APPENDIX 10.2.1

316 DEMONSTRATIONS

APPENDIX 10.2.1

316 DEMONSTRATIONS

FPL performed a 316 study for the Port Everglades Plant during 1974 and 1975. The 316(a) and 316(b) study culminated in a comprehensive report submitted to affected agencies including the U.S. Environmental Protection Agency (EPA) and the predecessor of the Florida Department of Environmental Protection. During the course of this study, the field programs, methodology, and draft report were submitted to EPA and other agencies for technical input. The final report prepared by Applied Biology, Inc., dated December 1974, was titled “An Evaluation of Ecological Parameter Monitoring at the Port Everglades Plant”. The objective of this study was to evaluate whether the operation of the Port Everglades Plant interfered with the protection and propagation of a balanced, indigenous population of fish, shellfish, and wildlife or caused substantial damage to the biological community of the adjacent waters. The data and conclusions of this report formed the technical basis for 316(a) and 316(b) decisions by EPA.

An additional study entitled “Port Everglades Plant Surface Water Mixing Zones” was performed by Envirosphere Company (c. 1975) and the report is provided on the attached CD.

An additional thermal impact assessment was conducted in 1987 by ABI (May 1987) (see attached CD).

In accordance with the implementation of the Phase II 316(b) Rule for Existing Facilities (69 Federal Register 41576, July, 2004), FPL performed an Impingement and Entrainment Characterization Study for the Port Everglades Plant from April 26, 2006 to April 11, 2007 and prepared a report by ENSR Corporation (March 2008) titled “Port Everglades Impingement Mortality and Entrainment Characterization Study” with the NPDES permit renewal application and is also provided on the attached CD.

Summarized below is information related to 316(a) and (b).

316(a)

FDEP has determined that the Port Everglades Plant is subject to the requirements of Rule 62-302.520(1)(a), F.A.C., which states that facilities with heated water discharges existing on July 1, 1972, “shall not increase the temperature of the receiving body of water (RBW) so as to cause substantial damage or harm to the aquatic life or vegetation therein or interfere with beneficial uses assigned to the RBW”. As a thermal discharge that was in existence prior to July 1, 1972, the existing Port Everglades Plant is not subject to numerical thermal surface water criteria or temperature limits.

The existing Plant has operated at this location for over 45 years using a once through cooling system. As discussed in SCA Sections 3.3.4.1 and 6.1.1, previous biological assessments have found no adverse impact of the existing thermal plume on fish, shellfish, or plankton from operation of the Plant (ABI, 1987); and the studies found no adverse impact to benthos outside the discharge canal. Within the discharge canal the impacts were seasonal and temporary. When PEEC is operational, the size of the thermal plume in the ICW will be significantly reduced because the heat load to the aquatic environment will be about half that of the existing Plant (see SCA Section 6.1.1).

316(b)

The U.S. Court of Appeals for the Second Circuit in January 2007 remanded most of the substantive provisions of the Phase II Rule requirements [40 CFR, Subpart J, as incorporated by reference at Rule 62-620.100(3)(v), F.A.C.]. Additionally, EPA's March 20, 2007 Memorandum to all Regional Administrators confirmed that the Phase II Rule "should be considered suspended", and advised that during the interim period intake considerations shall be evaluated based on Best Professional Judgment.

The NPDES Permit No. FL0001538 issued by the FDEP on July 22, 2010 requires FPL under Condition I.B.15 to develop a plan in accordance with the schedule in Condition VI.6 to help return live fish, shellfish, and other aquatic organisms collected or trapped on the intake screens to their natural habitat…" FPL will implement this 316(b) related permit condition as part of the PEEC project. PEEC will have state-of-the-art traveling screens with an organism return system in the existing intake structures to minimize impingement mortality. In addition, the intake flow rate for PEEC will be reduced by half relative to the existing plant, which will further reduce impingement and entrainment mortality of fish and shellfish by approximately 50 percent.

The state-of-the-art traveling screens will incorporate protective measures including modified Ristroph-type screens with collection buckets, or equivalent, designed to minimize turbulence to aquatic organisms; and a guard rail or barrier to prevent loss of fish from the collection bucket. The screen panels will be use smooth woven mesh (or equivalent) to prevent abrasion of the organisms. The screen wash will use a dual-spray system (or equivalent) with a low pressure wash to remove fish prior to a high pressure wash to remove trash. The organism return system will return the organisms to the source water in a manner that does not promote predation or re-impingement.

FPL will revisit the 316(b) demonstration when EPA revises the rule, and follow the assessment, evaluation, and Best Technology Available (BTA) selection process as appropriate under the revised rule.

ATTACHMENT B

PORT EVERGLADES PLANT

SURFACE WATER MIXING ZONES

PORT EVERGLADES PLANT

SURFACE WATER MIXING ZONES

1. Summary

The Port Everglades Plant requires mixing zones to meet both thermal and chemical discharge criteria. The size of the thermal mixing zone varies with plant load and ambient water temperatures. Assuming full plant load, the thermal mixing zones are estimated to be as follows:

Criteria	Required Area (Acres)
Effluent limit when ambient temperature is less than or equal to 85° F	13.4
Effluent limit when ambient temperature exceeds 85° F	19.3
Water Quality Standard when ambient is 90° F	54

Chemical mixing zones are required for each of the six surface water discharges. These discharges, the parameter requiring the largest mixing zone from each discharge, and the mixing zone area required to meet the water quality standards, are as follows:

Source	Parameter	Area (Square Feet)
Boiler Blowdown/ Storm Water Drain*	Phosphorus	3,500
Neutralization Basin**	Total Dissolved Solids	30

Storm Water Basin	Phosporus	18,000
Auxiliary Cooling Water	Odor	18,000
Circulating Water	Several Parameters	Unable to meet because ambient does not meet

*These two discharges are adjacent, and so have been combined into one mixing zone.

**Total dissolved solids has no water quality standard. This mixing zone, to meet the effluent standard, is the largest mixing zone required for the neutralization basin discharge.

2. Thermal Mixing Zone

The Port Everglades Plant is located at latitude 26° 05' 08" and longitude 80° 07' 31". The location is shown on Figure 1.

The plant has four steam electric generating units with a capacity of about 1200 megawatts. Condenser cooling is accomplished by the use of a once-through circulating water system. The design flow rate and temperature rise for each unit are as follows:

Unit	Flow (CFS)	Flow (GPM)	Temperature Rise (°F)
1	357	160,000	13.1
2	357	160,000	13.1
3	613	275,000	14.2
4	613	275,000	14.2

The circulating water system is illustrated on Figure 2. It takes suction from the west end of Slip 3 in Port Everglades. The water flows through culverts to the northern end of the intake canal. The circulating water pumps, located at the south end of the intake canal, pump the water through the plant condensers to the northern end of the discharge canal. The water then flows down the discharge canal to the Intracoastal Waterway.

Auxiliary cooling water is discharged to the same location as circulating water. Because of its low flow rate (12,000 gpm), the heat load from this discnarge is negligible in comparison to the circulating water.

With all four units operating at full load, the design circulating water flow rate is 1940 cfs and the temperature rise is about 13.8°F. The estimated tidal flow past the confluence of the discharge canal and the Intracoastal Waterway averages about 70,000 cfs.

Although FPL has performed surveys of the thermal plume from the Port Everglades Plant, these surveys do not indicate the maximum size (worst case) thermal plume. The worst case plume is a rare condition in which maximum plant load coincides with highest ambient water temperature. In order to estimate the size of this worst case thermal plume, mathematical modeling has been performed.

The mathematical model selected for the Port Everglades Plant thermal discharge is based on work presented by Stefan, Bergstedt, and Mrosla (Reference 1). Essentially, this model calculates the entrainment of ambient water by the thermal plume, and the resultant dilution effect. To make the model complete, equations were added to enforce conservation of mass and energy.

As input, the model requires values for the following parameters:

- Discharge water temperature and flow rate;
- Ambient water temperature;
- Discharge velocity;
- Aspect ratio (ratio of discharge channel width to depth); and
- Ambient cross-flow velocity.

To determine the design conditions for the worst case thermal plume, intake water temperatures were analyzed for the period from February 1, 1985, through January 31, 1987. A plot of intake temperature vs. frequency is presented as Figure 3. The maximum intake temperature was 90°F. This was assumed to represent the worst case ambient temperature. At full design condenser rise, the discharge water temperature is calculated to be 103.8°F.

The worst case plume is predicted by the model to occur during slack tide, when the ambient cross-flow velocity is zero. In particular, the worst case occurs at slack of high tide. At this time the channel depth is a maximum and consequently, the discharge velocity is a minimum (about 1.7 ft./sec.). At the same time, the discharge channel aspect ratio is at a minimum (about 4.1).

The Broward County thermal regulations have two effluent requirements, that the effluent temperature rise not exceed 10°F, and that the effluent discharge not exceed 95°F, in the receiving body of water (RBW).

The results from modeling the worst case are shown in Figure 4. Since the county limits the absolute effluent water temperature to 95°F, and the ambient is 90°F, the 5°F isotherm on Figure 4 represents the extent of the worst case thermal plume mixing zone. If the ambient water temperature is less than or equal to 85°F (about 78% of the time, from Figure 3), the 10°F isotherm on Figure 4 represents the edge of the mixing zone. The areas encompassed by the 5°F and 10°F isotherms, respectively, in the Intracoastal Waterway, are about 7.6 and 1.7 acres. Additionally, they both include the discharge canal, which has a surface area of approximately 11.7 acres.

The mixing zone described above is required to bring the discharge temperature down to the county effluent limit. The water quality standard is set at 90°F. Since the ambient temperature in the worst case is equal to the water quality standard, the thermal plume can never cool down to the standard by mixing with ambient water. However, the plume temperature can be estimated to a point where the difference between the plume and the ambient is not measurable. This has been done and the results are shown on Figure 5. The extent of the mixing zone required to meet the county water quality standard is represented by the isotherm labelled 0°F. The area enclosed by this isotherm is estimated to be about 54 acres, including the discharge canal.

3. Chemical Mixing Zone

Surface water discharges from the Port Everglades Plant come from the following sources and are discharged to the following locations:

Circulating Water (C.W.)	Discharge Canal
Boiler Blowdown	Intake Canal
Neutralization Basin	Intake Canal
Stormwater Forwarding Basin Overflow	Discharge Canal
Stormwater Drain	Intake Canal
Auxiliary Cooling Water	Discharge Canal

The discharge locations are shown on Figure 6.

Water Quality sampling has been performed for each of the five discharges and also for the intake. The intake samples represent ambient water. The results of the sampling, and the Broward County effluent limits, are presented in Table 1. No sampling was performed for pesticides and herbicides because such substances are neither used nor present on site.

Chlorination is practiced at the Port Everglades Plant. It is performed daily, for one half a condenser at a time for a period of 15 minutes. The amount of circulating water being chlorinated at any one time is a small percentage of the total. Chlorine is injected to achieve about 1.5 ppm at the waterbox discharge. Repeated measurements show that no free residual reaches the seal well (structure where the discharge enters the discharge canal). It can only be assumed that the chlorine demand of the circulating water is sufficient to consume all of the free residual. Thus, no mixing zone will be required for chlorine.

Table 1 has been reviewed and all parameters in exceedance of either effluent or water quality standards have been identified. These parameters are tabulated on Table 2. Of these nine parameters, three cannot meet the water quality standard because the ambient does not meet the standard. (Ambient is measured at the intake). These three parameters are COD, oil and grease (at the C.W. discharge, storm water drainage, and the storm water basin overflow), and selenium (C.W. discharge and neutralization basin). The remainder includes copper (boiler blowdown, neutralization basin, and storm water basin). lead (storm water drainage), nitrogen (neutralization basin and storm basin overflow), odor (neutralization basin, storm water drainage, storm water basin, and auxiliary cooling water), phosphorus (boiler blowdown, neutralization basin, storm water basin), and total dissolved solids (neutralization basin). All of these parameters, except for total dissolved solids (neutralization basin), meet the effluent standard but exceed the water quality standard.

Maximum discharge flow rates have been estimated for each of the waste streams which require a mixing zone and are as follows:

Boiler Blowdown	360 gpm
Neutralization Basin	1,000 gpm
Storm Water Drain	19,700 gpm
Storm Water Basin Overflow	22,136 gpm
Auxiliary Cooling Water	12,000 gpm

Each of the parameters requiring a mixing zone, and the waste stream it is associated with, are tabulated in Table 3. Also tabulated therein are the parameter concentration and waste stream flow rate, and the dilution flow of ambient water required to lower the concentration to meet the water quality criteria.

Based on the results presented in Table 3, the worst case mixing zone is for the parameter phosphorus as it is discharged in boiler blowdown and the storm water basin; the worst case parameter from the neutralization basin is TDS; the worst case parameter for auxiliary cooling water and the storm water drain is odor. TDS from the neutralization basin requires a mixing zone to meet the effluent standard; there is no water quality standard for this parameter. It still represents the worst case mixing zone for the neutralization basin discharge. Since the boiler blowdown and the storm water drain discharges are adjacent, they have been combined and are treated as one mixing zone.

A simple mixing model, based on conservation of momentum, mass, and energy, has been used to predict the worst case mixing zone. There are actually two mixing zone areas; one is in the intake canal and the other is in the discharge canal. The intake canal mixing zone is shown on Figure 7. The neutralization basin mixing zone is small, estimated at about 30 square feet. The boiler blowdown/storm drain mixing zone is larger, estimated at about 3500 square feet. Similarly, the discharge canal mixing zone is shown on Figure 8. Its size is estimated to be about 18,000 square feet, and it includes the auxiliary cooling water discharge and the storm water basin overflow.

REFERENCES

1. Flow Establishment and Initial Entrainment of Heated Water Surface Jets. Heinz Stefan, Loran Bergstedt, and Edward Mrosla. U.S. EPA. EPA-660/3-75-014, May, 1975.

TABLE 1

PORT EVERGLADES SURFACE WATER DISCHARGES QUALITY
(milligrams/liter)

Parameter	Intake	Discharge	Boiler Blowdown	County Effluent Limit	County Water Quality Standard
Arsenic	B	B	B	0.05	0.05
BOD5				20	7.0
Cadmium	B	B	B	0.5	0.005
Chlorinated Hydrocarbons	B	B	B	0.01	0.01
Chromium (Total)	B	B	B	1.0	0.05
Chromium (Hex)	B	B	B	0.1	-
COD	140	~~190~~ 160 see Table II	~~53~~ 31	100	15
Coliform (Total)	B	B	B	1000/100 ml	1000/100 ml
Coliform (Fecal)	B	B	B	400/100 ml	Varies
Copper	B	B	0.2	0.5	0.015
Cyanide	B	B	B	0.1	0.005
Detergent	B	B	B	6.0	0.5
Lead	B	B	B	0.3	0.03
Mercury	B	B	B	0.001	0.0001
Nickel	B	B	B	1.0	0.1
Nitrogen	0.7	0.3	0.8	30	1.5
Odor (T.O.N.)(1)	1.0	1.0	1.0	None	None
Oil & Grease	1.6	1.4	B	10.0	1.0
Oxygen, Dissolved	6.65	6.50	6.0	Min. 2.0	Min. 4.0
Pathogens				1/gallon	1/gallon
PCBs	B	B	B	0.000001	0.001
pH	8.19	8.17	7.23	6-8.5	6.5-8.5
Phenolics	B	B	B	0.01	0.001
Phosphorus	B	B	2.5	10.0	0.05
Radioactivity	None Expected				
Selenium	.14	.04	B	0.25	0.025
Silver	B	B	B	0.1	0.00005
Floating Solids	None Expected				
Total Suspended Solids	4	4	0.5	30	-
Total Dissolved Solids	34000	34000	2.2	500*	-
Turbidity (N.T.U.)	0.8	0.7	1.7	30 JTU	10 JTU
Zinc	B	B	B	1.0	1.0
Pesticides/ Herbicides	None Expected				
Chlorine (Free Residual)	B	B	B	0.01	0.01

NOTE: B indicates below detection limit.
*Exceeding natural salts of sea water.
(1) Odor reported as Threshold Odor Number.

TABLE 1
(continued)

PORT EVERGLADES SURFACE WATER DISCHARGES QUALITY
(milligrams/liter)

Parameter	Neutral Basin	Storm Water Drainage	Storm Water Basin	County Effluent Limit	County Water Quality Standard
Arsenic	B	B	B	0.05	0.05
BOD5				20	7.0
Cadmium	B	B	B	0.5	0.005
Chlorinated Hydrocarbons	B	B	B	0.01	0.01
Chromium (Total)	B	B	B	1.0	0.05
Chromium (Hex)	B	B	B	0.1	-
COD	~~230~~ 38	~~120~~ 31 see Table II	75	100	15
Coliform (Total)	B	B	B	1000/100 ml	1000/100 ml
Coliform (Fecal)	B	B	B	400/100 ml	Varies
Copper	0.1	B	0.02	0.5	0.015
Cyanide	B	B	B	0.1	0.005
Detergent	B	B	B	6.0	0.5
Lead	B	0.06	B	0.3	0.03
Mercury	B	B	B	0.001	0.0001
Nickel	B	B	B	1.0	0.1
Nitrogen	4.8	1.2	2.3	30	1.5
Odor (T.O.N.)(1)	3.3	1.3	2.0	None	None
Oil & Grease	0.3	4.3	2.5	10.0	1.0
Oxygen, Dissolved	8.1	9.4	11.2	Min. 2.0	Min. 40
Pathogens				1/gallon	1/gallon
PCBs	B	B	B	0.000001	0.001
pH	8.48	8.19	8.45	6-8.5	6.5-8.5
Phenolics	B	B	B	0.01	0.001
Phosphorus	0.59	B	1.3	10.0	0.05
Radioactivity	---------------	None	Expected	-------------	-------------
Selenium	0.04	B	B	0.25	0.025
Silver	B	B	B	0.1	0.00005
Floating Solids	---------------	None	Expected	-------------	-------------
Total Suspended Solids	2.0	12.0	2.5	30	-
Total Dissolved Solids	6200	200	410	500*	-
Turbidity (N.T.U.)	0.8	1.6	2.5	30 JTU	10 JTU
Zinc	B	B	B	1.0	1.0
Pesticides/ Herbicides	---------------	None	Expected	-------------	-------------
Chlorine (Free Residual)	B	B	B	0.01	0.01

NOTE: B indicates below detection limit.
*Exceeding natural salts of sea water.
(1) Odor reported as Threshold Odor Number.

TABLE 1
(continued)

PORT EVERGLADES SURFACE WATER DISCHARGES QUALITY
(milligrams/liter)

Parameter	Auxiliary Cooling Water	County Effluent Limit	County Water Quality Standard
Arsenic	B	0.05	0.05
BOD5		20	7.0
Cadmium	B	0.5	0.005
Chlorinated Hydrocarbons	B	0.01	0.01
Chromium (Total)	B	1.0	0.05
Chromium (Hex)	B	0.1	-
COD	280	100	15
Coliform (Total)	B	1000/100 ml	1000/100 ml
Coliform (Fecal)	B	400/100 ml	Varies
Copper	B	0.5	0.015
Cyanide	B	0.1	0.005
Detergent	B	6.0	0.5
Lead	B	0.3	0.03
Mercury	B	0.001	0.0001
Nickel	B	1.0	0.1
Nitrogen	1.5	30	1.5
Odor (T.O.N.)(1)	24	None	None
Oil & Grease	B	10.0	1.0
Oxygen, Dissolved	6.2	Min. 2.0	Min. 40
Pathogens		1/gallon	1/gallon
PCBs	B	0.000001	0.001
pH	7.53	6-8.5	6.5-8.5
Phenolics	B	0.01	0.001
Phosphorus	B	10.0	0.05
Radioactivity	------------ None Expected	---------------	
Selenium	B	0.25	0.025
Silver	B	0.1	0.00005
Floating Solids	------------ None Expected	---------------	
Total Suspended Solids	11	30	-
Total Dissolved Solids	30,000	500*	-
Turbidity (N.T.U.)	0.6	30 JTU	10 JTU
Zinc	B	1.0	1.0
Pesticides/ Herbicides	------------ None Expected	---------------	
Chlorine (Free Residual)	B	0.01	0.01

NOTE: B indicates below detection limit.
*Exceeding natural salts of sea water.
(1) Odor reported as Threshold Odor Number.

TABLE 2

PORT EVERGLADES SURFACE DISCHARGE PARAMETERS
EXCEEDING COUNTY STANDARDS (milligrams/liter)

Parameter	C.W. Intake	C.W. Discharge	Boiler Blow-down	County Effluent Limit	County Water Quality Standard
COD	140	160	31	100	15
Copper	B	-	0.2	0.5	0.015
Nitrogen	0.7	0.3	0.8	30	1.5
Lead	B	-	-	0.3	0.03
Oil & Grease	1.6	1.4	-	10.0	1.0
Phosphorus	B	-	2.5	10.0	0.05
Selenium	0.14	0.04	-	0.25	0.025

Parameter	Neutral Basin	Storm Water Drainage	Storm Water Basin	County Effluent Limit	County Water Quality Standard
COD	38	31	75	100	15
Lead	-	0.06	-	0.3	0.03
Nitrogen	4.8	-	2.3	30	1.5
Odor(1)	3.3	1.3	2.0	None	None
Oil & Grease	-	4.3	2.5	10.0	1.0
Phosphorus	0.59	-	1.3	10.0	0.05
Selenium	0.04	-	-	0.25	0.025
Total Dissolved Solids	6448	-	-	500	-
Copper	0.1	-	0.02	0.5	0.015

Parameter	Auxiliary Cooling Water	County Effluent Limit	County Water Quality Standard
COD	280	100	15
Odor(1)	24	None	None

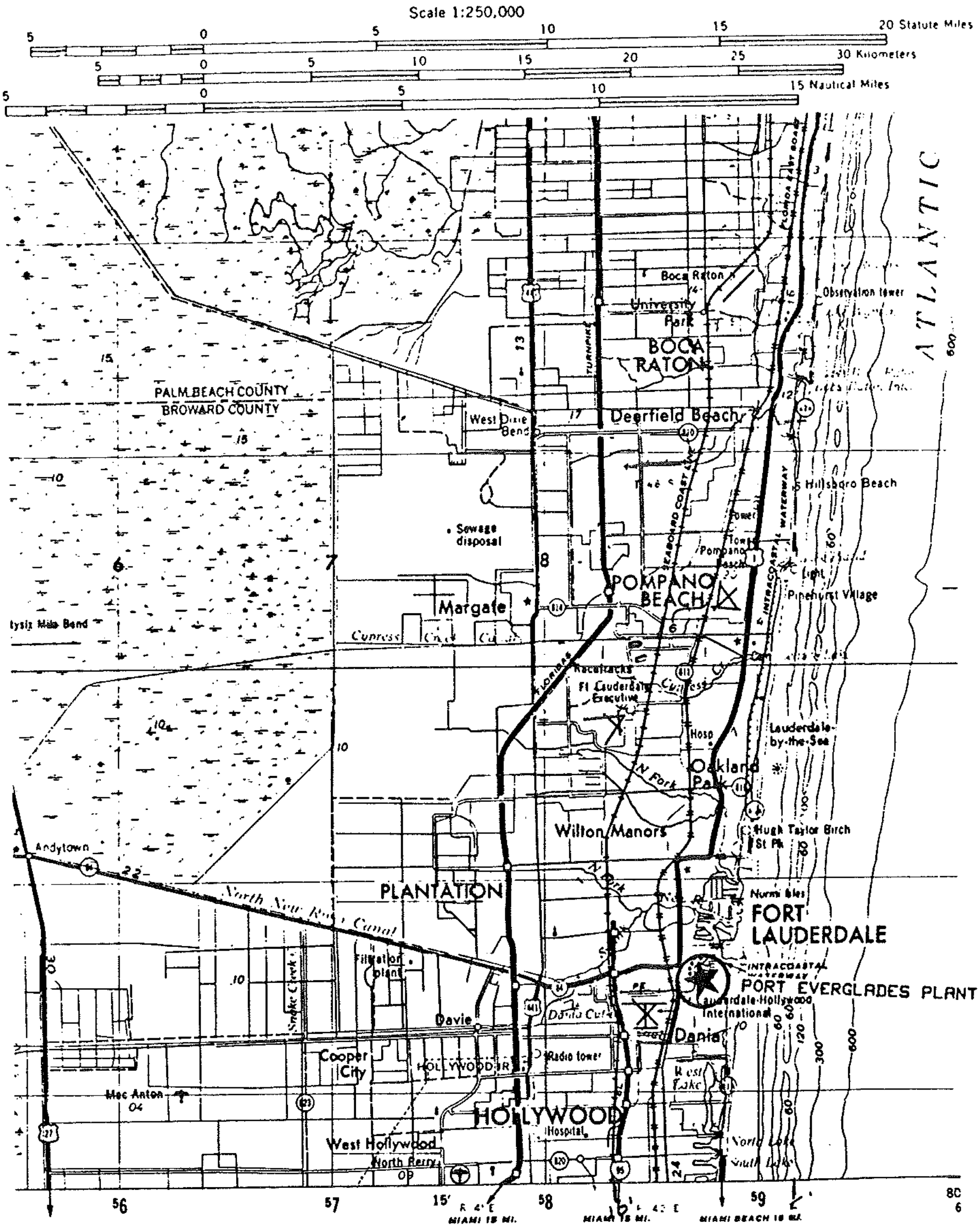
NOTE: B indicates below detection limit.
(1) Odor reported as Threshold Odor Number.

TABLE 3

PARAMETERS REQUIRING MIXING ZONES

Parameter	Concentration (mg/l)	Stream	Flow (gpm)	Required Dilution Flow (gpm)
Copper	0.2	Boiler Blowdown	360	5,328
Copper	0.1	Neutralization Basin	1,000	7,667
Copper	0.02	Storm Basin Overflow	22,136	7,379
Lead	0.06	Storm Drain	19,700	19,700
Nitrogen	4.8	Neutralization Basin	1,000	4,125
Nitrogen	2.3	Storm Basin Overflow	22,136	22,136
Odor	3.3(1)	Neutralization Basin	1,000	2,300
Odor	1.3(1)	Storm Drain	19,700	65,952
Odor	2.0(1)	Storm Basin Overflow	22,136	22,136
Odor	24(1)	Auxiliary Cooling Water	12,000	468,000
Phosphorus	2.5	Boiler Blowdown	360	17,640
Phosphorus	0.59	Neutralization Basin	1,000	10,800
Phosphorus	1.3	Storm Basin Overflow	22,136	553,400
Total Dissolved Solids	6448	Neutralization Basin	1,000	11,896

NOTES: (1) Odor reported as Threshold Odor Number.



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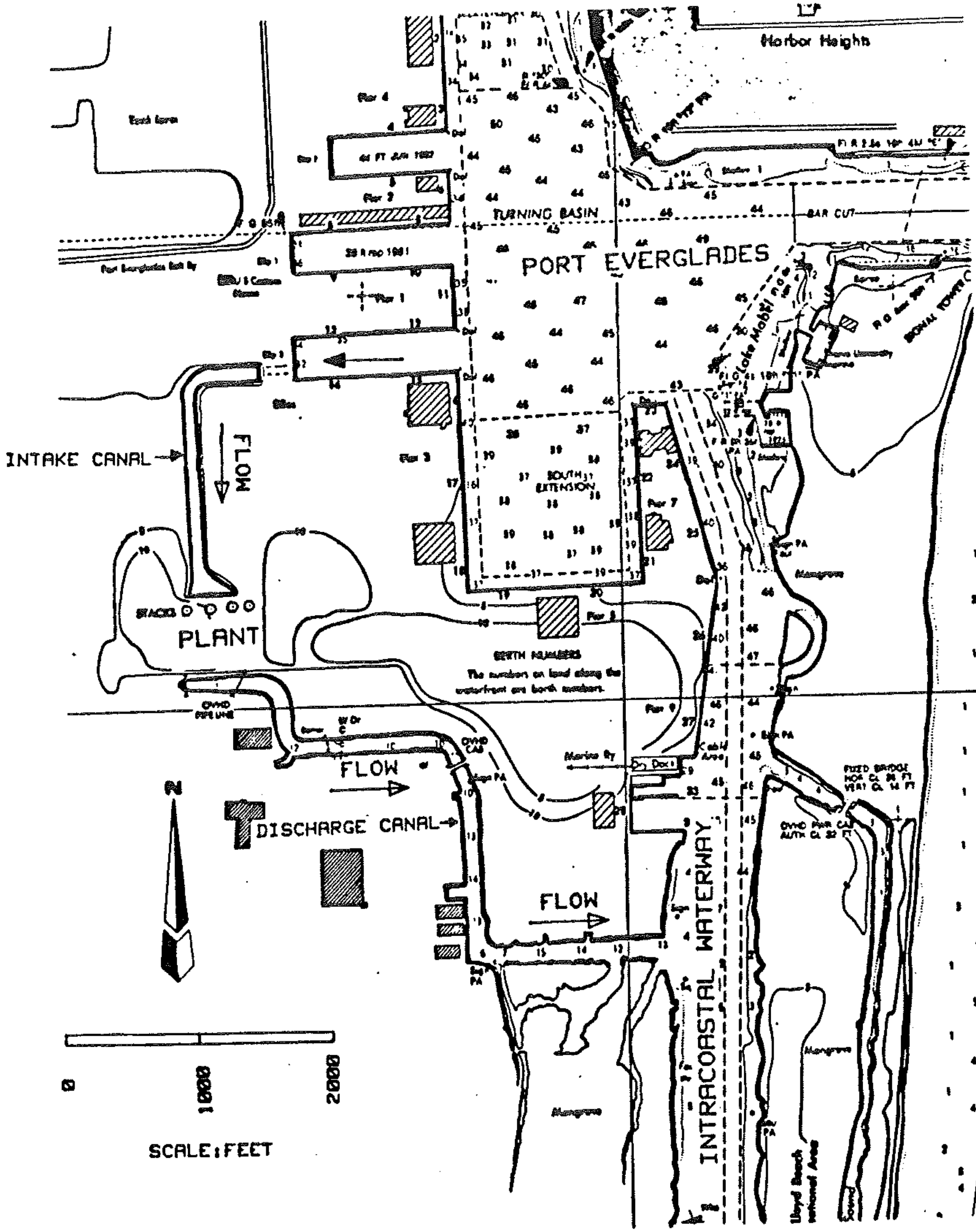
LOCATION MAP
PORT EVERGLADES PLANT

FIGURE 1



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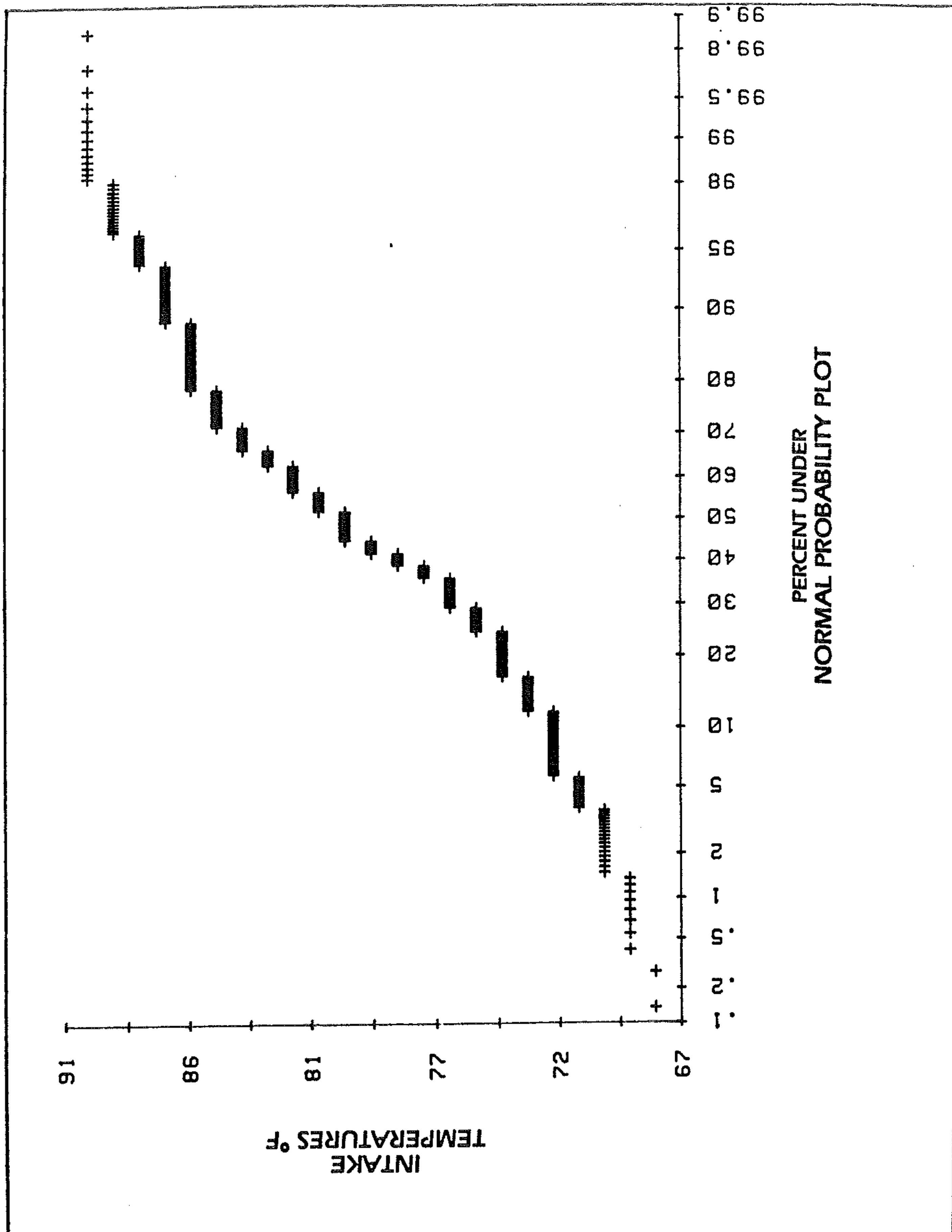
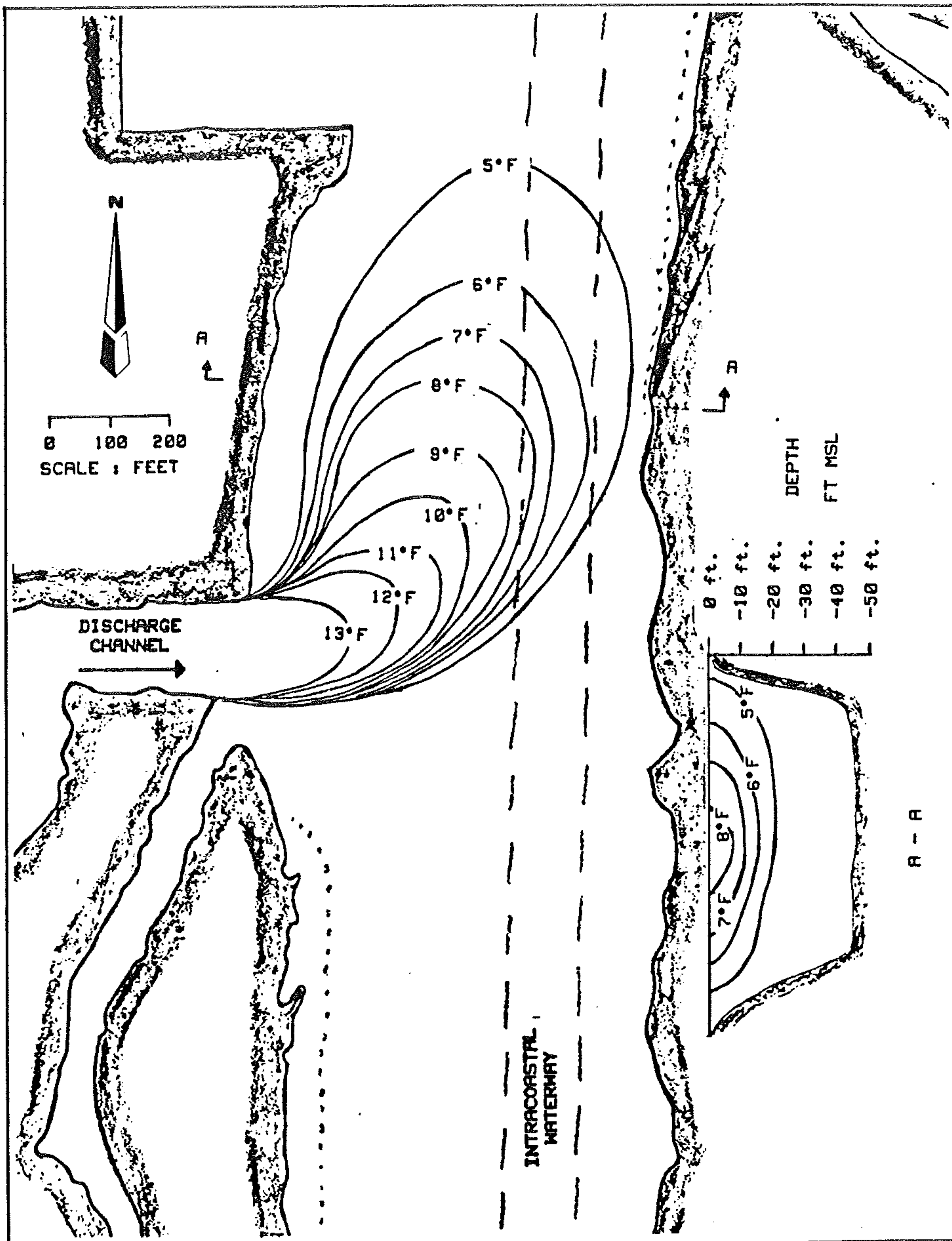
PORT EVERGLADES PLANT
CIRCULATING WATER FLOW PATTERN

FIGURE 2



envirosphere company	PORT EVERGLADES PLANT INTAKE TEMPERATURE FREQUENCY	FIGURE 3



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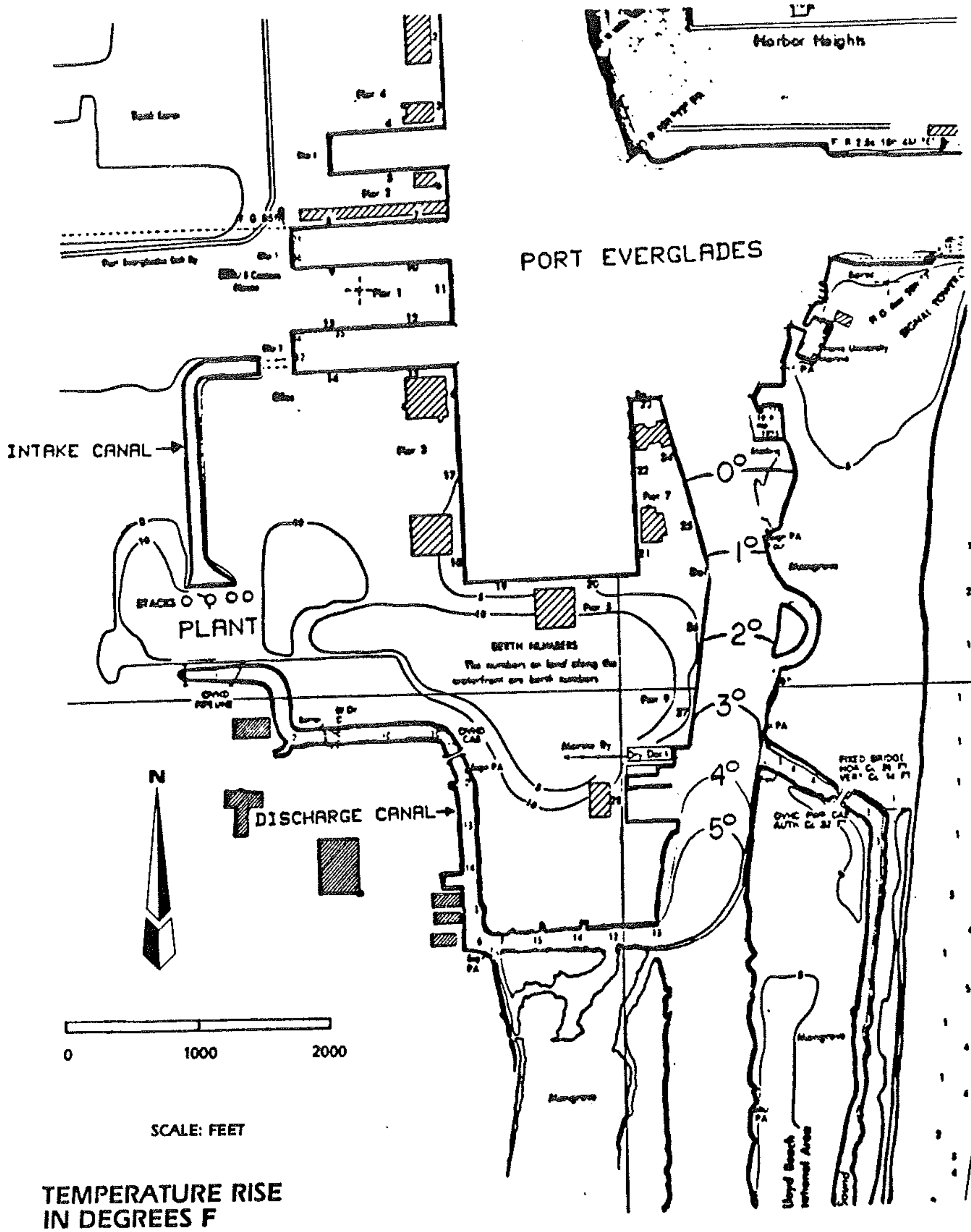
PORT EVERGLADES PLANT
WORST CASE THERMAL
MIXING ZONE

FIGURE 4



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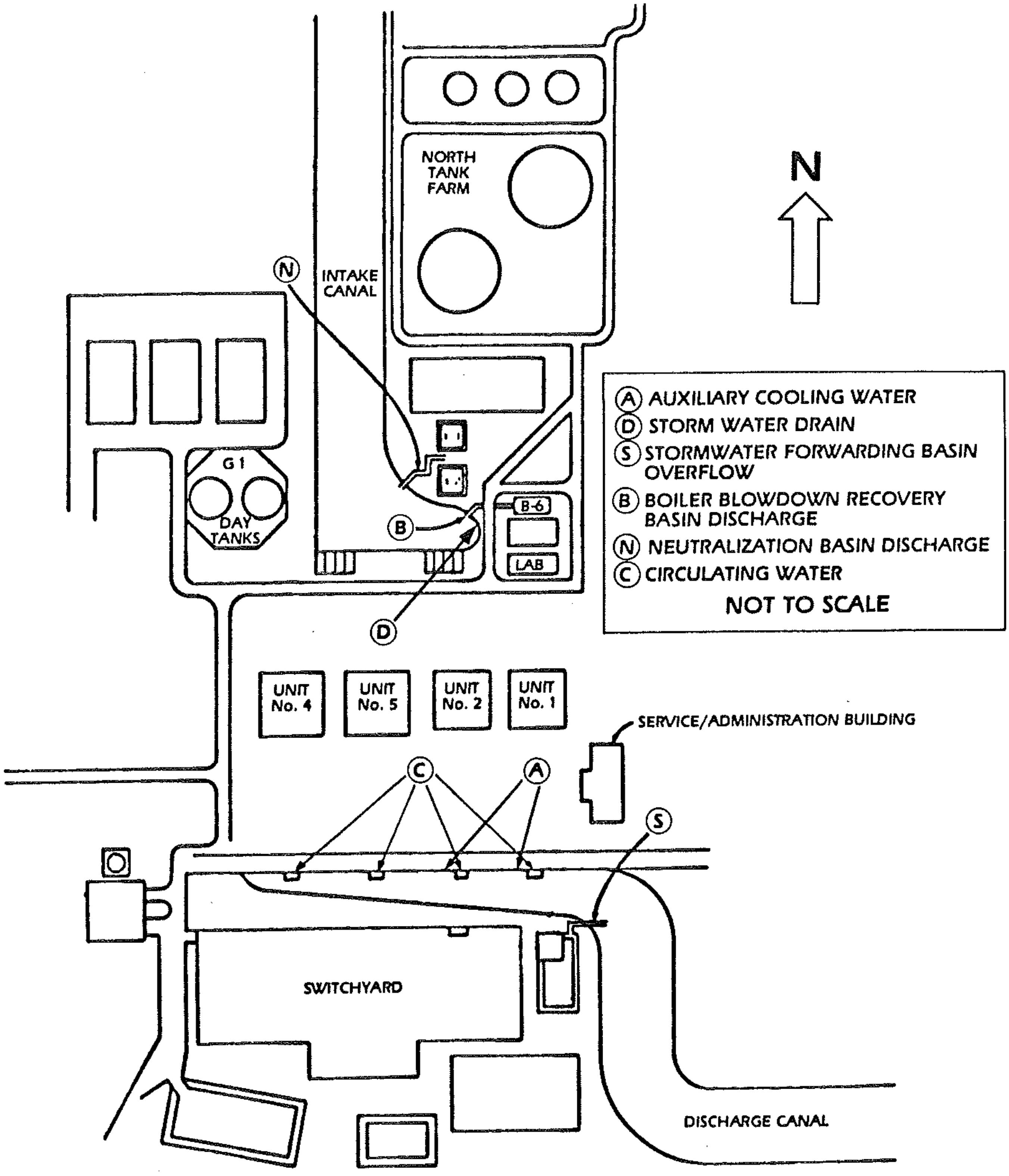
PORT EVERGLADES PLANT

WORST CASE THERMAL PLUME FAR FIELD

FIGURE 5



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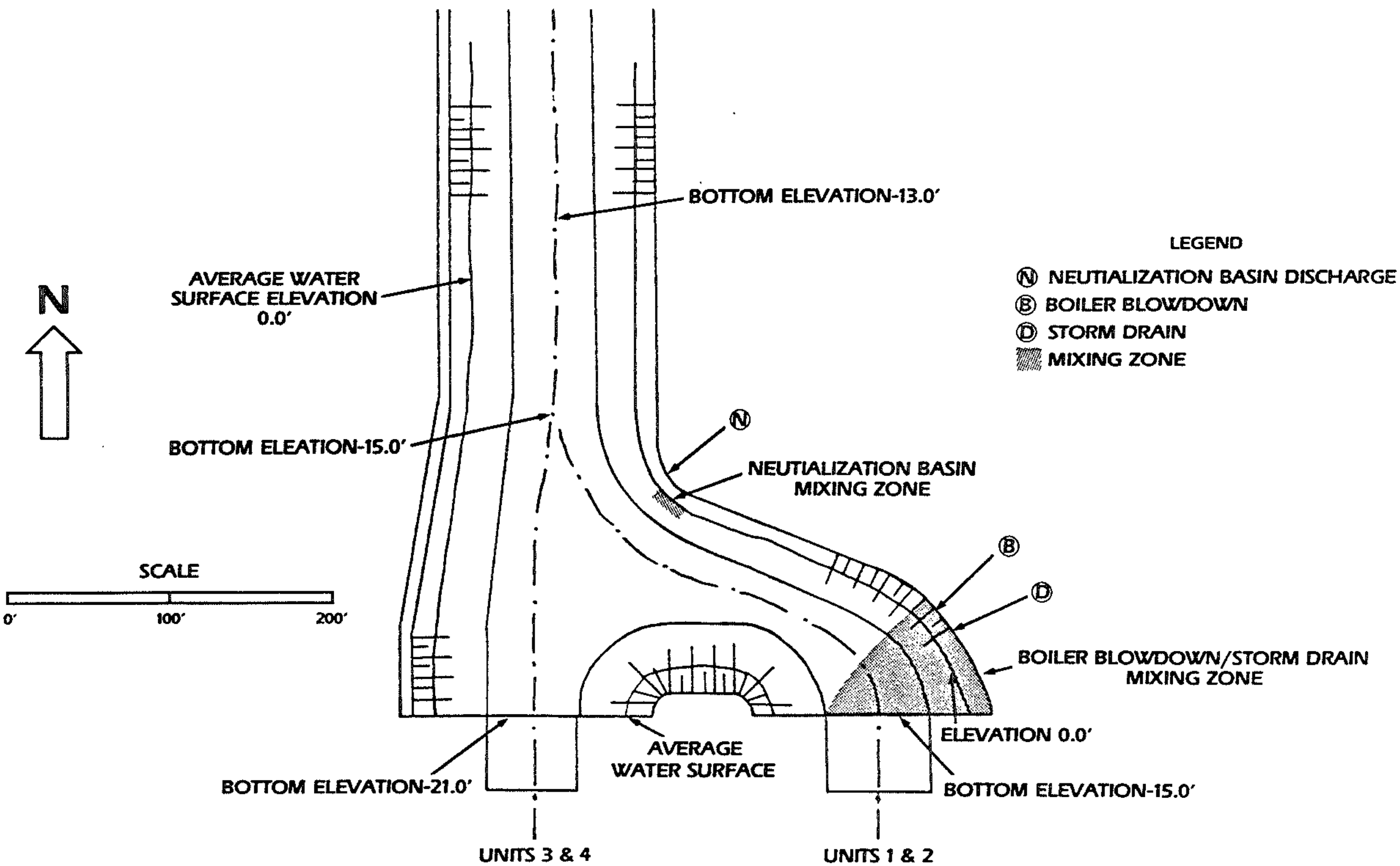
PORT EVERGLADES PLANT SURFACE WATER DISCHARGES

FIGURE 6



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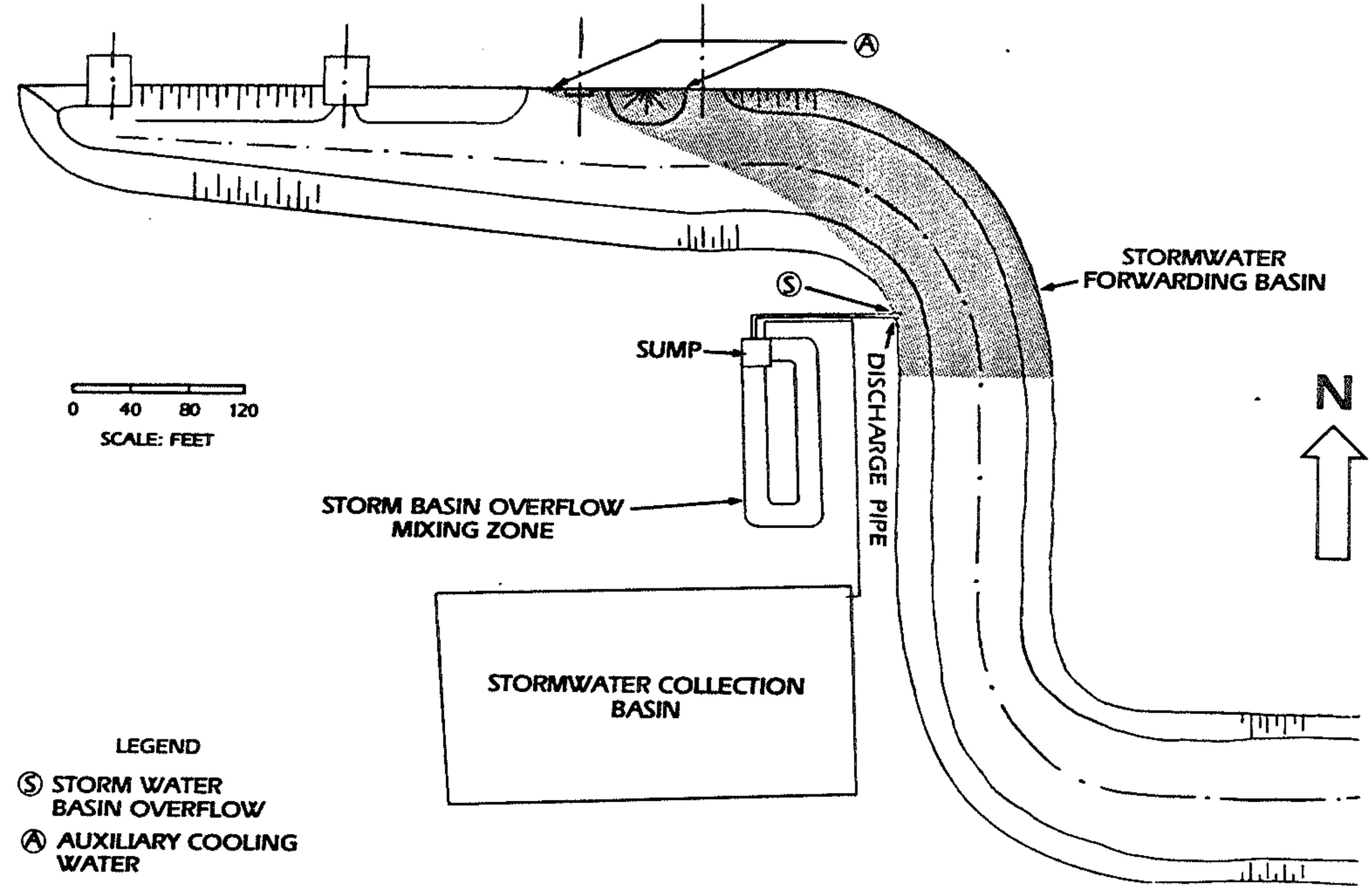
INTAKE CANAL MIXING ZONE

FIGURE 7



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DISCHARGE CANAL MIXING ZONE

FIGURE 8

Prepared for:
Florida Power & Light
Juno Beach, Florida

Port Everglades Impingement Mortality and Entrainment Characterization Study

ENSR Corporation
March 2008
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Executive Summary

This document provides a summary and discussion of an Impingement Mortality and Entrainment Characterization Study (IMECS) conducted between April 25, 2006 and April 11, 2007 at the Florida Power & Light (FPL) Port Everglades Power Plant (PPE). The Port Everglades Plant is located in Broward County in southeast Florida on the corporate boundary of Hollywood and Ft. Lauderdale. Historical impingement mortality and entrainment (IM&E) data collected at the facility are also presented in this document as background for the current study.

Port Everglades Power Plant is a four-unit, oil-fired, steam electric generation plant with a net plant output of 1,142 megawatts (MW). Units 1 and 2 were placed into operation in 1960 and 1961 (respectively), and Units 3 and 4 were placed into operation in 1964 and 1965. The Port Everglades plant is an “intermediate” load plant that runs throughout the year with higher capacity factors in the summer and winter peaks, and lower capacity factors in the “shoulder” months. Units 1 and 2 run less (by about 50 percent) than Units 3 and 4.

The facility uses once-through cooling, withdrawing cooling water from the Port Everglades Harbor/Turning Basin at the west end of Slip No. 3. The Turning Basin is located at the west end of the 800-foot wide channel connecting the Port to the Atlantic Ocean. The cooling water system has a combined capacity of approximately 1,295 million gallons per day (MGD).

In July 2004, the U.S. Environmental Protection Agency (EPA) published the Phase II Rule implementing Section 316(b) of the Clean Water Act for Existing Facilities (69 FR 41576). The rule became effective on September 7, 2004 and included numeric performance standards for reductions in IM&E that would demonstrate that the cooling water intake system (CWIS) constitutes the Best Technology Available (BTA) for minimizing IM&E impacts. Existing facilities subject to the rule were required to demonstrate compliance with the rule’s performance standards through development of a Comprehensive Demonstration Study (CDS). The IMECS presented in this report is one of the several components of the CDS.

On January 25, 2007 the Second Circuit Court of Appeals remanded significant portions of the Phase II Rule, resulting in substantial uncertainty as to how facilities should proceed toward compliance. On March 20, 2007 EPA issued guidance indicating it intended to suspend the rule and that permit writers should continue to utilize Best Professional Judgment (BPJ) to comply with §316(b) for Phase II facilities. EPA officially suspended the rule on July 9, 2007 and has stated its intention to issue guidance to delegated NPDES agencies regarding §316(b) implementation prior to resolution of the Court’s concerns. Guidance provided by the Florida Department of Environmental Protection (FDEP) requires power plants to submit an IMECS with the NPDES permit renewal to support its BPJ determination of BTA. FPL has therefore prepared this report to document the results of the IMECS study performed at the Port Everglades plant, summarized below.

Impingement Mortality

A total of 5,577 individual organisms were collected from the traveling screens at PPE during the 2006-07 impingement sampling program, consisting of 102 fish and 47 invertebrate taxa. The Port Everglades cooling water intake does not have a fish return system, thus 100 percent mortality was assumed to have occurred.

Dominant Species Impinged:

- Over the 52 week program the overall fish impingement rate was 0.166/Million Gallons of water withdrawn

- Two species of anchovy, big-eye anchovy (*Anchoa lamprotaenia*) and broad-striped anchovy (*Anchoa hepsetus*), represented 67 percent of the total annual impingement at PPE.

- Other dominant fish species included bandtail puffer, checkered puffer, spotfin mojarra, and tidewater mojarra, which along with anchovy species comprised approximately 85 percent of the impinged fish.

- Pink shrimp represented 23 percent of the annual invertebrate impingement and 4 percent of the total impingement.

- Other dominant invertebrate species included Atlantic brief squid, sargassum crab, caridean shrimp, mud crabs, penaeid shrimp, roughneck shrimp, portunid crabs, and blue crabs, together comprising 76 percent of impinged invertebrate species.

- An estimated total of 63.2 kg of fish and invertebrates was impinged during the study period. This impingement biomass was dominated by checkered puffer (33.8 percent), followed by lookdown (16.45 percent) and bandtail puffer (12.1 percent). Blue crab was the dominant invertebrate species on a biomass basis with 4.2 kg collected.

Seasonality

- The highest impingement rates were observed from mid-July to September (late summer) due to the presence of big-eye anchovy.

- Peak abundance of impinged fish occurred during the first week of September when big-eye anchovy impingement during this one event comprised approximately 25 percent of the overall annual IM rate.

- Pink shrimp were the dominant shellfish species impinged, with an early season peak during late April through June and throughout September.

- Impingement rates of small invertebrates such as non-commercial crabs, shrimp, and squid species varied throughout the year, with peaks in December to January, March, June, and September.

Diel Variation

- 78 percent of the 5,580 individuals collected during the 26 sampling events were taken at night.

Annualized Estimated IM Rates

- The estimated annual impingement rate under actual flow conditions during the monitoring period was 64,555 fish, and for the estimated annual impingement rate for design flow (i.e., all circulating water pumps assumed to be on for the full year) was 73,653 fish.

- The estimated annualized impingement of invertebrates for the 2006-07 study period was 14,359 for actual flow and approximately 17,490 for design flow.

- These annualized rates assume that IM is proportional to flow and that the results from each event are representative of the impingement rates between sampling periods.

Entrainment

A total of 72,052 fish and 197,988 invertebrates were collected by entrainment sampling at PPE during the 2006-07 sampling program, consisting of 84 fish and 38 invertebrate taxa. Of the invertebrates, 2,223 individuals (0.79 percent of the total) were recreational or commercially important shellfish, with the bulk of invertebrates consisting of non-commercial crab and shrimp species (e.g., mud crabs, grass shrimp, mole crabs).

Dominant Species and Life Stages Entrained

- Fish entrainment was dominated by organisms of unidentifiable taxonomy (83.4 percent, primarily unidentified eggs), followed by a complex comprised of Carangidae, Labridae, and Sciaenidae (4.46 percent). Unidentifiable eggs were predominately undeveloped with no differential characteristics that would allow further taxonomic differentiation. Some may have been spawned shortly before collection and thus and cell division was not yet evident, while others were unfertilized and not viable.

- Fish eggs accounted for 25 percent of the total entrainment and 93 percent of the annualized fish entrainment.

- Fish larvae comprised 7 percent of the fish entrainment count and 2 percent of annual entrainment.

- Invertebrates were dominated by decapod zoea (88 percent), comprised mostly of brachyuran crabs (mud crabs, sargassum crabs, 47 percent), caridean shrimp (grass shrimp, 29 percent), and anomuran crabs (hermit crabs, mole crabs and porcelain crabs; 12 percent).

Seasonality

- Entrainment exhibited an initial peak in January followed by a gradual decline through May, a slight upward trend in the summer, and an annual peak during the fall.

Diel Variations

- There was little day to night variation in total entrained organisms, with entrainment rates at night approximately 7 percent higher than the daytime rates.

Annualized Estimated E Rates

- Total annual entrainment for the study period based on actual flows was 38.7 billion organisms, including an estimated 10.3 billion fish and 28.4 billion invertebrates.

- Total entrainment on an annualized basis based on design flow was 46 billion organisms. Annualized fish entrainment was estimated to be 12.5 billion, while annualized entrainment of invertebrates was estimated at 33.5 billion.

- Maximum design flow entrainment by life stage included approximately 11.6 billion eggs, 34 billion larvae and 435 million juveniles, adults and unidentifiable life stages.

- These annualized rates assume that entrainment is proportional to flow and that the results from each event are representative of the entrainment rates between sampling periods.

E Rates Adjusted to Age-1 Equivalents

Entrainment was largely dominated by early life stages of organisms, which experience high natural mortality and thus a large percentage of the viable eggs and larvae collected in entrainment samples would not have survived to adulthood. EPA recognized this in the Phase II Rule and presented entrainment effects in terms of age-1 equivalents.

Age-1 equivalents were estimated for the 7 dominant fish taxa collected in entrainment samples and 10 taxa that were categorized as recreational or commercially important shellfish. The age-1 equivalent analysis yielded the following entrainment loss estimates:

- 2.75 million fish, 43 percent of which were Clupeidae (e.g., menhaden and herring species); followed by drum and perch-like fish; and
- 18.8 million shellfish, dominated by pink shrimp (59 percent) and brown shrimp (39 percent).

1.0 Introduction

This document provides a summary and discussion of an Impingement Mortality and Entrainment Characterization Study (IMECS) conducted between April 25, 2006 and April 11, 2007 at the Florida Power & Light (FPL) Port Everglades Power Plant (PPE). The Port Everglades Plant is located in Broward County in southeast Florida on the corporate boundary of Hollywood and Ft. Lauderdale (Figure 1-1). Historical impingement mortality and entrainment (IM&E) data collected at the facility are also presented in this document as background for the current study.

1.1 Facility Description and Operation

Port Everglades Power Plant is a four-unit, oil-fired, steam electric generation plant with a net plant output of 1,142 megawatts (MW). Units 1 and 2 were placed into operation in 1960 and 1961 (respectively), and Units 3 and 4 were placed into operation in 1964 and 1965. The Port Everglades plant is an “intermediate” load plant that runs throughout the year with higher capacity factors in the summer and winter peaks, and lower capacity factors in the “shoulder” months. Units 1 and 2 run less (by about 50 percent) than Units 3 and 4.

The facility uses once-through cooling water withdrawn from the Port Everglades Harbor/Turning Basin at the west end of Slip No. 3 (Figure 1-2). The Turning Basin is located at the west end of the 800-foot wide channel connecting the Port to the Atlantic Ocean. The cooling water system has a combined capacity of approximately 1,295 million gallons per day (MGD; Table 1-1). The circulating water pumps are operated continuously during operational periods. Circulating water pumps for Units 1 and 2 typically are operated when these units are cycling, and may be shut down when demand for electricity is lowest.

Once-through cooling water is withdrawn from the head of Slip No. 3 through four 12-foot diameter, 244-foot long reinforced concrete pipes that pass under Eisenhower Blvd. The pipes lead to a 1,900-foot long open canal that widens into a basin adjacent to the cooling water intakes. The canal is approximately 100 feet wide and has a depth at mean low water of approximately 13 feet. The intake canal has been considered not to be waters of the State in previous NPDES permits.

Each intake is located below the waterline at the concrete bulkhead wall located at the end of the basin and withdraws water through trash racks into concrete forebays. The CWIS for each unit has two intake bays, each equipped with one single-entry 1/8-inch x 1/2-inch vertical traveling screen with automatically controlled high-pressure spray wash. Through-screen intake velocities for Units 1 and 2 are 1.93 feet per second (ft/s), and for Units 3 and 4 are 2.9 ft/s. Screen wash water is discharged into troughs equipped with trash baskets and then returned to the intake basin. The material collected in the baskets is deposited into a roll-off dumpster for offsite disposal.

After passing through the condenser, heated water is discharged to a 5,200-foot long discharge canal originating on the south side of the facility and ultimately to the Intracoastal Waterway approximately 1.4 miles south of the intake area.

1.2 Purpose of this Report

In July 2004, EPA published the Phase II Rule implementing Section 316(b) of the Clean Water Act for Existing Facilities (69 FR 41576). The rule became effective on September 7, 2004 and included numeric performance standards for reductions in IM&E that would demonstrate that the cooling water intake system (CWIS) constitutes the Best Technology Available (BTA) for minimizing IM&E impacts. Existing facilities subject to the rule were required to demonstrate compliance with the rule’s performance standards through development of a Comprehensive Demonstration Study (CDS). The IMECS presented in this report is one of several components of the CDS.

On January 25, 2007 the Second Circuit Court of Appeals remanded significant portions of the Phase II Rule, resulting in substantial uncertainty as to how facilities should proceed toward compliance. On March 20, 2007 EPA issued guidance indicating it intended to suspend the rule and that permit writers should continue to utilize Best Professional Judgment (BPJ) to comply with §316(b) for Phase II facilities. EPA officially suspended the rule on July 9, 2007 and has stated its intention to issue guidance to delegated NPDES agencies regarding §316(b) implementation prior to resolution of the Court's concerns.

Guidance provided by the Florida Department of Environmental Protection (FDEP) requires power plants to submit an IMECS with the NPDES permit renewal to support its BPJ determination of BTA (FDEP, 2007). The IMECS is to provide a taxonomic identification of all life stages of fish and shellfish in the vicinity of the plant that are susceptible to IM&E, a description of their abundance and temporal and spatial characteristics near the CWIS, and documentation of current IM&E rates. FPL has therefore prepared this report to document the results of the IMECS study undertaken as part of the Port Everglades Power Plant CDS. Both impingement mortality and entrainment reduction requirements apply to PPE since it is an existing facility that withdraws cooling water from a tidal estuary.

Following the (now suspended) requirements for an IMECS under 40 CFR 125.95 (b)(3), this report provides information to support the development of the calculation baseline as defined in the Phase II rule. The calculation baseline is an estimate of impingement mortality and entrainment that would occur assuming that the cooling water system has been designed as a once-through system; a standard 3/8-inch mesh traveling screen is located at and parallel to the shoreline near the surface of the source waterbody; and no structural or operational controls have been implemented to reduce impingement mortality and/or entrainment.

For the Port Everglades plant, the shoreline intake as defined by the rule would be the mouth of Slip No. 3 in the harbor. The slip is similar to a small cove or embayment that could potentially affect the composition or abundance of species exposed to the effects of the intake. The 1,900-foot cooling water intake canal constitutes a substantial departure from EPA's baseline configuration, as does the location and orientation of the intake screens. Aside from the 1/8-inch x 1/2-inch mesh traveling screens, there are no other departures from the baseline configuration at the Port Everglades facility.

Based on the EPA's definition above, the calculation baseline would be the estimated impingement mortality and entrainment rates at a shoreline intake located in the harbor. This location is subject to substantial natural variability resulting from alternating tidal and wind-driven flows along the Intracoastal Waterway and the harbor's proximity to the channel and to the Atlantic Ocean to the east. This high degree of natural variability would have required an intensive and costly field sampling program to adequately characterize conditions in the harbor. Safety concerns from navigation activity in a busy port and port security restrictions resulted in FPL's election to sample at the intakes at the head of the canal to characterize existing IM&E rates (i.e., the as-built condition described in the Phase II rule).

1.3 Organization of this Report

A description of the environment surrounding the Port Everglades plant including the source waterbody is provided in Section 2. A review of the historical impingement and entrainment data at the plant is provided in Section 3. Section 4 provides a description of the methods for the IMECS study conducted between April 25, 2006 and April 11, 2007, and results of this study are presented in Section 5. Section 6 provides a summary of the findings of this report. References are provided in Section 7.

2.0 Environmental Setting and Habitat

This section describes the source waterbody and habitat in the vicinity of the Port Everglades power plant. The descriptions serve as context for development of the estimated impingement mortality and entrainment rates under the as-built condition at the facility.

2.1 Source Waterbody Habitat Overview

The Port Everglades Power Plant PPE draws cooling water from the Intracoastal Waterway (ICW) at the Port Everglades Turning Basin, located at the west end of the 800-foot wide channel connecting the Port to the Atlantic Ocean (refer to Figure 1-1). The depth of the Turning Basin is approximately 38 feet. The harbor is approximately one mile long (north to south) and one-half mile wide. The origin of the intake canal at the head (west end) of Slip #3 is approximately one mile from the Atlantic coastline.

The ICW to the north of the Port transits the Stranahan River and the New River, each of which is connected to numerous canals and waterways in Fort Lauderdale. The ICW continues to the south of the harbor and is approximately 250 to 300 feet wide with a depth of approximately 10-12 feet. An extensive canal system is also found off the ICW south of the harbor.

The harbor and ICW have a semi-diurnal tidal pattern with a tidal range of approximately 2.5 feet. Salinities range from 30 to 35 parts per thousand due to tidal exchange with the ocean and freshwater inflow from the ICW, the Stranahan River, and runoff entering the extensive canal systems north and south of the harbor.

2.2 Sensitive Species or Habitats

An online search for federal, state, or tribal-protected aquatic species was undertaken to determine whether listed species are present in the study area. Sources for listed species and habitat information included the Florida Fish and Wildlife Conservation Commission's Imperiled Species List (FFWCC 2007), the U.S. Fish and Wildlife Service's Endangered Species Program website (USFWS 2007), NatureServe (2007), and the Florida Natural Areas Inventory (FNAI 2007). Plant species information was obtained from Coile and Garland (2003). The Florida Natural Areas Inventory (FNAI) provides the most precise location information that is readily available. Table 2-1 lists the aquatic and semi-aquatic species listed for the one square-mile matrix unit encompassing aquatic habitats in the vicinity of the Port Everglades plant.

One fish species (mangrove rivulus) appears in the FNAI listing as having potential occurrence in the vicinity of the plant. The species is listed as having "Likely" occurrence within the matrix unit in which PPEs intake canal is located. This designation indicates the species is known to occur in the vicinity and is considered likely within the matrix units, but the documentation isn't sufficiently precise to document its occurrence and/or that suitable habitat exists within the matrix unit. The mangrove rivulus' status as a candidate for federal listing under the Endangered Species Act and its status as a state-listed Species of Special Concern afford no special protection to the species. It has been identified as having "significant vulnerability to habitat modification, environmental alteration, human disturbance, or human exploitation which, in the foreseeable future, may result in its becoming a threatened species unless appropriate protective or management techniques are initiated or maintained".

Life history information for the mangrove rivulus available from the FFWCC indicates that it primarily inhabits shallow fresh and brackish water, shallow mud-bottom ditches including artificial ditches for mosquito control, mangrove swamps, bays, salt marshes, and other brackish water environments. The proximity of the Port Everglades facility to the ocean and the extensive dredging and shoreline modifications suggest that the mangrove rivulus presence in the matrix unit surrounding the Port Everglades plant is probably restricted to the southern portion of the unit which is well removed from the PPE intake canal. The mangrove rivulus was not observed during impingement and entrainment sampling performed in 2006-2007.

One reptile species and one amphibian appear in the FNAI listing of potential occurrence in the vicinity of the Port Everglades plant. The hawksbill turtle, classified as endangered by the federal government and the State of Florida, are listed as having Potential to occur in the vicinity of the Port Everglades plant. The species is not listed as Likely to occur in the vicinity of the plant. The amphibian gopher frog is a state-listed Species of Special Concern. This species is also not classified as Likely to occur in the vicinity of the Plant.

The endangered West Indian manatee is known to occur in the vicinity of the Port Everglades Power Plant. The FNAI reports the existence of a manatee aggregation site in the matrix unit encompassing the plant. Port Everglades' NPDES permit requires continued compliance with the facility's Manatee Protection Plan, approved by FDEP on August 13, 1999. This plan includes notification requirements for manatees observed in the intake canal, as well as a requirement to operate under cold weather conditions to supply a warm-water refuge for manatees.

3.0 Review of Historic Data

A literature review was conducted to determine which species might be susceptible to impingement and entrainment at the Port Everglades facility. This review included studies in nearby waters as well as historical studies at the facility. The historical FPL Port Everglades Power Plant 316(b) studies were found to provide the most relevant information.

3.1 Historical FPL Port Everglades 316 Studies

Impingement and entrainment studies to assess the Port Everglades power plant were conducted by FPL during 1974 and 1975 (FPL 1976). In general, those studies found that facility impingement and entrainment rates were low and few species of recreational or commercial importance were collected.

3.1.1 Impingement

Impingement studies were conducted quarterly during the first half of 1974, after which sampling was conducted roughly twice per month through December 1975. A total of 4,830 fish were collected during the 36 impingement sampling events in 1974 and 1975. Impingement rates ranged from 10 to 1,199 individuals per 24 hours sampled. The overall average was 134 individuals per 24 hours sampled.

Fish were collected in the largest numbers between June and August during both years, with smaller peaks in abundance from November 1974 to January 1975. Increased sampling frequency during 1975 illustrated that periods of lowest impingement rates were between February and June and again in October and early November.

Anchovies (engraulids), sea catfishes (ariids) and puffers (tetraodontids) accounted for 41.6 percent, 24.9 percent and 15.6 percent, respectively, of the total number of fish collected in impingement sampling. Studies have demonstrated that anchovies have low extended survival after being impinged and returned to the water. Sea catfish and puffers were both found to be durable following release from impingement, with survival rates of 71 percent and 61 percent, respectively.

A total of 2,020 shellfish were collected during the 36 impingement sampling events in 1974 and 1975. Impingement rates ranged from 2 to 130 individuals per 24 hours sampled. The overall average was 27.6 individuals per 24 hours sampled. The exception was the August 8-9, 1974 sampling period when a total of 1,028 individuals (primarily shrimp and blue crabs) was collected. Edible shrimp and blue crabs comprised 66.9 percent and 21.4 percent of the shellfishes impinged, respectively. Edible shrimp and blue crabs also show high post-impingement survival rates, 66 percent and 80 percent, respectively.

3.1.2 Entrainment

Entrainment studies were conducted at the Port Everglades plant between March 1974 and December 1975 using a 1/8-inch square mesh net and holding box fished in the discharge canal. Sampling was conducted for 24 hours in 1974 and 48 hours in 1975. The historic monitoring data showed very low entrainment rates and low impact to recreational or commercial species; however, historic entrainment sampling utilized a 1/8-inch mesh, which likely underestimated entrainment rates for smaller larvae and eggs.

Fish entrainment rates ranged from 0 to 31 (average 4.8) individuals per 48 hours. Fish egg entrainment rates ranged from 0 to 65 (average 7.2) eggs per 48 hour sample. Anchovies (engraulids) were the predominant fish collected during the entrainment studies, accounting for approximately 50 percent of all fish collected. Anchovies generally did not survive entrainment. Similarly, the predominant eggs collected were also anchovy. Anchovies accounted for the majority of the fishes and eggs collected during the May 1975 sampling period, when the largest numbers of collected fish and eggs were obtained. The only fishes collected in entrainment samples of sport or commercial importance were a single snook (*Centropomus unidecimalis*) in December 1975 and a single snapper (lutjanid) collected in May 1975. Entrained shellfish were dominated by non-commercial shrimp species.

4.0 Study Design and Sample Collection

FPL conducted a one-year sampling program at Port Everglades to characterize existing impingement mortality and entrainment rates (Table 4-1). Samples were collected every other week between April 25, 2006 and April 11, 2007 (Table 4-2). Site-specific Standard Operating Procedures (SOPs) were developed for sampling at PPE which were consistent with FPL's Quality Assurance Plan (QAP) developed for IM&E sampling (FPL 2006). A Site-specific Health and Safety Plan was also developed prior to the initiation of sampling activities.

4.1 Impingement Sampling

Impingement sampling consisted of 24-hour collections of fish and shellfish contained in the screen wash of each unit pair (Units 1 & 2 and Units 3 & 4). Initial screen washes were performed to remove any organisms that may have been trapped prior to the start of the sample collection period. Day and night samples were collected to provide information on potential diel effects on impingement rates. Day and night periods were defined as follows: daytime (½ hour after sunrise to ½ hour before sunset) and nighttime (½ hour before sunset to ½ hour after sunrise).

If multiple screen washings occurred during the sampling period, fish and shellfish were collected with each wash and the results composited for the day or night period. If required due to volume of organisms or debris, subsampling of screen washes was performed and the count adjusted accordingly. Fish were counted, identified and weighed in the field, with photographs and voucher specimens retained as necessary. Given the absence of a fish return system at PPE, impingement mortality was assumed to be 100 percent and no survival studies were conducted.

4.2 Entrainment Sampling

Entrainment samples were collected using a 500 µm mesh plankton net held in a water bath to minimize physical damage to collected organisms. A trash pump was used to draw water through a 3/8-inch screened intake placed in front of the bar racks. During each sampling event, one bay per unit pair was randomly selected for sampling. Pumped samples of approximately 50 m^3 were collected from each bay twice during the day and twice at night to approximately coincide with periods of high and low tide. The high and low tide samples for each photoperiod were composited in the laboratory, yielding a total of four entrainment samples per sampling event (a day and night sample from either Unit 1 or Unit 2 and a day and night sample from either Unit 3 or Unit 4).

In the laboratory, entrainment samples were sorted to remove organisms from debris. Organisms were identified to the lowest practicable level, assigned an appropriate life stage (e.g. egg, yolk-sac larvae, post yolk-sac larvae, or juvenile) and enumerated.

4.3 Supporting Data Collection

Supporting data collection included *in situ* measurements of pH, temperature, salinity, and dissolved oxygen during each entrainment sample. Field notes included wind and weather conditions, tide stage, departures from the standard sampling protocol, and observed departures from normal plant operations (e.g., circulating water pump or screen wash operations, etc.). Daily circulating water pump rates were subsequently obtained from plant operators for normalization of results to actual flow rates.

4.4 Overview of Plant Operations during the Study Period

An average of 1,063 MGD was withdrawn from the Port Everglades Harbor through the CWIS during the study period (Table 4-2). With some exceptions during the onset of the sampling program (i.e., April 2006), Unit 1's pumps were operated continuously throughout the study (Figure 4-1). Overall, Unit 2's pumps cycled more frequently and were off during Events 2 and 3 in May 2006 and were down for much of the month of January 2007. Unit 3 went offline in early March 2007. Unit 4 ran only one pump from October 5 through December 11, 2006 due to work being conducted in the intake canal in front of the intakes.

5.0 Results

5.1 Impingement

Impingement results for the 26 sampling events were compiled in an Excel database along with supporting data and circulating water pumping rates obtained from plant operations. Tabular and graphic summaries of taxa collected, raw counts and biomass, collection times (i.e., intervals between screen washes), and flow-normalized impingement rates were initially reported in quarterly data reports that were also used for QA/QC reviews. The results from the annual sampling program are provided below.

5.1.1 Species Composition and Abundance

Identification of impinged finfish and shellfish to the lowest practical level resulted in 149 taxonomic categories (102 fish taxa and 47 invertebrate taxa; Appendix A). The fish taxonomic designations encompassed 87 species, 13 genera, and one family, plus a separate category for unidentifiable fish. Invertebrate taxonomic designations included 25 species, 13 genera, 6 families, 2 infraorders, and 1 order.

Sampling over the 26 events yielded 4,538 fish, with 67 percent of the fish collected consisting of big-eye anchovy (*Anchoa lamprotaenia*) and broad-striped anchovy (*Anchoa hepsetus*; Table 5-1). Twenty-two taxa constituted 95 percent of the fish collected, with sub-dominants consisting largely of puffers and mojarras.

Impingement sampling yielded a total of 1,039 invertebrates, with 22 taxa comprising 95 percent of the total number of invertebrate individuals collected (Table 5-2). Pink shrimp was the most abundant invertebrate collected (23.3 percent). Sub-dominants contributing from 8.7 percent to 3.7 percent included Atlantic brief squid, sargassum crab, caridean shrimp, mud crabs, penaeid shrimp, roughneck shrimp, and portunid crabs. Blue crabs contributed 3.6 percent of the total.

These raw counts were normalized to number per million gallons (#/MG) based on sample volumes, both as an annualized rate and a per event basis. Sample volumes were calculated using the sampling interval for each screen wash and the volume of circulating water used by each unit pair for the sample date. A total of 27,309.4 MG (10,009.5 MG at Units 1 & 2, and 17,299.9 at Units 3 & 4) was sampled for impinged organisms during the 2006-2007 study period.

Over the 52-week period encompassed by the sampling program, the overall fish impingement rate was 0.166/MG (Table 5-1). The dominant fish species (big-eye anchovy, 55 percent of total) was impinged at an average annual rate of 0.092/MG. Annual rates for sub-dominants were 0.019/MG for broad-striped anchovy (11.5 percent), 0.010/MG for bandtail puffer (5.9 percent), and 0.008/MG for checkered puffer (4.9 percent). With the exception of unidentified taxa (0.008/MG; 4.9 percent of total), the other taxa collected each constituted less than 3 percent of the total.

The overall invertebrate impingement rate during the sampling program was 0.038/MG (Table 5-2). The dominant invertebrate (pink shrimp, 23.3 percent of total) was impinged at an average annual rate of 0.009/MG. Rates for sub-dominant taxa were 0.003/MG or less.

Figure 5-1 illustrates the relative abundance of the species contributing the top 90 percent of impingement for the sampling program on a per event flow-normalized basis. The dominance by anchovy species is clearly evident during Event 10 (September 7, 2006) when big-eye anchovy had a maximum 24-hour impingement rate of 1.2 fish/MG. More typical for this species were results from Events 5 through 8 when 24-hour impingement rates for big-eye anchovy were between 0.1 and 0.2 fish/MG. The sub-dominant broad-striped anchovy reached 24-hour impingement rates of 0.13 to 0.27 fish/MG during Events 20 and 21 (January 2007).

5.1.2 Biomass

Impingement can also be assessed in terms of biomass. Fish and shellfish impinged were weighed in the field when possible. Length-weight regressions were used for individuals that were measured in the field but not weighed. For those individuals that were not measured or weighed in the field an average weight of individuals collected of that taxon was used.

Fish and invertebrates collected during the 26-event sampling program yielded a total of 63.2 kg of biomass. Twenty-six taxa constituted 95 percent of the fish and invertebrate biomass collected (Table 5-3). The overall average biomass in impingement samples was 2.3 g/MG. Checkered puffer dominated the samples on a biomass basis (0.74 g/MG) with just over one third of the biomass (but with only 5 percent of impingement on a numerical basis). The next most common species in terms of biomass was lookdown (0.36 g/MG), contributing 16.5 percent of the total, followed by bandtail puffer (0.26 g/MG) contributing 12.1 percent of the total. Blue crab contributed the highest invertebrate biomass total (0.15g/MG), constituting 7 percent of the total biomass.

Figure 5-2 illustrates the species contributions for the top 90 percent of impingement biomass for the sampling program on a per event flow-normalized basis. The dominance by checkered puffer is evident during Event 12 when this species reached a maximum 24-hour impingement rate of 5.7 g/MG. Rates from Events 10 and Events 13 through 15 ranged from 1.3 to 4.7 g/MG. Lookdown reached 24-hour biomass impingement rates of 3.6 g/MG during Events 11, with rates in adjacent events averaging around 1.1 g/MG.

5.1.3 Annualized Impingement under Design Flow and Actual Flow

Annual impingement totals were estimated for both design and actual flow conditions using the species-specific rate of impingement (#/MG) during each sampling event and then flow-weighting for design flows and for measured withdrawals between events throughout the April 2006 and April 2007 sampling period. The estimates assume that impingement is proportional to cooling water withdrawal rates, and that the event-specific rates of impingement are representative of impingement rates between sampling periods.

Under design flow conditions, an estimated 73,653 fish would be impinged annually at Port Everglades (Table 5-4), with 53 percent consisting of big-eye anchovy (39,063 individuals). Along with an estimated 8,091 broad-striped anchovy, 4,775 bandtail puffer, and 3,974 checkered puffer, these four species contributed 76 percent of the annual impingement total. Figure 5-3 illustrates the estimated numbers of fish impinged across the sampling program using design flows.

Under the design flow scenario, an estimated 17,490 invertebrates would be impinged annually at Port Everglades (Table 5-5). Pink shrimp constituted the largest portion (21.2 percent) of the estimated annualized invertebrate impingement with 3,712 individuals. Figure 5-4 illustrates the estimated numbers of invertebrates impinged across the sampling program using design flows.

With respect to actual flows, an estimated 64,555 fish were impinged during the 12-month monitoring period using cooling water flows measured at the plant (Table 5-6). The estimated actual impingement total for big-eye anchovy was 36,155, along with 6,829 broad-striped anchovy, 3,821 bandtail puffer, and 3,370 checkered puffer. An estimated 14,359 invertebrates were impinged during the 12-month sampling period under actual cooling flow conditions (Table 5-7). Pink shrimp accounted for 23.1 percent of the estimated actual invertebrate impingement (3,323 individuals).

5.1.4 Size Distributions

The average length of individuals impinged at Port Everglades during the 2006 to 2007 study was 51.3 mm. Lengths of fish impinged ranged from 11 to 896 mm with an average length of 62.8 mm (Table 5-8). Lengths of impinged invertebrates (or carapace width for decapods) ranged from 4.1 to 132.6 mm with an average length of 18.7 mm (Table 5-9). Approximately 75 percent of individuals impinged were less than 50 mm in length (Figure 5-5).

5.1.5 Seasonal and Diel Variation in Impingement Rates

Information previously provided for 24-hour impingement in Figures 5-1 and 5-2 and for impingement under design flows in Figures 5-3 and 5-4 documented substantial seasonal variation in both impingement numbers and biomass. Using the same interpolation between events described in Section 5.1.3, Figure 5-6 presents the April 2006-April 2007 sampling results by calendar year to illustrate seasonal peaks in impingement for fish and invertebrates. In this seasonal perspective, peak fish impingement occurred during the summer and a smaller peak was evident in January, both largely associated with anchovy species. The lowest rates of fish impingement occurred during the fall.

Impingement of invertebrates was more variable throughout the year with peaks in December and January, March and April, June, and September. These peaks were associated with a succession of species: caridean shrimp and penaeid shrimp were dominant in December; roughneck shrimp in January; Sargassum swimming crabs, caridean shrimp, portunid crabs and squid in March; pink shrimp in late April through June and September; and Atlantic brief squid in June and early July.

Of the actual number of individuals collected (5,577), 78 percent were collected during night samples. The flow-normalized total impingement rate was almost four times higher at night (0.3033/MG) than during the day (0.0792/MG; Table 5-10 and Figure 5-7), dominated by night-time impingement of the dominant big-eye anchovy. On this flow-normalized basis, ten times as many of the sub-dominant fish (broad-striped anchovy) were collected at night, and eight times as many pink shrimp were collected at night.

5.1.6 Impingement Location

The flow-normalized impingement rate was more than five times higher at Units 3 & 4 compared to Units 1 and 2 (0.297/MG versus 0.044/MG; Table 5-11). The number of taxa collected at Units 3 & 4 was also higher (135 versus 74 taxa). Since these rates are normalized to flow, the greater rate of impingement at Units 3 & 4 may be attributable to higher through-screen velocity at Units 3 & 4 compared to Units 1 & 2, or it could be due to the relative location of the intakes in the intake bay.

5.2 Entrainment

Entrainment results for the 26 sampling events were also compiled in an Excel database, and tabular and graphic summaries of taxa collected, raw counts, sample volumes, and flow-normalized entrainment rates were included in the quarterly data reports with the impingement results. The results from the annual sampling program are provided below.

5.2.1 Species Composition and Abundance

Laboratory identification of fish and invertebrates in entrainment samples to the lowest practical taxonomic level resulted in 122 reported taxonomic categories (84 fish categories and 38 invertebrate categories). A total of 72,052 fish were collected in the entrainment samples (Table 5-12). The most common category of fish entrained during this study were unidentifiable (83.4 percent), primarily undeveloped eggs with no differential characteristics that would allow further taxonomic differentiation. Undeveloped eggs could include eggs that may have been spawned shortly before collection and thus and cell division was not yet evident, or eggs that were not fertilized or viable. Eggs likely consisted of many of the larvae identified, including drum species, combtooth blennies, perch-like fishes, herrings, gobies, and three categories that share attributes of two or more families of fish (families included are Carangidae, Labridae, Scianidae, Haemulidae, and Serranidae). Together these categories represent 96 percent of the total annualized entrainment.

A total of 197,988 invertebrates were collected in the entrainment samples (Table 5-13). Short-tailed crabs (infraorder Brachyura) constituted 47.4 percent of this total. Next most abundant were true shrimp of the infraorder Caridea. This taxonomic group constituted 29.2 percent of the total. The classification Anomura (hermit crabs) contained 11.7 percent of the total, and 4.3 percent consisted of organisms classified as Thalassinidea (ghost and mud shrimp). All other classifications contained less than 2 percent of the total number of organisms collected in the entrainment samples. Figure 5-8 illustrates the relative abundance of species contributing to the top 95 percent of entrainment.

5.2.2 Annualized Entrainment under Design Flow and Actual Generation Flow

As with impingement, annualized entrainment for design flows and actual flows was calculated for the as-built condition. Annualized entrainment was calculated by using the average entrainment rate (#/MG) for each species by sampling event and then flow-weighting for design flows and for measured withdrawals between events throughout the April 2006 and April 2007 sampling period

Estimated annual fish entrainment under design flow conditions was 12.5 billion individuals (Table 5-14). Fish eggs and larvae of unidentifiable taxonomy constituted 83.5 percent of the total estimated annual fish entrainment. Fish classified as belonging to the Carangidae/Labridae/Sciaenidae complex constituted 4.6 percent of the total annual fish entrainment. All other taxonomic classifications comprised less than 2 percent of the total.

Estimated annual invertebrate entrainment was 33.5 billion individuals under design flow conditions (Table 5-15). Short-tailed crabs constituted 47.6 percent of the total estimated invertebrate entrainment. That taxon and five others (Caridean shrimp, Anomuran crabs, ghost and mud shrimp, Sergestid shrimp, and mantis shrimp) comprised slightly more than 95 percent of the estimated annualized invertebrate entrainment.

An estimated 10.3 billion fish were entrained during the 12-month sampling period under actual flow conditions. Taxonomically unclassified fish constituted 83 percent of this total (8.5 billion organisms; Table 5-16). The group entrained in next greatest number was the Carangidae/Labridae/Sciaenidae complex (4.7 percent). Drum (Sciaenidae) ranked third (2.0 percent), and fish eggs and larvae classified as belonging to blennies (Blenniidae) constituted 1.1 percent of the total estimated annual entrainment of fishes under actual flow conditions.

An estimated 28.4 billion invertebrates were entrained on an annual basis during the 12-month sampling program (Table 5-17). Short-tailed crabs constituted nearly half (47.6 percent, 13.5 billion individuals) of this total. An estimated 8.2 billion caridean shrimp were entrained during the period, constituting 28.7 percent of the total. Approximately 3.4 billion anomuran crabs were entrained. Ghost and mud shrimp (Thalassinidea) constituted 1.2 billion organisms (4.2 percent of the total). Each of the remaining taxa constituted less than one billion organisms and less than 2 percent of the total.

5.2.3 Life Stage

Fish and invertebrate larvae constituted 74 percent of the total annualized entrainment based on design flow. Fish eggs constituted 25 percent of the total annualized entrained and 93 percent of the annualized fish entrainment. Meroplankton zoea were the most common invertebrate life stage entrained, constituting 62 percent of the total annualized entrainment and 85 percent of annualized invertebrate entrainment. Juveniles and adult stages were much less common (0.3 percent and 0.2 percent, respectively). Maximum design flow entrainment by life stage includes approximately 11.6 billion eggs, 34 billion larvae and 434 million juveniles, adults and unidentifiable life stages.

5.2.4 Age-1 Equivalent Analysis

Entrainment was largely dominated by early life stages of organisms which experience high natural mortality and thus a large percentage of the eggs and larvae collected in entrainment samples would not have survived to adulthood in the natural environment. EPA recognized this in the Phase II rule and presented entrainment effects in terms of age-1 equivalents. EPA stated that "Expressing impingement mortality and entrainment losses as age 1-equivalents is an accepted method for converting losses of all life stages into individuals of an equivalent age and provides a standard metric for comparing losses among species, years, and facilities" (61 FR 41586). It also facilitates comparison of mitigation technologies by focusing on the later life stages that are far more likely to survive.

Following EPA's approach, the numbers of eggs, larvae, and juveniles were adjusted to age-1 equivalents using species-specific survival rates taken from EPA (2002a) and other relevant literature. In many cases, life history information for surrogate species had to be used due to lack of species-specific information. The model incorporates life stage-specific entrainment counts and applies life stage-specific mortality rates to eggs, larvae, or juveniles to estimate the age-1 equivalents.

Age-1 equivalents were calculated as follows:

$$AE1_a = N_a \times S_{a,1}$$

Where:

$AE1_a$ = number of age-1 equivalents killed during life stage a

N_a = number of individuals killed during life stage a

$S_{a,1}$ = cumulative survival rate for individuals passing form life stage a to age 1

$$S_{i,1} = S_i^{adj} \times \prod_{j=i+1}^{j\,max} S_j$$

Where:

S_i,1 = cumulative survival fraction from stage i to stage 1

S_j = survival fractions from stage i to stage i+1

S_i^{adj} = adjusted survival rate to account for the fact that the individual fish were entrained at various times within stage i.

At the Port Everglades plant, age-1 equivalents were estimated for the 7 dominant fish taxa collected in entrainment samples and 10 taxa which were categorized as recreational or commercially important shellfish. In several cases, life history information from a surrogate species was used to estimate age-1 equivalents. The age-1 equivalent analysis yielded the following entrainment loss estimates:

- 2.75 million fish, 43 percent of which were Clupeidae (e.g., menhaden and herring species); followed by drum and perch-like fish; and
- 18.8 million shellfish, dominated by pink shrimp (59 percent) and brown shrimp (39 percent).

While virtually all entrainable organisms experience high rates of natural mortality, finfish and several of the commercially important shellfish have the potential to survive for more than one year. Most of the organisms entrained at PPE have life cycles that last much less than a year and tend to have very high rates of fecundity and thus high densities in the environment. These organisms do not lend themselves to age-1 analysis; and neglecting this category of entrained invertebrates appears to be consistent with the analysis performed by EPA (61 FR 41586). However, the age-1 equivalent model was used to estimate mortality rates associated with entrainment at PPE to place the high entrainment numbers in context, recognizing that they are still overestimates.

The total annual entrainment (based on design flow) of age-1 equivalents for all identifiable fish, shellfish, and other invertebrate taxa for which life history or surrogate information was available was estimated to be approximately 623 million. When adjusted for species not included in the analysis using the same percent survival, the estimated entrainment of age-1 equivalents is approximately 846 million. This total was dominated by caridean shrimp (grass shrimp, jumpers, glass shrimp, popcorn shrimp, glass pawns and hardbacks), representing 56 percent of the total.

5.2.5 Seasonal and Diel Variation in Entrainment

Overall fish entrainment at Port Everglades is variable seasonally with an initial peak in the winter followed by a gradual decline through May, a slight upward trend in the summer, and an annual peak during the fall (Figure 5-9). Invertebrate entrainment was much more variable, with peaks attributable to short-tailed crab zoea, unidentifiable species, caridean shrimp, and anomuran crabs.

Average flow-normalized entrainment rates across all sampling events were roughly similar during day and night (93,979 organisms/MG and 100,199 organisms/MG, respectively), and day vs. night entrainment rates were similar during most sampling events (Figure 5-10).

5.2.6 Entrainment Location

Species composition did not differ appreciably among the Port Everglades intakes (Table 5-18). The entrainment rate at Units 3 and 4 (192,885/MG) was approximately three times the entrainment rate at Units 1 and 2 (67,512/MG).

6.0 Summary

An estimated 64,555 fish and 14,359 invertebrates would have been impinged during the 12-month sampling period under actual cooling water withdrawal conditions. Estimated impingement under design flow conditions at Port Everglades was estimated at 73,653 fish and 17,490 invertebrates. Due to the absence of a fish return system at the plant, 100 percent mortality was assumed although smaller individuals could have been returned alive to the intake canal through the trash basket.

Fish impingement was dominated by big-eye anchovy (55.2 percent) and broad-striped anchovy (11.5 percent). These species generally experience high impingement mortality at other facilities. Pink shrimp was the most abundant invertebrate collected (23.3 percent). Pink shrimp has been shown to have relatively high survival from impingement.

An estimated total of 63.2 kg of fish and invertebrates were collected in impingement samples during the sampling program, dominated by checkered puffer (33.8 percent). Other fishes, lookdown (16.5 percent) and bandtail puffer (12.1 percent) also constituted significant portions of the total estimated impingement biomass. Potential impingement survival of these species is not well characterized. Blue crab was the dominant impinged invertebrate species on a biomass basis. Potential impingement survival for this species is known to be high.

An estimated 12.5 billion fish and 33.5 billion invertebrates would have been entrained during the 12-month monitoring program under the design flow conditions. Estimated entrainment under actual cooling water withdrawal conditions was approximately 10.3 billion fish and 28.4 billion invertebrates. Of these numbers, an estimated 2.75 million age-1 fish would have been lost to entrainment, 43 percent of which were Clupeidae (e.g., menhaden and herring species); followed by drum and perch-like fish. An estimated 18.8 million age-1 shellfish would have been lost to entrainment, dominated by pink shrimp (59 percent) and brown shrimp (39 percent).

Fish entrainment was dominated by organisms of unidentifiable taxonomy (83 percent), followed by a complex comprising Carangidae, Labridae, and Sciaenidae (4.7 percent). Invertebrate entrainment was dominated by short-tailed crabs (infraorder Brachyura, 47.6 percent), followed by shrimp of the infraorder Caridea (28.7 percent). Hermit crabs (infraorder Anomura) constituted 11.7 percent of the total.

The vast majority of the species impinged and entrained at Port Everglades are forage species, with shrimp representing the notable recreational or commercially important shellfish species documented at the intakes during the sampling program.

7.0 References Cited

Coile, N. C. and M. A. Garland. 2003. *Notes on Florida's Endangered and Threatened Plants*. Florida Department of Agricultural and Consumer Services, Gainesville, Florida. Contribution No. 38, 4th edition.

FDEP. 2007. Electronic mail communication between Marc Harris, Supervisor, Power Plant NPDES Permitting at DEP and Ron Hix at FPL dated December 5, 2007.

FFWCC (Florida Fish and Wildlife Conservation Commission). 2007. *Florida's Endangered Species, Threatened Species, and Species of Special Concern*. November 2007.

FNAI (Florida Natural Areas Inventory). 2007. FNAI Biodiversity Matrix Map Server. Available online at: http://www.fnai.org/biointro.cfm.

FPL. 2006. 316(b) Biological Sampling Program Quality Assurance Plan. February 8, 2006

FPL. 1976. Ecological Parameter Monitoring at the Port Everglades Plant. Prepared by Applied Biology for FPL, September 1976.

NatureServe. 2007. NatureServe Explorer. Available online at: http://www.natureserve.org/explorer/index.htm.

USFWS 2007. Endangered Species Program. U.S. Fish & Wildlife Service. Available online at: http://www.fws.gov/endangered/.

Tables

Table 1-1 Port Everglades Cooling Water Pumps and Capacities

Units	Pumps	Number per Unit	Flow Rate per pump – gpm (MGD)	Total Flow Rate – gpm (MGD)
1 & 2	Circulating Water Pump	2	80,000 (115)	320,000 (461)
1 & 2	Open (Auxiliary) Cooling	2	3,000 (4.3)	12,000 (17)
3 & 4	Circulating Water Pump	2	137,500 (198)	550,000 (792)
3 & 4	Open (Auxiliary) Cooling	2	4,400 (6.3)	17,600 (25)
Total				**899,600 (1,295)**

Table 2-1 Threatened (T), Endangered (E), Special Concern (SC), and Listing Candidate (LS) Aquatic and Semi-aquatic Species Potentially Occurring in the Vicinity of the Port Everglades Power Plant

Scientific Name	Common Name	Federal Status	State Status
Rivulus marmoratus	Mangrove rivulus	LS	SC
Eretmochelys imbricata	Hawksbill turtle	E	E
Trichedhus manatus	Manatee	E	E
Rana capito	Gopher frog	-	SC

Table 4-1 Port Everglades Impingement Mortality and Entrainment Sampling Regime

Sample Type	Frequency	Sampling Location	Samples per Event	Total #
Impingement mortality	Every 2 weeks	Intake screens 1&2 sluiceway Intake screens 3&4 sluiceway	1 day and 1 night sample per event	52
Entrainment	Every 2 weeks	One randomly selected intake bay per Unit pair	2 day & 2 night samples per Unit pair per event*	104
* Samples collected at approximately 6-hour intervals to coincide with tidal cycle. Composites yielded one day and one night sample for taxonomic analysis.				

Table 4-2 Port Everglades IM&E Sampling Dates and Actual CWIS Intake Volume

Event #	Month/Year	Dates	CWIS Intake Volume (MGD) Day 1	Day 2
1	April 2006	25-26	1252	1250
2	May 2006	9-10	1057	1253
3		23-24	1022	1022
4	June 2006	6-7	1198	1195
5		20-21	1253	1252
6	July 2006	6-7	1253	1222
7		18-19	1137	1042
8	August 2006	1-2	1248	1252
9		15-16	1209	1043
10	September 2006	7-8	1137	1210
11		12-13	1252	1252
12		26-27	1098	1120
13	October 2006	10-11	985	988
14		24-25	797	770
15	November 2006	9-10	779	777
16		21-22	594	611
17	December 2006	5-6	941	887
18		19-20	1250	1250
19	January 2007	3-4	1021	1021
20		16-17	1084	1102
21		30-31	1253	1253
22	February 2007	13-14	1138	1205
23		27-28	1138	1137
24	March 2007	13-14	742	741
25		27-28	856	857
26	April 2007	10-11	806	840

Table 5-1 Total Numbers and Densities of Impinged Finfish Collected at Port Everglades

Common Name	Scientific Name	Number Collected	Impingement Rate (#/MG)	Percent of Total Collected	Cumulative Percent Collected
Big-eye anchovy	*Anchoa lamprotaenia*	2,507	0.0918	55.24	55.24
Broad-striped anchovy	*Anchoa hepsetus*	522	0.0191	11.50	66.75
Bandtail puffer	*Sphoeroides spengleri*	268	0.0098	5.91	72.65
Checkered puffer	*Sphoeroides testudineus*	224	0.0082	4.94	77.59
Silver mojarra	*Eucinostomus argenteus*	120	0.0044	2.64	80.23
Tidewater mojarra	*Eucinostomus harengulus*	93	0.0034	2.05	82.28
Anchovy	*Anchoa sp.*	90	0.0033	1.98	84.27
Tomtate	*Haemulon aurolineatum*	83	0.0030	1.83	86.10
Mojarra	*Eucinostomus sp.*	55	0.0020	1.21	87.31
Bonefish	*Albula sp.*	48	0.0018	1.06	88.36
Lookdown	*Selene vomer*	40	0.0015	0.88	89.25
Planehead filefish	*Stephanolepis hispida*	38	0.0014	0.84	90.08
Grunt	*Haemulon sp.*	32	0.0012	0.71	90.79
Houndfish	*Tylosurus crocodilus*	29	0.0011	0.64	91.43
Lined seahorse	*Hippocampus erectus*	28	0.0010	0.62	92.04
Southern puffer	*Sphoeroides nephelus*	26	0.0010	0.57	92.62
Herring	*Clupeidae*	24	0.0009	0.53	93.15
Ladyfish	*Elops saurus*	22	0.0008	0.48	93.63
Jenny mojarra	*Eucinostomus gula*	22	0.0008	0.48	94.12
Sargassumfish	*Histrio histrio*	15	0.0005	0.33	94.45
Gulf pipefish	*Syngnathus scovelli*	15	0.0005	0.33	94.78
Sharpnose pufferfish	*Canthigaster rostrata*	14	0.0005	0.31	95.09
Other		223	0.0082	4.91	100.00
Total		**4,538**	**0.1662**		

Table 5-2 Total Numbers and Densities of Impinged Invertebrates Collected at Port Everglades

Common Name	Scientific Name	Number Collected	Impingement Rate (#/MG)	Percent of Total Collected	Cumulative Percent Collected
Pink shrimp	*Farfantepenaeus duorarum*	232	0.0085	23.33	23.33
Atlantic brief squid	*Lolliguncula brevis*	90	0.0033	8.66	30.99
Sargassum swimming crab	*Portunus sayi*	79	0.0029	7.60	38.59
Carridean shrimp	*Caridea*	72	0.0026	6.93	45.52
Xanthid crab	*Xanthidae*	71	0.0026	6.83	52.36
Penaeid shrimp	*Rimapenaeus sp.*	70	0.0026	6.74	59.10
Roughneck shrimp	*Rimapenaeus constrictus*	50	0.0018	4.81	63.91
Penaeid shrimp	*Penaeidae*	47	0.0017	4.52	68.43
Portunid crab	*Portunus sp.*	38	0.0014	3.66	72.09
Blue crab	*Callinectes sapidus*	37	0.0014	3.56	75.65
Caribbean reef squid	*Sepioteuthis sepioidea*	34	0.0012	3.27	78.92
Swimming crab	*Callinectes sp.*	32	0.0012	3.08	82.00
Flatface swimming crab	*Portunus depressifrons*	24	0.0009	2.31	84.31
Ornate blue crab	*Callinectes ornatus*	23	0.0008	2.21	86.53
Snapping shrimp	*Alpheidae*	18	0.0007	1.73	88.26
Lesser blue crab	*Callinectes similis*	16	0.0006	1.54	89.80
Portunid crab	*Portunidae*	11	0.0004	1.06	90.86
Blotched swimming crab	*Portunus spinimanus*	11	0.0004	1.06	91.92
Panaeid shrimp	*Farfantepenaeus sp.*	10	0.0004	0.96	92.88
Florida stone crab	*Menippe mercenaria*	10	0.0004	0.96	93.84
Pistol shrimp	*Alpheus sp.*	8	0.0003	0.77	94.61
Brown shrimp	*Farfantepenaeus aztecus*	6	0.0002	0.58	95.19
Other		50	0.0018	4.81	100
Total		**1,039**	**0.0380**	**100**	

Table 5-3 Biomass of Fish and Invertebrates Collected in Impingement Samples at Port Everglades

Common Name	Scientific Name	Total Weight (g) Collected	Density (g/MG)	Percent of Total	Cumulative Percent
Checkered puffer	*Sphoeroides testudineus*	20,149.3	0.7378	33.76	33.76
Lookdown	*Selene vomer*	9,820.3	0.3596	16.45	50.21
Bandtail puffer	*Sphoeroides spengleri*	7,206.6	0.2639	12.07	62.28
Blue crab	*Callinectes sapidus*	4,164.8	0.1525	6.98	69.26
Big-eye anchovy	*Anchoa lamprotaenia*	3,209.1	0.1175	5.23	74.49
Common snook	*Centropomus undecimalis*	3,122.5	0.1143	1.99	76.48
Redtail parrotfish	*Sparisoma chrysopterum*	2,375.2	0.0870	1.82	78.3
Atlantic spadefish	*Chaetodipterus faber*	1,085.7	0.0398	1.79	80.09
Purplemouth moray	*Gymnothorax vicinus*	1,000.0	0.0366	1.68	81.76
Southern puffer	*Sphoeroides nephelus*	894.0	0.0327	1.5	83.26
Porcupinefish	*Diodon hystrix*	890.2	0.0326	1.49	84.75
Southern stargazer	*Astroscopus y-graecum*	841.2	0.0308	1.41	86.16
Hairy porcupinefish	*Diodon holocanthus*	658.0	0.0241	1.1	87.26
Broad-striped	*Anchoa hepsetus*	596.0	0.0218	0.99	88.26
Grey anglefish	*Pomacanthus arcuatus*	505.2	0.0185	0.85	89.11
Bermuda chub	*Kyphosus sectatrix*	461.6	0.0169	0.77	89.88
Pink shrimp	*Farfantepenaeus duorarum*	438.4	0.0161	0.73	90.61
Flying gurnard	*Dactylopterus volitans*	351.4	0.0129	0.59	91.2
Ornate blue crab	*Callinectes ornatus*	330.8	0.0121	0.55	91.76
Atlantic brief squid	*Lolliguncula brevis*	328.4	0.0120	0.55	92.31
Planehead filefish	*Stephanolepis hispida*	324.1	0.0119	0.54	92.85
Northern stargazer	*Astroscopus guttatus*	310.8	0.0114	0.52	93.37
Florida stone crab	*Menippe mercenaria*	307.0	0.0112	0.51	93.88
Sergeant major	*Abudefduf saxatilis*	274.2	0.0100	0.46	94.34
Swimming crab	*Callinectes* sp.	259.8	0.0095	0.44	94.78
Porkfish	*Anisotremus virginicus*	250.6	0.0092	0.42	95.2
Other		3,008.0	0.1102	4.8	100
Total		**63,164.0**	**2.3129**	**100**	

Table 5-4 Annualized Fish Impingement Estimates for Design Flow

Common Name	Scientific Name	Annualized Impingement	Percent of Total Fish	Cumulative Percent
Big-eye anchovy	*Anchoa lamprotaenia*	39,063	53.04	53.04
Broad-striped anchovy	*Anchoa hepsetus*	8,091	10.99	64.02
Bandtail puffer	*Sphoeroides spengleri*	4,775	6.48	70.51
Checkered puffer	*Sphoeroides testudineus*	3,974	5.40	75.90
Silver mojarra	*Eucinostomus argenteus*	1,902	2.58	78.48
Tidewater mojarra	*Eucinostomus harengulus*	1,432	1.94	80.43
Anchovy	*Anchoa* sp.	1,709	2.32	82.75
Tomtate	*Haemulon aurolineatum*	1,409	1.91	84.66
Mojarra	*Eucinostomus* sp.	960	1.30	85.97
Bonefish	*Albula* sp.	782	1.06	87.03
Lookdown	*Selene vomer*	685	0.93	87.96
Planehead filefish	*Stephanolepis hispida*	802	1.09	89.05
Grunt	*Haemulon* sp.	569	0.77	89.82
Houndfish	*Tylosurus crocodilus*	548	0.74	90.56
Southern puffer	*Sphoeroides nephelus*	608	0.83	91.39
Lined seahorse	*Hippocampus erectus*	518	0.70	92.09
Herring	Clupeidae	336	0.46	92.55
Ladyfish	*Elops saurus*	375	0.51	93.06
Jenny mojarra	*Eucinostomus gula*	329	0.45	93.51
Sargassumfish	*Histrio histrio*	315	0.43	93.93
Gulf pipefish	*Syngnathus scovelli*	324	0.44	94.37
Sharpnose pufferfish	*Canthigaster rostrata*	217	0.29	94.67
Hairy porcupinefish	*Diodon holocanthus*	244	0.33	95.00
Other		3,683	5.00	100
	Fish Total	**73,653**	**100**	

Table 5-5 Annualized Invertebrate Impingement Estimates for Design Flow

Common Name	Scientific Name	Annualized Impingement	Percent of Total Inverts	Cumulative Percent
Pink shrimp	*Farfantepenaeus duorarum*	3,712	21.22	21.22
Atlantic brief squid	*Lolliguncula brevis*	1,434	8.20	29.42
Sargassum swimming crab	*Portunus sayi*	1,530	8.75	38.17
Carridean shrimp	Caridea	1,201	6.87	45.04
Xanthid crab	Xanthidae	1,193	6.82	51.86
Penaeid shrimp	*Rimapenaeus* sp.	1,125	6.43	58.29
Roughneck shrimp	*Rimapenaeus constrictus*	871	4.98	63.27
Penaeid shrimp	Penaeidae	664	3.79	67.07
Portunid crab	*Portunus* sp.	722	4.13	71.19
Blue crab	*Callinectes sapidus*	634	3.63	74.82
Caribbean reef squid	*Sepioteuthis sepioidea*	611	3.49	78.31
Swimming crab	*Callinectes* sp.	574	3.28	81.60
Flatface swimming crab	*Portunus depressifrons*	437	2.50	84.09
Ornate blue crab	*Callinectes ornatus*	374	2.14	86.23
Snapping shrimp	Alpheidae	362	2.07	88.30
Lesser blue crab	*Callinectes similis*	318	1.82	90.12
Blotched swimming crab	*Portunus spinimanus*	185	1.06	91.18
Portunid crab	Portunidae	181	1.03	92.21
Panaeid shrimp	*Farfantepenaeus* sp.	174	1.00	93.21
Florida stone crab	*Menippe mercenaria*	156	0.89	94.10
Pistol shrimp	*Alpheus* sp.	119	0.68	94.78
Brown shrimp	*Farfantepenaeus aztecus*	88	0.50	95.29
Other		825	4.71	100
	Invert Total	**17,490**	**100**	

Table 5-6 Annualized Fish Impingement under Actual Cooling Water Flow Conditions

Common Name	Scientific Name	Annualized Impingement	Percent of Total Fish	Cumulative Percent
Big-eye anchovy	*Anchoa lamprotaenia*	36,155	56.01	56.01
Broad-striped anchovy	*Anchoa hepsetus*	6,829	10.58	66.59
Bandtail puffer	*Sphoeroides spengleri*	3,821	5.92	72.50
Checkered puffer	*Sphoeroides testudineus*	3,370	5.22	77.72
Silver mojarra	*Eucinostomus argenteus*	1,646	2.55	80.27
Tidewater mojarra	*Eucinostomus harengulus*	1,316	2.04	82.31
Anchovy	*Anchoa* sp.	1,434	2.22	84.53
Tomtate	*Haemulon aurolineatum*	1,236	1.91	86.45
Mojarra	*Eucinostomus* sp.	811	1.26	87.71
Lookdown	*Selene vomer*	590	0.91	88.62
Bonefish	*Albula* sp.	605	0.94	89.56
Planehead filefish	*Stephanolepis hispida*	521	0.81	90.37
Grunt	*Haemulon* sp.	425	0.66	91.02
Houndfish	*Tylosurus crocodilus*	397	0.62	91.64
Herring	Clupeidae	304	0.47	92.11
Lined seahorse	*Hippocampus erectus*	375	0.58	92.69
Jenny mojarra	*Eucinostomus gula*	303	0.47	93.16
Ladyfish	*Elops saurus*	303	0.47	93.63
Southern puffer	*Sphoeroides nephelus*	369	0.57	94.20
Sharpnose pufferfish	*Canthigaster rostrata*	200	0.31	94.51
Sargassumfish	*Histrio histrio*	220	0.34	94.85
Gulf pipefish	*Syngnathus scovelli*	213	0.33	95.18
Other		3,111	4.82	
	Fish Total	**64,555**	**100**	

Table 5-7 Annualized Invertebrate Impingement under Actual Flow Conditions

Common Name	**Scientific Name**	**Annualized Impingement**	**Percent of Total Inverts**	**Cumulative Percent**
Pink shrimp	*Farfantepenaeus duorarum*	3,323	23.14	23.14
Atlantic brief squid	*Lolliguncula brevis*	1,271	8.85	31.99
Xanthid crab	Xanthidae	968	6.74	38.73
Sargassum swimming crab	*Portunus sayi*	1,088	7.58	46.31
Penaeid shrimp	*Rimapenaeus* sp.	953	6.64	52.95
Carridean shrimp	Caridea	928	6.46	59.41
Roughneck shrimp	*Rimapenaeus constrictus*	698	4.86	64.27
Penaeid shrimp	Penaeidae	600	4.18	68.45
Blue crab	*Callinectes sapidus*	526	3.67	72.11
Portunid crab	*Portunus* sp.	505	3.52	75.63
Caribbean reef squid	*Sepioteuthis sepioidea*	446	3.11	78.74
Swimming crab	*Callinectes* sp.	437	3.04	81.78
Flatface swimming crab	*Portunus depressifrons*	382	2.66	84.44
Ornate blue crab	*Callinectes ornatus*	312	2.17	86.61
Lesser blue crab	*Callinectes similis*	232	1.61	88.23
Snapping shrimp	Alpheidae	241	1.68	89.91
Portunid crab	Portunidae	153	1.07	90.97
Blotched swimming crab	*Portunus spinimanus*	147	1.02	91.99
Florida stone crab	*Menippe mercenaria*	135	0.94	92.93
Panaeid shrimp	*Farfantepenaeus* sp.	132	0.92	93.85
Pistol shrimp	*Alpheus* sp.	109	0.76	94.60
Brown shrimp	*Farfantepenaeus aztecus*	82	0.57	95.17
Other		693	4.83	100
	Invert Total	**14,359**	**100**	

Table 5-8 Lengths of Fish Impinged at Port Everglades

Common Name	Scientific Name	Maximum Individual Length	Minimum Individual Length	Average Individual Length
Big-eye anchovy	*Anchoa lamprotaenia*	66	18	45.1
Broad-striped anchovy	*Anchoa hepsetus*	58	24	43.8
Bandtail puffer	*Sphoeroides spengleri*	138	30	98.0
Checkered puffer	*Sphoeroides testudineus*	215	91	130.9
Silver mojarra	*Eucinostomus argenteus*	42	17	26.8
Tidewater mojarra	*Eucinostomus harengulus*	41.5	16.5	24.5
Anchovy	*Anchoa* sp.	93	28	43.1
Tomtate	*Haemulon aurolineatum*	107	14	27.5
Mojarra	*Eucinostomus* sp.	40	16	21.5
Lookdown	*Selene vomer*	314	13	135.9
Bonefish	*Albula* sp.	66	54	60.7
Planehead filefish	*Stephanolepis hispida*	183	13	39.1
Grunt	*Haemulon* sp.	61	17.5	33.7
Houndfish	*Tylosurus crocodilus*	55	33	41.8
Herring	Clupeidae	21.5	20	20.6
Lined seahorse	*Hippocampus erectus*	151	20.9	73.1
Jenny mojarra	*Eucinostomus gula*	87	20.5	42.0
Ladyfish	*Elops saurus*	59	54	56.8
Southern puffer	*Sphoeroides nephelus*	130	79	106.7
Sharpnose pufferfish	*Canthigaster rostrata*	60	37	46.3
Sargassumfish	*Histrio histrio*	49	17.1	31.6
Gulf pipefish	*Syngnathus scovelli*	154	90	126.4
Other		886	11.0	93.4

Table 5-9 Lengths of Invertebrates Impinged at Port Everglades

Common Name	Scientific Name	Maximum Individual Length	Minimum Individual Length	Average Individual Length
Pink shrimp	Farfantepenaeus duorarum	25.9	4.1	12.5
Atlantic brief squid	Lolliguncula brevis	80	12.6	33.2
Sargassum swimming crab	Portunus sayi	26	7.3	13.6
Xanthid crab	Xanthidae	22.2	4.5	12.0
Penaeid shrimp	Rimapenaeus sp.	10.8	5	7.1
Carridean shrimp	Caridea	9	9	9.0
Roughneck shrimp	Rimapenaeus constrictus	9.8	5.5	7.4
Penaeid shrimp	Penaeidae	9	6.5	7.8
Blue crab	Callinectes sapidus	132.6	5.6	55.7
Portunid crab	Portunus sp.	25.5	7.7	12.8
Caribbean reef squid	Sepioteuthis sepioidea	100.5	9	20.2
Swimming crab	Callinectes sp.	61.5	7.8	20.5
Flatface swimming crab	Portunus depressifrons	38	6.5	11.3
Ornate blue crab	Callinectes ornatus	81.7	7.3	36.6
Lesser blue crab	Callinectes similis	108.9	6	30.3
Snapping shrimp	Alpheidae	8	5	6.0
Portunid crab	Portunidae	47	7.8	20.5
Blotched swimming crab	Portunus spinimanus	45	9.9	17.1
Florida stone crab	Menippe mercenaria	45	11.6	26.6
Panaeid shrimp	Farfantepenaeus sp.	9	4.5	6.6
Pistol shrimp	Alpheus sp.	10.5	5	7.1
Brown shrimp	Farfantepenaeus aztecus	22.2	8	13.5
Other		132.6	4.1	19.0

Table 5-10 Day versus Night Impingement Rate – Taxa are ranked by total number counted

Common Name	Scientific Name	Day Count	Rate (#/MG)	Night Count	Rate (#/MG)	24 hr* Count	Total Count
Big-eye anchovy	*Anchoa lamprotaenia*	422	0.0351	2,085	0.1444		2,507
Broad-striped anchovy	*Anchoa hepsetus*	8	0.0007	470	0.0325	44	522
Bandtail puffer	*Sphoeroides spengleri*	134	0.0111	130	0.0090	4	268
Pink shrimp	*Farfantepenaeus duorarum*	22	0.0018	206	0.0143	4	232
Checkered puffer	*Sphoeroides testudineus*	78	0.0065	146	0.0101		224
Silver mojarra	*Eucinostomus argenteus*	2	0.0002	106	0.0073	12	120
Tidewater mojarra	*Eucinostomus harengulus*	9	0.0007	84	0.0058		93
Atlantic brief squid	*Lolliguncula brevis*	12	0.0010	70	0.0048	8	90
Anchovy	*Anchoa* sp.	24	0.0020	66	0.0046		90
Tomtate	*Haemulon aurolineatum*	4	0.0003	79	0.0055		83
Sargassum swimming	*Portunus sayi*	25	0.0021	46	0.0032	8	79
Carridean shrimp	Caridea			28	0.0019	44	72
Xanthid crab	Xanthidae	19	0.0016	40	0.0028	12	71
Penaeid shrimp	*Rimapenaeus* sp.	7	0.0006	63	0.0044		70
Mojarra	*Eucinostomus* sp.	1	0.0001	54	0.0037		55
Roughneck shrimp	*Rimapenaeus constrictus*			50	0.0035		50
Bonefish	*Albula* sp.	7	0.0006	41	0.0028		48
Penaeid shrimp	Penaeidae			3	0.0002	44	47
Lookdown	*Selene vomer*	12	0.0010	28	0.0019		40
Planehead filefish	*Stephanolepis hispida*	8	0.0007	30	0.0021		38
Portunid crab	*Portunus* sp.	10	0.0008	28	0.0019		38
Blue crab	*Callinectes sapidus*	5	0.0004	28	0.0019	4	37
Caribbean reef squid	*Sepioteuthis sepioidea*	2	0.0002	20	0.0014	12	34
Swimming crab	*Callinectes* sp.	10	0.0008	22	0.0015		32
Grunt	*Haemulon* sp.	1	0.0001	27	0.0019	4	32
Houndfish	*Tylosurus crocodilus*	3	0.0002	26	0.0018		29
Lined seahorse	*Hippocampus erectus*	15	0.0012	9	0.0006	4	28
Southern puffer	*Sphoeroides nephelus*			26	0.0018		26
Herring	Clupeidae					24	24
Flatface swimming crab	*Portunus depressifrons*	1	0.0001	23	0.0016		24
Ornate blue crab	*Callinectes ornatus*	1	0.0001	18	0.0012	4	23
Jenny mojarra	*Eucinostomus gula*			22	0.0015		22
Ladyfish	*Elops saurus*	1	0.0001	21	0.0015		22
Snapping shrimp	Alpheidae	14	0.0012	4	0.0003		18
Lesser blue crab	*Callinectes similis*	7	0.0006	9	0.0006		16
Gulf pipefish	*Syngnathus scovelli*	5	0.0004	10	0.0007		15
Sargassumfish	*Histrio histrio*	6	0.0005	9	0.0006		15
Sharpnose pufferfish	*Canthigaster rostrata*	5	0.0004	9	0.0006		14
Hairy porcupinefish	*Diodon holocanthus*	5	0.0004	7	0.0005		12
Chain pipefish	*Syngnathus louisianae*	4	0.0003	7	0.0005		11
Blotched swimming crab	*Portunus spinimanus*	1	0.0001	6	0.0004	4	11
Portunid crab	Portunidae	1	0.0001	10	0.0007		11
Florida stone crab	*Menippe mercenaria*	1	0.0001	9	0.0006		10
Other		61	0.0051	205	0.0142		274
	Total	**953**	**0.0792**	**4,380**	**0.3033**	**244**	**5577**

* A single 24-hr impingement sample was collected during Event 18 (December 19-20, 2006).

Table 5-11 Impingement Rate by Sample Location - Taxa are ranked by total number counted

Common Name	Scientific Name	Units 1 & 2		Units 3 & 4		Total Number
		Number	Rate	Number	Rate	
Big-eye anchovy	*Anchoa lamprotaenia*	50	0.00500	2457	0.14202	2507
Broad-striped anchovy	*Anchoa hepsetus*	12	0.00120	510	0.02948	522
Bandtail puffer	*Sphoeroides spengleri*	8	0.00080	260	0.01503	268
Pink shrimp	*Farfantepenaeus duorarum*	27	0.00270	205	0.01185	232
Checkered puffer	*Sphoeroides testudineus*	19	0.00190	205	0.01185	224
Silver mojarra	*Eucinostomus argenteus*	19	0.00190	101	0.00584	120
Tidewater mojarra	*Eucinostomus harengulus*	13	0.00130	80	0.00462	93
Atlantic brief squid	*Lolliguncula brevis*	10	0.00100	80	0.00462	90
Anchovy	*Anchoa* sp.	12	0.00120	78	0.00451	90
Tomtate	*Haemulon aurolineatum*	22	0.00220	61	0.00353	83
Sargassum swimming crab	*Portunus sayi*	12	0.00120	67	0.00387	79
Carridean shrimp	Caridea	1	0.00010	71	0.00410	72
Xanthid crab	Xanthidae	31	0.00310	40	0.00231	71
Penaeid shrimp	*Rimapenaeus* sp.	12	0.00120	58	0.00335	70
Mojarra	*Eucinostomus* sp.	14	0.00140	41	0.00237	55
Roughneck shrimp	*Rimapenaeus constrictus*	12	0.00120	38	0.00220	50
Bonefish	*Albula* sp.	2	0.00020	46	0.00266	48
Penaeid shrimp	*Penaeidae*	1	0.00010	46	0.00266	47
Lookdown	*Selene vomer*	6	0.00060	34	0.00197	40
Planehead filefish	*Stephanolepis hispida*	5	0.00050	33	0.00191	38
Portunid crab	*Portunus* sp.	20	0.00200	18	0.00104	38
Blue crab	*Callinectes sapidus*	11	0.00110	26	0.00150	37
Caribbean reef squid	*Sepioteuthis sepioidea*	2	0.00020	32	0.00185	34
Swimming crab	*Callinectes* sp.	7	0.00070	25	0.00145	32
Grunt	*Haemulon* sp.	6	0.00060	26	0.00150	32
Houndfish	*Tylosurus crocodilus*	4	0.00040	25	0.00145	29
Lined seahorse	*Hippocampus erectus*	3	0.00030	25	0.00145	28
Southern puffer	*Sphoeroides nephelus*			26	0.00150	26
Herring	Clupeidae			24	0.00139	24
Flatface swimming crab	*Portunus depressifrons*	9	0.00090	15	0.00087	24
Ornate blue crab	*Callinectes ornatus*	3	0.00030	20	0.00116	23
Jenny mojarra	*Eucinostomus gula*			22	0.00127	22
Ladyfish	*Elops saurus*			22	0.00127	22
Snapping shrimp	Alpheidae	6	0.00060	12	0.00069	18
Lesser blue crab	*Callinectes similis*	10	0.00100	6	0.00035	16
Gulf pipefish	*Syngnathus scovelli*	2	0.00020	13	0.00075	15
Sargassumfish	*Histrio histrio*	4	0.00040	11	0.00064	15
Sharpnose pufferfish	*Canthigaster rostrata*	2	0.00020	12	0.00069	14
Hairy porcupinefish	*Diodon holocanthus*	5	0.00050	7	0.00040	12
Chain pipefish	*Syngnathus louisianae*	5	0.00050	6	0.00035	11
Blotched swimming crab	*Portunus spinimanus*	5	0.00050	6	0.00035	11
Portunid crab	Portunidae	4	0.00040	7	0.00040	11
Florida stone crab	*Menippe mercenaria*	2	0.00020	8	0.00046	10
Other		43	0.00430	231	0.02308	277
Total		**441**	**0.04406**	**5,136**	**0.29688**	**5,577**

Table 5-12 Total Numbers and Entrainment Rates of Fish Collected in Entrainment Samples at Port Everglades

Common Name	Scientific Name	Total Count	Entrainment Rate (#/MG)	Percent of Total	Cumulative Percent
Unidentifiable	N/A	60,076	21,455.7	83.38	83.38
Jack-Wrasse-Drum complex	Carangidae/Labridae/ Sciaenidae complex	3,216	1,148.6	4.46	87.84
Drum	Sciaenidae	1,377	491.8	1.91	89.75
Grunt-Drum-Grouper complex	Haemulidae/Sciaenidae/ Serranidae complex	840	300.0	1.17	90.92
Blennies	Blenniidae	816	291.4	1.13	92.05
Perch-like fishes	Perciformes	618	220.7	0.86	92.91
Herring	Clupeidae	613	218.9	0.85	93.76
Jack-Grunt-Drum-Grouper complex	Carangidae/Haemulidae/ Sciaenidae/Serranidae complex	610	217.9	0.85	94.61
Gobies	Gobiidae	594	212.1	0.82	95.43
Other		3,292	1,175.7	4.6	100
	Total	**72,052**	**25,732.9**	**100**	

Table 5-13 Total Numbers and Entrainment Rates of Invertebrates Collected in Entrainment Samples at Port Everglades

Common Name	Scientific Name	Total Count	Entrainment Rate (#/MG)	Percent of Total	Cumulative Percent
Short tailed Crab	Brachyura	93,926	33,545.0	47.44	47.44
Caridean shrimp	Caridea	57,755	20,626.8	29.17	76.61
Anomuran crab (non-Thalasinidea)	Anomura	23,175	8,276.8	11.71	88.32
Ghost and mud shrimp	Thalassinidea	8,427	3,009.6	4.26	92.57
Sergestid shrimp	Sergestoidea	3,767	1,345.4	1.90	94.48
Mantis shrimp	Squilla empusa	2,859	1,021.1	1.44	95.92
Other		8,079	2,885.4	4.08	100
	Total	**197,988**	**70,710**	**100**	

Table 5-14 Estimated Annual Entrainment of Fish under Design Flow Conditions

Common Name	Scientific Name	Annual Fish Entrainment (Design Flow)	Percent of Total	Cumulative Percent
Unidentifiable	N/A	10,431,822,043	83.51	83.51
Jack-Wrasse-Drum complex	Carangidae/Labridae/ Sciaenidae complex	578,197,962	4.63	88.14
Drum	Sciaenidae	232,755,037	1.86	90.00
Grunt-Drum-Grouper complex	Haemulidae/Sciaenidae/ Serranidae complex	143,030,243	1.15	91.15
Blennies	Blenniidae	136,910,071	1.10	92.24
Perch-like fishes	Perciformes	104,711,544	0.84	93.08
Herring	Clupeidae	104,321,229	0.84	93.92
Jack-Grunt-Drum-Grouper complex	Carangidae/Haemulidae/ Sciaenidae/Serranidae complex	103,615,510	0.83	94.75
Gobies	Gobiidae	101,234,307	0.81	95.56
Other		554,874,740	4.44	100
	Total	**12,491,472,687**	**100**	

Table 5-15 Estimated Annual Entrainment of Invertebrates under Design Flow Conditions

Common Name	Scientific Name	Annual Invert Entrainment (Design Flow)	Percent of Total	Cumulative Percent
Short tailed Crab	Brachyura	15,958,854,909	47.57	47.57
Caridean shrimp	Caridea	9,735,376,242	29.02	76.59
Anomuran crab (non-Thalasinidea)	Anomura	3,943,498,251	11.75	88.34
Ghost and mud shrimp	Thalassinidea	1,422,598,275	4.24	92.58
Sergestid shrimp	Sergestoidea	635,921,260	1.90	94.48
Mantis shrimp	Squilla empusa	483,968,344	1.44	95.92
Other	Other	1,368,585,687	4.08	100
	Total	**33,548,802,967**	**100**	

Table 5-16 Estimated Annual Fish Entrainment at Port Everglades under Actual Flow Conditions

Common Name	Scientific Name	Annual Fish Entrainment (Actual Flow)	Percent of Total	Cumulative Percent
Unidentifiable	N/A	8,513,978,690	83.01	83.01
Jack-Wrasse-Drum complex	Carangidae/Labridae/ Sciaenidae complex	485,611,006	4.74	87.75
Croakers & Drum	Sciaenidae	207,645,095	2.03	89.77
Blennies	Blenniidae	114,668,111	1.12	90.89
Grunt-Drum-Grouper complex	Haemulidae/Sciaenidae/Serranidae complex	105,732,883	1.03	91.92
Herring	Clupeidae	93,865,688	0.92	92.83
Jack-Grunt-Hake-Flounder-Grouper complex	Carangidae/Haemulidae/Merlucciidae/ Paralichthyidae/Sciaenidae/Serranidae complex	92,914,646	0.91	93.74
Perch-like fishes	Perciformes	88,886,585	0.87	94.61
Jack-Grunt-Drum-Grouper complex	Carangidae/Haemulidae/Sciaenidae/ Serranidae complex	87,275,750	0.85	95.46
Other		465,908,196	4.54	100
	Total	**10,256,486,651**	**100**	

Table 5-17 Estimated Annual Entrainment of Invertebrates at Port Everglades under Actual Flow Conditions

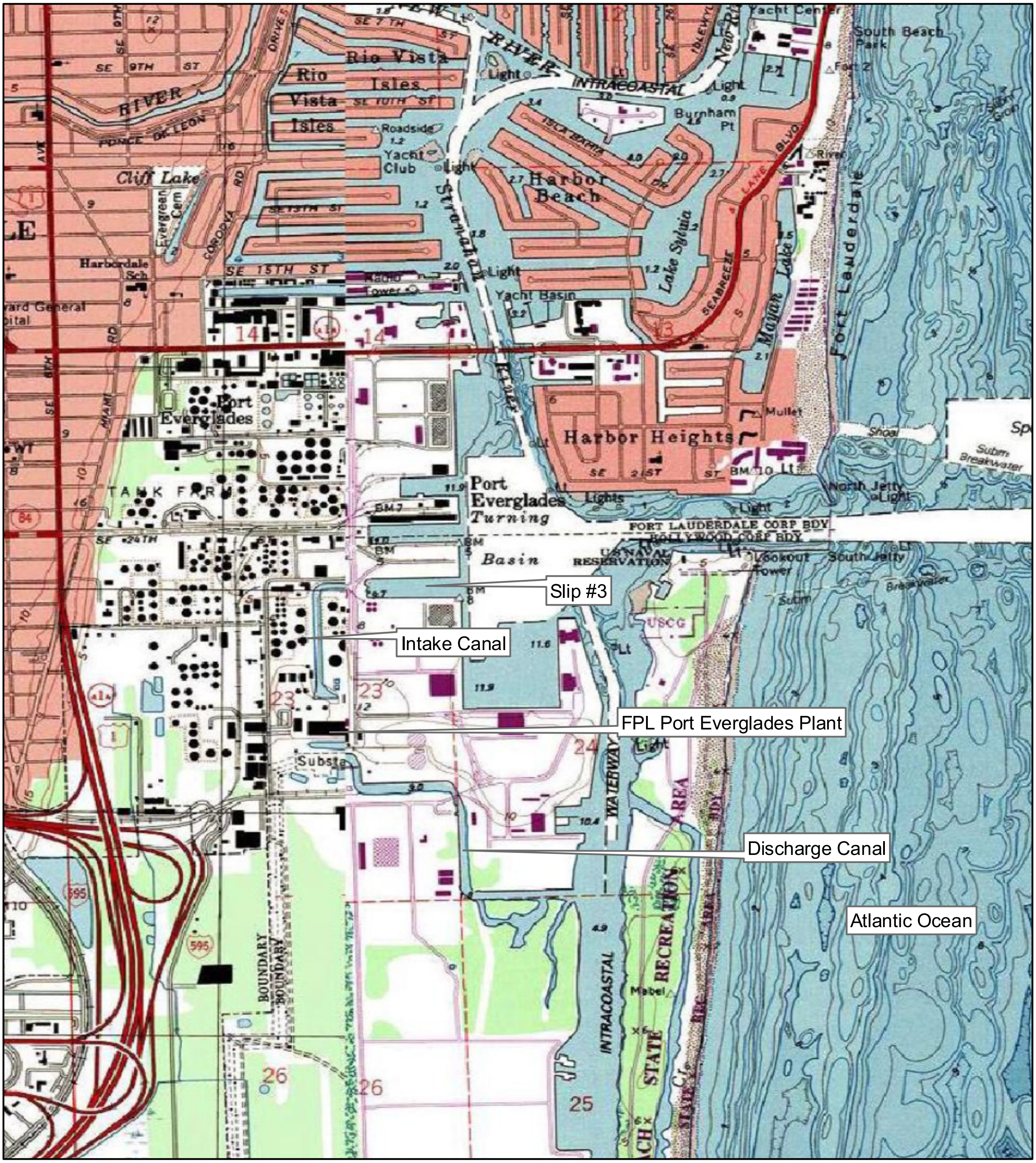
Common Name	Scientific Name	Annual Invert Entrainment (Actual Flow)	Percent of Total	Cumulative Percent
Short tailed Crab	Brachyura	13,556,487,058	47.68	47.68
Caridean shrimp	Caridea	8,157,176,064	28.69	76.37
Anomuran crab (non-Thalasinidea)	Anomura	3,390,008,648	11.92	88.29
Ghost and mud shrimp	Thalassinidea	1,192,745,985	4.20	92.49
Sergestid shrimp	Sergestoidea	525,534,473	1.85	94.34
Mantis shrimp	Squilla empusa	432,270,379	1.52	95.86
Other		1,177,970,023	4.14	100
	Total	**28,432,192,630**	**100**	

Table 5-18 Entrainment density at Port Everglades by location

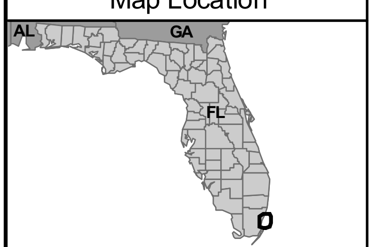
Common Name	Scientific Name	Units 1 & 2 Counts	Units 1&2 Rate (#/MG)	Units 3 & 4 Counts	Units 3&4 Rate (#/MG)	Total Counts	Total Rate (#/MG)
Short-tailed crab	Brachyura	28,304	20,217.1	65,622	46,872.9	93,926	33,545.0
Unidentifiable	N/A	31,179	22,270.7	31,353	44,665.7	62,532	22,332.9
Carridean shrimp	Caridea	18,573	13,266.4	39,182	41,253.6	57,755	20,626.8
Anomuran crab (non-Thalassinidea)	Anomura	5,344	3,817.1	17,831	16,553.6	23,175	8,276.8
Ghost and mud shrimp	Thalassinidea	1,783	1,273.6	6,644	6,019.3	8,427	3,009.6
Sergestid Shrimp	Sergestoidea	1,844	1,317.1	1,923	2,690.7	3,767	1,345.4
Jack-Wrasse-Drum complex	Carangidae/Labridae/ Sciaenidae complex	1,802	1,287.1	1,414	2,297.1	3,216	1,148.6
Mantis shrimp	Squilla empusa	780	557.1	2,079	2,042.1	2,859	1,021.1
Drum	Sciaenidae	18	12.9	1,359	983.6	1,377	491.8
	Other	4,890	3,492.9	8,116	9,290.0	13,006	4,645.0
Total		**94,517**	**67,512**	**175,523**	**192,885**	**270,040**	**94,517**

Note: - Taxa are ranked by total number counted

Figures



Map Location



N

Florida Power and Light
Port Everglades Power Plant

Image Source: USGS Topographic Quadrangles:
Port Everglades and Fort Lauderdale South (1983)

Miles: 0 0.25 0.5 0.75 1

Kilometers: 0 0.25 0.5 0.75 1

ENSR | AECOM

Figure: 1-1

Date: March 2008

Project Number: 10346-003

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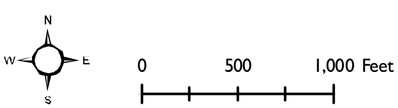


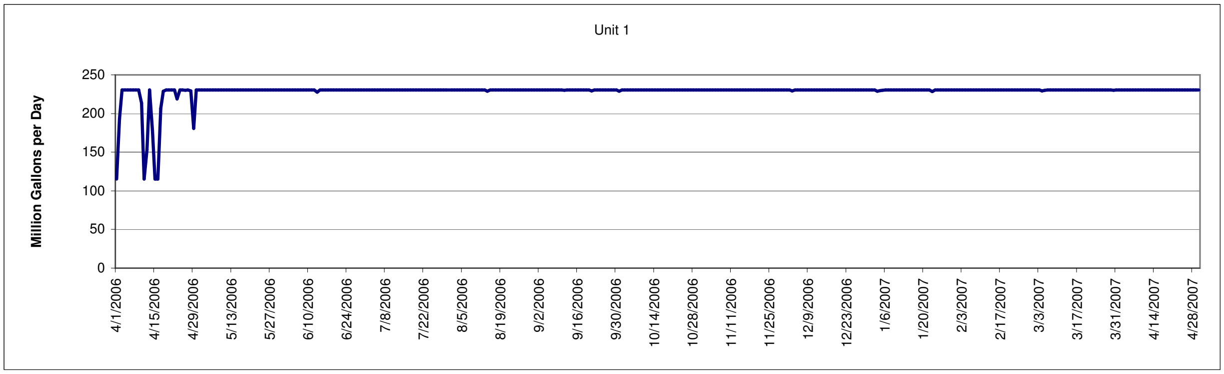
Site Plan

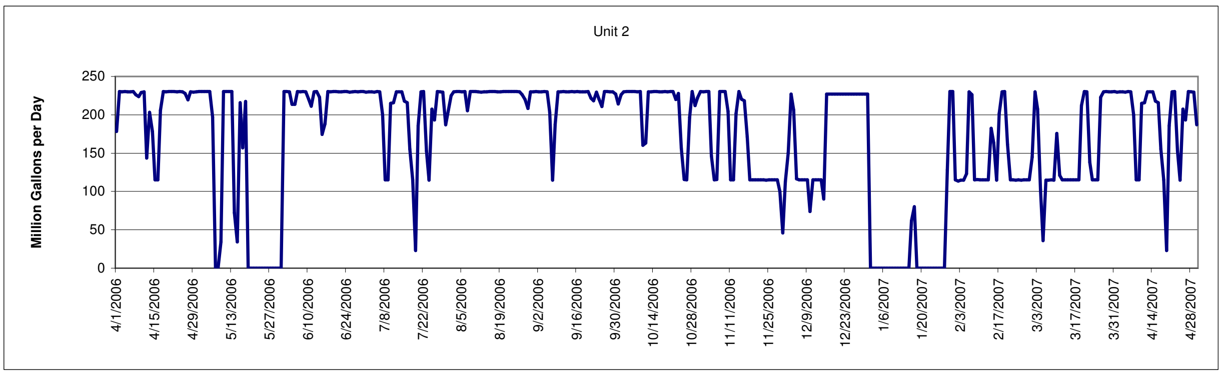
Port Everglades Florida

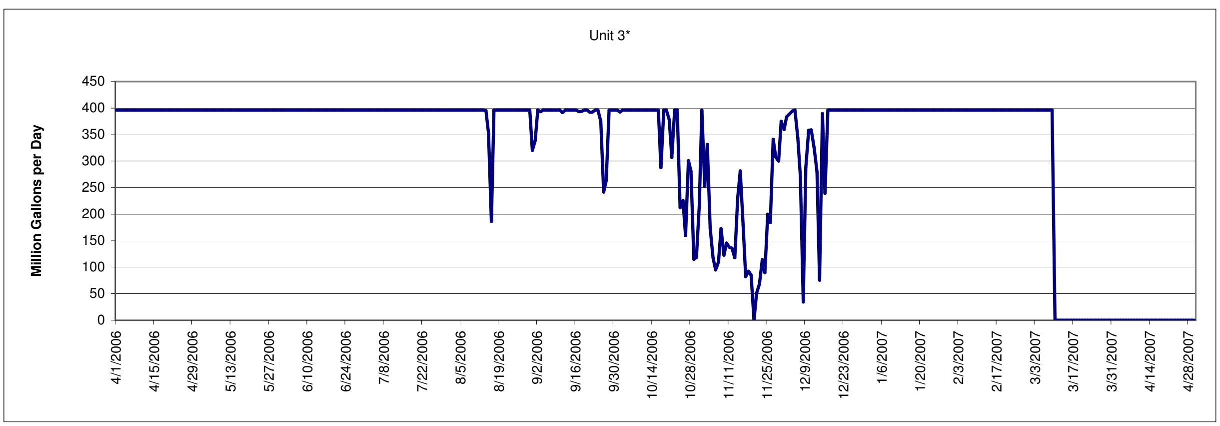
ENSR | AECOM

DATE:	PROJECT NUMBER:	FIGURE NUMBER
March 2008	10346-003	1-2

Figure 4-1 CWIS CWIS Pump Operations for Study Period







* Unit 3 PI tag not working April through August 2006; used max flow 396 MGD.

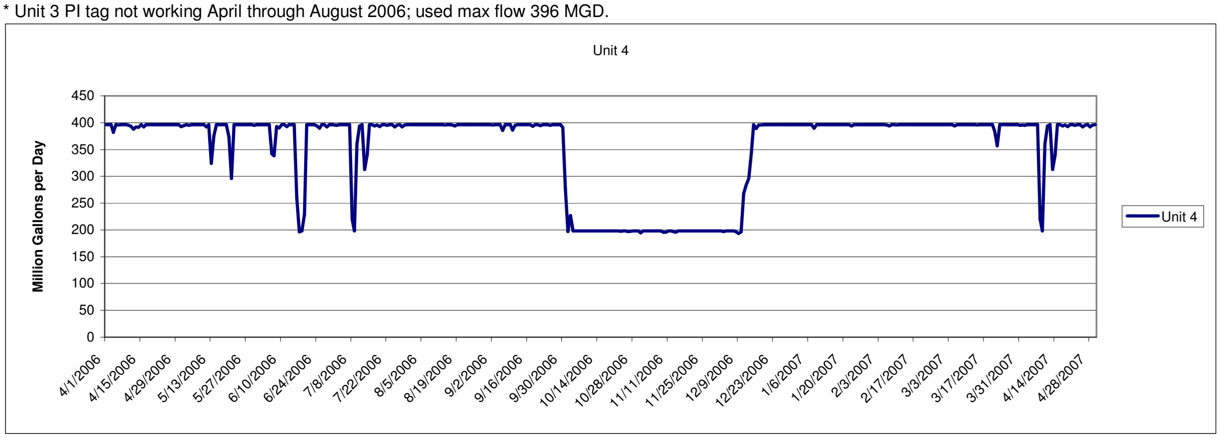


Figure 5-1 24-hr Impingement Rates – All Units

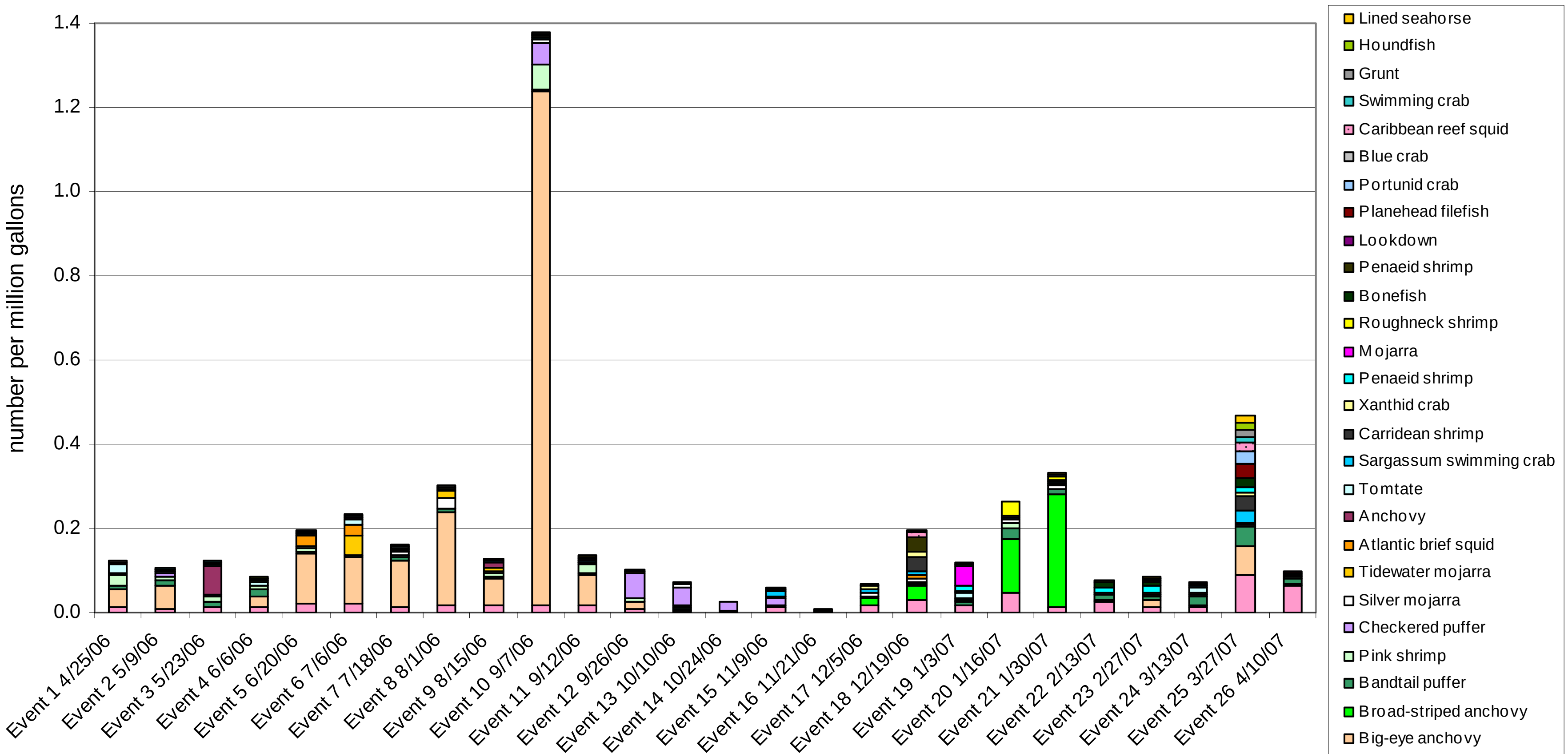


Figure 5-2 24-hr Biomass Impingement Rates – All Units

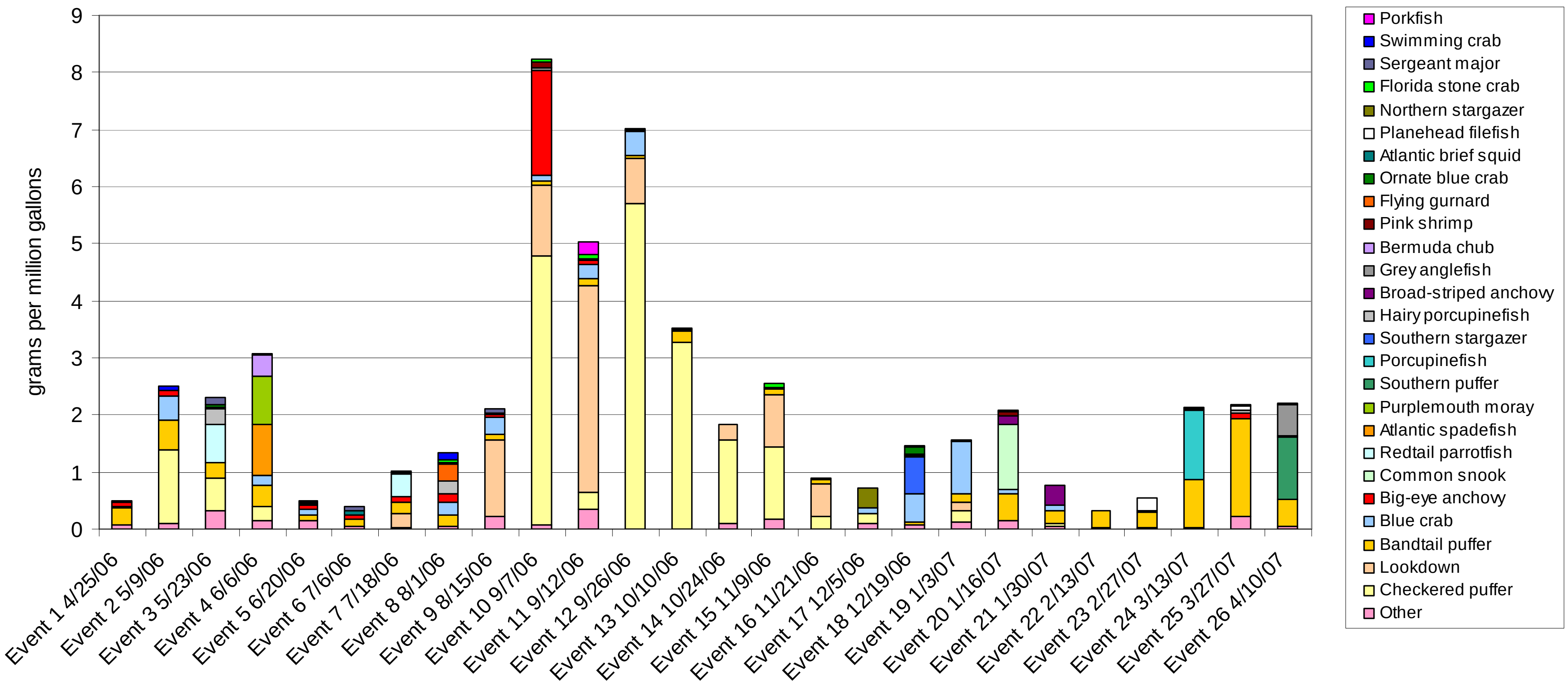
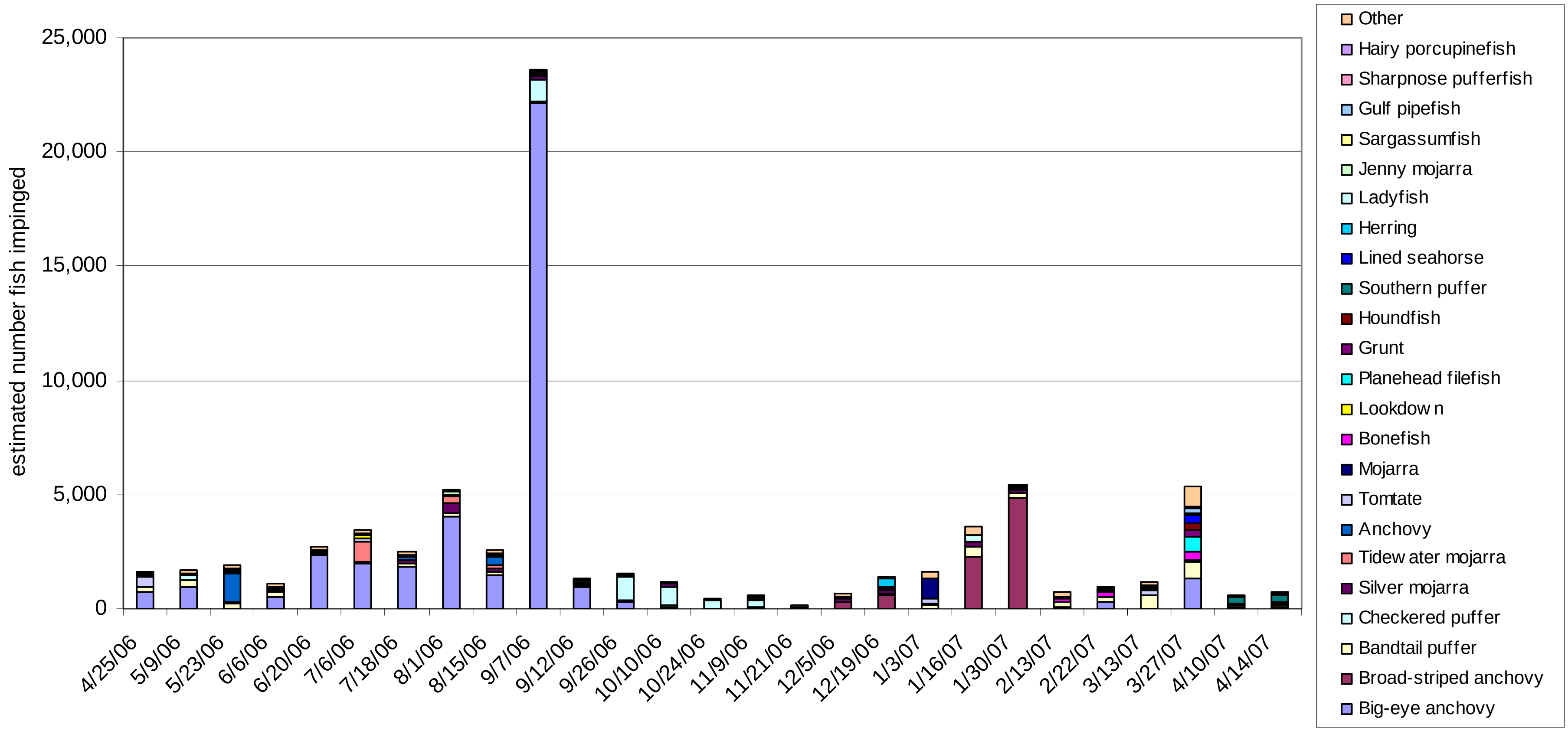
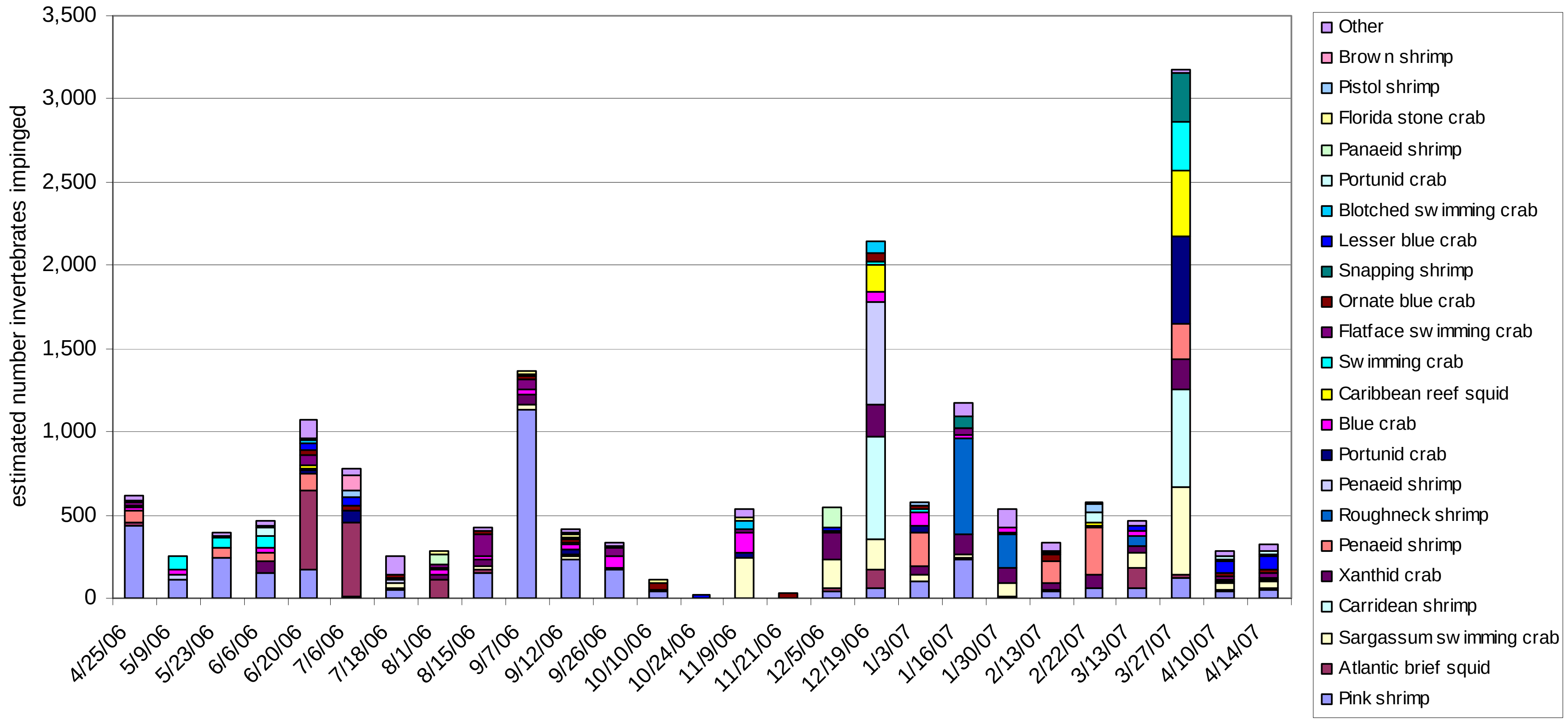


Figure 5-3 Fish Impingement by Species under Design Flow



*Data extrapolated to account for inter-event water withdrawal. Dates are interval mid-points.

Figure 5-4 Invertebrate Impingement by Species under Design Flow



*Data extrapolated to account for inter-event water withdrawal. Dates are interval mid-points.

Figure 5-5 Size Distribution of Impinged Organisms

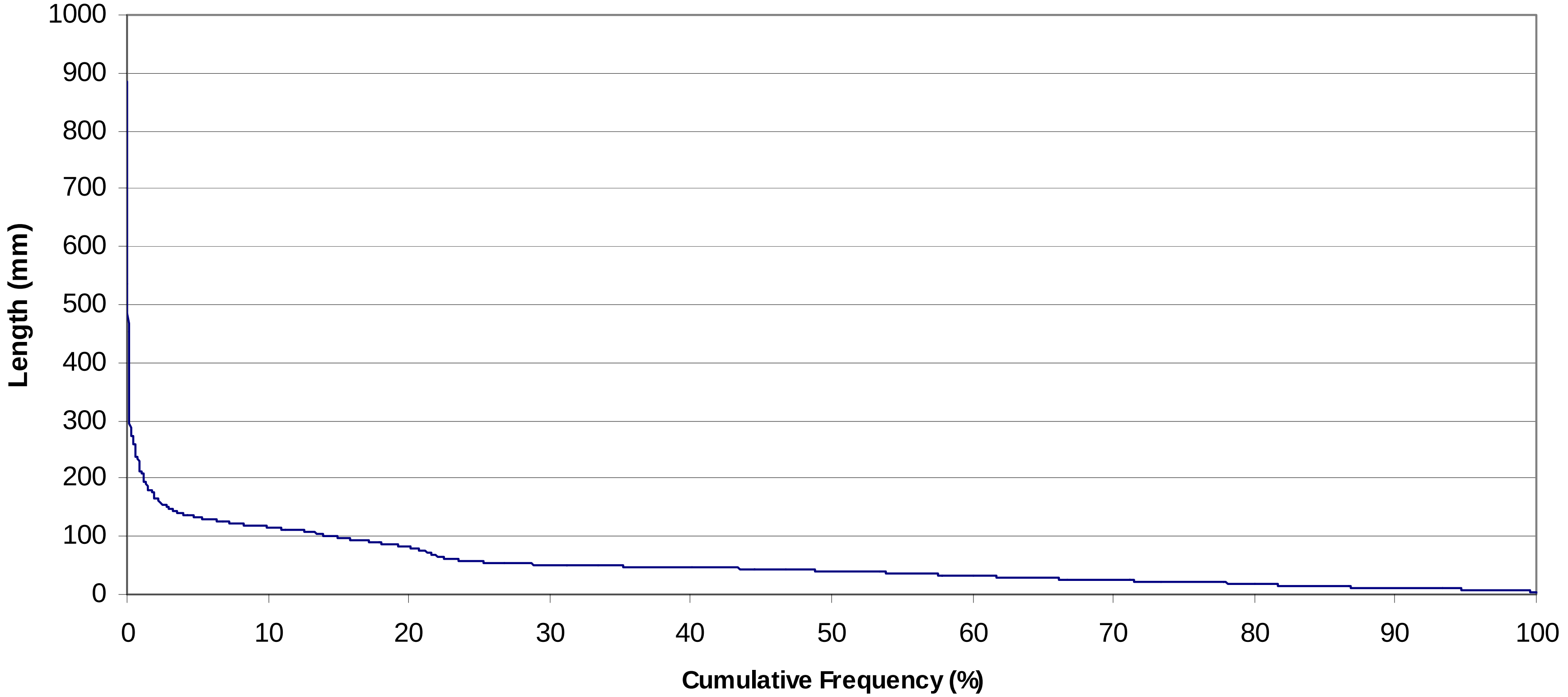


Figure 5-6 Seasonal Variation in Impingement

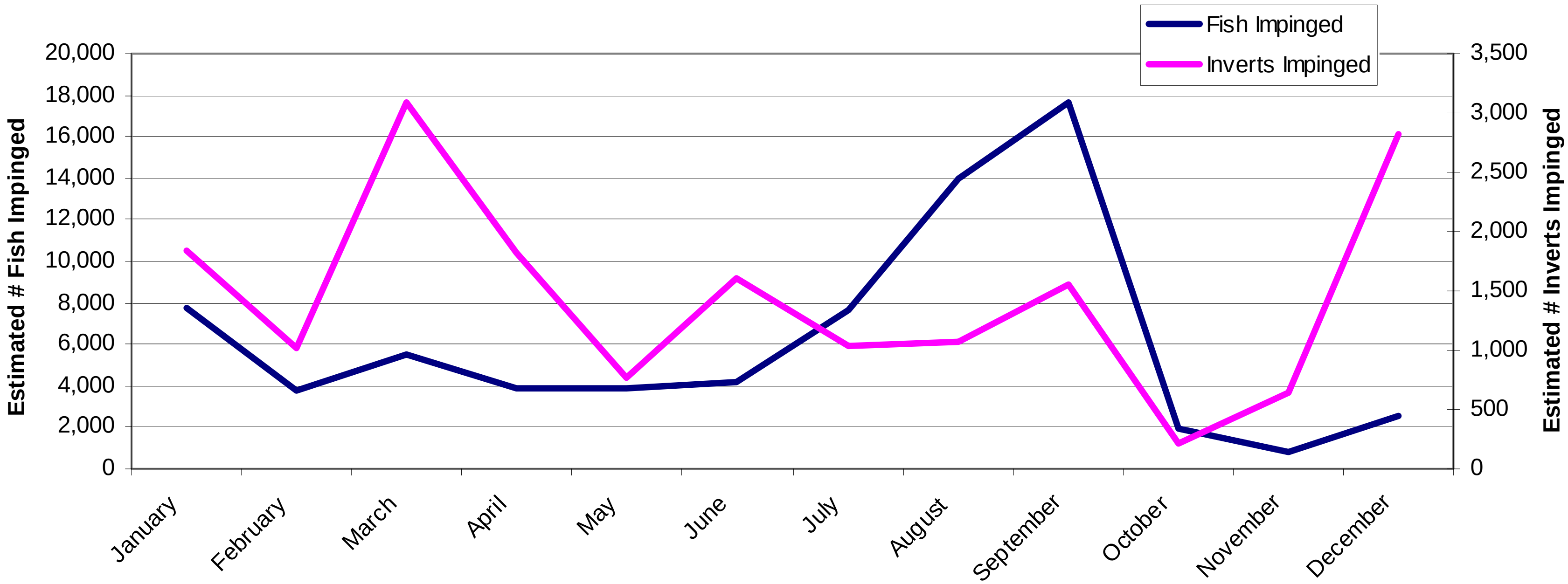
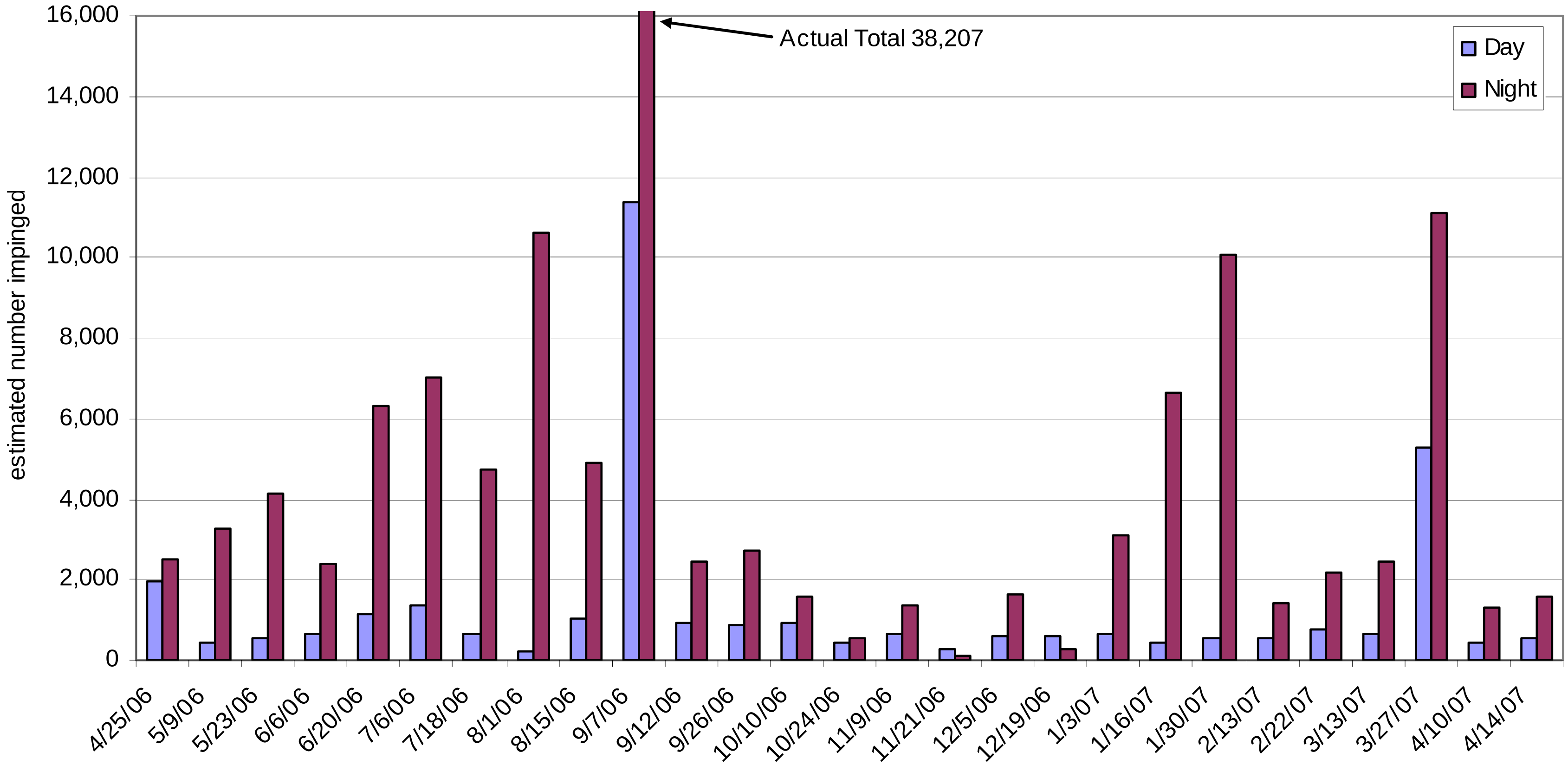


Figure 5-7 Diel Variation in Impingement



*12/19/06 interval only has day/night data from Units 1 & 2 (a single 24-hr sample was taken from Units 3 & 4 during this event).

*Data extrapolated to account for inter-event water withdrawal. Dates are interval mid-points.

Figure 5-8 Entrainment Rates by Species

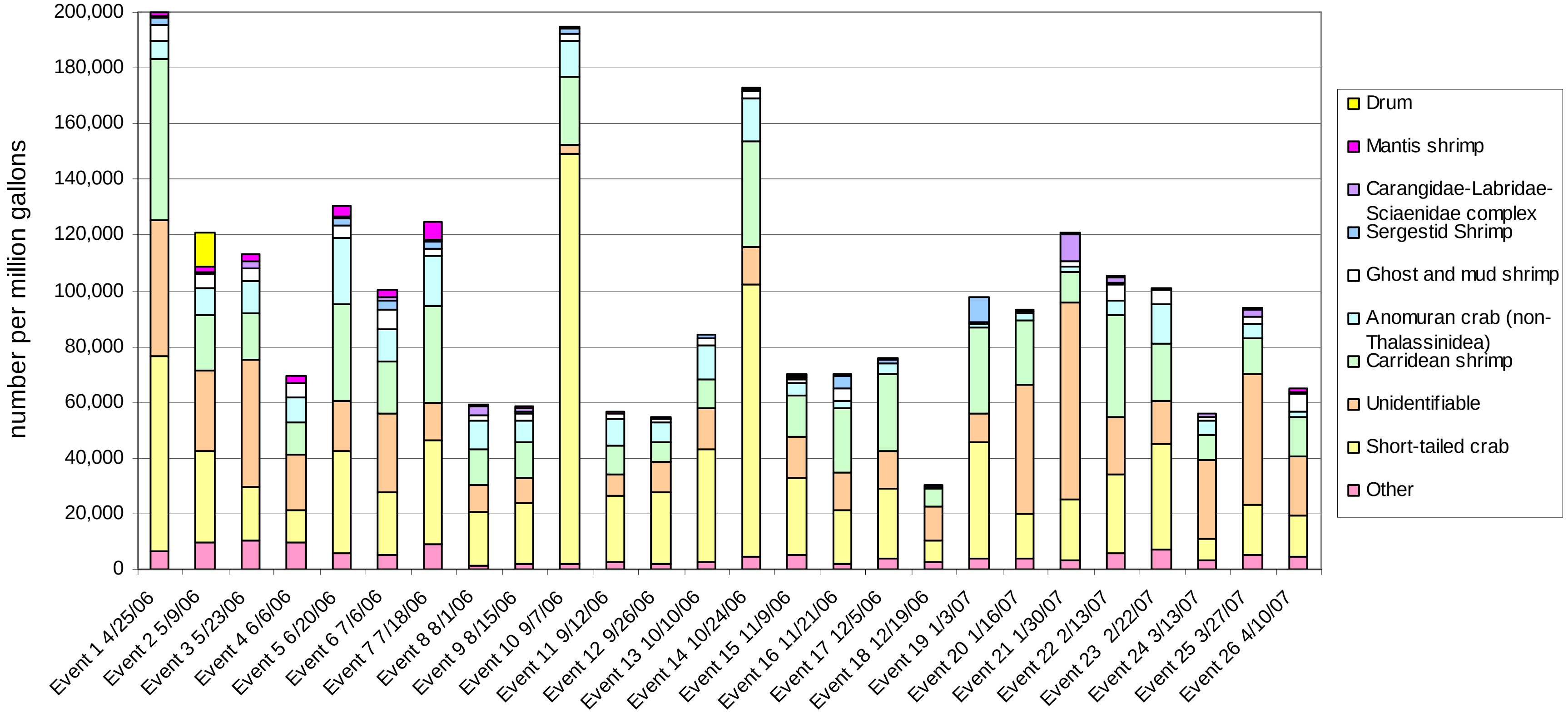


Figure 5-9 Seasonal Variation in Entrainment

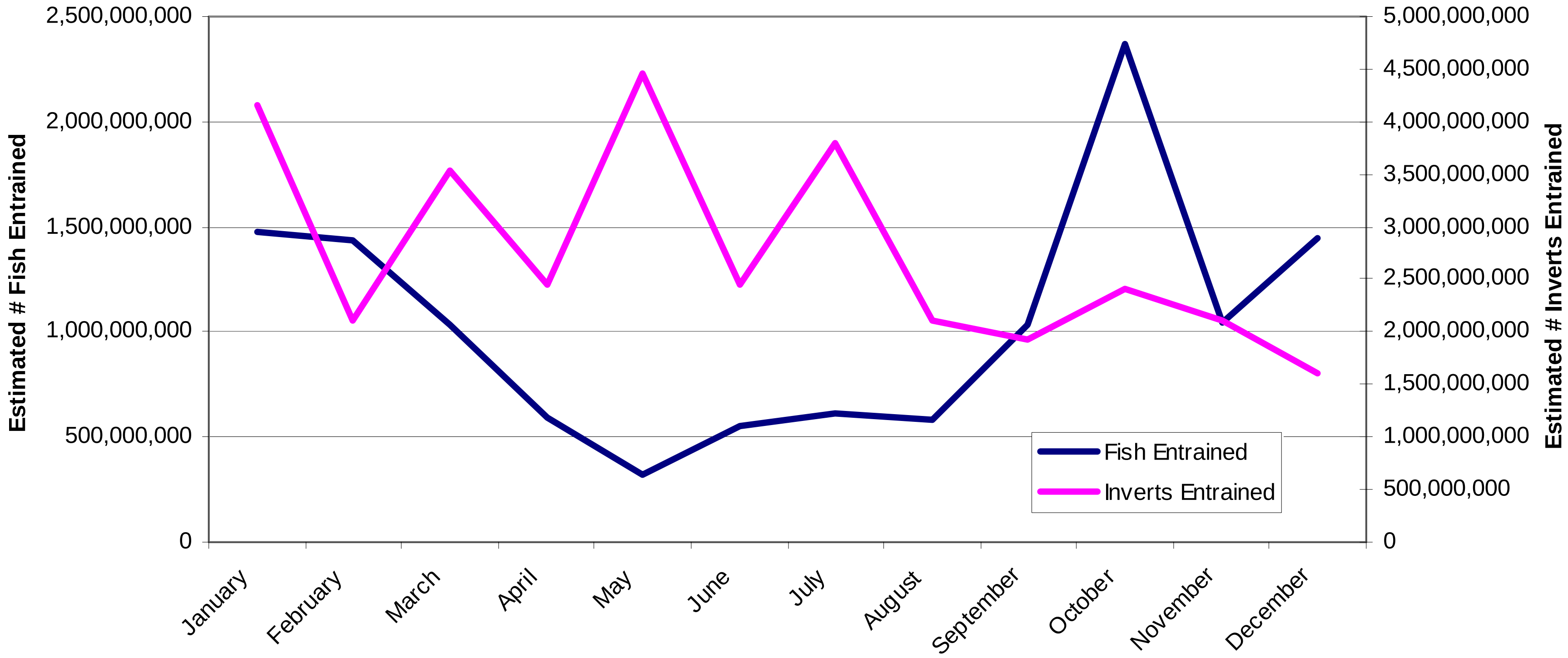
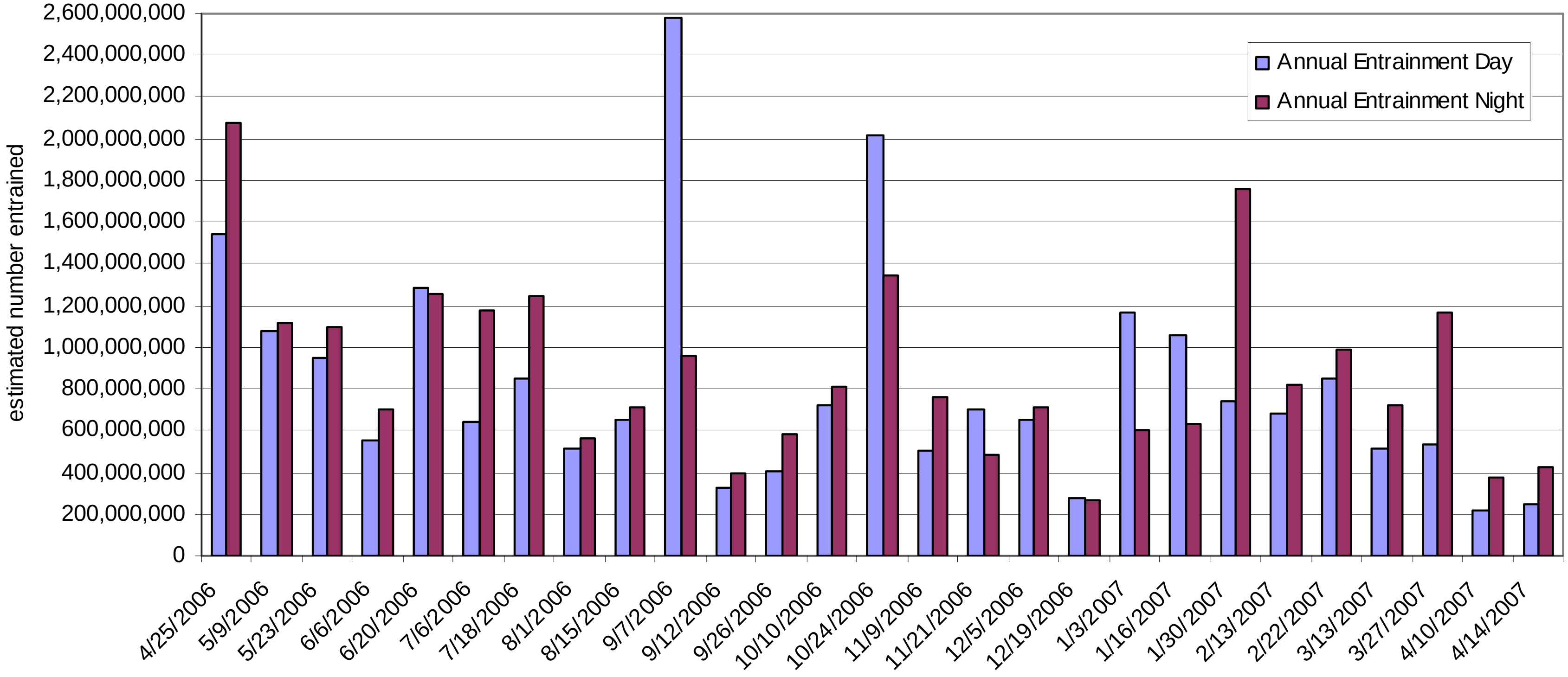


Figure 5-10 Diel Variation in Entrainment



*Data extrapolated to account for inter-event water withdrawal. Dates are interval mid-points.

Appendix A

Species List

Impingement Species List	
Fish	
Abudefduf saxatilis	Sergeant major
Acanthostracion quadricornis	Scrawled cowfish
Achirus lineatus	Lined sole
Aetobatus narinari	Spotted eagle ray
Albula sp.	Bonefish
Aluterus scriptus	Scrawled filefish
Anchoa hepsetus	Broad-striped anchovy
Anchoa lamprotaenia	Big-eye anchovy
Anchoa lyolepis	Dusky anchovy
Anchoa mitchilli	Bay anchovy
Anchoa sp.	Anchovy
Anchoviella perfasciata	Flat anchovy
Anisotremus virginicus	Porkfish
Antennarius striatus	Striated frogfish
Apogon binotatus	Barred cardinalfish
Apogon maculatus	Flamefish
Apogon sp.	Cardinalfish
Ariopsis felis	Hardhead catfish
Astrapogon alutus	Bronze cardinalfish
Astroscopus guttatus	Northern stargazer
Astroscopus y-graecum	Southern stargazer
Bairdiella chrysoura	Silver perch
Bothus ocellatus	Eyed flounder
Brevoortia tyrannus	Atlantic menhaden
Calamus arctifrons	Grass porgy
Canthigaster rostrata	Sharpnose pufferfish
Caranx hippos	Crevalle jack
Caranx latus	Horse-eye jack
Centropomus undecimalis	Common snook
Chaetodipterus faber	Atlantic spadefish
Citharichthys spilopterus	Bay whiff
Clupeidae	Herring
Coryphopterus dicrus	Colon goby
Dactylopterus volitans	Flying gurnard
Diodon holocanthus	Hairy porcupinefish
Diodon hystrix	Porcupinefish
Diplectrum bivittatum	Dwarf sand perch
Diplodus argenteus	Silver porgy
Elops saurus	Ladyfish
Eucinostomus argenteus	Silver mojarra
Eucinostomus gula	Jenny mojarra
Eucinostomus harengulus	Tidewater mojarra
Eucinostomus jonesii	Slender mojarra
Eucinostomus lefroyi	Mottled mojarra
Eucinostomus sp.	Mojarra

Impingement Species List	
Euleptorhamphus velox	Flying halfbeak
Gobiosoma robustum	Code goby
Gymnothorax vicinus	Purplemouth moray
Haemulon aurolineatum	Tomtate
Haemulon chrysargyreum	Smallmouth grunt
Haemulon parra	Sailor's choice
Haemulon sp.	Grunt
Hippocampus erectus	Lined seahorse
Hippocampus sp.	Seahorse
Histrio histrio	Sargassumfish
Hypleurochilus aequipinnis	Oyster blenny
Hypleurochilus bermudensis	Barred blenny
Hypleurochilus geminatus	Crested blenny
Hypoatherina harringtonensis	Reef silverside
Jenkinsia lamprotaenia	Dwarf herring
Kyphosus sectatrix	Bermuda chub
Lachnolaimus maximus	Hogfish
Lobotes surinamensis	Tripletail
Lupinoblennius nicholsi	Highfin blenny
Menidia sp.	Silverside
Microphis brachyurus	Opossum pipefish
Monacanthus sp.	Filefish
Mugil curema	White mullet
Mugil sp.	Mullet
Mycteroperca microlepis	Gag
Ophidion sp.	Cusk-eel
Pareques acuminatus	High-hat
Phaeoptyx conklini	Freckled cardinalfish
Phaeoptyx pigmentaria	Dusky cardinalfish
Phaeoptyx sp.	Cardinalfish
Phaeoptyx xenus	Sponge cardinalfish
Poecilia latipinna	Sailfin molly
Pomacanthus arcuatus	Grey anglefish
Prionotus scitulus	Leopard searobin
Sardinella aurita	Spanish sardine
Scophthalmus aquosus	Sand dab
Scorpaena bergii	Goosehead scorpionfish
Scorpaena grandicornis	Plumed scorpionfish
Scorpaena sp.	Scorpionfish
Selene vomer	Lookdown
Sparisoma chrysopterum	Redtail parrotfish
Sphoeroides nephelus	Southern puffer
Sphoeroides sp.	Puffer
Sphoeroides spengleri	Bandtail puffer
Sphoeroides testudineus	Checkered puffer
Stephanolepis hispida	Planehead filefish
Strongylura marina	Atlantic needlefish

Impingement Species List	
Strongylura notata	Redfin needlefish
Syngnathus louisianae	Chain pipefish
Syngnathus pelagicus	Sargassum pipefish
Syngnathus scovelli	Gulf pipefish
Trinectes inscriptus	Scrawled sole
Trinectes maculatus	Hogchoker
Tylosurus crocodilus	Houndfish
Unidentifiable	N/A
Xyrichtys novacula	Pearly razorfish
Invertebrates	
Alpheidae	Snapping shrimp
Alpheus sp.	Pistol shrimp
Aplysia sp.	Seahare
Arenaeus cribrarius	Speckled crab
Argopecten irradians	Atlantic bay scallop
Callinectes ornatus	Ornate blue crab
Callinectes sapidus	Blue crab
Callinectes similis	Lesser blue crab
Callinectes sp.	Swimming crab
Caridea	Carridean shrimp
Cymatium pileare	Hairy triton
Dromidia antillensis	Decorator crab
Farfantepenaeus aztecus	Brown shrimp
Farfantepenaeus duorarum	Pink shrimp
Farfantepenaeus sp.	Panaeid shrimp
Goniopsis sp.	Mangrove crab
Libinia dubia	Longnose spider crab
Libinia sp.	Spider crab
Lolliguncula brevis	Atlantic brief squid
Menippe mercenaria	Florida stone crab
Menippe nodifrons	Cuban stone crab
Mithrax caribbaeus	Clinging crab
Mithrax sculptus	Green clinging crab
Mithrax sp.	Clinging crab
Mithrax verrucosus	Paved clinging crab
Palaemonidae	Grass shrimp
Panopeus sp.	Mud crab
Penaeidae	Penaeid shrimp
Penaeus sp.	Penaeid shrimp
Pilumnus dasypodus	Short-spined hairy crab
Portunidae	Portunid crab
Portunus depressifrons	Flatface swimming crab
Portunus ordwayi	Redhair swimming crab
Portunus sayi	Sargassum swimming crab
Portunus sp.	Portunid crab
Portunus spinicarpus	Longspine spinning crab
Portunus spinimanus	Blotched swimming crab

Impingement Species List	
Rhithropanopeus sp.	Mud crab
Rimapenaeus constrictus	Roughneck shrimp
Rimapenaeus sp.	Penaeid shrimp
Sepioteuthis sepioidea	Caribbean reef squid
Sicyonia typica	Kinglet rock shrimp
Squillidae	Mantis shrimp
Stenorhynchus sp.	Arrow crab
Teuthoidea	Squid
Thalassinidea	Ghost and mud shrimp
Xanthidae	Xanthid crab

Entrainment Species List	
Fish	
Acanthuridae	Surgeonfish
Achirus lineatus	Lined sole
Anchoa mitchilli	Bay anchovy
Apogonidae	Cardinalfish
Astrapogon puncticulatus	Blackfin cardinalfish
Atheriniformes	Silversides
Atherinomorus stipes	Hardhead silverside
Bathygobius soporator	Frillfin goby
Blenniidae	Combtooth blenny
Blennioidei	Blenny
Bothidae	Lefteye flounder
Callionymidae	Dragonet
Caproidae	Boarfish
Carangidae	Jack
Carangidae-Haemulidae-Labridae-Sciaenidae complex	Jack-Grunt-Wrasse-Drum complex
Carangidae-Haemulidae-Merluccidae-Paralichthyidae-Sciaenidae-Serranidae complex	Jack-Grunt-Hake-Flounder-Drum-Grouper complex
Carangidae-Haemulidae-Merluccidae-Paralichthyidae-Serranidae complex	Jack-Grunt-Hake-Flounder-Grouper complex
Carangidae-Haemulidae-Paralichthyidae-Sciaenidae-Serranidae complex	Jack-Grunt-Flounder-Drum-Grouper complex
Carangidae-Haemulidae-Paralichthyidae-Serranidae complex	Jack-Grunt-Flounder-Grouper complex
Carangidae-Haemulidae-Sciaenidae complex	Jack-Grunt-Drum complex
Carangidae-Haemulidae-Sciaenidae-Serranidae complex	Jack-Grunt-Drum-Grouper complex
Carangidae-Kyphosidae complex	Jack-Chub complex
Carangidae-Labridae-Paralichthyidae-Sciaenidae complex	Jack-Wrasse-Flounder-Drum complex
Carangidae-Labridae-Scaridae complex	Jack-Wrasse-Parrotfish complex

Entrainment Species List	
Carangidae-Labridae-Sciaenidae complex	Jack-Wrasse-Drum complex
Carangidae-Paralichthyidae-Sciaenidae-Serranidae complex	Jack-Flounder-Drum-Grouper complex
Carangidae-Serranidae complex	Jack-Grouper complex
Ceratoscopelus sp.	Lanternfish
Cerdale floridana	Pugjaw wormfish
Chaenopsidae	Flag blenny
Chasmodes saburrae	Florida blenny
Clupeidae	Herring
Clupeiformes	Anchovies and herrings
Cottidae	Sculpin
Ctenogobius boleosoma	Darter goby
Cyclothone sp.	Bristlemouth
Cynoscion nebulosus	Spotted weakfish
Dactyloscopidae	Stargazer
Diplogrammus pauciradiatus	Spotted dragonet
Dormitator maculatus	Fat sleeper
Eleotridae	Sleeper
Engraulidae	Anchovy
Gerreidae	Mojarra
Gobiesocidae	Clingfish
Gobiesox strumosus	Skilletfish
Gobiidae	Goby
Gobiosoma bosc	Naked goby
Gobiosoma robustum	Code goby
Haemulidae	Grunt
Haemulidae-Labridae-Sciaenidae complex	Grunt-Wrasse-Drum complex
Haemulidae-Paralichthyidae-Sciaenidae-Serranidae complex	Grunt-Flounder-Drum-Grouper complex
Haemulidae-Sciaenidae-Serranidae complex	Grunt-Drum-Grouper complex
Labridae	Wrasse
Labridae-Paralichthyidae-Sciaenidae complex	Wrasse-Flounder-Drum complex
Labridae-Sciaenidae complex	Wrasse-Drum complex
Labrisomidae	Labrisomid blenny
Lagodon rhomboides	Pinfish
Lutjanidae	Snapper
Menticirrhus sp.	Kingfish
Microdesmidae	Dartfish
Microgobius gulosus	Clown goby
Micropogonias undulatus	Atlantic croaker
Monacanthidae	Filefish
Myctophidae	Lanternfish
Nomeidae	Driftfish
Ophioblennius macclurei	Redlip blenny
Orthopristis chrysoptera	Pigfish

Entrainment Species List	
Parablennius marmoreus	Seaweed blenny
Paralichthyidae	Flounder
Paralichthyidae-Sciaenidae complex	Flounder-Drum complex
Paralichthyidae-Sciaenidae-Serranidae complex	Flounder-Drum-Grouper complex
Perciformes	Perch-like fishes
Pleuronectiformes	Flatfishes, flounders and soles
Pomacentridae	Damselfish
Scaridae	Parrotfish
Sciaenidae	Drum
Sparidae	Porgy
Sphyraenidae	Barracuda
Syngnathidae	Pipefish
Syngnathus louisianae	Chain pipefish
Tetradontidae	Pufferfish
Tetraodontiformes	Filefish
Triglidae	Searobin
Unidentifiable	N/A
Invertebrates	
Albunea sp.	Mole crab
Alpheus sp.	Pistol shrimp
Anomura	Anomuran crab (non-Thalassinidea)
Arcidae	Arc clam
Brachyura	Short-tailed crab
Callinectes sapidus	Blue crab
Callinectes sp.	Swimming crab
Caridea	Carridean shrimp
Emerita sp.	Mole crab
Emerita talpoida	Common mole crab
Farfantepenaeus aztecus	Brown shrimp
Farfantepenaeus duorarum	Pink shrimp
Farfantepenaeus sp.	Panaeid shrimp
Hippolyte sp.	Hippolyte Shrimp
Latreutes fucorum	Slender sargassum shrimp
Lepidopa sp.	Mole crab
Loliginidae	Loliginid squid
Loligo pealeii	Longfin inshore squid
Loligo sp.	Loliginid squid
Lolliguncula brevis	Atlantic brief squid
Mactridae	Surf clam
Menippe mercenaria	Florida stone crab
Menippe sp.	Stone crab
Mytilidae	Mussel
Palinurellus sp.	Furry lobster
Palinuroidea	Palinuroid lobster
Panopeidae	Crab
Penaeidae	Penaeid shrimp
Scyllaridae	Slipper lobster

Entrainment Species List	
Scyllarus americanus	American slipper lobster
Scyllarus sp.	Slipper lobster
Sergestoidea	Sergestid Shrimp
Squilla empusa	Mantis shrimp
Squilla sp.	Mantis shrimp
Thalassinidea	Ghost and mud shrimp
Unidentifiable shrimp	Shrimp
Upogebia affinis	Coastal mud shrimp

ATTACHMENT 6

AB-582

BIOLOGICAL IMPACT ASSESSMENT OF THERMAL DISCHARGES
FROM FLORIDA POWER & LIGHT COMPANY'S
PORT EVERGLADES PLANT,
BROWARD COUNTY, FLORIDA

Prepared for

FLORIDA POWER & LIGHT COMPANY
JUNO BEACH, FLORIDA

MAY 1987

Prepared by

APPLIED BIOLOGY, INC.
DECATUR, GEORGIA

TABLE OF CONTENTS

In addition to existing state and federal operating license permits for the Port Everglades Plant, FPL has recently been required to obtain an Industrial Wastewater Permit from Broward County. As a result of this new permitting requirement, FPL requested ABI to provide an updated assessment of thermal impacts at their Broward County plants. The revised impact assessment, presented herein, incorporates a review of data collected during 1975, results of a new biological survey, and an analysis of long-term biological changes related to power plant operation. This information is intended to assist reviewers in evaluating the merits and liabilities of amending/exempting thermal criteria from FPL's Broward County permits for industrial wastewater discharges.

2.2 Materials and Methods

Timing constraints precluded establishment of a one-year monitoring program similar to the one conducted in 1975. Instead, a single set of samples was collected on 13 March 1987. Benthic collections made during April 1975 were used for comparative purposes. Historically, spring collections contained larger numbers of individuals and species than collections taken during other seasons.

To facilitate data comparisons between 1975 and 1987, sampling methodologies remained unchanged. Five replicates were collected at each station using a Ponar grab sampling a surface area of 6 x 6 inches. Each replicate was sieved in the field through a US Standard Sieve No. 30 (0.595 mm) and preserved in a 10 percent buffered formalin solution. Rose bengal dye was added to facilitate sorting. In the lab, stained organisms were hand-sorted and identified to the lowest practicable taxon. Numbers of individuals were recorded for each species present in a replicate. However, for reporting purposes, data from all five replicates were combined.

Fishes captured by minnow traps were significantly more abundant in the intake canal than in the discharge canal, while the reverse was true for shellfish. Discharge water temperatures generally exceeded intake temperatures by 2°-6°C, suggesting that observed distributional patterns were thermally influenced. However, distinct habitat differences also existed between the intake canal, with its deep channel and steeply sloping rock walls, and the mangrove-lined shores of the more shallow discharge canal. The relative importance of water temperature versus habitat in structuring fish and shellfish communities in the plant canal system could not be determined from data generated during the study. Considering the physically dynamic nature of the study area and the water quality impacts resulting from industrialization of the adjacent deep-water port, it was concluded that thermal discharges were probably of minor significance in affecting the overall distribution and abundance of fish and shellfish near the plant.

Benthos - Benthic communities in the vicinity of the Port Everglades Plant during 1975 were composed primarily of polychaete worms, crustaceans and bivalve and gastropod molluscs. In both intake and discharge areas, densities, diversity and biomass of these assemblages were uncharacteristically low for a typical estuarine system. Again, industrialization of the port area and habitat alteration associated with residential development were thought to be primarily responsible.

During 1975, benthic community characteristics were compared among thermally altered and unaffected stations. During the summer, species

3.2 Results of 1987 Monitoring

During March 1987, three of the five Port Everglades stations sampled during 1975 were resampled (Figure 1). Station 2 in the discharge canal represented an area continually exposed to thermal effluents, while Stations 3 and 4 in the ICW represented unaffected or marginally affected areas.

March 1987 collections yielded 1656 individuals, representing 65 taxa (Table 1). Annelids accounted for about 92 percent of all individuals collected. The remaining organisms were composed primarily of crustaceans and miscellaneous taxa such as nemerteans and nematodes. Very few molluscs were contained in the samples.

Station 2 supported only about one fourth of the number of species found at either Station 3 or Station 4 in the adjacent ICW. Similarly, the density of benthic organisms was an order of magnitude lower in the discharge canal than in the ICW. Polychaetes, particularly members of the family Cirratulidae (e.g., *Tharyx* cf. *annulosus*), accounted for over 90 percent of all individuals collected in the ICW, but contributed only 56 percent of the total abundance in the discharge canal. The most abundant macroinvertebrate at Station 2 was the polychaete *Glycera abranchiata*.

Diversity (H') measures both the number of species present in a sample and the relative apportionment of individuals among those species (Lloyd, Zar and Karr, 1968). An assemblage containing many species each estuarine benthic assemblages; thus, reductions in density do not necessarily imply long-term deterioration of water quality (Coull, 1985; Holland, 1985). Stations 3 and 4, for example, were under similar influences of thermal discharges, yet densities increased at one station between 1975 and 1987 and decreased at the other. Annual variability in overall community density naturally results from population fluctuations among constituent species. Nothing in the density data suggests major shifts in ICW community structure resulting from long-term exposure to thermal effluents. However, low densities at Station 2 during both 1975 and 1987 sampling periods indicate persistent stressful conditions in the discharge canal.

Although very few species identified in 1975 samples were collected again during 1987, overall community structure was generally similar. Polychaetes predominated at most stations during both years. Only at Station 4 did a major shift occur. The crustacean Cylindroleberis mariae (Ostracoda) was the numerical dominant in 1975, whereas the polychaete Tharyx cf. annulosus predominated in 1987. As in 1975, relatively few molluscs were collected at any station near the Port Everglades Plant during 1987.

There was about a two- to three-fold increase in species richness at ICW stations over the 12-year period (Table 2). Species richness at Station 2 was about the same in 1987 as in 1975, even though the species composition changed between years.

mal impacts, the following analysis assumes that observed community characteristics in the discharge canal are a consequence of power plant discharges.

Thermal impacts at the Port Everglades Plant appear to be confined to the immediate discharge canal. Temperature profiles made during March 1987 benthic monitoring showed little variability in water temperatures between the plant and the point of discharge at the ICW. This suggests that heat is slowly dissipated from thermal effluents as they flow through the discharge canal. However, within the ICW only a short distance downstream from the point of discharge (Station 3), bottom water temperatures were similar to an unexposed upstream area (Station 4; Table 3). This data further suggests that effluents are dispersed as a surface plume within the ICW and thus probably exert little stress on benthic organisms.

Surface temperatures at Station 3 were 2.5°C higher than bottom temperatures but 1.5°C below surface temperatures measured at the point of discharge. Because of the physically dynamic nature of the ICW and its large volume relative to the discharge canal, heat dissipation is probably rapid once effluents mix with receiving waters. However, a systematic study of water temperatures over different tidal cycles and climatic conditions would be necessary to define the exact dispersion area of the thermal plume. Regardless of distribution its impact on benthic communities in the ICW is probably negligible.

ments and heavy boat traffic creates chronic bottom turbulence and turbidity problems. Collectively these factors probably exert considerable stress on resident communities within the ICW. It has already been documented that benthic communities in the vicinity of the Port Everglades Plant contain fewer species than is typical for estuarine habitats. Given the proximity of the plant to the Port Everglades ship channel and the high flushing potential, a much more diverse assemblage of organisms should be expected.

Coupled with anthropogenic (man-made) factors are a suite of natural physical variables, such as substrate type, salinity, temperature and dissolved oxygen (DO). In 1975, salinities in the study area varied from 12 to 32 ppt, a considerable range considering the proximity of the plant to the Port Everglades ship channel and oceanic waters. Because of the great variety of factors influencing the structure of benthic communities near the plant, it is extremely difficult to segregate plant effects from other unrelated structuring mechanisms. However, based on data collected in 1975 and 1987, it appears that outside of the immediate discharge canal, thermal effluents have relatively little impact on benthic communities.

5.0 LITERATURE CITED

ABI. 1976. Ecological parameter monitoring at the Port Everglades Plant. Prepared for Florida Power & Light Co., Miami. Applied Biology, Inc., Decatur, GA.

Bader, R.G. and M.A. Roessler. 1972. An ecological study of south Biscayne Bay and Card Sound. Progress report to US Atomic Energy Commission (AT(40-1)-3801-4). Rosenstiel School of Marine and Atmospheric Science, University of Miami. Coral Gables, FL.

Coull, B.C. 1985. The use of long-term biological data to generate testable hypotheses. Estuaries 8, 84-92.

EPA. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. (EPA 670/4-73-001). C.I. Webber (ed). Environmental Protection Agency, National Environmental Research Center, Cincinnati, OH.

Holland, A.F. 1985. Long-term variation of macrobenthos in a mesohaline region of Chesapeake Bay. Estuaries 8, 93-113.

Lloyd, M., J.H. Zar and J.R. Karr. 1968. On the calculation of information-theoretical measures of diversity. Amer. Mid. Natur. 79 (2): 257-272.

Naylor, E. 1965. Effects of heated effluents upon marine and estuarine organisms. In F.S. Russell (ed.), Advances in marine biology, Vol. 3, p. 63-103. Academic Press, NY.

Virnstein, R.W. 1972. Effects of heated effluent on density and diversity of benthic infauna at Big Bend, Tampa Bay, Florida. M.S. Thesis, University of South Florida, Tampa, FL. 60 pp.

TABLE 1

BENTHIC MACROINVERTEBRATES COLLECTED MARCH 1987
PORT EVERGLADES PLANT, BROWARD COUNTY, FLORIDA

Taxon	Station Number 2	3	4
PHYLUM NEMERTINEA			
Nemertinea spp.	7	19	12
PHYLUM NEMATODA			
Nematoda spp.	2	9	
PHYLUM ANNELIDA			
CLASS POLYCHAETA			
Aricidea philbinae	1	39	11
Aricidea taylori			1
Aricidea spp.			1
Armandia agilis	1		
Capitella capitata		2	
Capitellidae spp.		1	
Caulleriella spp.		80	10
Cirratulidae genus A		9	
Cirratulidae spp.		37	7
Cossura delta		26	3
Dasybranchus lumbricoides		1	
Eusyllinae sp. A		37	27
Fabricia sp. A		9	
Glycera abranchiata	15	6	3
Lumbrineris verrilli		20	25
Magelona spp.		1	
Mediomastus spp.		7	35
Neanthes acuminata			1
Notomastus spp.		39	14
Phyllodoce arenae			1
Piromis roberti		2	
Paraonidae spp.		2	
Prionospio cristata	2		79
Prionospio dayi		1	
Prionospio spp.		2	1
Sigambra tentaculata		1	
Spio pettiboneae		3	3
Spionidae spp.			1
Syllidae spp.			1
Syllides verrilli		1	
Tharyx cf. *annulosus*		482	357
CLASS OLIGOCHAETA			
Oligochaeta spp.		103	21

TABLE 2

COMPARISON OF BENTHIC COMMUNITY CHARACTERISTICS
PORT EVERGLADES PLANT
1975 AND 1987

Parameter	Station 2		Station 3		Station 4	
	1975	1987	1975	1987	1975	1987
Total Number of Individuals	98	34	468	964	952	658
Density/m^2	844	293	4030	8301	8198	5666
Total Number of Species	12	10	13	44	18	40
Mean Number of Species/Replicate	4.2	3.6	7.6	19.6	8.0	16.4
Diversity (H')	3.12	2.55	3.12	2.92	2.30	2.80
Evenness (J')	.87	.77	.84	.54	.55	.53