

## **JOB IV.**

# **ABUNDANCE AND DISTRIBUTION OF JUVENILE AMERICAN SHAD IN THE SUSQUEHANNA RIVER, 2010**

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### **INTRODUCTION**

This report summarizes the results of bio-monitoring activities for juvenile alosines conducted in the Susquehanna River and its tributaries in 2010.

The Conowingo West Fish Lift continued to be used as a source of adult American shad and river herring to support monitoring activities and tank spawning. A total of 5,605 adult shad were collected at the Conowingo West Lift. The majority were released back into the Conowingo tailrace, with 1,075 retained for tank spawning. Since the completion of fish passage facilities at Holtwood and Safe Harbor in 1997, the Conowingo East Lift has operated in fish passage mode. American shad had access to the Inflatable Dam at Sunbury on the Susquehanna main stem, and Warrior Ridge or Raystown Dams on the Juniata. Portions of large tributaries including Muddy Creek, West Conewago Creek, Conestoga River, Conodoguinet Creek, and Swatara Creek were also accessible to American shad.

During the 2010 spring migration, Conowingo East Lift passed 37,757 American shad while fishways at Holtwood, Safe Harbor, and York Haven passed 16,472, 12,706, and 907 American shad, respectively. Some 4 blueback herring and 1 alewife were passed at Conowingo Dam. No other river herring were passed at Holtwood or Safe Harbor Dams. The two alewife passed at York Haven were likely fish from landlocked

populations in freshwater lakes such as Raystown Dam. No hickory shad were passed at any of the four dams.

Juvenile American shad in the Susquehanna River above Conowingo Dam are derived from two sources, natural reproduction of adults passed at the lower river hydroelectric projects, and hatchery produced, marked larvae from Pennsylvania Fish and Boat Commission's (PFBC) Van Dyke Hatchery in Pennsylvania. Juveniles occurring in the river below Conowingo and the upper Chesapeake Bay may result from natural spawning below or above dams and hatchery fry stockings either in Maryland or from upstream releases in Pennsylvania.

During the 2010 production season, the PFBC Van Dyke Research Station for Anadromous Fish produced 4.7 million shad larvae which were released in the Susquehanna Basin in Pennsylvania. Larval releases occurred from 27 May to 10 June during a period of steadily decreasing flows. Larvae were released in the following locations and numbers:

Juniata/Middle Susquehanna River	3,348,650
North Branch Susquehanna River (PA)	114,662
West Branch Susquehanna River	400,096
Bald Eagle Creek	100,000
Conodoguinet Creek	185,563
West Conewago Creek	178,932
Swatara Creek	198,469
Conestoga River	216,988

The production goal of 10 million larvae was not met, primarily due to the loss of the Hudson River as an egg source.

## **METHODS**

Sampling for juvenile American shad was conducted at locations in the Susquehanna

River Basin during the summer and fall in an effort to document in-stream movement, out-migration, abundance, growth, and stock composition/mark analysis. Juvenile recoveries from all sources were provided to the PFBC for otolith analysis. Otoliths were analyzed for tetracycline marks to determine hatchery versus wild composition of the samples.

Lift net collections in the forebay at Holtwood were permanently discontinued due to construction of the new powerhouse and the associated reconfiguration of the forebay. An additional haul seine site at City Island in Harrisburg was added to compensate for the loss of the lift netting. Geometric mean catch-per-unit effort (GM CPUE) was calculated as an index of juvenile abundance for haul seine collections. Ideally, CPUE would be calculated using data from individual lifts or seine hauls. Unfortunately, this data is not available prior to 1995 for lift netting and prior to 1997 for haul seining. As a result, geometric means could not be computed in the usual way for those years. Combined daily catch for each gear is available and was used as a surrogate to compute GM means. ASMFC stock assessment (ASMFC 2007) recommends use of area-under-the-curve (AUC) methods in cases where sampling is targeted at migrants moving through an area. Because the Holtwood dam lift net collected juvenile shad during the directed outmigration, AUC measures of juvenile abundance were calculated for lift net collections.

#### Haul Seining - Main Stem

Haul seining in the lower Susquehanna River was scheduled once each week beginning mid-July and continuing through October. Twenty-nine sampling events were conducted in 2010. Sampling was concentrated near the Columbia Borough boat launch (14 events) and City Island in Harrisburg (15 events). Sampling consisted of 6 hauls per date beginning at sunset and continuing into the evening with a net measuring 400 ft x 6 ft with 3/8 in stretch mesh.

#### Peach Bottom Atomic Power Station (PBAPS) and Conowingo Dam

Intake screens were monitored for impinged alosines at Peach Bottom APS in 2010.

Intake screen sampling was conducted daily, (Monday through Friday), from 25 October to 10 December, 2010. Thirty-five sampling events were conducted during the outmigration period. Conowingo Hydroelectric Station's cooling water intake strainer sampling was conducted twice weekly (Monday and Friday) from 12 October through 4 December 2010. Sampling occurred twice weekly during this period for a total of 16 sampling events.

### Susquehanna River Mouth and Flats

Maryland DNR sampled the upper Chesapeake Bay using haul seines in the summer and fall.

### Disposition of Samples

Sub-samples of up to 30 juveniles per day were used for otolith analysis. Samples of shad from most collections were returned to the PFBC's Benner Spring Fish Research Station for analysis of tetracycline marks on otoliths. Otoliths were surgically removed from the fish, cleaned and mounted on slides, ground to the focus on the sagittal plane on both sides, and viewed under ultraviolet light to detect fluorescent rings indicating tetracycline immersion treatments.

## **RESULTS**

### Haul Seining - Main Stem

Five juvenile American shad were captured by haul seine; three at the Columbia boat launch and two at City Island. The Geometric Mean Catch-Per-Unit-Effort (GM CPUE, individual haul) for the Columbia site was 0.03 (Tables 1 and 2). Table 3 lists weekly catches of American shad by haul seine at Columbia from 1989 to 2010. Catches generally peaked in August and September, except in 1989 and 1992 when catches peaked in July, in 2010 when catches peaked in October and in 2005 -2010 when there was no peak. The Geometric Mean Catch-Per-Unit-Effort (GM CPUE, individual haul) for the City Island site was 0.02 (Tables 4 and 5). Table 6 lists weekly catches of American shad by haul seine at City Island in 2010.

### Lift Netting at Holtwood

Lift netting did not occur in 2010 due to construction activities in the Holtwood forebay. Geometric Mean CPUE (individual lift), GM CPUE (combined daily) and Area under the curve (AUC) for collections from 1985 to 2009 are listed in Table 7. Historical weekly catches peaked in October, except in 1985, 1997, 2000, and 2001 when catches peaked in November (Table 8).

### Peach Bottom APS, and Conowingo Dam

Peach Bottom intake screens produced 11 juvenile American shad and 510 alewife between 29 October and 1 December (Tables 9 and 10).

Cooling water intake strainers at Conowingo produced two American shad collected on October 5 and October 29 (Tables 11 and 12). One alewife and one unidentified *Alosa* sp. were collected in strainer samples in 2010.

### Electrofishing

Electrofishing collections were made at numerous sites by Normandeau Associates as part of FERC re-licensing studies. One juvenile shad was collected by electrofishing gear at Dock St. Dam on 11 October and one at Otter Creek on 8 October.

### Susquehanna River Mouth and Flats

In 2010, 115 juvenile American shad were captured at seven permanent sites and seven auxiliary sites (Table 13).

### Otolith Mark Analysis

Results of otolith analysis are presented in Table 14. (see Job III, Appendix 1 for a discussion of relative survival). Fifteen of the 18 (83%) evaluated for otolith marks were hatchery and 3 were wild. One fish collected on October 26 exhibited an immersion mark and a single feed mark indicating it was stocked as a raceway-reared fingerling in the Juniata River at Arch Rock on Oct 22, 2010. This specimen was collected four days later at City Island, a distance of 51 miles downstream.

## DISCUSSION

River conditions for the Susquehanna River Basin during 2010 could be characterized by generally decreasing flows throughout spring and summer, culminating in a drought by August (Figure 1). High water events at Marietta in early October and early December ended the drought and increased river flow substantially.

Fish passage at Conowingo Dam improved from 2009 with 37,757 shad passed, but was still well below the levels passed during 2000 to 2004. Fish passage efficiency at Holtwood (16,472) was better than average with 44% passage, based on counts at Conowingo and Holtwood (long-term mean = 33%). Fish passage at Safe Harbor (12,706) was 77%, slightly higher than the long-term mean of 72%, based on counts at Holtwood and Safe Harbor. Fish passage at York Haven (907) was 7%, lower than the long-term mean of 10%, based on counts at Safe Harbor and York Haven. Production of wild juvenile shad was, no doubt, negatively impacted by the low numbers of shad passed into spawning habitat above York Haven Dam.

### Abundance – Main Stem

Comparison of relative abundance of juvenile alosines in the Susquehanna River from year to year is difficult due to the opportunistic nature of sampling and wide variation in river conditions, which may influence catches. In 2010, 5 juvenile shad were collected by haul seine. This is well below the numbers captured during 1990 to 2001 when an average of 330 juvenile shad were captured by haul seine.

GM CPUE for haul seine at Columbia (both individual lifts, and combined daily lifts, (Table 2) was 0.03. GM CPUE for haul seine at City Island (both individual lifts, and combined daily lifts, (Table 5) was 0.02. Juvenile shad abundance has been well below normal for six consecutive years (Figure 2), a disturbing trend that will impact upstream fish passage counts until at least 2015. In 2002, problems at the Van Dyke Hatchery resulted in release of comparatively few healthy larvae. In 2003 and 2004,

high river flows had a negative impact on survival of stocked hatchery larvae and on fish passage efficiency. Poor catch rates for juvenile shad in 2005 may have been due, in part, to fewer larvae stocked. In 2006, poor catch rates were attributed to fewer larvae stocked (compared to the decade of the 1990's) and the late June flood which, undoubtedly, impacted survival. In 2007, flows were low and decreased steadily during the entire season. Poor catch rates in 2007 were attributed to decreased egg deliveries, poor survival in the hatchery (see Job III), and poor fish passage. The poor catch rates in 2008 to 2010 are troubling. The number of larvae stocked during those years averaged 3.3 million. This represents 42% of the average number of larvae stocked during 1993 to 2001. CPUE for 2008 to 2010 was less than 1% of the CPUE for 1993 to 2001. It is clear that survival of hatchery-reared American shad larvae in the Susquehanna River Basin has plummeted in recent years. The cause of this phenomenon is unknown. We do know that YOY smallmouth bass have suffered outbreaks of *Columnaris* bacterial infections which have caused high mortalities and resulted in poor year classes for 2005 to 2010. The suspected cause of this is low dissolved oxygen in shallow water habitats where smallmouth bass YOY are found. American shad larvae and juveniles are generally not found in these shallow water habitats, preferring deeper water. No *Columnaris* symptoms have been noted on juvenile American shad and it is unknown if smallmouth bass and shad survival are in any way related.

#### Stock Composition and Mark Analysis

For all sites combined, hatchery contribution was 83% (15 of 18 successfully processed shad). Juvenile shad were captured from releases at a number of sites including the Juniata/Susq. R. (day 3 mark, 1 specimen), the Juniata/Susq. R. (day 3,6,9 mark, 1 specimen), the Juniata/Susq. R. (day 3,6,12,15,18,21 mark, 1 specimen), the North Branch Susquehanna River (1 specimen), the West Branch Susquehanna River or Bald Eagle Creek (3 specimens), Conodoguinet Creek (1 specimen), Swatara Creek (2 specimens), West Conewago Creek, (1 specimen) and a specimen reared in the Benner Spring raceways and stocked as a juvenile in the Juniata River. The only stocking site not represented in the recaptures was the Conestoga River.

## SUMMARY

- Juvenile American shad were collected by electrofishing at Dock St. Dam and at Otter Creek, by haul seine at City Island and Columbia, in cooling water intakes at Peach Bottom Atomic Power Station, and in strainers at Conowingo Dam.
- Haul seine GM CPUE at Columbia (combined daily lifts) of 0.03 was among the lowest recorded for that gear type since 1990 and continues a disturbing trend since 2002.
- Lift-net collections in the Holtwood Dam forebay were permanently discontinued due to construction associated with Holtwood re-development.
- Otoliths from all sites combined were 83% hatchery origin.
- Production of hatchery larvae from the Van Dyke Hatchery was 4.7 million, the highest since 2003. Adult shad passage improved over the last three years but only three wild juvenile shad were collected.
- **Based on haul seine CPUE at Columbia, survival of hatchery-reared American shad larvae was 167 times lower during 2008 to 2010 than during 1993 to 2001 indicating that survival of hatchery-reared larvae has plummeted in recent years. The cause of this is not known.**

## ACKNOWLEDGMENTS

Normandeau Associates (Drumore, PA) was contracted by the PFBC to perform juvenile collections. Many individuals supplied information for this report. John Cingolani and Christina Steltz processed shad otoliths.

## LITERATURE CITED

ASMFC 2007. American Shad Stock Assessment Report for Peer Review. Volume I. Stock Assessment Report No. 07-01 (Supplement) of the Atlantic States Marine Fisheries Commission. Atlantic States Marine Fisheries Commission, Bethesda, MD.



Figure 1. Discharge (cfs) in the Susquehanna River at Marietta, April 15, 2010 to December 15, 2010.

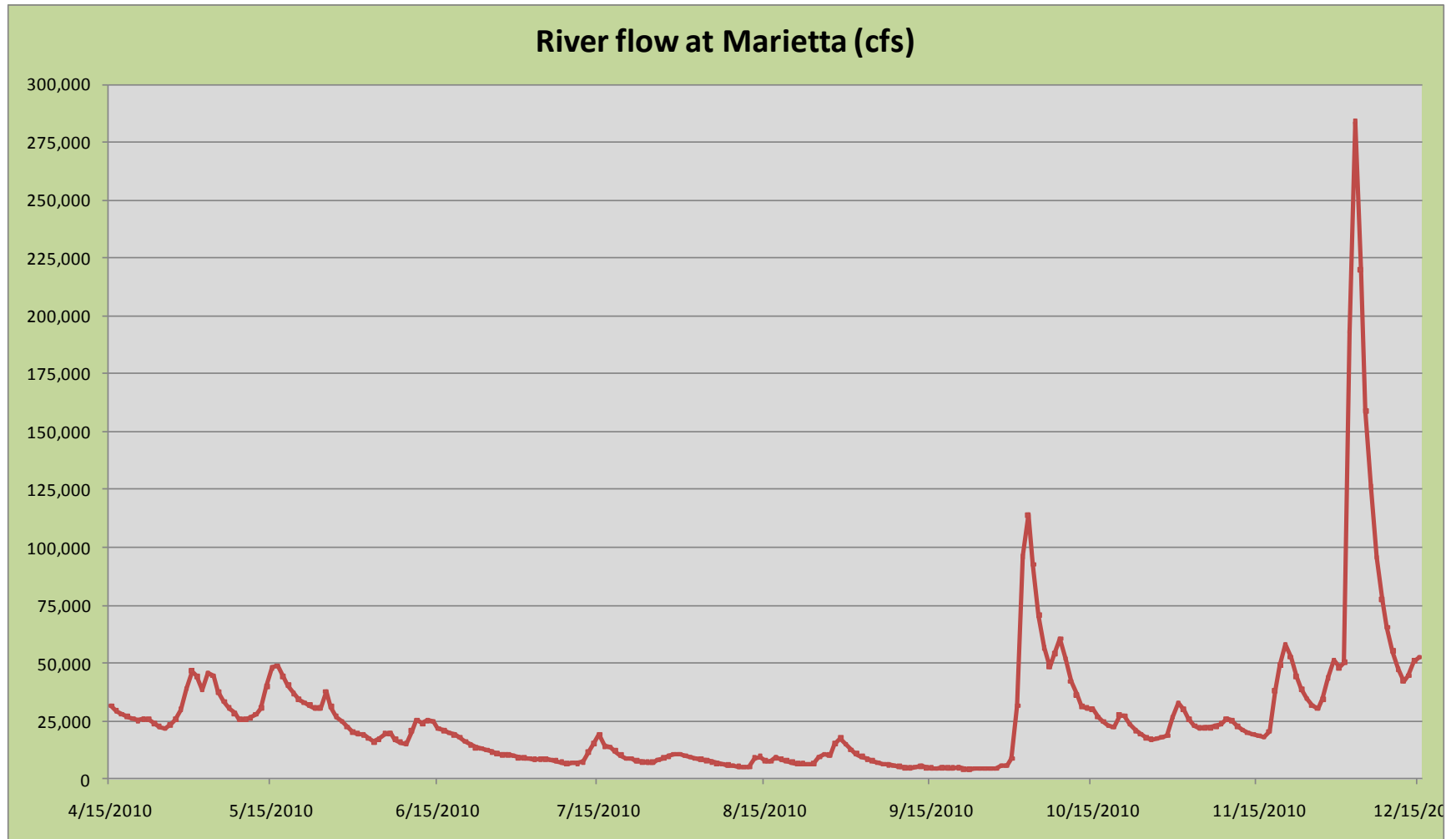
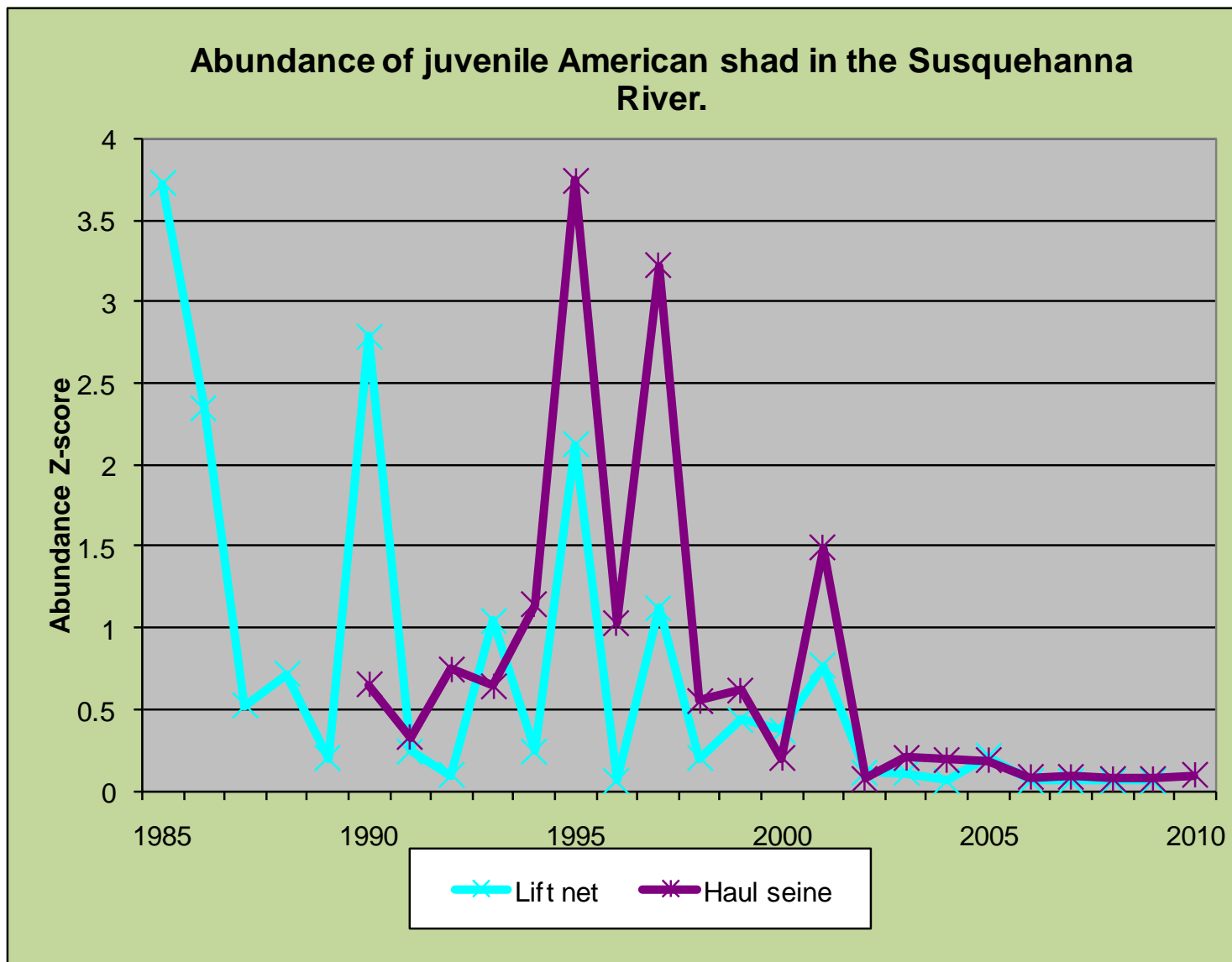


Figure 2. Annual YOY American shad CPUE for haul seine and lift net collections in the Susquehanna River.



**Table 1. Number and percent composition of the fish collected by haul seine from the lower Susquehanna River near Columbia, Pennsylvania in 2010.**

Date	19-Aug	26-Aug	31-Aug	7-Sep	16-Sep	23-Sep	28-Sep	13-Oct	21-Oct	28-Oct	4-Nov	11-Nov	18-Nov	22-Nov	Total	%
Daily Mean River Flow (c	7,730	11,100	12,200	6,260	4,800	5,040	6,010	30,600	26,000	18,200	22,100	22,300	42,800	42,700		
Water Temperature (°C)	28.0	24.0	28.5	23.0	28.5	24.5	23.0	16.5	10.0	16.0	9.5	7.0	10.0	6.0		
Secchi Disk (in)	40	32	32	40	60	63	60	30	47	40	60	98	12	30		
American shad	-	-	-	-	-	-	-	1	-	2	-	-	-	-	3	0.1%
Gizzard shad	44	48	19	33	5	4	-	155	16	23	-	-	144	42	533	20.7%
Common carp	2	-	-	1	-	-	1	-	-	-	-	-	1	-	5	0.2%
Comely shiner	1	1	3	10	6	1	3	7	27	6	-	9	19	17	110	4.3%
Spottail shiner	-	-	-	-	-	-	-	1	54	46	3	58	18	39	219	8.5%
Swallowtail shiner	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.0%
Spotfin shiner	16	4	5	11	9	8	17	2	130	45	163	126	211	107	854	33.2%
Mimic shiner	2	-	1	-	-	-	-	-	48	1	10	3	1	-	66	2.6%
Bluntnose minnow	1	-	4	-	-	-	7	-	22	5	8	-	-	2	49	1.9%
Fallfish	19	2	3	11	11	7	5	7	7	20	1	11	2	1	107	4.2%
Quillback	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.0%
White sucker	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	0.0%
Northern hog sucker	2	1	1	1	-	-	-	-	-	-	-	-	-	-	5	0.2%
Shorthead redhorse	-	-	-	1	-	-	-	-	-	1	-	-	-	-	2	0.1%
Channel catfish	-	3	11	2	2	-	-	22	1	-	-	-	-	23	64	2.5%
Banded killifish	-	-	2	2	1	2	1	-	27	1	1	1	2	22	62	2.4%
Mosquitofish	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	0.0%
Rock bass	-	-	-	2	2	2	-	10	2	2	2	-	2	-	24	0.9%
Redbreast sunfish	-	-	-	-	-	-	-	1	-	-	-	-	2	-	3	0.1%
Green sunfish	-	-	-	-	-	-	1	6	6	2	-	-	-	3	18	0.7%
Pumpkinseed	-	-	-	-	-	-	-	1	3	-	-	-	-	-	4	0.2%
Bluegill	12	15	4	5	3	2	9	63	180	9	2	-	69	16	389	15.1%
Smallmouth bass	2	-	-	1	-	1	-	-	-	-	-	-	-	-	4	0.2%
Largemouth bass	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	0.0%
White crappie	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	0.0%
Tessellated darter	2	-	-	-	-	1	1	1	13	6	3	11	-	4	42	1.6%
Walleye	-	-	-	-	-	-	-	1	-	-	-	-	-	2	3	0.1%
<b>Total</b>	<b>104</b>	<b>75</b>	<b>53</b>	<b>81</b>	<b>39</b>	<b>28</b>	<b>45</b>	<b>279</b>	<b>538</b>	<b>169</b>	<b>193</b>	<b>219</b>	<b>471</b>	<b>278</b>	<b>2,572</b>	<b>100.0%</b>
<b>No. of Species</b>	<b>12</b>	<b>8</b>	<b>10</b>	<b>13</b>	<b>8</b>	<b>9</b>	<b>9</b>	<b>15</b>	<b>16</b>	<b>14</b>	<b>9</b>	<b>7</b>	<b>11</b>	<b>12</b>	<b>27</b>	

**Table 2. Index of abundance for juvenile American shad collected by haul seine at Marietta, Columbia and Wrightsville, Susquehanna River, 1990-2010.**

Year	No. Hauls	Total				Wild			Hatchery		
		No. Fish	Mean	GM	GM	No. Fish	Mean	GM	No. Fish	Mean	GM
			Combined	Combined	Individual		Combined	Combined		Combined	Combined
			Daily	Daily	Haul		Daily	Daily		Daily	Daily
CPUE	CPUE	CPUE*	CPUE	CPUE	CPUE	CPUE	CPUE	CPUE	CPUE		
			(Wild)	(Wild)		(Hatchery)	(Hatchery)		(Hatchery)	(Hatchery)	
1990	87	285	4.40	1.23		0	0.15	0.11	272	4.25	1.18
1991	144	170	1.01	0.54		80	0.48	0.35	90	0.53	0.21
1992	92	269	4.24	1.45		146	2.49	0.78	172	2.63	0.91
1993	111	218	1.90	1.22		174	1.61	1.01	44	0.29	0.19
1994	110	390	4.74	2.29		254	3.19	1.38	322	3.64	2.04
1995	48	409	8.92	7.89		58	1.29	1.06	351	7.63	6.85
1996	105	283	2.89	2.05		157	1.61	1.20	126	1.28	0.99
1997	90	879	9.77	6.77	3.36	136	1.51	1.24	743	8.26	5.65
1998	94	230	2.51	1.03	0.50	5	0.05	0.05	225	2.46	0.97
1999	90	322	3.58	1.16	0.67	13	0.15	0.13	309	3.43	1.06
2000	90	31	0.34	0.26	0.14	0	0.00	0.00	31	0.34	0.26
2001	90	377	4.19	3.04	1.52	119	1.32	1.25	258	2.87	2.14
2002	84	-	0.00	0.00	0.00	0	0.00	0.00	0	0.00	0.00
2003	48	17	0.35	0.28	0.20	2	0.04	0.04	15	0.31	0.25
2004	66	25	0.38	0.25	0.17	0	0.00	0.00	25	0.38	0.25
2005	90	23	0.26	0.24	0.16	21	0.23	0.24	2	0.02	0.02
2006	66	1	0.02	0.01	0.01	0	0.00	0.00	1	0.02	0.01
2007	66	2	0.02	0.02	0.02	2	0.02	0.02	0	0.00	0.00
2008	90	0	0.00	0.00	0.00	0	0.00	0.00	0	0.00	0.00
2009	84	0	0.00	0.00	0.00	0	0.00	0.00	0	0.00	0.00
2010	84	3	0.04	0.03	0.03	2	0.02	0.02	1	0.01	0.01

**Table 3. Weekly catch of juvenile American shad by haul seine from the lower Susquehanna River near Columbia, 1989 through 2010.**

Month	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
1-7 Jul	-	-	-	0	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
8-15 Jul	1,048	-	0	120	0	27	-	2	44	-	0	7	-	-	-	0	-	-	-	-	-	-	1,248
16-23 Jul	-	-	0	6	-	70	53	18	28	24	0	3	46	0	0	0	2	*	0	0	0	0	250
24-31 Jul	45	31	-	-	0	60	24	15	22	144	1	0	42	0	0	*	0	*	2	0	0	0	386
1-7 Aug	-	0	0	20	0	24	29	32	14	30	1	2	70	0	*	*	5	0	0	0	*	0	227
8-15 Aug	61	0	0	2	8	13	35	56	20	0	0	6	37	0	*	0	1	0	0	0	0	0	239
16-23 Aug	7	69	0	16	0	46	40	43	171	9	0	1	36	0	0	*	2	0	0	0	0	0	440
24-31 Aug	-	-	-	-	13	-	42	39	120	10	10	0	36	0	8	16	2	0	0	0	0	0	296
1-7 Sep	-	25	12	-	20	-	43	34	129	3	*	0	23	0	5	5	3	*	0	0	0	0	302
8-15 Sep	-	97	16	-	41	75	65	4	135	3	264	0	31	0	4	4	0	0	0	0	0	0	739
16-23 Sep	-	28	30	-	27	14	46	12	59	4	17	0	15	0	0	*	1	0	0	0	0	0	253
24-30 Sep	-	0	73	-	11	5	15	15	32	0	20	1	34	0	*	*	2	0	0	0	0	0	208
1-7 Oct	-	0	69	2	22	5	19	10	91	3	1	0	6	0	*	0	0	0	0	0	0	0	* 228
8-15 Oct	-	0	7	-	0	2	31	3	0	0	3	11	1	0	0	0	2	0	0	0	0	0	1 61
16-23 Oct	-	-	5	-	-	10	-	-	14	0	5	0	0	*	*	0	3	1	0	0	0	0	38
24-31 Oct	-	-	0	0	-	-	0	0	-	-	-	-	0	0	*	0	*	-	-	-	-	-	2 2
1-7 Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	0	0
8-15 Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	0	0
16-23 Nov																						0	0
24-30 Nov																							0
1-7 Dec																							0
<b>TOTAL</b>	<b>1,161</b>	<b>250</b>	<b>212</b>	<b>166</b>	<b>142</b>	<b>353</b>	<b>442</b>	<b>283</b>	<b>879</b>	<b>230</b>	<b>322</b>	<b>31</b>	<b>377</b>	<b>0</b>	<b>17</b>	<b>25</b>	<b>23</b>	<b>1</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>4,919</b>

\* No sampling due to high river flow.

**Table 4. Number and percent composition of the fish collected by haul seine from the middle Susquehanna River at City Island, Harrisburg, Pennsylvania in 2010.**

Date	10-Aug	17-Aug	24-Aug	2-Sep	9-Sep	14-Sep	21-Sep	29-Sep	15-Oct	19-Oct	26-Oct	2-Nov	9-Nov	15-Nov	23-Nov	Total	%
Daily Mean River Flow (cfs)	3,820	6,870	8,900	7,840	4,750	4,230	4,060	5,290	25,000	23,800	14,400	21,550	23,800	16,000	33,800		
Water Temperature (°C)	31.0	29.7	23.5	27.0	28.5	20.0	23.0	22.0	13.5	11.5	12.5	10.0	8.5	9.0	8.0		
Secchi Disk (in)	84	60	55	60	67	40	79	60	55	79	80	59	69	79	59		
Alewife	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	3	0.1%
American shad	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	2	0.1%
Muskellunge	-	-	-	-	-	-	-	4	1	-	1	-	-	-	-	6	0.2%
Central stoneroller	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	0.0%
Common carp	1	-	1	-	-	-	-	-	1	-	-	-	-	-	-	3	0.1%
River chub	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.0%
Golden shiner	-	-	2	-	-	1	-	-	-	-	-	-	-	-	-	3	0.1%
Comely shiner	-	-	-	14	-	-	-	-	33	-	-	-	-	-	-	47	1.6%
Common shiner	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	3	0.1%
Spottail shiner	-	-	-	-	-	-	-	-	-	-	1	15	48	23	1	88	3.1%
Swallowtail shiner	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	0.0%
Spotfin shiner	1	4	7	3	38	123	167	15	69	108	293	101	223	187	53	1,392	48.5%
Mimic shiner	-	5	-	-	1	2	3	2	2	13	15	15	-	8	-	66	2.3%
Bluntnose minnow	2	1	8	-	1	-	-	-	51	-	8	1	-	-	-	72	2.5%
Fallfish	19	13	67	32	52	33	39	30	64	60	23	51	2	56	4	545	19.0%
White sucker	-	-	-	-	-	-	4	-	4	1	3	4	1	4	-	21	0.7%
Northern hog sucker	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.0%
Shorthead redhorse	-	-	-	-	1	-	-	-	1	-	-	2	-	-	-	4	0.1%
Brown bullhead	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	2	0.1%
Channel catfish	-	-	1	-	1	-	2	-	-	-	-	-	-	1	-	5	0.2%
Banded killifish	75	37	33	49	31	54	81	47	38	6	5	4	1	5	1	467	16.3%
Rock bass	-	1	-	-	-	1	-	3	27	3	-	3	1	3	2	44	1.5%
Redbreast sunfish	-	1	-	1	3	2	6	-	-	13	5	2	-	3	1	37	1.3%
Green sunfish	-	-	1	-	-	-	-	-	-	1	-	-	-	-	1	3	0.1%
Bluegill	1	1	-	2	-	1	-	1	8	1	1	-	-	-	7	23	0.8%
Smallmouth bass	4	2	2	2	-	-	-	2	2	-	1	-	-	-	-	15	0.5%
Tessellated darter	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2	0.1%
Greenside darter	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	2	0.1%
Yellow perch	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	2	0.1%
Walleye	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	12	0.4%
<b>Total</b>	<b>105</b>	<b>65</b>	<b>123</b>	<b>104</b>	<b>131</b>	<b>218</b>	<b>303</b>	<b>105</b>	<b>316</b>	<b>206</b>	<b>356</b>	<b>199</b>	<b>276</b>	<b>290</b>	<b>71</b>	<b>2,873</b>	<b>100.0%</b>
<b>No. of Species</b>	<b>9</b>	<b>10</b>	<b>10</b>	<b>8</b>	<b>10</b>	<b>9</b>	<b>8</b>	<b>9</b>	<b>17</b>	<b>9</b>	<b>12</b>	<b>11</b>	<b>6</b>	<b>9</b>	<b>9</b>	<b>30</b>	

**Table 5. Index of abundance for juvenile American shad collected by haul seine from the middle Susquehanna River at City Island, Harrisburg, Pennsylvania in 2010.**

		Total				Wild			Hatchery		
			Mean	GM	GM		Mean	GM		Mean	GM
			Combined	Combined	Individual		Combined	Combined		Combined	Combined
			Daily	Daily	Haul		Daily	Daily		Daily	Daily
<b>Year</b>	No. Hauls	No. Fish	Daily CPUE	Daily CPUE	Haul CPUE*	No. Fish	CPUE (Wild)	CPUE (Wild)	No. Fish	CPUE (Hatchery)	CPUE (Hatchery)
<b>2010</b>	89	2	0.02	0.02	0.02	0	0.00	0.00	2	0.02	0.02

**Table 6. Weekly catch of juvenile American shad by haul seine from the middle Susquehanna River at City Island, Harrisburg, Pennsylvania, 2010.**

<b>Month</b>	<b>2010</b>	<b>Total</b>
1-7 Jul		0
8-15 Jul		0
16-23 Jul		0
24-31 Jul		0
1-7 Aug		0
8-15 Aug	0	0
16-23 Aug	1	1
24-31 Aug	0	0
1-7 Sep	0	0
8-15 Sep	0	0
16-23 Sep	0	0
24-30 Sep	0	0
1-7 Oct	0	0
8-15 Oct	0	0
16-23 Oct	0	0
24-31 Oct	1	1
1-7 Nov	0	0
8-15 Nov	0	0
16-23 Nov	0	0
24-30 Nov		0
1-7 Dec		0
<b>TOTAL</b>	<b>2</b>	<b>2</b>



**Table 7. Index of abundance for juvenile American shad collected by lift net in the forebay of Holtwood Hydroelectric Station, 1985-2009.**

Year	Total						Wild				Hatchery			
	No. Lifts	No. Fish	Mean Combined Daily CPUE	GM Combined Daily CPUE	GM Individual Lift CPUE*	Area under curve CPUE	No. Fish	Mean Combined Daily CPUE (Wild)	GM Combined Daily CPUE (Wild)	Area under curve CPUE	No. Fish	Mean Combined Daily CPUE (Hatchery)	GM Combined Daily CPUE (Hatchery)	Area under curve CPUE
1985	378	3,626	20.31	7.55		1422	***	***						
1986	404	2,926	10.30	5.71		888	***	***						
1987	428	832	3.17	1.90		178	***	***						
1988	230	929	3.87	1.28		254	***	***						
1989	286	556	0.86	0.43		53	***	***						
1990	290	3,988	13.75	3.67		1059	70	0.24	0.18	16	3,984	13.74	3.66	1042
1991	370	208	0.56	0.39		72	19	0.05	0.05	7	189	0.51	0.36	65
1992	250	39	0.16	0.12		13	14	0.06	0.05	5	25	0.10	0.08	9
1993	250	1,095	4.38	1.20		383	669	2.79	0.86	233	426	1.70	0.72	149
1994	250	206	0.82	0.48		71	35	0.15	0.13	12	171	0.68	0.42	59
1995	115	1,048	9.11	1.26	1.07	801	83	0.72	0.32	53	965	8.39	1.01	742
1997	300	1,372	4.57	0.88	0.61	411	100	0.33	0.23	30	1,272	4.24	0.85	381
1998	300	180	0.60	0.37	0.22	53	9	0.03	0.03	2	171	0.57	0.35	49
1999	300	490	1.63	0.78	0.50	145	19	0.06	0.07	5	471	1.57	0.76	140
2000	300	406	1.35	0.61	0.18	121	4	0.01	0.01	1	402	1.34	0.60	120
2001	299	1,245	4.18	1.37	0.43	273	538	1.81	0.45	112	707	2.38	0.99	161
2002	220	68	0.31	0.15	0.09	20	15	0.07	0.05	3	53	0.24	0.13	16
2003	300	61	0.20	0.13	0.07	17	3	0.01	0.01	1	58	0.23	0.15	17
2004	240	0	0.00	0.00	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0
2005	300	200	0.67	0.15	0.10	59	47	0.16	0.11	13	153	0.00	0.00	46
2006	230	8	0.03	0.03	0.01	1.6	0	0.00	0.00	0	8	0.03	0.03	1.6
2007	300	0	0.00	0.00	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0
2008	300	1	0.004	0.004	0.002	0.2	0	0.00	0.00	0	1	0.003	0.003	0.2
2009	300	0	0.000	0.000	0.000	0.0	0	0.00	0.00	0	0	0.000	0.000	0.0

\* Required by ASMFC

\*\*Mean flow during outmigration.

\*\*\*Most of the Holtwood samples processed were from cast net collections.

**Table 8. Historical weekly catch per unit effort (CPUE) of juvenile American shad collected by an 8 x 8 ft lift net at Holtwood Power Station inner forebay\*.**

Week	Historical Years															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1997	1998	1999	2000	2001
1-7 Aug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-15 Aug	-	-	-	-	-	-	0.00	-	-	-	0.00	-	-	-	-	-
16-23 Aug	-	-	-	-	-	0.00	0.00	0.00	-	-	0.00	-	-	-	-	-
24-31 Aug	-	-	-	-	-	0.00	0.00	0.00	-	-	0.00	-	-	-	-	-
1-7 Sep	-	-	-	0.00	-	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	-
8-15 Sep	-	-	1.25	-	-	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00
16-23 Sep	-	-	0.69	-	2.30	0.00	0.00	0.05	0.00	0.00	-	0.00	0.00	6.67	0.00	0.00
24-30 Sep	-	-	0.28	-	-	7.55	0.00	0.00	0.30	0.10	0.00	0.00	0.00	0.30	0.00	0.00
1-7 Oct	-	-	0.89	0.00	1.20	3.87	0.10	0.90	0.20	4.30	0.10	0.00	0.05	4.67	0.00	0.50
8-15 Oct	-	16.67	4.08	0.09	1.20	6.93	0.10	0.03	0.20	3.55	0.00	0.00	0.80	3.65	0.00	0.07
16-23 Oct	0.12	30.29	4.50	0.00	3.22	65.13	0.55	0.45	0.10	0.75	5.05	0.00	2.07	1.87	0.20	0.13
24-31 Oct	1.00	5.40	1.25	9.97	0.50	43.63	0.90	0.50	17.50	0.23	68.90	0.20	2.45	0.50	1.17	0.90
1-7 Nov	41.60	5.29	4.78	19.07	0.00	5.33	1.10	0.00	14.80	0.70	56.05	0.00	1.07	0.00	1.45	1.90
8-15 Nov	28.63	4.09	4.47	2.00	0.00	0.50	2.40	0.00	19.00	0.10	9.30	25.10	0.10	0.00	2.80	7.30
16-23 Nov	10.79	19.52	0.25	0.25	0.00	0.20	0.50	0.00	1.60	0.03	0.00	27.10	0.10	0.00	7.23	6.67
24-30 Nov	36.37	6.31	0.67	0.35	-	0.00	1.18	-	0.10	0.00	0.00	1.46	0.05	0.00	1.85	2.75
1-7 Dec	62.80	14.20	0.00	0.00	-	-	-	-	-	0.00	-	0.00	0.00	0.00	0.00	23.37
8-15 Dec	4.30	0.11	-	-	-	-	1.20	-	-	-	-	-	0.60	0.00	0.00	-
16-23 Dec	0.51	0.00	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-
24-31 Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Total shad</b>	3,626	2,926	832	929	556	3,988	208	39	1,095	206	2,100	1,372	180	490	406	1,245
<b>Total lifts</b>	378	404	428	230	286	290	370	240	240	250	230	300	300	300	300	300
<b>CPUE</b>	9.59	7.24	1.94	4.04	1.94	13.75	0.56	0.16	4.56	0.82	9.13	4.57	0.60	1.63	1.35	4.15

\* The lift net program was not conducted in 1996 due to flood damage to the platform.

Table 8. Continued.

Week	Historical Years							Year
	2002	2003	2004	2005	2006	2007	2008	2009
1-7 Aug	-	-	-	-	-	-	-	-
8-15 Aug	-	-	-	-	-	-	-	-
16-23 Aug	-	-	-	-	-	-	-	-
24-31 Aug	-	-	-	-	-	-	-	-
1-7 Sep	-	-	-	-	-	-	-	-
8-15 Sep	-	-	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
16-23 Sep	-	0.00	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
24-30 Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
1-7 Oct	0.00	1.30	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
8-15 Oct	0.03	0.50	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
16-23 Oct	3.30	0.27	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
24-31 Oct	0.03	0.00	0.00	6.67	0.20	0.00	0.00	<b>0.00</b>
1-7 Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
8-15 Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.10	<b>0.00</b>
16-23 Nov	0.00	0.00	0.00	0.00	-	0.00	0.00	<b>0.00</b>
24-30 Nov	0.00	0.00	0.00	0.00	-	0.00	0.00	<b>0.00</b>
1-7 Dec	0.00	0.00	0.00	-	-	0.00	0.00	<b>0.00</b>
8-15 Dec	0.00	0.00	-	-	-	-	-	<b>0.00</b>
16-23 Dec	-	-	-	-	-	-	-	-
24-31 Dec	-	-	-	-	-	-	-	-
<b>Total shad</b>	68	61	0	200	8	0	1	<b>0</b>
<b>Total lifts</b>	260	300	240	270	230	300	300	<b>300</b>
<b>CPUE</b>	0.26	0.20	0.00	0.74	0.03	0.00	0.003	<b>0.000</b>

**Table 9. Number of fish collected during intake screen sampling by unit at Peach Bottom Atomic Power Station in fall, 2010.**

<b>Species</b>	<b>Unit 2</b>	<b>Unit 3</b>	<b>Total</b>
American shad	6	5	11
Alewife	137	373	510
Blueback herring	0	0	0
Gizzard shad	2,849	4,942	7,791
Carp	0	2	2
Comely shiner	11	9	20
Spottail shiner	3	7	10
Spotfin shiner	5	5	10
Bluntnose minnow	2	3	5
Quillback	0	2	2
Shorthead redhorse	1	6	7
Channel catfish	137	465	602
Flathead catfish	2	3	5
White sucker	0	1	1
Rock bass	12	30	42
Green sunfish	20	50	70
White Perch	1	0	1
Bluegill	2,513	3,020	5,533
Largemouth bass	2	0	2
White crappie	3	18	21
Black crappie	0	3	3
Tessellated darter	10	22	32
Walleye	1	0	1
Yellow perch	0	2	2
Logperch	2	5	7
Crayfish	9	4	13
<b>TOTAL</b>	<b>5,726</b>	<b>8,977</b>	<b>14,692</b>

**Table 10. Number of juvenile American shad collected during intake screen sampling by unit at Peach Bottom Atomic Power Station in fall, 2010.**

<b>Date</b>	<b>Unit 2</b>	<b>Unit 3</b>	<b>Total</b>
29 Oct	1	0	1
01 Nov	0	1	1
03 Nov	2	0	2
08 Nov	0	1	1
10 Nov	0	1	1
15 Nov	2	0	2
19 Nov	1	0	1
22 Nov	0	1	1
01 Dec	0	1	1
<b>TOTAL</b>	<b>6</b>	<b>5</b>	<b>11</b>

**Table 11. Species and number of fish collected during cooling water intake sampling at Conowingo Dam in Fall, 2010.**

<b>Species</b>	<b>Francis Units (7)</b>	<b>Kaplan Units (4)</b>	<b>Total</b>
American shad	2	0	2
Alewife	1	0	1
Alosa sp. (Decapitated)	1	0	1
Gizzard shad	3,410	2,509	5,919
Brown trout	0	1	1
Comely shiner	1	2	3
Channel catfish	12	1	13
Flathead catfish	1	0	1
Spotfin shiner	1	3	4
Bluntnose minnow	1	0	1
Bluegill	8	6	14
Northern hogsucker	1	0	1
Banded killifish	1	0	1
<b>TOTAL</b>	<b>3,440</b>	<b>2,522</b>	<b>5,962</b>

**Table 12. Number of juvenile American shad collected during cooling water intake strainer sampling at Conowingo Dam in fall, 2010.**

<b>Date</b>	<b>Francis Units (7)</b>	<b>Kaplan Units (4)</b>	<b>Total</b>
08 Oct	1	0	1
29 Oct	1	0	1
<b>TOTAL</b>	<b>2</b>	<b>0</b>	<b>2</b>

**Table 13. Catch of juvenile American shad by location from the upper Chesapeake Bay during the 2010 Maryland DNR juvenile finfish haul seine survey.**

<b>SITE</b>	<b>AMSHAD Round 1</b>	<b>AM SHAD Round 2</b>	<b>AM SHAD Round 3</b>
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UPPER BAY PERM

HOWELL PT.	0	0	0
TIMS CR	1	0	0
SASSAFRAS NRMA	0	0	0
PARLOR PT.	0	0	3
ELK NECK PARK	7	1	0
WELCH PT.	0	0	9
HYLAND PT.	31	35	0
<b>TOTALS</b>	<b>39</b>	<b>36</b>	<b>12</b>

HOB (AUX)

CARPENTER PT	4	0	10
POPLAR PT	no haul	no haul	no haul
PLUM PT	4	0	10
SPOIL ISLAND	0	0	0
TYDINGS ESTATE	0	0	0
TOLCHESTER	0	0	0
<b>TOTALS</b>	<b>8</b>	<b>0</b>	<b>20</b>

**Table 14. Analysis of juvenile American shad otoliths collected in the Susquehanna River, 2010.**

Collection Site	Coll. Date	Day	Days	Day	Days	Days	Days	Days	Days	Days	Days	Total Hatchery	Total Wild	Total Processed	Total Collected
		3	3,6,9	1	3,6,9,15	5	2,15	15	5,18	5,18	various + sngl feed				
		Jun/ Susq.	Jun/ Susq.	Jun/ Susq.	N. Br. Susq. (PA)	W. Br. Susq./Bald Eagle Cr.	Cono dogui net Cr.	Conest oga R.	Swatar a Cr.	W. Conewa go Cr.	Raceway				
City Island	8/17/2010	1	0	0	0	0	0	0	0	0	0	1	0	1	1
	10/26/2010	0	0	0	0	0	0	0	0	1	0	1	0	1	1
Dock St. Dam	10/11/2010	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Columbia	10/13/2010	0	0	0	0	0	0	0	0	0	0	0	1	1	1
	10/28/2010	0	0	0	0	0	0	0	0	0	1	1	0	1	1
Otter Cr.	10/8/2010	0	0	0	0	0	0	0	1	0	0	1	0	1	1
Peach Bottom	10/29/2010	0	0	0	1	0	0	0	0	0	0	1	0	1	1
	11/1/2010	0	1	0	0	0	0	0	0	0	0	1	0	1	1
	11/3/2010	0	0	0	0	2	0	0	0	0	0	2	0	2	2
	11/8/2010	0	0	0	0	0	0	0	0	0	0	0	1	1	1
	11/10/2010	0	0	0	0	0	1	0	0	0	0	1	0	1	1
	11/15/2010	0	0	0	0	0	0	0	0	0	0	1	1	2	2
	11/19/2010	0	0	1	0	0	0	0	0	0	0	1	0	1	1
	11/22/2010	0	0	0	0	1	0	0	0	0	0	1	0	1	1
12/1/2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Conowingo	10/8/2010	0	0	0	0	0	0	0	1	0	0	1	0	1	1
Strainers	10/29/2010	0	0	0	0	0	0	0	0	0	0	1	0	1	1
	11/5/2010	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Holt./P. Bot./Con.		1.0	1.0	1.0	1.0	3.0	1.0	0.0	2.0	1.0	1.0	14.0	4.0	18.0	20.0
Percent		5.0%	5.0%	5.0%	5.0%	15.0%	5.0%	0.0%	10.0%	5.0%	5.0%	70.0%	20.0%	90.0%	
Grand Total		1.0	1.0	1.0	1.0	3.0	1.0	0.0	2.0	1.0	1.0	14.0	4.0	18.0	20.0
Percent		5.0%	5.0%	5.0%	5.0%	15.0%	5.0%	0.0%	10.0%	5.0%	5.0%	70.0%	20.0%	90.0%	

\*\*When the entire sample collected was not processed, the shad successfully processed were weighted to ensure that row totals equalled the total number collected.