RAVENSWOOD POWER STATION
ENTRAINMENT AND IMPINGEMENT MONITORING

MARCH 2005 –FEBRUARY 2006

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REPORT SUMMARY

An entrainment and impingement monitoring program was conducted at the Ravenswood Power Station ("Ravenswood" or "Station") from 2 March 2005 through 21 February 2006 to fulfill a State Pollution Discharge Elimination Pennit (SPDES) requirement to conduct a one-year study to estimate the numbers of fish and selected invertebrates entrained and impinged at Ravenswood.

Ravenswood Power Station is a steam-electric generating facility that is owned and operated by KeySpan-Ravenswood, Inc. ("KeySpan"). The Station is located in Long Island City, Queens County, New York and is situated along the east bank of the lower East River. Ravenswood consists of three oil-fired, steam-electric generating units which utilize a non-contact, once-through cooling water system. The operating units, Units 10, 20, and 30, have a combined nominal rated capacity of 1,742 MWe and a design flow of 964,000 gpm (5,255,000 m^3/day). Cooling water is withdrawn from the East River into a protected embayment and to the intake structures. The intake structures are screened by wooden debris skimmers and conventional vertical traveling screens incorporating screen panels of 3/8-inch square opening vertical mesh.

Entrainment monitoring for the early life stages of fish and shellfish was conducted at Ravenswood weekly from 8 March through 30 September 2005, and then once every two weeks through 21 February 2006. One entrainment collection each for fish and shellfish was made during each 6-hour interval over the 24-hour sampling period resulting in 4 entrainment collections for fish and 4 entrainment collections for shellfish on each sampling date. Cooling water was pumped from the combined discharge canal at Ravenswood using a gasoline-powered pump with a pipe extending to mid-depth in the canal. Each entrainment collection for fish consisted of at least 100 m^3 of water and sampling typically lasted 2 hours. Entrainment samples for shellfish using a were collected concurrently with samples for fish and generally consisted of 7-8 m^3 of water.

Special entrainment studies were also conducted to examine the depth distribution and diel variation of the early life stages of fish entrained at Ravenswood. These entrainment samples were collected from surface, mid-, and bottom depths immediately in front of the center of the Unit 20 intake on a total of ten survey days, scheduled during peak seasonal periods of entrainment. One entrainment collection was made during each 3-hour interval over the 24-hour sampling period resulting in 8 entrainment collections from each of the three depths for a total of 24 samples per day on each sampling date.

For all entrainment sampling, water was pumped from the sampling location to a circular tank equipped with a 75-cm diameter plankton net with 335-μm mesh netting for the fish entrainment collections. For the shellfish entrainment collections, a fraction of the exit water from the circular tank was subsequently filtered through a 60-μm mesh net suspended in a similar barrel sampler. At the completion of each collection, the tanks were drained and the nets were carefully washed to concentrate all materials collected into the collection cups. Samples were placed in glass jars, preserved, stained, labeled, and transported to the laboratory for processing.

Impingement monitoring was conducted weekly at Ravenswood throughout the study period from 2 March 2005 through 21 February 2006. Samples consisted of all materials washed off

the intake traveling screens and collected in a 5/16-inch mesh collection basket at the screen wash water debris sump for Units 10, 20, and 30. All impinged fish and selected invertebrates were removed and identified to taxon (typically species) and age group. The total count and weight of each taxon and age group were recorded. A random sub-sample of up to 50 individuals collected from each taxon and age group were measured to the nearest millimeter and their condition recorded. A separate study of collection efficiency utilizing releases of test fish was also conducted.

Twenty-seven distinct taxonomic groups of fish were collected in entrainment sampling at Ravenswood, and 21 of these were identified to species. Post yolk-sac larvae were the most commonly entrained life stage (56 percent), followed by eggs (31 percent). Five taxa (grubby, Gobiidae, bay anchovy, fourbeard rockling, and unidentified Clupeiformes) comprised about two-thirds of the total entrainment catch. No overall patterns were discernable in the entrainment depth distribution and diel variation studies for commonly entrained species and all species combined.

Fifty-two distinct species of fish were collected in impingement sampling. Yearling and older fish made up the majority (56 percent) of impinged fish, and contributed 83 percent by weight. The top three species (blueback herring, alewife, and bay anchovy) accounted for about 45 percent of the total number impinged. Blue crab dominated targeted macroinvertebrate counts, with 98 percent of the total. Initial impingement survival varied widely by species (0 to 100 percent), and averaged 5.1 percent for all young of year fish and 21 percent for yearling and older fish. Diel variation studies showed that collections of yearling and older fish were greatest in the late evening hours. Most of the young of year fish were collected in the early morning hours. Impingement collection was consistently lowest during the mid-day.

Direct losses from entrainment and impingement at the Ravenswood intake were estimated for all species based on their sample densities and actual plant flows during the study period. Total entrainment was estimated to be 149,722,760 individuals for the year, and total impingement was 25,842 individuals. Estimates of annual losses for each species were also made utilizing full design flow at the Station.

3 MATERIALS AND METHODS

Entrainment and impingement monitoring at the Ravenswood Power Station began 2 March 2005 and ran through 21 February 2006. In general, sampling was conducted over one 24-hour period each week. Sampling protocols adhered to carefully defined Standard Operating Procedures (SOPs) (ASA 2005). The following provides a brief overview of each monitoring program.

3.1 ENTRAINMENT MONITORING

Entrainment monitoring for the early life stages of fish and shellfish was conducted at Ravenswood weekly from 8 March through 25 October 2005, and then once every two weeks through 21 February 2006. One entrainment collection each for fish and shellfish was made during each 6-hour interval over the 24-hour sampling period resulting in 4 entrainment collections for fish and 4 entrainment collections for shellfish on each sampling date. A total of 160 entrainment samples for fish and 149 entrainment samples for shellfish from Ravenswood were successfully collected (Table 3-1). Shellfish samples were not collected in early March because the sampling equipment was on backorder. Entrainment monitoring and shellfish samples were not collected for four weeks in early April and early to mid-May due to a malfunction in the discharge sampling pipe.

Sampling was conducted using a pumped entrainment sampler. Cooling water was pumped from the combined discharge canal at Ravenswood using a gasoline-powered pump with a pipe extending to mid-depth in the canal. Each entrainment collection for fish consisted of at least 100 m^3 of water and sampling typically lasted 2 hours. Entrainment samples for shellfish were collected concurrently with samples for fish and generally consisted of 7-8 m^3 of water.

Special studies were also conducted to examine the depth distribution and diel variation of the early life stages of fish entrained at Ravenswood. These entrainment samples were collected from surface, mid-, and bottom depths immediately in front of the center of the Unit 20 intake on a total of ten survey days, scheduled during peak seasonal periods of entrainment. One entrainment collection was made during each 3-hour interval over the 24-hour sampling period resulting in 8 entrainment collections from each of the three depths for a total of 24 samples per day on each sampling date. For this special study, a total of 241 entrainment samples for depth distribution and diel variation from Ravenswood were successfully collected (Table 3-1).

For all entrainment sampling, water was pumped from the sampling location to a circular tank equipped with a 75-cm diameter plankton net with 335-μm mesh netting for the fish entrainment collections. For the shellfish entrainment collections, a fraction of the exit water from the circular tank was subsequently filtered through a 60-μm mesh net suspended in a similar barrel sampler. At the completion of each collection, the tanks were drained and the nets were carefully washed to concentrate all materials collected into the collection cups. After a thorough wash-down, the collected materials (plankton and detritus) were removed from the cups, placed in glass jars, and preserved with 10 percent Formalin containing Rose Bengal dye. Each jar was then carefully labeled and transported to the laboratory for subsequent processing.

In the laboratory, the shellfish samples were archived and will not be processed unless or until appropriate and meaningful analytical protocols are developed. From the fish samples, all fish eggs, larvae and juveniles were carefully sorted from sample detritus and invertebrates. When numbers of ichthyoplankters was high, samples were randomly split using a Motota plankton-splitter and a sufficient number of splits were analyzed such that a minimum of 200 fish eggs and/or 200 fish larvae/juveniles had been sorted. For ichthyoplankters except winter flounder larvae, all specimens removed from each sample were identified to the lowest practical taxon and separated into the following life stages:

Egg – The embryonic developmental stages from spawning to hatching.

Yolk-sac larvae – The transition stage from hatching through the development of a complete, functional digestive system (regardless of the degree of yolk and/or oil globule retention).

Post yolk-sac larvae – The transition stage from development of a complete, functional digestive system to transformation to juvenile form (regardless of the degree of yolk and/or oil globule retention), including the leptocephalus stage of eels.

Juvenile – The stage following completion of a full complement of fin rays up to 12 months of age.

Winter flounder larvae were further classified into the following four stages for comparability to other winter flounder monitoring being conducted in Long Island Sound:

Stage 1 – from hatching until the yolk-sac is fully absorbed

Stage 2 – from the end of Stage 1 until the fin rays begin to develop and flexion of the notochord begins

Stage 3 – from the end of Stage 2 until the left eye migrates past the midline of the head during transformation, and

Stage 4 – from the end of Stage 3 to metamorphosis to a juvenile.

In addition, a random sample of up to 50 winter flounder larvae was measured to the nearest 0.1 mm (TL). For the other entrained larval species, length measurements to the nearest 0.1 mm (TL) were taken from up to 30 individuals per species per life stage.

The results of this laboratory processing including counts and lengths were recorded on project-specific data sheets. All laboratory processing was subject to a statistically-based quality control process based on a continuous sampling plan (derived from military-standard MIL-STD 1235B) that guarantees an Average Outgoing Quality Level (AOQL) of 90 percent or more. That is, samples selected based on the continuous sampling plan are re-inspected to assure that more than 90 percent of organisms have been removed during sorting and that an accuracy of at least 90 percent is achieved in identifying, assigning a life stage, or counting any species. Samples not achieving these acceptance limits are rejected and reprocessed.

3.2 IMPINGEMENT MONITORING

Impingement monitoring was conducted weekly from 2 March 2005 through 21 February 2006 at Ravenswood. During most weeks through October, one impingement collection was made during each 6-hour interval over the 24-hour sampling period, resulting in 4 impingement collections on each sampling date. Once per month for the other weeks, the sampling interval was shortened to 2 hours for a total of 12 impingement collections on the sampling date. From November through February, 12 samples were collected per sampling date. Samples consisted of all materials washed off the intake traveling screens and collected in a collection basket at the screen wash water debris sump for Units 10, 20, and 30 at Ravenswood. Over the study period, a total of 392 impingement samples from Ravenswood were successfully collected (Table 3-1).

A collection basket consisting of 5/16-inch mesh was placed in the debris sumps at the intakes of each unit at the start of each sampling event to intercept all screen wash water from the continuously washed screens. At the completion of each 6-hour or 2-hour impingement collection, the impinged materials were then extracted from each collection basket. All fish and selected invertebrates (blue crab, rock crab, American lobster, mantis shrimp, long-finned squid, and Japanese shore crab) were removed and identified to taxon (typically species) and age group (young of year or yearling and older). The total count and weight of each taxon and age group were recorded on project-specific data sheets. In addition, a random sample of up to 50 individuals collected from each sample, each fish taxon as well as blue crab and American lobster, and each age/length group were measured to the nearest millimeter and their condition (live, stunned, dead) was recorded.

In addition to the regularly scheduled impingement monitoring, a study to evaluate the collection efficiency of impingement was conducted on 22 March, 19 April, 19 July, and 15 November 2005 at Ravenswood using frozen white perch and goldfish. Test fish were release into the intake forebay between the trash racks and traveling screens of in-service units. The results of this direct-release study are included in Appendix A.

Table 3-1 Number of Samples Collected in Entrainment and Impingement Monitoring at Ravenswood Power Station, March 2005 – February, 2006

Date	Entrainment Monitoring Samples	Entrainment Shellfish Samples	Entrainment Depth/Diel Samples	Impingement Monitoring Samples
3/2/2005	0[1]	0[2]	NS[3]	4
3/8/2005	4	0	NS	4
3/15/2005	4	0	NS	4
3/22/2005	4	4	NS	4
3/29/2005	4	4	NS	4
4/5/2005	0[4]	0[4]	NS	4
4/12/2005	4	3	NS	4
4/18/2005	4	4	NS	4
4/26/2005	4	4	NS	4
5/3/2005	0[4]	0[4]	4	4
5/10/2005	0[4]	0[4]	21	4
5/17/2005	0[4]	0[4]	24	4
5/24/2005	4	4	24	4
5/31/2005	4	4	NS	12
6/7/2005	4	4	24	4
6/14/2005	4	4	NS	4
6/21/2005	4	4	24	4
6/28/2005	4	4	NS	12
7/5/2005	4	4	24	4
7/12/2005	4	4	NS	4
7/19/2005	4	4	24	4
7/26/2005	4	4	NS	12
8/2/2005	4	3	24	4
8/9/2005	4	4	NS	12
8/16/2005	4	4	24	4
8/23/2005	4	4	NS	4
8/30/2005	4	4	24	4
9/6/2005	4	4	NS	12
9/13/2005	4	4	NS	4
9/20/2005	4	4	NS	4
9/27/2005	4	4	NS	4
10/4/2005	4	3	NS	4
10/11/2005	4	4	NS	12
10/18/2005	4	4	NS	4
10/25/2005	4	4	NS	4
11/1/2005	4	4	NS	12
11/8/2005	NS	NS	NS	12
11/15/2005	4	4	NS	12
11/22/2005	NS	NS	NS	12
11/29/2005	4	4	NS	12
12/6/2005	NS	NS	NS	12

Table 3-1 Continued

Date	Entrainment Monitoring Samples	Entrainment Shellfish Samples	Entrainment Depth/Diel Samples	Impingement Monitoring Samples
12/13/2005	4	4	NS	12
12/20/2005	NS	NS	NS	12
12/26/2005	4	4	NS	NS
12/27/2005	NS	NS	NS	12
1/3/2006	NS	NS	NS	12
1/10/2006	4	4	NS	12
1/17/2006	NS	NS	NS	12
1/24/2006	4	4	NS	12
1/31/2006	NS	NS	NS	12
2/7/2006	4	4	NS	12
2/14/2006	NS	NS	NS	12
2/21/2006	4	4	NS	12
Total	160	149	241	392

[1] No entrainment samples were collected due to delay in initial start-up.
[2] No entrainment shellfish samples were collected due to equipment backorder.
[3] NS = no samples scheduled.
[4] Samples missed due to malfunction of discharge sampling pipe.

Table 5-1 Estimated Annual Direct Losses from Entrainment and Impingement at Ravenswood Power Station Using Actual Flow (3/2/2005 – 2/21/2006)

Taxon	Direct Losses							
	Eggs	Yolk-sac Larvae	Post Yolk-sac Larvae	Juvenile (Ent.)	All Entrained Life Stages	Juvenile (Imp.)	Yearling & Older	All Impinged Life Stages
Alewife	-	-	-	-	0	2,277	651	2,928
American eel	0	0	0	329,559	329,559	9	15	24
American shad	-	-	-	-	0	19	22	41
Atlantic croaker	0	0	2,281,339	159,888	2,441,227	95	1,589	1,684
Atlantic cutlassfish	-	-	-	-	0	0	10	10
Atlantic herring	0	0	43,003	0	43,003	88	7	95
Atlantic menhaden	22,476,098	290,458	4,894,584	0	27,661,140	899	234	1,133
Atlantic moonfish	-	-	-	-	0	32	0	32
Atlantic seasnail	-	-	-	-	0	0	9	9
Atlantic silverside	-	-	-	-	0	270	486	756
Atlantic tomcod	0	0	1,471,836	280,333	1,752,169	110	0	110
Bay anchovy	11,431,363	10,717	22,497,943	222,211	34,162,234	129	3,370	3,499
Black sea bass	-	-	-	-	0	14	34	48
Blueback herring	-	-	-	-	0	4,168	1,467	5,635
Bluefish	-	-	-	-	0	5	0	5
Bluegill	-	-	-	-	0	7	0	7
Butterfish	-	-	-	-	0	220	141	361
Clupeiformes	0	0	9,407,902	0	9,407,902	-	-	0
Cod family	2,652,092	0	0	0	2,652,092	-	-	0
Conger eel	-	-	-	-	0	0	93	93
Cunner	0	0	254,059	46,951	301,010	23	697	720
Feather blenny	0	12,628	20,095	0	32,723	-	-	0
Fourbeard rockling	8,743,187	0	0	0	8,743,187	-	-	0
Fourspot flounder	12,221	10,621	2,576	0	25,418	0	15	15
Gizzard shad	0	0	0	12,285	12,285	0	39	39
Goby family	10,712	0	18,392,887	273,909	18,677,508	-	-	0
Goldfish	-	-	-	-	0	0	6	6
Grubby	0	266,853	8,812,825	0	9,079,678	7	292	299
Gulf Stream flounder	-	-	-	-	0	21	1,432	1,453

Table 5-1 Continued

Taxon	Direct Losses							
	Eggs	Yolk-sac Larvae	Post Yolk-sac Larvae	Juvenile (Ent.)	All Entrained Life Stages	Juvenile (Imp.)	Yearling & Older	All Impinged Life Stages
Herring family	0	0	1,625,791	0	1,625,791	-	-	0
Hogchoker	0	0	9,642	0	9,642	-	-	0
Lined seahorse	-	-	-	-	0	0	40	40
Little skate	-	-	-	-	0	0	5	5
Lookdown	-	-	-	-	0	7	17	24
Northern pipefish	0	0	1,006,402	193,198	1,199,600	14	365	379
Northern puffer	-	-	-	-	0	53	9	62
Northern searobin	-	-	-	-	0	7	33	40
Northern stargazer	-	-	-	-	0	5	29	34
Oyster toadfish	0	0	0	234,710	234,710	471	426	897
Prionotus species	3,136,731	0	0	0	3,136,731	-	-	0
Red hake	-	-	-	-	0	0	200	200
Rock gunnel	0	0	549,765	0	549,765	0	81	81
Scrawled cowfish	-	-	-	-	0	0	5	5
Scup	-	-	-	-	0	283	152	435
Seaboard goby	-	-	-	-	0	0	7	7
Silver hake	-	-	-	-	0	243	289	532
Smallmouth flounder	0	0	87,766	0	87,766	0	11	11
Spiny dogfish	-	-	-	-	0	0	27	27
Spotted hake	-	-	-	-	0	0	244	244
Striped bass	0	0	89,992	0	89,992	196	698	894
Striped burrfish	-	-	-	-	0	0	12	12
Striped cusk-eel	-	-	-	-	0	0	33	33
Striped searobin	-	-	-	-	0	154	65	219
Summer flounder	0	0	159,888	0	159,888	0	22	22
Tautog	40,950	0	595,183	209,167	845,300	0	64	64
Threespine stickleback	-	-	-	-	0	0	689	689
Weakfish	9,861,948	0	741,037	0	10,602,985	502	16	518
White perch	-	-	-	-	0	0	137	137
Windowpane	3,903,396	10,396	164,564	0	4,078,356	14	101	115

Table 5-1 Continued

Taxon	Direct Losses							
	Eggs	Yolk-sac Larvae	Post Yolk-sac Larvae	Juvenile (Ent.)	All Entrained Life Stages	Juvenile (Imp.)	Yearling & Older	All Impinged Life Stages
Winter flounder	268,475	0	3,597,907	10,338	3,876,720	379	735	1,114
Wrasse family	7,904,379	0	0	0	7,904,379	-	-	0
All Taxa	70,441,552	601,673	76,706,986	1,972,549	149,722,760	10,721	15,121	25,842