the Biological Report to the Department for review and approval no later than 90 days after the approved Biological POS completion date.

References

EAI (Ecological Associates, Inc.). 2001. Survey of Aquatic Environments Potentially Affected by the Operation of the St. Lucie Power Plant, Hutchinson Island, Florida. Prepared by Ecological Associates, Inc., Jensen Beach, Florida, for Florida Power & Light Company. 41 pp.

EPA (U.S. Environmental Protection Agency). 1977. Interagency 316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements. U.S. Environmental Protection Agency, Office of Water Enforcement, Permits Division, Industrial Permits Branch, Washington, D.C. 79 pp.

FDEP (Florida Department of Environmental Protection). 2004. Standard Operating Procedures for Field Activities. DEP-SOP-001/01, Volumes 1 and 2. Florida Department of Environmental Protection, Bureau of Laboratories Environmental Assessment Section, Tallahassee, FL.

Fish, M. P., and W. H. Mowbray. 1970. Sounds of Western North Atlantic Fishes. A Reference File of Biological Underwater Sounds. John Hopkins Press, Baltimore. 205 pp.

Gilmore, Jr., R. G. 2002. Passive acoustic transects: mating calls and spawning ecology in east Florida sciaenids. Pages 39-48 *in* R. Rountree, C. Goudey and T. Hawkins (editors), Listening to Fish: Passive Acoustic Applications in Marine Fisheries. Proceedings of the International Workshop on Applications of Passive Acoustics to Fisheries, April 8-10, 2002, MIT Sea Grant Program.

Gilmore, Jr., R.G. 2003. Chapter 11. Sound production in the spotted seatrout. Pages 177-195 *in* S. A. Bortone (editor), The Biology of the Spotted Seatrout. CRC Press, Boca Raton, Florida.

Gilmore, R. G., C. J. Donohoe and D. W. Cooke. 1983. Observations on the distribution and biology of east-central Florida populations of the common snook, *Centropomus undecimalis* (Bloch). Florida Scientist, Special Supplemental Issue, 46: 313-336.

Gilmore, R. G., A. M. Clark and J. Cooke. 2003. Technologies for sustained biological resource observations with potential applications in coastal homeland security. Marine Technology Society Journal, 37(3): 134-141.

Herrema, D. J., B. D. Peery, N. Williams-Walls, and J. R. Wilcox. 1985. Spawning periods of common inshore fishes on the Florida east coast. Northeast Gulf Science 7(2): 153-155.

Mok, H. K. and R.G. Gilmore. 1983. Analysis of sound production in estuarine spawning aggregations of *Pogonias cromis*, *Bairdiella chrysoura*, and *Cynoscion nebulosus* (Sciaenidae). Bulletin of the Institute of Zoology, Academia Sinica 22: 157-186.

Rountree, R. A. , R. G. Gilmore, C. A. Goudey, A. D. Hawkins, J. J. Luczkovich, and D. A. Mann. 2006. Listening to fish: applications of passive acoustics to fisheries science. Fisheries, 31(9): 433- 446.

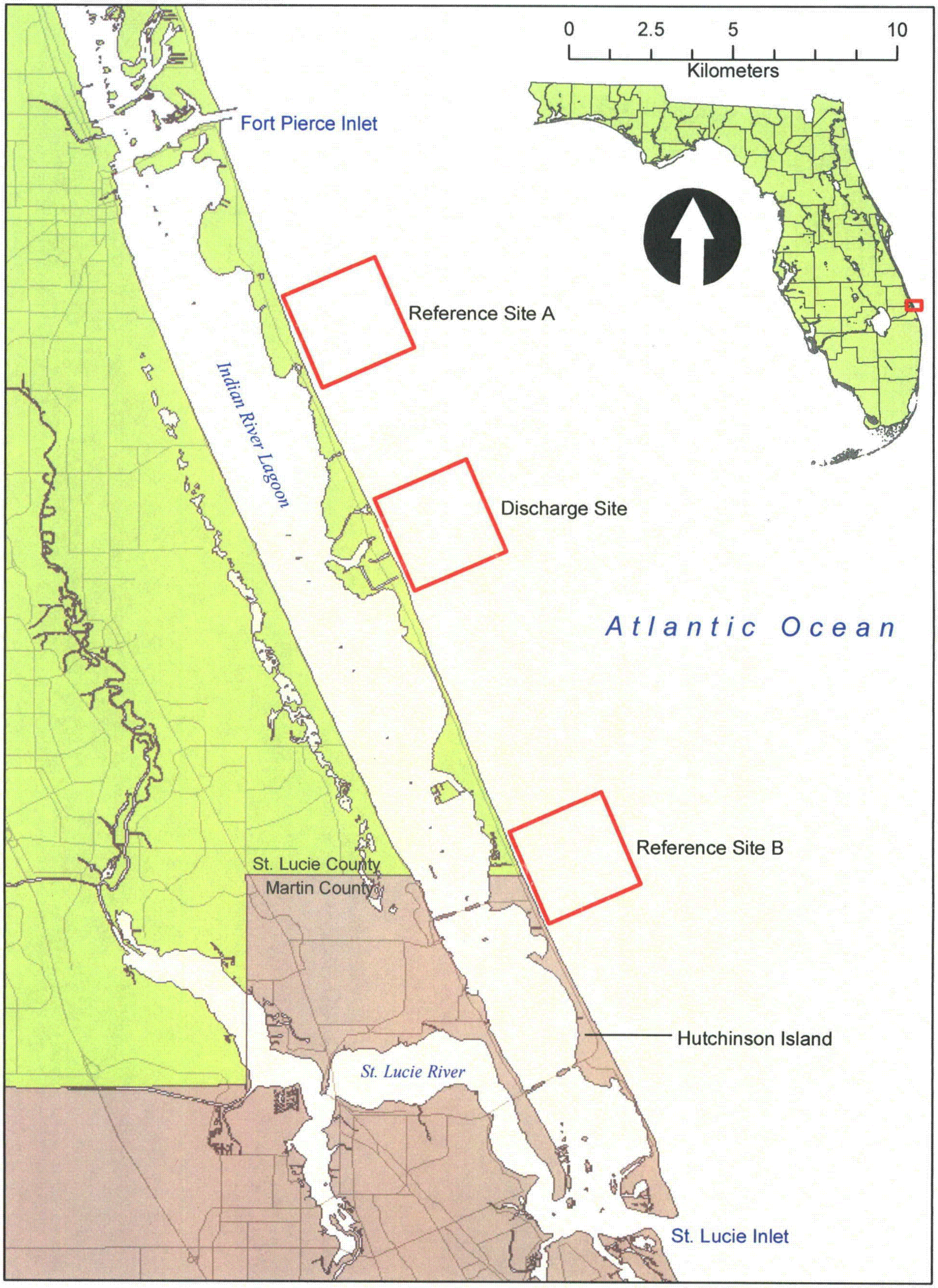


Figure 1. Location of three study sites for Biological Plan of Study, FPL St. Lucie Plant Uprate Project.

ECOLOGICAL ASSOCIATES, INC.

Table 1

Activity Period, Water Column Utilization and Local Spawning Months for Representative Important Species
St. Lucie Plant Biological Plan of Study

RIS			Active Period		Water Column Utilization			Months Fish Captured in Spawning Condition Near Plant [1]											
Common Name	**Taxa**	**Group**	**Day**	**Night**	**Lower**	**Mid**	**Upper**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Sheepshead	*Archosargus probatocephalus*	Sparidae	x	x	x			x	x	x	x							x	
Atlantic croaker	*Micropogonias undulatus*	Sciaenidae	x	x	x			x	x	x	x		x	x		x	x	x	x
Snook	*Centropomus spp.*	Centropomidae		x	x														x
Seatrout	*Cynosicion spp.*	Sciaenidae	x	x	x			x	x	x	x					x	x	x	x
Spanish Mackerel	*Scomberomorus maculatus*	Scombridae	x	x	x	x	x			x	x	x	x	x	x	x			x
Bluefish	*Pomatomus saltatrix*	Pomatomidae	x	x	x	x	x	x	x	x	x	x	x	x		x	x		
Kingfish	*Menticirrhus sp.*	Sciaenidae	x	x	x	x		x	x	x	x	x	x	x	x			x	x
Florida Pompano	*Trachinotus carolinus*	Carangidae	x	x	x	x			x		x								
Herring/Anchovy/ Sardine	Clupeids	Clupeiformes	x	x	x	x	x	x	x	x	x	x			x				
Mullet	*Mugil spp.*	Mugilidae	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sea robins	*Prionotus sp.*	Triglidae		x	x			x	x	x	x	x	x		x	x		x	x

[1] Herrema et al. (1985)

Table 2

Summary of Sampling Design for St. Lucie Plant Biological Plan of Study

Component	Frequency per Year	Sampling Period	Sampling Points			Total Samples/Sampling Points per Year
			No. Study Sites	No. Samples or Sampling Points per Site	Number of Depths	
Water Quality[1]	6	Day/Night	3	3	3	324
Imaging Sonar[2]	6	Day/Night	3	25	2	1800
Acoustic Recording	6	Night	3	15	1	270
Ichthyoplankton Tows	6	Night	3	2	1	36
Sea Turtle Transects	6	Day	3	2	1	36

[1]Concurrent with other sampling components

[2]A minimum of 2 depths per sample point. Additional depths may be required.

APPENDIX A

FLORIDA POWER & LIGHT COMPANY
ST. LUCIE PLANT
BIOLOGICAL PLAN OF STUDY MONITORING RATIONALE

Introduction

Florida Power & Light Company (FPL) applied to the Florida Department of Environmental Protection (FDEP) for a revision to NPDES Permit No. FL0002208, which authorizes thermal discharges into the Atlantic Ocean from the St. Lucie Nuclear Plant on Hutchinson Island in St. Lucie County, Florida. The revision, which became effective on December 23, 2010, allows for a minor increase in effluent temperatures (approximately 2.0° F under normal operating conditions) resulting from an extended power uprate (EPU) for both Units 1 and 2 at the plant.

Administrative Order (AO) AO022TL, which also became effective on December 23, 2010, authorizes the above-referenced St. Lucie Plant EPU with conditions. Paragraph 20 of the AO stipulates that no later than 90 days after the effective date of the AO, FPL shall prepare and submit for the Department's review and approval a biological plan of study (Biological POS). The AO further identifies specific elements to be incorporated into the Biological POS. These elements were derived from historical Environmental Protection Agency (EPA) guidance addressing the regulation of thermal effects associated with nuclear plants.

As required by Paragraph 20 of the AO, the Biological POS shall be designed to generate information relevant to the following elements: 1) "a population typically characterized by diversity at all trophic levels;" 2) "the capacity to sustain itself through cyclic seasonal changes;" 3) "presence of necessary food chain species;" 4) "non-domination of pollution-tolerant species;" and 5) "indigenous." As discussed below, based on the nature of the receiving water body (Atlantic Ocean – open waters), the small change in discharge temperature resulting from the EPU, the limited spatial area affected, the effectiveness of the diffusers through which the cooling water is discharged, and EPA guidance on monitoring for thermal effects, the proposed Biological POS coupled with prior 316(a) studies at the St. Lucie Plant will satisfy each of these elements. The Plan will utilize Representative Important Species (RIS) to demonstrate that the EPU is not jeopardizing the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in the receiving water body.

Background

During construction and prior to operation of the St. Lucie Plant, extensive physical and biological baseline studies were conducted in the vicinity of the plant's ocean intake and discharge structures. These studies were performed between 1971 and 1974 by the Florida Department of Natural Resources Marine Research Laboratory (now Florida Fish and Wildlife Research Institute) and were summarized by EAI (2001). (The EAI summary document, which is attached hereto, has been submitted previously to FDEP as part of FPL's permit revision process.) They involved water quality, sediments, phytoplankton, zooplankton, macrophytes, infaunal and epifaunal macroinvertebrates, worm reef communities, fish, and sea turtles. Following start-up of Unit 1 in March 1976, post-construction operational monitoring commenced to demonstrate the extent of thermal impacts (ABI, 1977, 1978, 1979a, 1980, 1981, 1982, and 1983). These sampling programs addressed the same biological components of the environment characterized during baseline studies. Both control and impact stations were established, and in combination with baseline studies, resulting data permitted strong inferences as to thermal effects.

As summarized by EAI (2001), most monitoring requirements were deleted from the St. Lucie Plant's Environmental Technical Specifications in May 1982 after demonstration that Unit 1 operation was having no substantial, persistent, or widespread effect on biological communities in the receiving water body. This owes primarily to the design and siting of discharge structures and the enormous capacity of the ocean to quickly dissipate heat.

Unit 2 was placed on-line in May 1983 and monitoring of offshore benthic macroinvertebrate and fish communities continued through 1984 to assess the combined operation of Units 1 and 2 (ABI, 1983, 1984, and 1985). Although offshore trawl and seine sampling was deleted from the St. Lucie Plant's Environmental Technical Specifications, an increased effort was placed on offshore gill netting to determine if thermal effluents were disrupting the normal migratory behavior of commercial species, such as mackerel and bluefish. These studies showed that the intake and discharge structures and thermal effluents were not interfering with the natural migratory movements of commercial species. Similarly, monitoring of macroinvertebrates indicated that heated effluents from the plant were having no measurable effect on the abundance or diversity of infaunal communities.

Prior to plant operation, modelers reviewed meteorological data and studies of currents in the nearshore area off Hutchinson Island to predict thermal plume configuration and dispersal patterns (EBASCO, 1971). They determined that thermal plumes associated with plant operation 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 3.0° 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 8.2 ft (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.

Infrared mapping of the thermal plume conducted in the summer of 1984, a period of maximum ambient summer temperatures (August-September) 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 surface plume temperatures in the ocean did not exceed 32° C (90° F).

316(a) Demonstrations

The prevailing guidance document for addressing thermal impacts at nuclear facilities is found in the *Interagency 316(a) Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements* (EPA, 1977). It was designed primarily to address initial plant siting, licensing, and construction, although it is also relevant to "major changes" in facilities operational mode. The EPA guidance for 316(a) demonstrations is designed for all types of receiving water bodies (reservoirs, rivers, bays, estuaries, and oceans) and recognizes that demonstration requirements will vary considerably in relation to prevailing physical and biological conditions at a particular site. Accordingly, three types of demonstrations may be applicable: Type II Demonstrations for RIS, Type III Low Potential Impact Demonstrations, and Other Type III Demonstrations.

Other Type III Demonstrations are for those sites that have low potential impact for most, but not all, biotic categories. Specifically, Section 2.1.3 of the Interagency 316(a) Guidance Manual "attempts to discourage the collection of masses of costly, unnecessary data" by focusing only on those biotic categories most likely to be impacted by thermal effluents at the plant site. As discussed below, the St. Lucie Plant clearly falls within the Other Type III Demonstration category. The six biotic categories that must be addressed in a site demonstration include: phytoplankton, zooplankton and meroplankton, habitat formers, shellfish/macroinvertebrates, fish, and other vertebrate wildlife.

Phytoplankton

Section 3.3.1 of the Interagency 316(a) Guidance Manual includes open ocean habitats in its definition of areas of low potential impact for phytoplankton. Furthermore, comparisons of data collected during prior 316(a) demonstration (Table 1) and baseline studies at the St. Lucie Plant, as summarized by EAI (2001), provided no evidence of long-term or widespread adverse impacts of plant operation on the ocean phytoplankton community. Consequently, the projected impacts associated with issuance of NPDES Permit No. FL0002208 are sufficiently inconsequential that the protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife in and on the receiving water body will be assured.

Zooplankton and Meroplankton

Section 3.3.2 of the Interagency 316(a) Guidance Manual defines areas of low potential impact as those characterized by low concentrations of commercially important species, rare and endangered species, and/or those forms that are important components of the food web ***or*** where the thermal discharge will affect a relatively small proportion of the receiving water body. Prior 316(a) demonstration studies at the St. Lucie Plant (Table 1) indicated that the ocean zooplankton community was characterized primarily by neritic holoplanktonic species (species that spend their entire life cycle in the water column), with copepods and urochordates being the first and second most dominant groups, respectively (ABI, 1983). Meroplankton (benthic macroinvertebrate larvae that are temporary members of the plankton community) were major contributors to the zooplankton community only during brief periods. Complimentary studies demonstrated that species of commercial value found in the vicinity of the plant, the Calico scallop, penaeid shrimp, rock shrimp, and the blue crab, were infrequently collected and in very small numbers (EAI, 2001). Highest concentrations of zooplankton consistently occurred during the spring of each year, a period when the addition of thermal effluents would be expected to have the least impact. Comparisons of data among discharge and control stations and between operational and baseline years revealed no major changes in zooplankton community composition indicative of adverse thermal effluent effects. The confinement of elevated plume temperatures to near surface waters over a small spatial scale further supports the designation of the St. Lucie Plant as an area of low potential impact for zooplankton and meroplankton.

Habitat Formers

Habitat formers are assemblages of plants and/or animals characterized by a relatively sessile life stage with aggregated distributions that provide substrate, food, shelter, or nursery habitat for fish and shellfish and/or otherwise provide important ecosystem functions. As examples, these include seagrasses, macroalgae, oyster reefs, and coral reefs. During previous 316(a) demonstration studies at the St. Lucie Plant (Table 1), as summarized by EAI (2001), the ocean environment exposed to thermal effluents was found to be largely devoid of habitat formers. No seagrasses were present, and attached algae consisted primarily of small plants or fragments on pieces of unconsolidated shell and rock. With the exception of nearshore worm reef, no stable hardbottom areas were encountered, which greatly limited the occurrence of attached benthic macrophytes. 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.

During recent years, intermittent hardbottom has been documented near the plant in areas landward of the discharge structures (Dial Cordy and Associates, 2010). It is possible that this hardbottom had been previously buried and was uncovered during the intense hurricane seasons of 2004 and 2005 when large quantities of sediments were carried by storm surge landward of the dune line in the vicinity of the plant. The now exposed, low-relief hardbottom is dominated by turf algae (Baumberger, 2010; Dial Cordy and Associates, 2010).

The previous absence of exposed hardbottom in the nearshore environment largely precluded the establishment of exotic and invasive species, such as the green algae, *Caulerpa brachypus*. This species has become widespread on reefs in south Florida where it out competes native algae for space and can smother and kill sessile habitat formers, such as sponges and corals. During a recent survey of hardbottom areas in the vicinity of the plant's intake structures, no attached macroalgae forming harmful algal blooms (HABs) was found. However, *C. brachypus* was observed suspended in the water column, indicating that it may exist in nearby areas where hardbottom is present.

Regardless of its distribution, it is unlikely that *C. bracypus* would be affected by the EPU at the St. Lucie Plant. Research has shown that the abundance of this species is largely correlated with nutrient enrichment from land runoff, particularly from sewage (Lapointe et al., 2005a and 2005b). There are few, if any, areas on Hutchinson Island, other than the two major inlets north and south of the plant, where non-point runoff can enter the ocean, and there is limited potential for nutrient enrichment via plant discharges. The South Hutchinson Island Sewage Treatment Plant is permitted by the FDEP, under a separate permit issued to that facility, to discharge to the ocean via the St. Lucie Plant discharge canal. However, these discharges are both infrequent (most of the treated effluent is reused for irrigation) and minor (low volume) and are not in any way related to current St. Lucie Plant or post-EPU operations. Furthermore, the thermal plume is limited to surface waters and rarely meanders into areas where hardbottom is present. Consequently, it is highly unlikely that the small incremental change in water temperature associated with the EPU would cause a shift in the benthic community from one dominated by indigenous species to one dominated by pollution-tolerant species. Although changes in the occurrence or frequency of HABs in the vicinity of the plant are possible, they are much more likely to be related to the relative abundance of exposed hardbottom and/or general changes in water quality conditions, neither of which are related to plant operations.

The only appreciable habitat former documented in the vicinity of the plant during previous 316(a) demonstration studies was the nearshore, intertidal worm reef (*Phragmatopoma labpidosa*) community. It supports a unique assemblage of macroalgae and macroinvertebrates (ABI, 1979b). 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 worm reefs. This is not unexpected given the dispersal pattern of the thermal plume, which is largely away from or parallel to shore.

Based on the above analysis, the site can be considered an area of low potential impact for habitat formers. However, Section 3.3.3 of the Interagency 316(a) Guidance Manual states that "where there is a probability that the power plant will impact a threatened or endangered species through adverse impacts on habitat formers," it should not be considered a low potential impact area. The green sea turtle, an endangered species, is known to utilize the worm reef communities. Juveniles shelter there as well as feed on the algae that colonize the reef. Green turtles may also forage on the turf algae recently documented on exposed nearshore hardbottom.

Sea turtles are entrained with the St. Lucie Plant's cooling water and become entrapped in the plant's intake canal. The rate of entrapment for juvenile green turtles increased considerably beginning about 1993, and presently several hundred are captured and released each year (EAI, 2000). Green sea turtle utilization of worm reef and other hardbottom habitats in the vicinity of the plant was not addressed in prior 316(a) demonstration studies. Even though no impacts to these communities are expected to result from the issuance of NPDES Permit No. FL0002208, in an exercise of due caution, the green sea turtle will be considered a RIS and an assessment of its utilization of nearshore hardbottom habitats will be included in the Biological POS.

Shellfish/Macroinvertebrates

Section 3.3.4 of the Interagency 316(a) Guidance Manual identifies areas of low potential impact as those sites where species of commercial value are absent or their occurrence is marginal, no threatened or endangered species are present, shellfish and macroinvertebrates do not serve as an important component of the aquatic community, and the site does not serve as an important spawning or nursery area for commercially valuable or protected species. Prior 316(a) demonstration studies evaluated both epibenthic and infaunal macroinvertebrate communities. These studies, as summarized by EAI (2001), concluded that thermal effluents from the combined operations of Units 1 and 2 had little impact on benthic environments in the vicinity of the plant. This owes largely to the design of the diffuser pipes that directs heated water up and away from the bottom. Water quality monitoring during the period of combined plant operations showed that bottom water temperatures at all ocean stations in the vicinity of the discharge pipes averaged less than 1.8° F (1.0° C) higher than ambient bottom temperatures and never exceeded 3.1° F (1.7° C) above background. Furthermore, the only species of commercial importance, as noted for zooplankton and meroplankton above, were present in very low numbers. No federally listed shellfish/macroinvertebrates occur within the vicinity of the plant. Collectively, these data support designation of the St. Lucie Plant as an area of low potential impact for shellfish/macroinvertebrates.

Fish

The aquatic region in the vicinity of the St. Lucie Plant has been shown to have an extremely rich fish fauna, many species of which are of commercial and/or recreational value (Gilmore et al., 1981). Furthermore, many of these species are known to be ocean spawners, and numerous gravid females were among the specimens captured during prior 316(a) demonstration studies at the plant (Herrema et al., 1985). Consequently, Section 3.3.5 of the Interagency 316(a) Guidance Manual disallows consideration of the St. Lucie Plant as an area of low potential impact for fish.

Notwithstanding the above assessment, baseline and operational monitoring performed at the St. Lucie Plant (Table 1), provided no indication of any significant or widespread effects of combined Unit 1 and 2 operation on local fish populations (ABI, 1985). In particular, the intensified ocean gill netting program instituted from 1982 to 1984 demonstrated that the ocean discharge structures and related thermal effluents did not permanently congregate fish around the structures and did not interfere with the natural migratory movements of commercial species, such as Spanish mackerel and bluefish. Although anecdotal evidence suggests that the vertical relief provided by the structures on an otherwise relatively flat, barren bottom attract grouper and snapper, it is unlikely that the activity patterns of these species are affected in any appreciable way by the thermal effluents. Nevertheless, in an abundance of caution, FPL has included several species of fish as RIS in the proposed Biological POS.

Other Vertebrate Wildlife

Section 3.3.6 of the Interagency 316(a) Guidance Manual stipulates that most sites in the United States will be classified as areas of low potential impact for other vertebrate wildlife. The exceptions are those sites where thermal effluents tend to congregate or inhibit normal activity patterns of wildlife, particularly if the affected species are federally listed as threatened or endangered. Prime examples would be power plants in Florida sited along major migratory pathways of manatees. Although manatees do occasionally enter the ocean to travel between inlets, the principal pathway for their seasonal movement along the east coast of Florida is the Indian River Lagoon (EAI, 2002). Manatees have been observed near the beach along Hutchinson Island, and a few have been entrapped in the St. Lucie Plant's cooling water intake canal (EAI, 2001). However, throughout the period of previous 316(a) demonstration studies at the plant there were no observations of them congregating in the vicinity of the plant's ocean discharge structures, nor are there any known anecdotal reports of such behavior.

Both sea turtles and shorebirds are regularly observed in the vicinity of the St. Lucie Plant. As for manatees, there is no evidence that thermal effluents are affecting their activity patterns. Sea turtles are routinely entrapped in the plant's cooling water intake canal where they are captured and returned to the ocean (EAI, 2000 and 2001). However, seasonal patterns and size classes of entrapped turtles are very similar to those captured in other areas of east central Florida where thermal discharges are absent. Collectively, these findings support designation of the St. Lucie Plant as an area of low potential impact for other vertebrate wildlife. Nevertheless, green sea turtles will be included as a RIS in the Biological POS, but only in relation to their association with habitat formers (worm reef and hardbottom) in the vicinity of the plant.

References

ABI (Applied Biology, Inc.). 1977. Ecological Monitoring at the Florida Power & Light Co. St. Lucie Plant, Annual Report 1976. Volumes I and II. AB-44. Prepared by Applied Biology, Inc., Atlanta, Georgia, for Florida Power & Light Company.

ABI (Applied Biology, Inc.). 1978. Ecological Monitoring at the Florida Power & Light Co. St. Lucie Plant, Annual Report 1977. Volumes I and II. AB-101. Prepared by Applied Biology, Inc., Atlanta, Georgia, for Florida Power & Light Company.

APPENDIX A

ABI (Applied Biology, Inc.). 1979a. Florida Power & Light Company, St. Lucie Plant, Annual Non-Radiological Environmental Monitoring Report 1978. Volume II, Biotic Monitoring. AB-177. Prepared by Applied Biology, Inc., Atlanta, Georgia, for Florida Power & Light Company.

ABI (Applied Biology, Inc.). 1979b. Worm Reef Monitoring at the Florida Power & Light Company St. Lucie Plant, April 1976 – April 1979. AB-209. Prepared by Applied Biology, Inc., Atlanta, Georgia, for Florida Power & Light Company.

ABI (Applied Biology, Inc.). 1980. Florida Power & Light Company, St. Lucie Plant, Annual Non-Radiological Environmental Monitoring Report 1979. Volumes II and III, Biotic Monitoring. AB-244. Prepared by Applied Biology, Inc., Atlanta, Georgia, for Florida Power & Light Company.

ABI (Applied Biology, Inc.). 1981. Florida Power & Light Company, St. Lucie Plant, Annual Non-Radiological Environmental Monitoring Report 1980. Volume II, Biotic Monitoring. AB-324. Prepared by Applied Biology, Inc., Atlanta, Georgia, for Florida Power & Light Company.

ABI (Applied Biology, Inc.). 1982. Florida Power & Light Company, St. Lucie Plant, Annual Non-Radiological Environmental Monitoring Report 1981. Volume II, Biotic Monitoring. AB-379. Prepared by Applied Biology, Inc., Atlanta, Georgia, for Florida Power & Light Company.

ABI (Applied Biology, Inc.). 1983. Florida Power & Light Company, St. Lucie Plant, Annual Non-Radiological Environmental Monitoring Report 1982. Volumes I and II. AB-442. Prepared by Applied Biology, Inc., Atlanta, Georgia, for Florida Power & Light Company.

ABI (Applied Biology, Inc.). 1984. Florida Power & Light Company, St. Lucie Plant, Annual Non-Radiological Environmental Monitoring Report 1983. AB-530. Prepared by Applied Biology, Inc., Atlanta, Georgia, for Florida Power & Light Company.

ABI (Applied Biology, Inc.). 1985. Florida Power & Light Company, St. Lucie Plant, Annual Non-Radiological Environmental Monitoring Report 1984. AB-553. Prepared by Applied Biology, Inc., Atlanta, Georgia, for Florida Power & Light Company.

Baumberger, R.E. 2010. Harmful Algal Bloom Monitoring Adjacent to St. Lucie Power Plant. Monitoring Report #2, May 7, 2010. Report prepared for Florida Power and Light Company, Jensen Beach, Florida. Harbor Branch Oceanographic Institute at Florida Atlantic University, Ft. Pierce, Florida. 10 pp.

APPENDIX A

Dial Cordy and Associates. 2010. Hutchinson Island FPL Power Plant Hardbottom Biological Survey. Report prepared for Taylor Engineering, Inc., Jacksonville, Florida. Dial Cordy and Associates, Inc. Hollywood, Florida. 6 pp.

EAI (Ecological Associates, Inc.). 2000. Physical and Ecological Factors Influencing Sea Turtle Entrapment Levels at the St. Lucie Nuclear Plant: 1976-1998. Prepared by Ecological Associates, Inc., Jensen Beach, Florida, for Florida Power & Light Company. 184 pp.

EAI (Ecological Associates, Inc.). 2001. Survey of Aquatic Environments Potentially Affected by the Operation of the St. Lucie Power Plant, Hutchinson Island, Florida. Prepared by Ecological Associates, Inc., Jensen Beach, Florida, for Florida Power & Light Company. 41 pp.

EAI (Ecological Associates, Inc.). 2002. Manatee Protection Plan. A Comprehensive Approach to Reducing Manatee Mortalities and Protecting Manatee Habitat in St. Lucie County, Florida. Prepared by Ecological Associates, Inc., Jensen Beach, Florida, for St. Lucie County, Florida. 159 pp.

EBASCO (1971). Hutchinson Island – Unit No. 1 Cooling Water Discharge Report. Prepared by EBASCO Services, Inc., NY for Florida Power and Light Company.

EPA (U.S. Environmental Protection Agency). 1977. Interagency 316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements. U.S. Environmental Protection Agency, Office of Water Enforcement, Permits Division, Industrial Permits Branch, Washington, D.C. 79 pp.

Gilmore, R. G., C. J. Donohoe, D. W. Cooke, and D. J. Herrema. 1981. Fishes of the Indian River Lagoon and Adjacent Waters, Florida. Harbor Branch Foundation, Inc. Technical Report No. 41. 28 pp.

Gore, R. H., L. E. Scotto, and L. J. Becker. 1978. Community composition, stability and trophic partitioning in decapod crustaceans inhabiting some subtropical sabellariid worm reefs. Studies on decapod crustacea from the Indian River Lagoon Region of Florida. IV. Bulletin of Marine Science, 28(2): 221-248.

Herrema, D. J., B. D. Peery, N. Williams-Walls, and J. R. Wilcox. 1985. Spawning periods of common inshore fishes on the Florida east coast. Northeast Gulf Science 7(2): 153-155.

Intera. 1984. Airborne Thermal Infrared Mapping Surveys of Discharge Plumes, St. Lucie Plant, August 27 and September 12, 1984. A84-039. Prepared by Intera Technologies, Ltd., Ottawa, Ontario, for Florida Power & Light Company. 17 pp.

APPENDIX A

Lapointe, B. E., P. J. Barile, M. M. Littler, D. S. Littler, B. J. Bedford, C. Gasque. 2005a. Macroalgal blooms on southeast Florida coral reefs I. Nutrient stoichiometry of the invasive green alga *Codium isthmocladum* in the wider Caribbean indicates nutrient enrichment. Harmful Algae 4: 1092-1105.

Lapointe, B. E., P. J. Barile, M. M. Littler, and D. S. Littler. 2005b. Macroalgal blooms on southeast Florida coral reefs II. Cross-shelf discrimination of nitrogen sources indicates widespread assimilation of sewage nitrogen. Harmful Algae 4: 1106-1122.

APPENDIX A

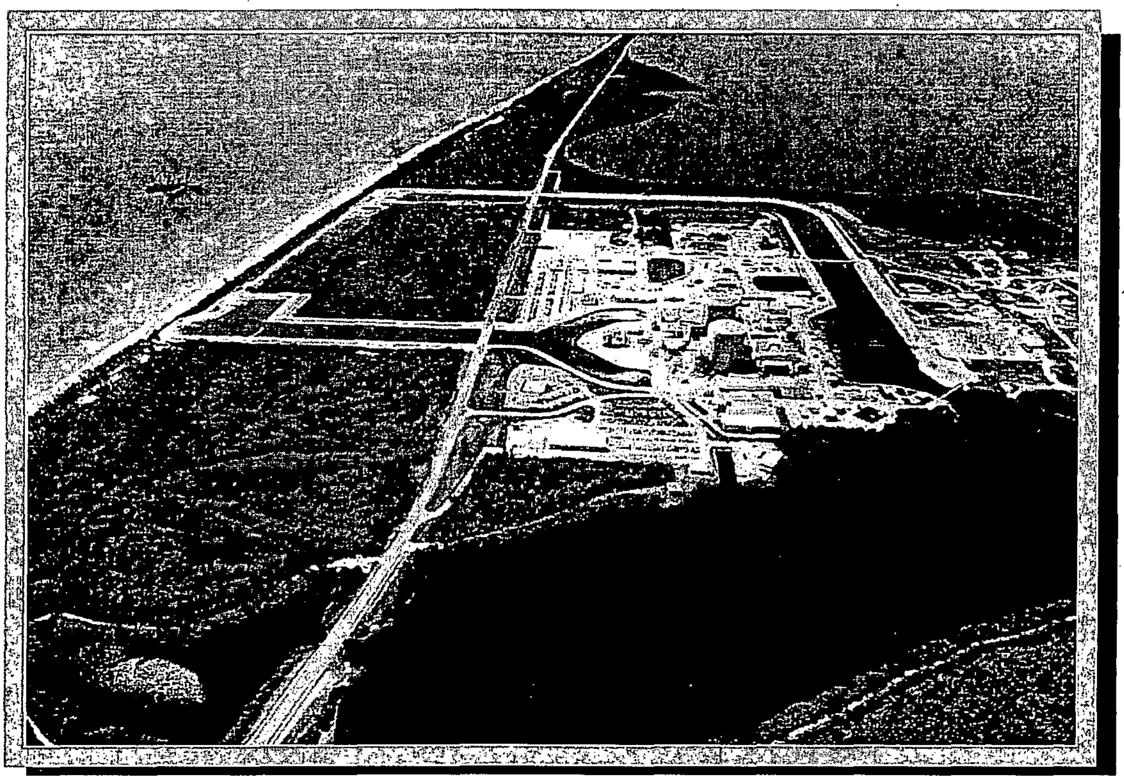
Table 1
Summary of Water Quality and Biological Monitoring
Performed in the Atlantic Ocean by FPL During Prior 316(a) Demonstrations at the St. Lucie Plant

Component	Began	Completed	Method	Frequency	No. Stations	No. Samples/ Station	Sampling Point(s)
Temperature	March-76	May-82	In-situ	Monthly	6	1	Sur/Mid/Bot
Salinity	March-76	May-82	In-situ	Monthly	6	1	Sur/Mid/Bot
DO	March-76	May-82	In-situ	Monthly	6	1	Sur/Mid/Bot
Turbidity	March-76	May-82	In-situ	Monthly	6	1	Sur/Mid/Bot
Light Transmittance	March-76	May-82	In-situ	Monthly	6	1	Sur/Mid/Bot
Phytoplankton	March-76	May-82	Pump	Monthly	6	4	2Sur/2Bot
Chlorophyll *a*	March-76	May-82	Pump	Monthly	6	4	2Sur/2Bot
Holoplankton	March-76	May-82	Half Meter Net (202u)	Monthly	6	4	2Sur/2Bot
Meroplankton	March-76	May-82	Half Meter Net (202u)	Monthly	6	4	2Sur/2Bot
Worm Reef	April-76	Apr-79	Hand	Quarterly	2	2	Bottom
Algae	March-76	May-82	Dredge	Monthly	6	2	Bottom
Infauna	March-76	Dec-84	Grab	Quarterly	6	4	Bottom
Epifauna	March-76	May-82	Otter Trawl	Monthly	6	1	Bottom
Fish (Adults & Juveniles)	March-76	May-82	Beach Seine	Monthly	3	3	Bottom
	March-76	Dec-84	Gill Net	Monthly	6	1	Mid/Bot
	April-76	May-82	Otter Trawl	Monthly	6	1	Bottom
Fish Eggs	March-76	May-82	20 cm Bongo Net (505u)	Twice/Month	6	2	Surface
Fish Larvae	March-76	May-82	20 cm Bongo Net (505u)	Twice/Month	6	2	Surface

Report

Survey of Aquatic Environments Potentially Affected by the Operation of the St. Lucie Power Plant, Hutchinson Island, Florida

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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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)

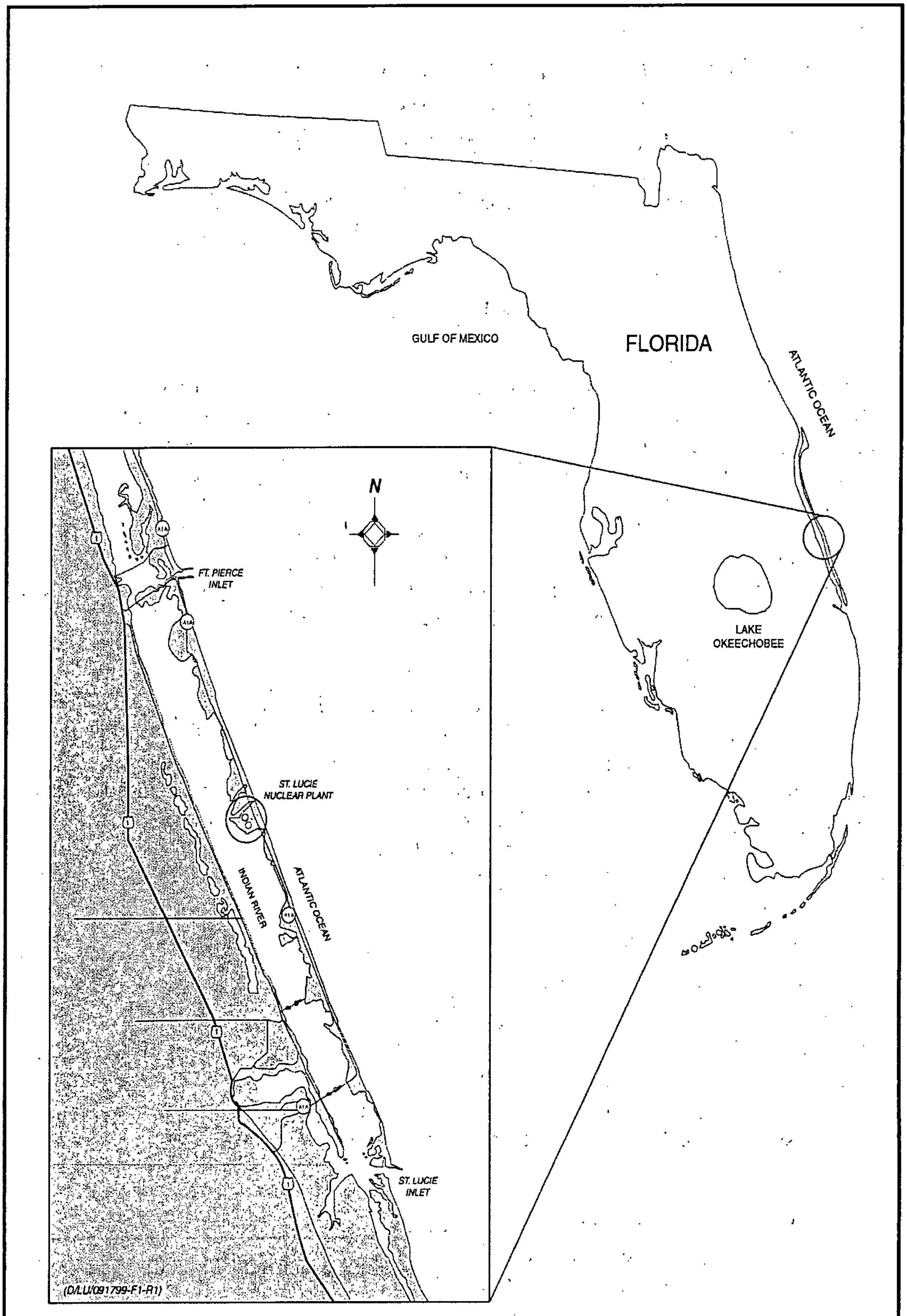

Figure 1. Location of St. Lucie Plant, Hutchinson Island, Florida.

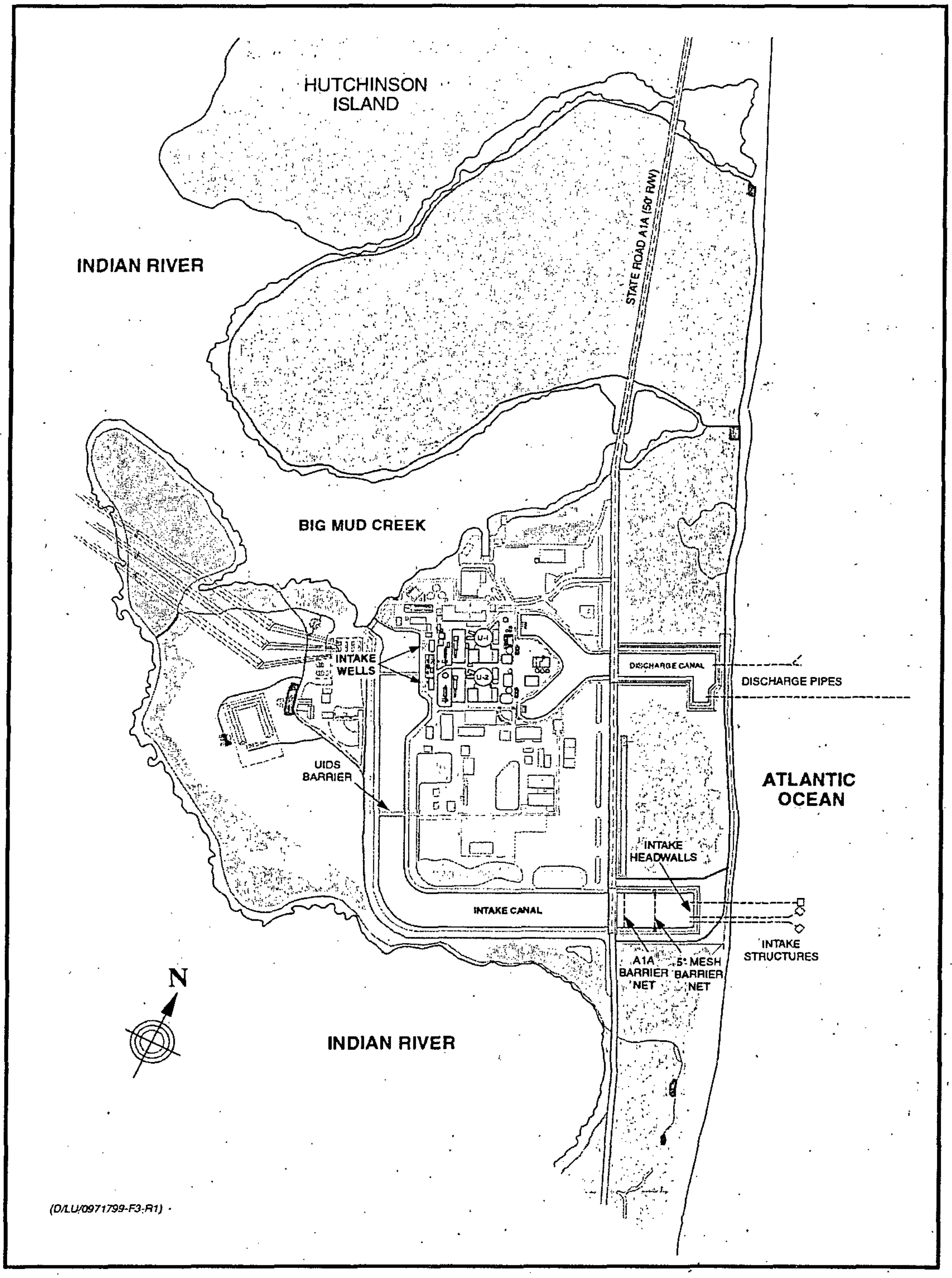

Figure 2. St. Lucie Plant facility layout showing cooling water intake and discharge system.

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

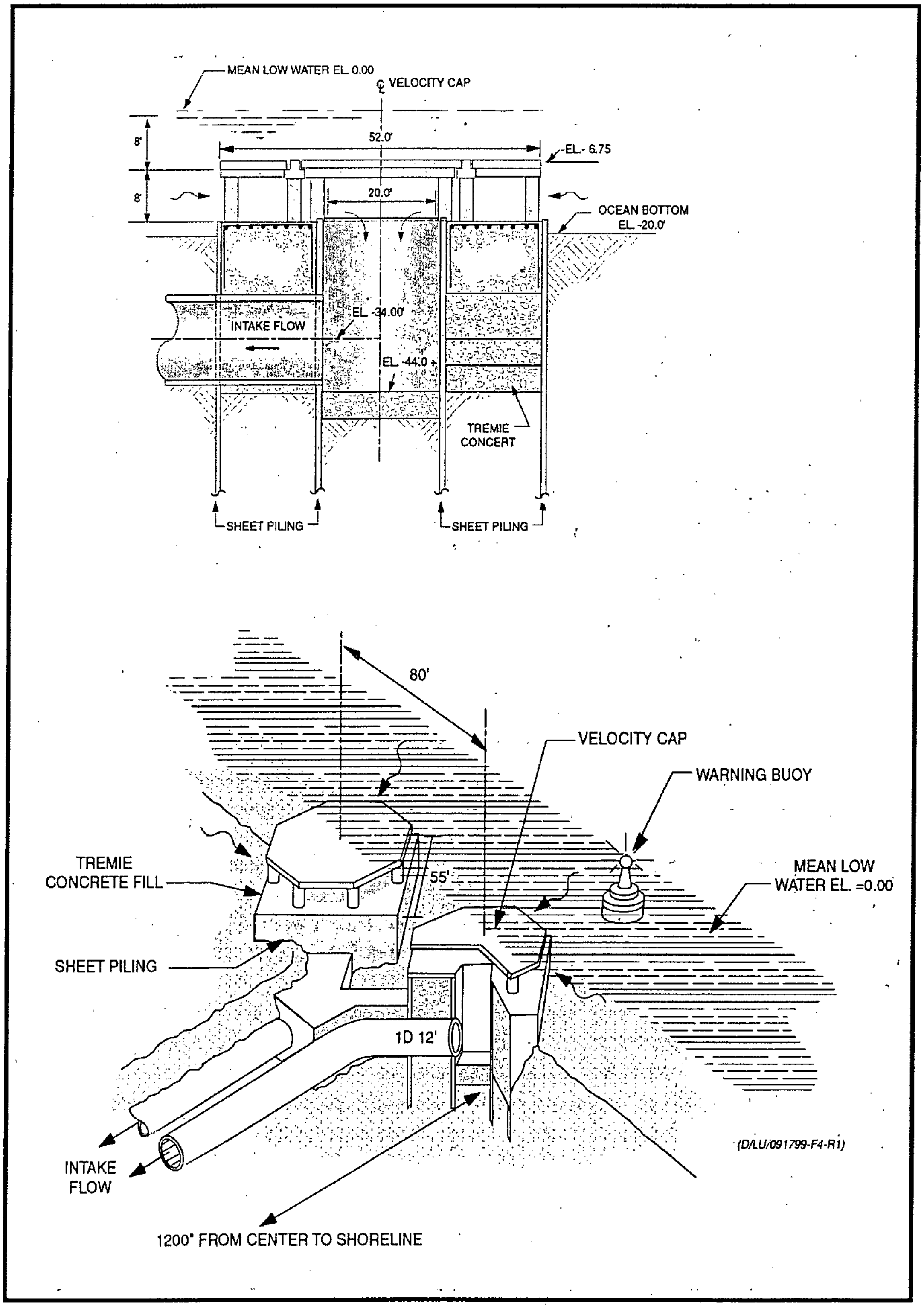

Figure 3. Configuration of the two 3.7 meter-diameter intake structures, St. Lucie Plant, Hutchinson Island, Florida.

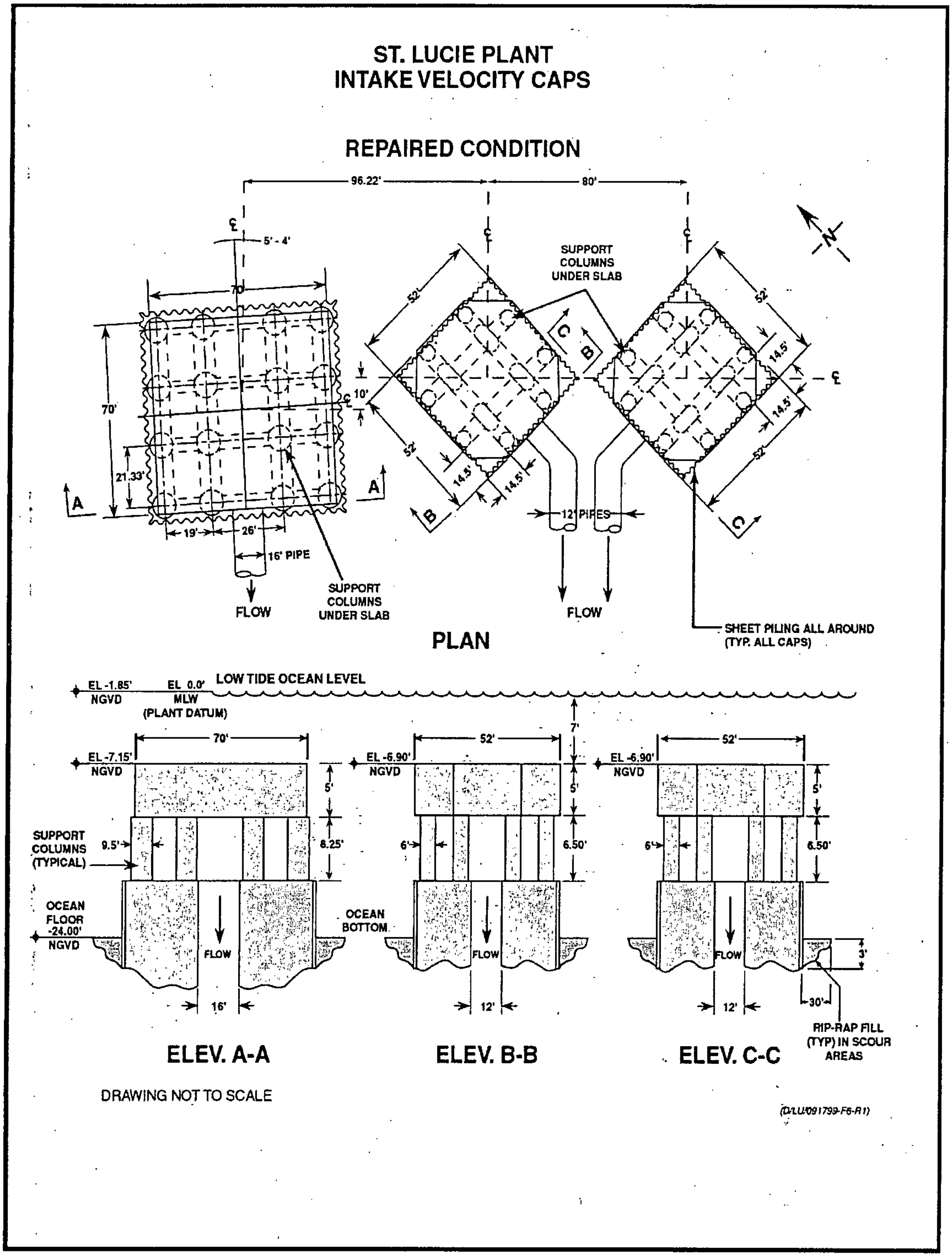

Figure 4. Diagram of the three intake structures located 1200 feet (365 m) offshore the St. Lucie Plant, Hutchinson Island, Florida. Dimensions represent conditions after velocity cap repairs were completed in February 1992.

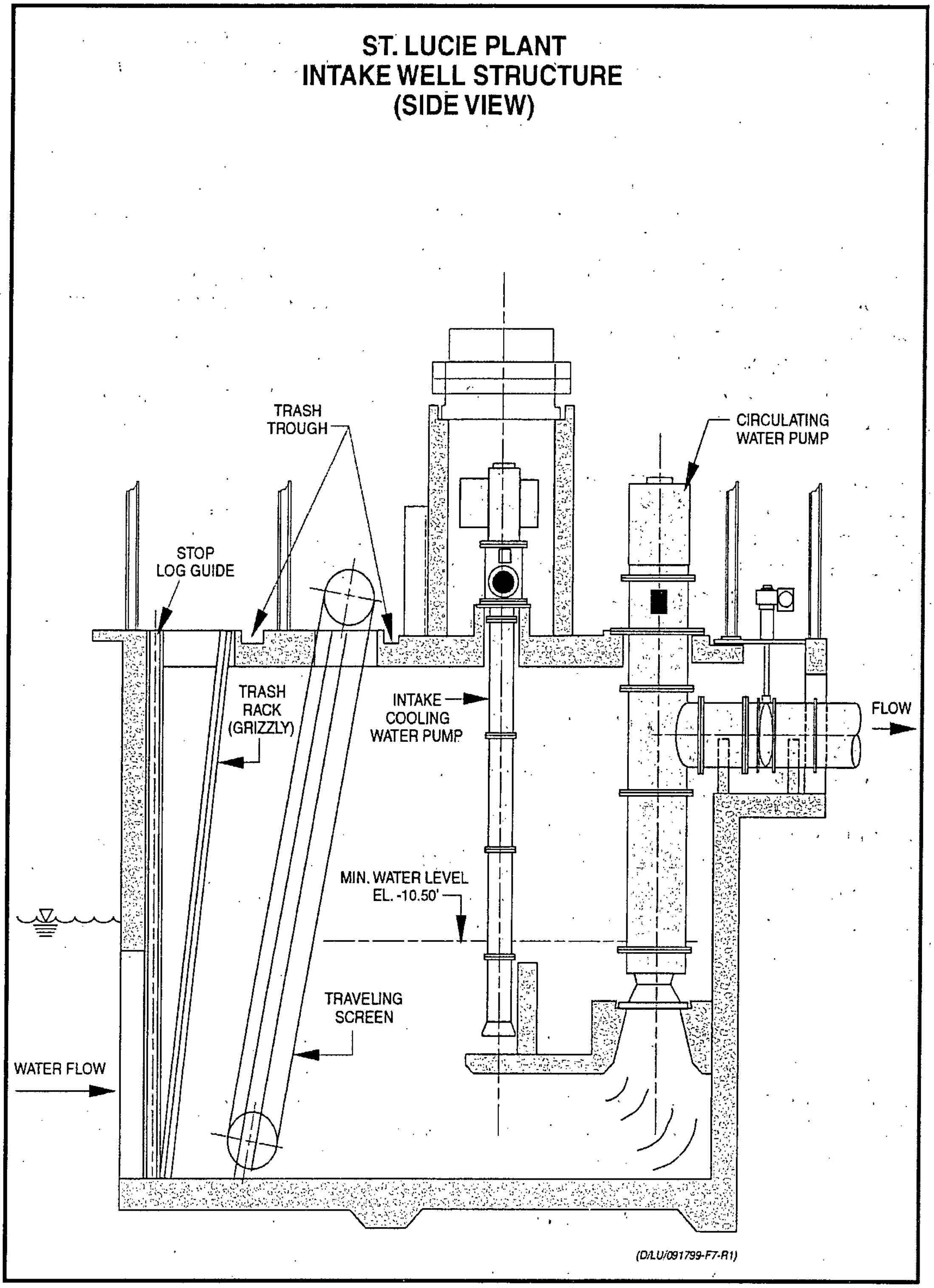

Figure 5. Diagram of an intake well at the St. Lucie Plant, Hutchinson Island, Florida.

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

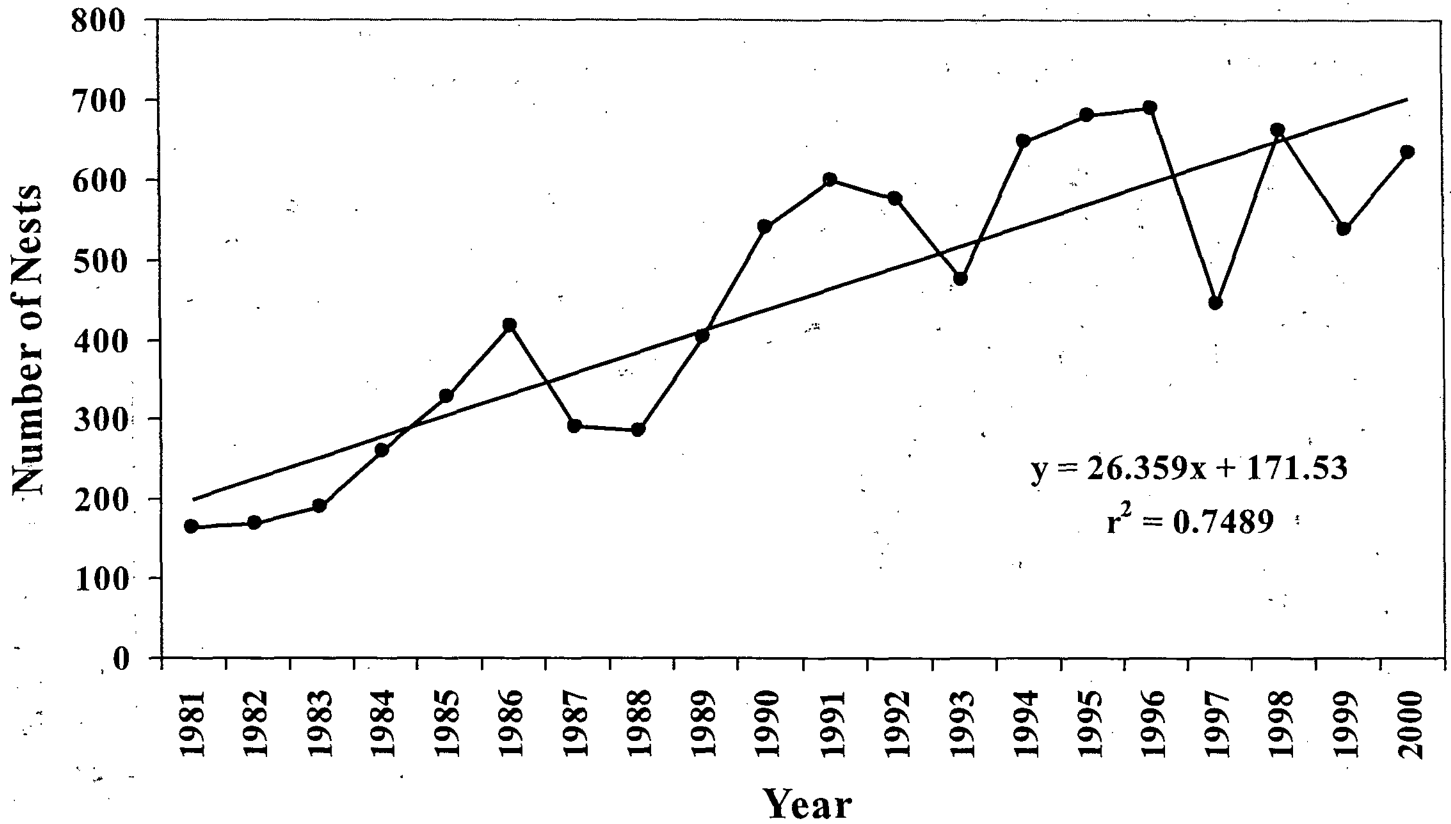

Figure 6. Annual nesting by loggerhead turtles within a 2-km section of beach adjacent to the St. Lucie Plant, Hutchinson Island, Florida, 1981-2000.

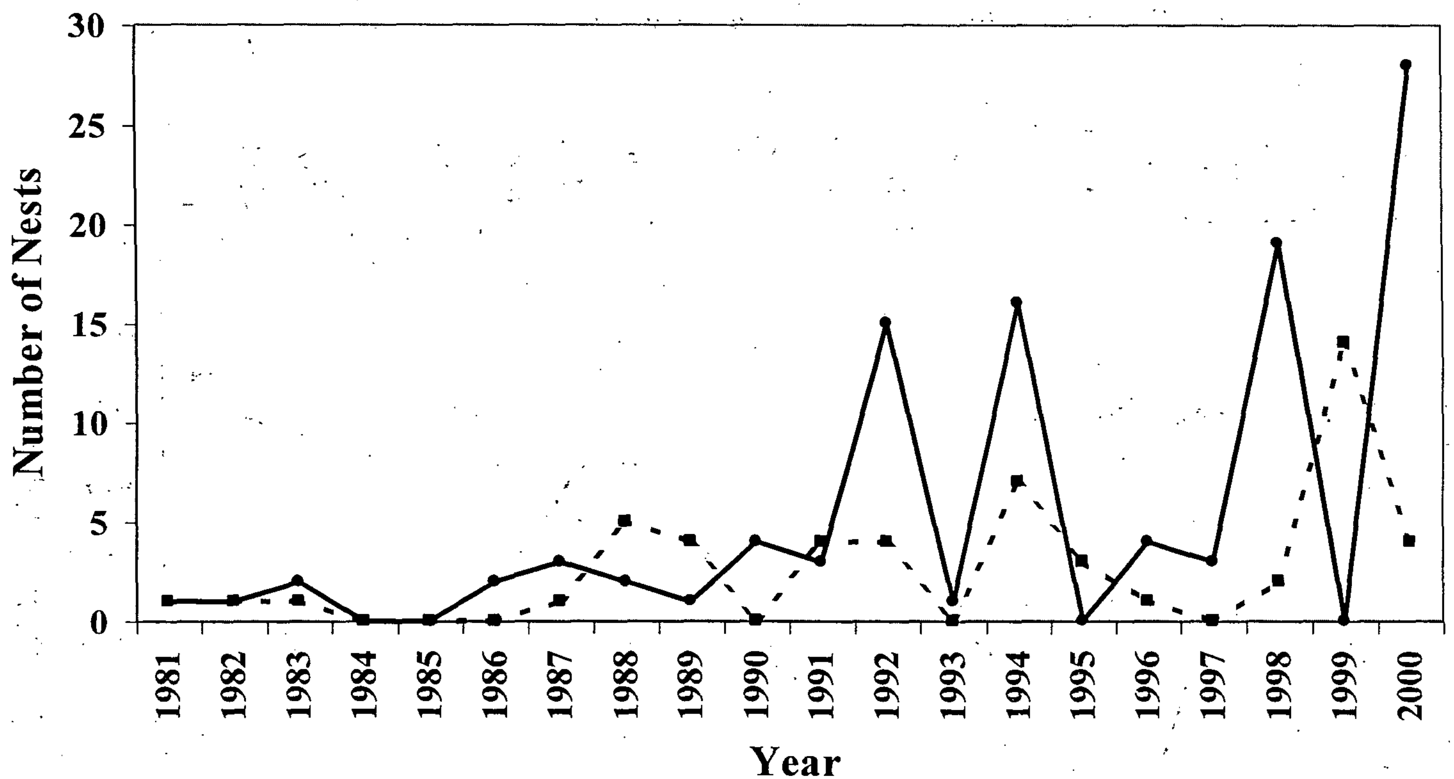

Figure 7. Annual nesting by leatherback and green turtles within a 2-km section of beach adjacent to the St. Lucie Plant, Hutchinson Island, Florida, 1981-2000.

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 commercially important crustaceans in the area potentially affected by plant operation. Although two major migratory species of commercially important fish, Spanish mackerel and blue fish, utilize the area, they are rarely entrained with cooling water, and their migration patterns are not interrupted by the discharge of heated effluents. Similarly, sea turtle nesting on adjacent beaches is unaffected by plant operations. The minimization of environmental impacts in the receiving water body was achieved through proper siting and design of intake and discharge structures.

Although the impingement of aquatic organisms on the plant's intake screens is relatively minor, entrapment of larger, motile vertebrates and invertebrates within the intake canal requires continued attention. Five species of threatened and endangered marine turtles are routinely entrapped in the canal. The endangered Florida manatee has also occasionally been entrapped in the canal. Additionally, numerous species of fish of recreational and commercial importance are entrained with cooling water. In each of these cases, FPL has been proactive in developing programs and improving methods for capturing entrapped animals in a safe and timely manner and returning them unharmed to the ocean. These programs have not only minimized impacts to affected species, but generated a great deal of important biological information not otherwise available to the scientific community. Through these programs, FPL has kept environmental impacts to a minimum.

With the exception of sea turtle nesting surveys, and programs to remove entrapped animals from the intake canal, FPL has not been required by its Environmental Technical Specifications to monitor water quality or biological communities in the receiving water body since 1984. However, there have been no changes in the design or operating characteristics of the St. Lucie Plant since Unit 2 became operational that could reasonably be expected to alter conditions previously documented. A recent informal visual inspection of Walton Rocks by Ecological Associates, Inc. (February 4, 2001) found the worm reef community to be thriving. Sea turtle nesting on ocean beaches adjacent to the St. Lucie Plant appears to be increasing. The numbers of turtles entrapped annually in the intake canal is also increasing, suggestive of increases in local turtle populations. These positive indicators in concert with FPL's commitment to minimizing mortalities and residency times of protected species entrapped in the intake canal, suggest that continued operation of the St. Lucie Plant is unlikely to have any unexpected or unacceptable adverse impacts on adjacent aquatic environments.

REFERENCES

ABI. 1977. Periphyton monitoring at the Florida Power & Light Co. St. Lucie Plant, March 1976 – January 1977. AB-53. Prepared by Applied Biology, Inc., Atlanta, Georgia for Florida Power & Light Company.

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

ABI. 1979b. Worm reef monitoring at the Florida Power & Light Company St. Lucie Plant, April 1976 – April 1979. AB-209. Prepared by Applied Biology, Inc., Atlanta, Georgia for Florida Power & Light Company.

ABI. 1979c. Potential effects of water withdrawal from the Indian River in the area of the St. Lucie Plant. AB-216. Prepared by Applied Biology, Inc., Atlanta, Georgia for Florida Power & Light Company.

ABI. 1979d. Physical parameter monitoring of Big Mud Creek at the Florida Power & Light Co. St. Lucie Plant, April 1977 – March 1979. AB-219. Prepared by Applied Biology, Inc., Atlanta, Georgia for Florida Power & Light Company.

ABI. 1981. Turtle entrainment deterrent study. AB-290. Prepared by Applied Biology, Inc., Atlanta, Georgia for Florida Power & Light Company.

ABI. 1983. Florida Power & Light Company St. Lucie Plant, annual non-radiological aquatic monitoring report, 1982. AB-442. Prepared by Applied Biology, Inc., Atlanta, Georgia for Florida Power & Light Company.

ABI. 1985. Florida Power & Light Company St. Lucie Plant, annual non-radiological environmental monitoring report, 1984. AB-553. Prepared by Applied Biology, Inc., Atlanta, Georgia for Florida Power & Light Company.

ABI. 1992. Florida Power & Light Company St. Lucie Unit 2, annual environmental operating report, 1991. AB-617. Prepared by Applied Biology, Inc., Atlanta, Georgia for Florida Power & Light Company.

Camp, D. K., N. H. Whiting, and R. E. Martin. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. V. Arthropods. Florida Department of Natural Resources, Marine Research Laboratory, Florida Marine Research Publications No. 25. 74 pp.

EBASCO. 1971. Hutchinson Island – Unit No. 1 cooling water discharge report. Prepared by EBASCO Services, Inc., New York, New York for Florida Power & Light Company.

FPL. 1984. Sea turtle intake entrapment studies. Florida Power & Light Company, Juno Beach, Florida. 19 pp. plus appendices.

FPL and Quantum Resources, Inc. 2000. Florida Power & Light Company Annual Environmental Operating Report, 1999. Florida Power & Light Company, Juno Beach, Florida. 43 pp.

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

Gallagher, R. M. 1977. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. II. Sediments. Florida Department of Natural Resources, Marine Research Laboratory, Florida Marine Research Publications No. 23: 6-24.

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

Gallagher, R. M., M. C. Hollinger, R. M. Ingle and C. R. Futch. 1972. Marine turtle nesting on Hutchinson Island, Florida in 1971. Florida Department of Natural Resources, Special Scientific Report No. 37: 1-11.

Gilbert, C. R. (editor). 1992. Rare and endangered biota of Florida. Vol. II. Fishes. University of Florida Press. 247 pp.

Gilmore, G. R. 1995. Environmental and biogeographic factors influencing ichthyofaunal diversity: Indian River Lagoon. Bulletin of Marine Science, 57(1): 153-170.

Gilmore, G. R., and D. J. Herrema. 1981. Fishes of the Indian River Lagoon and adjacent waters, Florida. Harbor Branch Foundation, Inc., Technical Report No. 41. 36 pp. + tables.

Gore, R. H., L. E. Scotto, and L. J. Becker. 1978. Community composition, stability and trophic partitioning in decapod crustaceans inhabiting some subtropical sabellariid worm reefs. Studies on decapod crustacea from the Indian River Lagoon Region of Florida. IV. Bulletin of Marine Science, 28(2): 221-248.

Intera, 1984. Airborne thermal infrared mapping surveys of discharge plumes, St. Lucie nuclear power site, August 27 and September 12, 1984. A84-039. Prepared by Intera Technologies Ltd., Ottawa, Ontario, for Florida Power & Light Company. 17 pp.

Lyons, W. G. 1989. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. XI. Mollusks. State of Florida, Department of Natural Resources, Florida Marine Research Institute, Florida Marine Research Publications No. 47. 131 pp.

Martin, R. E., and R. G. Ernest. 2000. Physical and ecological factors influencing sea turtle entrainment at the St. Lucie Nuclear Plant: 1976-1998. Prepared by Ecological Associates, Inc., Jensen Beach, Florida for Florida Power and Light Company. 55 pp. + 6 tables and 106 figures.

Moffler, M. D., and J. F. Van Breedveld. 1979. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. X. Benthic algae species list. Florida Department of Natural Resources, Marine Research Laboratory, Florida Marine Research Publications No. 34: 118-122.

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

O'Hara, J. and H. J. Kania. 1981. Avoidance responses by sea turtles to exposed electrical fields. Prepared by Environmental & Chemical Sciences, Inc., Atlanta, Georgia for Florida Power and Light Company. 34 pp.

O'Hara, J., and J. R. Wilcox. 1983. Seismic exploration, air guns as a tool for sea turtle deterrence. Prepared by Environmental & Chemical Sciences, Inc., Atlanta, Georgia for Florida Power and Light Company. 18 pp.

Raesly, R. L., J. R. Stauffer, Jr., C. H. Hocutt, and D. R. Sager. 1984. Behavioral responses of loggerhead sea turtles to light. Prepared by the Center for Environmental and Estuarine Studies, University of Maryland, for Florida Power and Light Company. 36 pp.

Tester, L. A., and K. A. Steidenger. 1979. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. VII. Phytoplankton, 1971-1973. Florida Department of Natural Resources, Marine Research Laboratory, Florida Marine Research Publications No. 34: 16-61.

USFWS. 1999. South Florida multi-species recovery plan. U. S. Fish and Wildlife Service, Atlanta, Georgia. 2172 pp.

Walker, L. M. 1979. Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. IX. Diel plankton, 1973-1974. Florida Department of Natural Resources, Marine Research Laboratory, Florida Marine Research Publications No. 34: 99-117.

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

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

Waring, G. T., D. L. Palka, P. J. Clapham, S. Swartz, M. C. Rossman, T. V. N. Cole, L. J. Hansen, K. D. Isack, K. D. Mullin, R. S. Wells, D. K. Odell, and N. B. Barros. 1999. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments – 1999. NOAA Technical Memorandum, NMFS-NE-153. 187 pp.

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

Worth, D. F., and J. B. Smith. 1976. Marine turtle nesting on Hutchinson Island, Florida, in 1973. Florida Department of Natural Resources, Florida Marine Research Publication No. 18: 1-17.