Ravenswood Generating Station

Impingement Survival Monitoring Studies

June 2006 – February 2007

Final Report

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Introduction

The operation of cooling water intake structures is regulated under Section 316(b) of the Clean Water Act. This section requires "that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impact" (AEI). Operation of these cooling water intake structures is permitted under the National Pollutant Discharge Elimination System (NPDES) administered by the US Environmental Protection Agency (USEPA). In New York, the responsibility for the day-to-day operation of NPDES has been delegated to the New York State Department of Environmental Conservation (NYSDEC), and the requirement for BTA is administered pursuant to regulations set forth at 6 NYCRR 704.5.

As part of meeting NPDES permit requirements, KeySpan Energy conducted a detailed evaluation of BTA compliance alternatives for Ravenswood to meet NYSDEC mandated entrainment and impingement reduction requirements (ASA 2005). The compliance evaluations were conducted for Ravenswood using impingement survival rate information available from the literature together with best professional judgment on the application of those data to Ravenswood. Based on the results of this evaluation, a combination of variable-speed cooling water pumping and continuous operation of the traveling screens were selected as BTA for Ravenswood.

This report provides estimates of the survival rate of selected species of fish impinged at the Ravenswood Generating Station based on a site-specific study conducted in 2006 and 2007. The purpose of this study was to provide more reliable estimates of impingement mortality at Ravenswood.

Methods

Ravenswood Power Station is a steam-electric generating facility that is owned and operated by 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, directly across from Roosevelt Island. The East River is actually a 16-mile long tidal strait that separates Long Island from Manhattan Island and connects Long Island Sound to the northeast with upper New York Harbor to the south.

Ravenswood consists of three oil- and gas-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, which are recessed 60 ft inside the bulkhead line. 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.

For this study, impingement collection baskets at Ravenswood were modified to insure the all fish impinged were retained in adequate water to minimize holding stress and a holding facility was constructed to evaluate potential post-impingement mortality. The collection system consisted of an aluminum frame attached over the end of the fish return lines. A soft net with ¼ inch mesh that was 8 feet deep with a 5 gallon pail with no drain holes attached to the cod-end was hung from the bottom of this frame. Prior to each collection, the device was lowered into place with a davit and tied into place with tag lines. The cod end was always below the surface of the water. At the end of each collection period, the tag lines were released and the device was hoisted to the deck level. The davit was then rotated over the deck and the net lowered down over the pail. The pail was decanted into plastic pans and the fish were transferred to the holding facility.

Sampling was generally conducted weekly unless plant operations or lack of fish precluded collections. On each sampling date, intake traveling screens were continuously operated. All fish were collected from the unit being sampled over an hourly or shorter interval during an eight hour period from about 6:00 pm to 2:00 am. This period was selected as it was expected to be the diel period of highest impingement rates. All fish were removed from the modified collection baskets and classified into one of three initial mortality categories: live, stunned, or dead. All live and stunned fish were then placed in holding containers which were then placed in one of two 350-gal water troughs supplied with a continuous flow of water from the East River near the Ravenswood intake.

All specimens retained were maintained in separate holding containers by collection interval and multiple containers were used to minimize the potential for predation. All retained fish were checked at the completion of 24 and 48 hours after collection to determine condition (live, stunned[1], and dead) and all dead fish were removed at each check. All dead fish and all fish remaining at the end of the test period were identified to species, counted, and measured. In addition, water quality parameters (water temperature, salinity, dissolved oxygen, and ammonia) were monitored at each check to ensure adequate holding conditions.

Results and Discussion

The original study design called for weekly impingement survival sampling during March, April, November and December 2006 and during January and February 2007. In addition, sampling was to be conducted every other week during May – October 2006. As a result of unit outages, both planned and unplanned, survival sampling could not be initiated until June 2006. As a result, impingement survival sampling was conducted on 25 dates from 12 June 2006 through 27 February 2007 (Table 1). Over this period, water temperatures ranged from near freezing (0.3 C) to more than 25 C. At the same time, dissolved oxygen ranged from 5.3 mg/l in September to more than 11 mg/l during late January and February. On all dates, dissolved oxygen concentrations were sufficiently high so as to not adversely affect impingement survival. Conductivity was generally lower in later winter and spring as a result of higher freshwater flows from the Hudson River.

A total of 545 fish spanning 35 species were collected during the course of this study (Table 2). One individual was not identifiable to species. Most of those collected were relatively small (<150 mmTL) and likely less than one year old. Survival results for all

[1] For the purposes of calculating impingement survival at each time interval, any fish classified as stunned at that time were included with those dead. However, is some cases, these stunned fish recovered resulting in higher estimates of survival in subsequent time periods.

species are presented in Table A-1. Twenty-eight of the species collected consisted of a total of less than 20 individuals. Data for these species is considered insufficient for reliable estimates of impingement survival.

Three species, black seabass, oyster toadfish, and winter flounder, were collected in relatively large numbers (>60), sufficient to permit detailed analysis of their rates of impingement survival. Together, these three species accounted for slightly more than 53 percent of the total catch in this study. Black seabass collected ranged in length from 48 to 214 mm (TL) however all but two were less than 150 mm and likely less than 1 year old (Figure 1). All were collected during the colder period of the year, beginning in early November and extending through early February. Overall initial survival was 79.0 (71.9 – 84.6)[2] percent and 78.3 (71.2 – 84.1)[2] percent after both 24 and 48 hours (Table 3). These results indicate little delayed mortality as a result of impingement stresses for this species. Estimates of impingement survival were lower for individuals collected in November (48-hr rate = 50 percent) when water temperatures averaged 12 – 14 C than for those collected when water temperatures were colder (48-hr rate = 89.4 percent).

Oyster toadfish collected ranged in length from 36 to 253 mm (TL). However, most (84 percent) were less than 150 mm and likely less than 1 year old (Figure 1). This species was collected through the study period although they were most abundant in early November and early December. Overall initial survival was 85.3 (75.0 – 91.8)[2] percent, 89.7 (80.2 – 94.9)[2] percent after 24 and 88.2 (78.4 – 93.9)[2] percent after 48 hours (Table 3). As with black seabass, these results indicate little to no delayed mortality as a result of impingement stresses for oyster toadfish. Estimated 48-hr impingement survival was 100 percent for summer (Jun – Aug), 76.7 percent for fall (Sep – Nov) and 96.3 percent for winter (Dec – Jan).

Winter flounder collected ranged in length from 40 to 290 mm (TL). However, most (72 percent) were less than 150 mm and likely less than 1 year old (Figure 1). The rest were likely a mixture and one- and two-year old individuals. This species was collected in summer (Jun – Aug) and in winter (Dec – Feb). Overall initial survival was 90.8 (81.3 – 95.6)[2] percent and 89.2 (79.4 – 94.6)[2] percent after both 24 and 48 hours (Table 3). As with the other two abundant species, these results indicate little delayed mortality as a result of impingement stresses for winter flounder. Estimated 48-hr impingement survival was 71.4 percent for summer (Jun – Aug) and 97.7 percent for winter (Dec – Feb).

In addition to the three more numerous species discuss above, sufficient numbers (20 – 26) of four other species (Atlantic silverside, blueback herring, bay anchovy, and butterfish) were collected to justify calculation of annual estimates of impingement survival, albeit with greater uncertainty than for the more abundant species. Overall annual estimates of impingement survival are presented on Table 3. Length frequency distributions for these four species are displayed on Figure 2.

Estimated impingement survival for Atlantic silverside exhibit some decline from 69.2 (49.8 – 83.5)[2] percent based on initial observation to 57.7 (38.8 – 74.5)[2] percent after 48

[2] 95 percent exact confidence interval using Bayesian methods (http://www.causascientia.org/math_stat/ProportionCI.html)

hours. However, given the width of the confidence bounds such a decline might not be statistically significant. Only for blueback herring was there strong evidence for delayed mortality resulting from impingement. For this species, impingement survival declined from 53.8(35.3 – 71.3)[2] percent based on initial observation to 34.6 (19.4 – 54.0)[2] percent after 48 hours. Since this species would be expected to be sensitive to the stresses of handling and holding as well as impingement, mortality following initial collection is likely the result of the combination of impingement and testing stresses. To the extent that handling and holding cause mortality, the 48-hr survival observed is a conservative (i.e., underestimate) of the impingement survival potential for this species at Ravenswood. Bay anchovy and butterfish exhibited very high sensitivity to impingement, with a 95% confidence interval for extended survival of 0.1 - 16.1 percent.

Based on the results of this study, the following estimates of percent impingement survival were selected as most appropriate for Ravenswood based on results from 48-hour post impingement observations:

Species	**Ravenswood Impingement Survival**	**95 Percent Confidence Bounds[2]**	**Original Estimate for the FAP Alternative Evaluation[3]**
Black seabass	78.3	71.2 – 84.1	50.0
Oyster toadfish	88.2	78.4 – 93.9	82.1
Winter flounder	89.2	79.4 – 94.6	41.3
Atlantic silverside	57.7	38.8 – 74.5	50.5
Blueback herring	34.6	19.4 – 54.0	14.8
Bay anchovy	0.0	0.1-16.1	0.4
Butterfish	0.0	0.1-16.1	17.6

Of these seven species, estimates of impingement survival for three of the species, oyster toadfish, Atlantic silverside, and bay anchovy, were comparable to those used in the original intake alternatives assessment at Ravenswood. For three other species, black seabass, winter flounder, and blueback herring, the site-specific estimates of impingement survival from the current study were substantially higher than those used in the original assessment. Only for one species, butterfish, was the current site-specific estimate lower than that used in the original alternatives assessment.

[3] For continuously-operated conventional traveling screens (ASA 2005).

The seven species for which sufficient numbers of individuals were collected in this study to allow estimation of impingement survival accounted for 46.4 percent of all fish collected in the most recent impingement monitoring studies conducted at Ravenswood in 2005 and 2006 (ASA 2006). This percentage, coupled with the fact that impingement survival estimates from the current study were equal to or higher than those used in the original intake alternatives assessment, suggest that the actual reductions in impingement mortality at Ravenswood may be higher than those estimated earlier.

Literature Cited

ASA 2005. Evaluation of the Fish Protection Benefits of Cooling Water Intake System Alternatives at the Ravenswood Generating Station Phase 2 Report (Revised February 2005 to Include Additional Information Requested by the NYSDEC in Letter Dated 17 November 2004). Prepared for KeySpan Energy.

ASA 2006. Ravenswood Power Station. Entrainment and Impingement Monitoring March 2005 –February 2006. Prepared for KeySpan Energy.

Table 1 - Dates of impingement survival collections and coincident water quality measurements at the Ravenswood Generating Station, 2006 - 2007.

Sample Date	Mean Water Temperature (C)	Mean Dissolved Oxygen (mg/l)	Mean Conductivity (µS/cm)
6/12/2006	17.7	7.9	30,210
6/19/2006	18.1	7.7	29,900
6/26/2006	19.3	7.8	30,520
7/3/2006	21.4	7.7	27,380
7/17/2006	23.4	7.2	35,410
7/31/2006	25.5	6.8	32,910
8/21/2006	23.2	6.2	37,300
8/28/2006	21.6	6.1	36,600
9/12/2006	20.7	5.3	35,710
10/16/2006	17.7	5.9	34,040
11/6/2006	12.4	8.1	31,767
11/13/2006	14.2	8.3	31,450
11/27/2006	12.2	9.8	31,500
12/4/2006	10.4	9.4	33,615
12/11/2006	8.8	8.7	32,730
12/26/2006	8.0	9.5	33,860
1/1/2007	8.7	9.3	34,075
1/8/2007	---------------Meter out of service---------------		
1/15/2007	9.4	9.9	35,085
1/22/2007	5.1	10.0	34,260
1/29/2007	5.0	11.1	35,080
2/5/2007	0.6	11.1	33,850
2/12/2007	2.2	10.1	34,795
2/20/2007	0.3	11.2	20,520
2/27/2007	2.0	11.3	30,135

Table 2 – Numbers and length ranges of fish collected in impingement survival monitoring at the Ravenswood Generating Station, 2006 - 2007.

Common name	Number Collected	Length Range (TL mm)
Black sea bass	157	48 – 214
Oyster toadfish	68	36 - 253
Winter flounder	65	40 - 290
Atlantic silverside	26	89 - 119
Blueback herring	26	65 - 119
Bay anchovy	20	59 - 101
Butterfish	20	28 - 51
Atlantic menhaden	16	35 - 112
Grubby	16	50 - 122
Gulf Stream flounder	14	49 - 83
Scup	14	33 - 69
Cunner	10	63 - 170
Red hake	10	54 - 223
Alewife	9	66 - 100
Feather blenny	8	54 - 83
Silver hake	8	66 - 98
Smallmouth flounder	8	45 - 65
Northern searobin	6	49 - 125
Spotted hake	6	77 - 101
Threespine stickleback	6	56 - 66
Northern pipefish	5	134 - 197
Spotfin butterflyfish	4	40 - 50
Striped searobin	4	31 - 89
Lined seahorse	3	75 - 98
Conger eel	2	272 - 291
Naked goby	2	46 - 58
Rock gunnel	2	119 - 128
Striped bass	2	87 - 88
American sand lance	1	113 - 113
Atlantic moonfish	1	75 - 75
Bluefish	1	55 - 55
Gizzard shad	1	131 - 131
Seaboard goby	1	50 - 50
Unidentifiable	1	447 - 447
White perch	1	139 - 139
Windowpane	1	44 - 44
Total	545	

Table 3 – Estimates of initial and extended impingement survival for the seven most abundant species collected in impingement survival monitoring at the Ravenswood Generating Station, 2006 - 2007.

Common Name	Time Period	N	Initial Observation		After 24 Hours		After 48 Hours	
			S	95% CI	S	95% CI	S	95% CI
Black seabass	Nov.	44	52.3	37.9-66.3	50.0	35.8-64.2	50.0	35.8-64.2
	Dec – Feb	113	89.4	82.3-93.8	89.4	82.3-93.8	89.4	82.3-93.8
	Overall	157	79.0	71.9-84.6	78.3	71.2-84.1	78.3	71.2-84.1
Oyster toadfish	Jun – Aug	11	100.0	73.5-99.8	100.0	73.5-99.8	100.0	73.5-99.8
	Sep – Nov	30	70.0	52.0-83.3	80.0	62.5-90.4	76.7	58.9-88.1
	Dec – Jan	27	96.3	81.7-99.1	96.3	81.7-99.1	96.3	81.7-99.1
	Overall	68	85.3	75.0-91.8	89.7	80.2-94.9	88.2	78.4-93.9
Winter flounder	Jun – Aug	21	76.2	54.6-89.3	71.4	49.8-86.1	71.4	49.8-86.1
	Dec – Feb	44	97.7	88.3-99.5	97.7	88.3-99.5	97.7	88.3-99.5
	Overall	65	90.8	81.3-95.6	89.2	79.4-94.6	89.2	79.4-94.6
Atlantic silverside	Overall	26	69.2	49.8-83.5	61.5	42.4-77.6	57.7	38.8-74.5
Blueback herring	Overall	26	53.8	35.3-71.3	38.5	22.4-57.6	34.6	19.4-54.0
Bay anchovy	Overall	20	5.0	1.1-23.8	0.00	0.1-16.1	0.00	0.1-16.1
Butterfish	Overall	20	0.00	0.1-16.1	0.00	0.1-16.1	0.00	0.1-16.1

Figure 1 Length frequency distribution for the three most abundant species collected in impingement survival sampling at Ravenswood, Jun 2006 - Feb 2007.

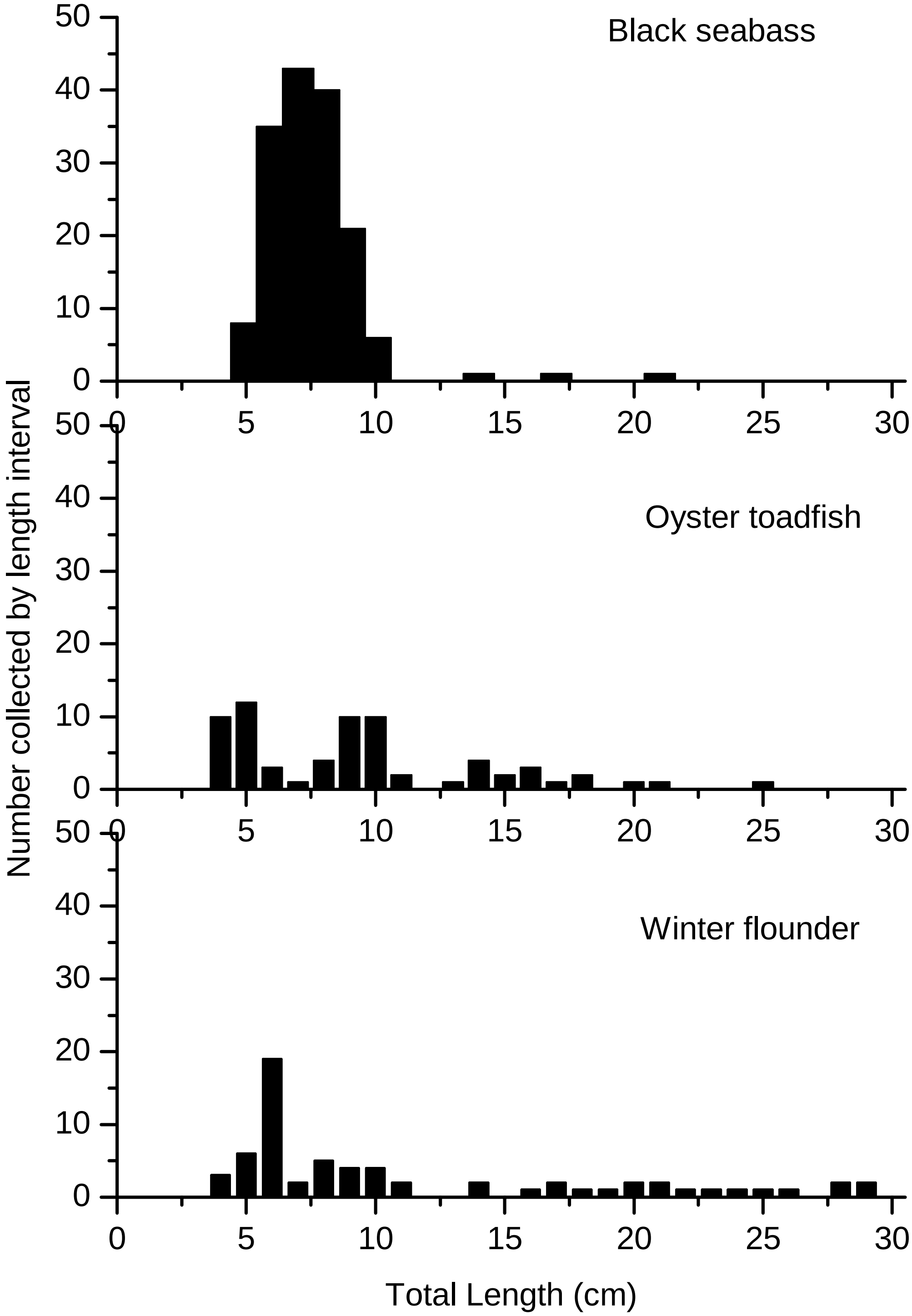
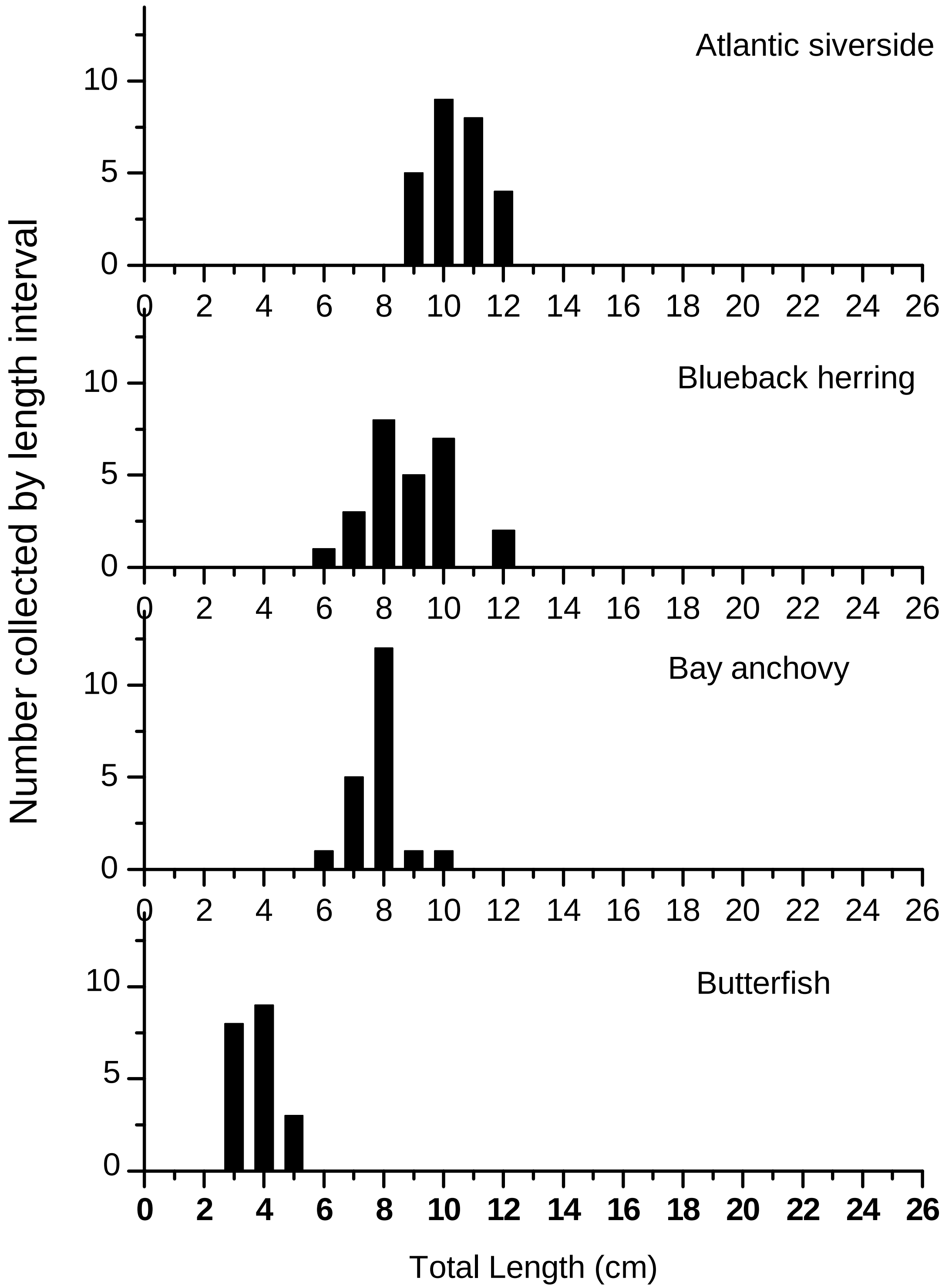


Figure 2 Length frequency distribution for the next four most abundant species collected in impingement survival sampling at Ravenswood, Jun 2006 - Feb 2007.



Appendix A

Table A-1 – Results of impingement survival monitoring at the Ravenswood Generating Station, 2006 - 2007.

Common name	Number Collected	Initial Observation			After 24 Hours			After 48 Hours		
		Live	Stun	Dead	Live	Stun	Dead	Live	Stun	Dead
Black sea bass	157	124	0	33	123	0	34	123	0	34
Oyster toadfish	68	58	3	7	61	0	7	60	0	8
Winter flounder	65	59	1	5	58	0	7	58	0	7
Atlantic silverside	26	18	0	8	16	0	9	15	0	10
Blueback herring	26	14	0	12	10	0	16	9	0	17
Bay anchovy	20	1	0	19	0	0	20	0	0	20
Butterfish	20	0	1	19	0	0	20	0	0	20
Atlantic menhaden	16	5	0	11	1	0	15	1	0	15
Grubby	16	12	0	4	12	0	4	12	0	4
Gulf Stream flounder	14	6	0	8	4	0	10	2	0	12
Scup	14	0	0	14	0	0	14	0	0	14
Cunner	10	10	0	0	10	0	0	10	0	0
Red hake	10	5	0	5	5	0	5	5	0	5
Alewife	9	7	0	2	7	0	2	5	0	4
Feather blenny	8	5	0	3	5	0	3	3	0	5
Silver hake	8	5	0	3	5	0	3	5	0	3
Smallmouth flounder	8	0	0	8	0	0	8	0	0	8
Northern searobin	6	4	0	2	4	0	2	4	0	2
Spotted hake	6	3	0	3	3	0	3	3	0	3
Threespine stickleback	6	6	0	0	6	0	0	6	0	0
Northern pipefish	5	1	0	4	1	0	4	1	0	4
Spotfin butterflyfish	4	3	0	1	3	0	1	3	0	1
Striped searobin	4	2	0	2	2	0	2	2	0	2
Lined seahorse	3	3	0	0	3	0	0	3	0	0
Conger eel	2	2	0	0	2	0	0	2	0	0
Naked goby	2	0	0	2	0	0	2	0	0	2
Rock gunnel	2	2	0	0	2	0	0	2	0	0
Striped bass	2	2	0	0	0	0	2	0	0	2
American sand lance	1	0	0	1	0	0	1	0	0	1
Atlantic moonfish	1	0	0	1	0	0	1	0	0	1
Bluefish	1	0	0	1	0	0	1	0	0	1
Gizzard shad	1	0	0	1	0	0	1	0	0	1
Seaboard goby	1	0	0	1	0	0	1	0	0	1
Unidentifiable	1	1	0	0	1	0	0	1	0	0
White perch	1	0	0	1	0	0	1	0	0	1
Windowpane	1	1	0	0	1	0	0	1	0	0