JOB III. AMERICAN SHAD HATCHERY OPERATIONS, 2011

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INTRODUCTION

The Pennsylvania Fish and Boat Commission has operated the Van Dyke Research Station for Anadromous Fishes since 1976 as part of an effort to restore diadromous fishes to the Susquehanna River Basin. The objectives of the Van Dyke Station were to research culture techniques for American shad and to rear juveniles for release into the Juniata and Susquehanna Rivers. The program goal was to develop a stock of shad imprinted to the Susquehanna drainage, which will subsequently return to the river as spawning adults. With the completion of York Haven Dam fish passage facilities in 2000, upstream hydroelectric project owners were no longer responsible for funding the hatchery effort. Funding was provided by the Pennsylvania Fish and Boat Commission.

In 2003, a new effort in migratory fish restoration was undertaken. Adult hickory shad (*Alosa mediocris*) were collected and tank-spawned as part of the initial efforts to culture, release and restore runs of hickory shad to the Susquehanna and Delaware River basins. No hickory shad culture occurred in 2010 due to budget constraints, however it resumed in 2011.

As in previous years, production goals for American shad for 2011 were to stock 10-20 million American shad larvae. All Van Dyke hatchery-reared American shad larvae were marked by immersion in tetracycline bath treatments in order to distinguish hatchery-reared shad from those produced by natural spawning of wild adults. All eggs received at Van Dyke were disinfected to prevent the spread of infectious diseases from out-of-basin sources.

EGG SHIPMENTS

A total of 23.5 million American shad eggs (415.6 L) was received in 31 shipments in 2011 (Table 1). This was the second highest quantity of eggs received since 2003 (Table 2, Figure 1). Overall American shad egg viability (which we define as the percentage of eggs that ultimately hatch) was 22.6%, yielding 5.3 million viable eggs. Experimental shipment coolers were used in 2011 for the transport of fertilized American shad eggs from the Delaware and Potomac rivers (results summarized in Appendix 1). Ten Potomac River egg shipments (6.2 million eggs) were received from April 14 to May 8, 2011, with an overall viability of 43.7% (Table 1). There were 11.6 million fewer Potomac River eggs available for culture work in 2011 than in 2010 (Table 3).

Delaware River egg shipments were received from May 15 to June 2. A total of thirteen shipments, consisting of 9.9 million eggs were processed at Van Dyke. This was the largest egg take since 1998 (Table 3, Figure 1); however, overall egg viability of 14.7% was the lowest on record for the Delaware River (Figure 2).

American shad and hickory shad eggs were also obtained from tank-spawning efforts at Conowingo Dam, operated by Normandeau Associates. Pre-spawn adult hickory shad were obtained from shore anglers at the mouth of Deer Creek and electrofishing operations conducted by Maryland Department of Natural Resources (MDNR) biologists at Lapidum, MD. All captured hickory shad broodstock were taken to the tank-spawning facility by Pennsylvania Fish & Boat Commission transport truck. American shad broodstock were obtained from the West Fish Lift at Conowingo Dam.

All American shad were injected with hormones and allowed to spawn naturally, whereas hickory shad received no injections. The tank-spawn array at Conowingo uses water pumped directly from the river and is subject to natural fluctuations in water temperature. Ability to control temperature in the tank (gradual warming to optimal temperature) is thought to be critical for successful tank-spawning without hormones (Jeff Evans, NC Wildlife Resource Commission, personal communication).

Spawning trials of American shad in 2011 produced 7.3 million eggs, in eight shipments delivered to the Van Dyke Hatchery. Overall viability of those eggs averaged 15.7% (or some 1.1 million hatched eggs). This has become a consistent source of American shad eggs for the restoration program, but viability has been low, ranging from 9% to 33%.

Tank-spawning of hickory shad (non-hormone spawning) produced 12.1 million eggs over five shipments in 2011. Average egg viability was 78.9%, the second highest recorded in eight years of spawning trials, and falls within the upper range of viabilities (range 44.1% to 84.9%).

No eggs were collected from the Hudson River in 2011 due to concerns over declines in the Hudson River stock. The loss of the Hudson River as an egg source is unfortunate because of its consistent production of high quality eggs. Egg production from the Potomac River has been consistently below the historical production from the Hudson River and it has become apparent that additional or expanded sources of eggs will be required to meet the goal of 10-15 million larvae stocked.

SURVIVAL

Survival of individual tanks followed patterns similar to those observed in the past in that the majority of the tanks experienced their highest mortality after nine days of age (Figure 3a). Larval American shad in culture tanks B1 and B4 were split into two additional tanks (D2 and D3, respectively) due to higher than estimated densities and concerns over increased mortality (resulting from intra-specific competition) (Figure 3b). Approximately half of the larvae in tank B1 were moved to D2 at 19d (via water brailing). Mortality substantially increased in D2 following the move with a final (40d) survival of 37%. Survival in B1 was relatively stable throughout culturing (40d survival of 79%). Culture tank B4 was also split, with about half of its larvae going into D3 at 3d. Both tanks experienced similar mortality rates through stocking (26d survival of 86% and 84%, respectively). The cause of the higher than normal mortality in D2 likely resulted from handling stress induced during the tank-to-tank transfer. Culture tank H1 also experienced higher than normal mortality (22d survival of 57%) for unknown reasons (Figure 3a). The mortality experienced in 2011 was below average based on the overall survival of 78% compared to an average of 63%

(range of 19% to 94%) since hatchery operations began in 1976 (Table 2). Additionally, no tanks suffered complete mortality in 2011.

The fluidized bed system installed in 2008 worked extremely well and pH of the fish culture water ranged from 7.0 to 7.6 with a mean of 7.3. Daily monitoring of gas saturation and adjustment of the oxygen injection system maintained nitrogen, oxygen and total gas saturation at acceptable levels. Oxygen saturation averaged 101.4% with a maximum of 106.5%. The high value occurred a few days after the initial egg shipment was received and was quickly corrected before any hatching occurred. Nitrogen saturation averaged 100.6% with a maximum of 104.9%. Total gas saturation averaged 100.2% with a maximum of 103.7%. As a result, no incidents of gas bubble disease occurred. Larvae stocked in 2011 appeared active and robust.

LARVAL PRODUCTION

Production and stocking of American shad larvae, summarized in Tables 2, 3, and 4, totaled 4.1 million. A total of 1.3 million were released in the Juniata River, 83 thousand in the North Branch Susquehanna River in Pennsylvania, 1.4 million in the West Branch Susquehanna River and 191 thousand in Bald Eagle Creek. Due to an inability to test and certify that the larvae were VHS free, no larvae were stocked in the Potomac River or New York waters of the Susquehanna River.

Delaware River egg collections in 2011 yielded the greatest quantity of eggs since 1998. However, eggs collected from the Delaware River were not sufficient to meet the goals for stocking larvae in the Delaware River Basin, largely because of low egg viability. Larvae were stocked in the Lehigh River (473 thousand), the Schuylkill River (643 thousand). No larvae were stocked in the Delaware River. More than 80 percent of the 2011 spawning run being composed of the 2005 year class (which was also the dominant year class of the 2010 run).

TETRACYCLINE MARKING

All American shad larvae stocked received marks produced by immersion in tetracycline (Table 6). Immersion marks for American shad were administered by 4h bath treatments in 512-

ppm. In addition to immersion markings, cultured fingerling shad were fed tetracycline lace feed (88g tetracycline per one kilogram of feed) for three consecutive days prior to stocking, producing a fingerling tag.

All American shad larvae were marked according to stocking site and/or egg source (Table 6). Some 1.4 million larvae received marks on days 3 and18 and were stocked in the West Branch Susquehanna River. This was a unique mark used in 2011 as a result of protracted high flows in the Juniata River (original destination for fry with day 3 OTC mark) and flows conducive for stocking in the West Branch Susquehanna River (fry OTC marked on day 18 prior to stocking). Bald Eagle Creek, a tributary to the West Branch, received some 191 thousand larvae marked on days 3, 6, 9, 12, and 15. One million larvae were marked on days 3, 6 and 9 (Susquehanna River egg source) and an additional 296 thousand larvae marked on day 3, all being stocked in the Juniata River. The North Branch Susquehanna River in Pennsylvania received some 83 thousand larvae, marked on days 3, 6, 9, and 15. The Lehigh River received 473 thousand larvae marked on days 9, 12, and 15. The Schuylkill River received 643 thousand larvae marked on days 3, 6, 9, and 12.

Octoraro Creek, a tributary to the lower Susquehanna River, received 500 thousand hickory shad larvae that were marked on day 3. Pennypack Creek (a tributary to the Delaware River) received 1.9 million hickory shad larvae marked on day 3. Ridley Creek, another tributary to the Delaware River, was stocked with 1.2 million hickory shad larvae marked on day 3, days 3 and 9, and days 3 and 15.

Verification of mark retention was accomplished by stocking groups of marked fry in raceways at the Benner Spring State Fish Hatchery and examining otolith samples collected later. Otoliths were extracted and mounted in Permount on microscope slides. A thin section was produced by grinding the otolith on both sides. Otolith sections were examined for marks with an epi-fluorescent microscope with a UV light source.

Raceway culture was successful in 2011, yielding specimens for verification of each mark produced. All fingerling American and hickory shad examined exhibited marks, conforming to the marking protocol on Table 6. Digital photographs have been archived from representative samples of the marks detected for future reference. These will assist in identifying the origin of marks

detected in out-migrating juveniles and returning adults from the 2011 cohort.

Groups of American shad which exhibited the intended mark in 100 percent of the specimens examined included the West Branch Susquehanna (3, 18), Bald Eagle Creek (3,6,9,12,15), Juniata River (3 and 3,6,9), North Branch Susquehanna (3,6,9,15) and the Lehigh River (9,12,15). The Schuylkill River group (3,6,9,12) exhibited mark retention of 97 percent. American shad larvae grown out to fingerlings were fed OTC laced feed prior to stocking and those examined exhibited 100 percent retention of the feed mark. The single group of hickory shad examined exhibited 96 percent retention of the day 3 immersion mark (stocked in Octoraro and Pennypack creeks). Some hickory shad fry were kept in the hatchery for feed trials. These hickory shad were given an additional immersion mark (3, 9 or 3,15), but none were retained for mark retention.

SUMMARY

A total of 31 shipments of American shad eggs (23.5 million eggs) were received at Van Dyke in 2011. Total egg viability was 22.6% and survival of viable eggs to stocking was 78%, resulting in production of 4.1 million larvae. Larvae were stocked in the Juniata River (1.3 million), the West Branch Susquehanna River (1.4 million), Bald Eagle Creek (191 thousand), and the North Branch Susquehanna River in Pennsylvania (83 thousand). Delaware River source American shad larvae were stocked in the Lehigh (473 thousand) and the Schuylkill (643 thousand) rivers. No American shad larvae were stocked in the Delaware River because our stocking goals in the Lehigh and Schuylkill Rivers were not met.

A total of 5 shipments of hickory shad eggs (12.1 million eggs) were received and processed at Van Dyke in 2011. Overall egg viability was 78.9% resulting in the production of some 3.6 million larvae. Hickory shad larvae were stocked in Octoraro Creek (500 thousand), a tributary to the Susquehanna River, while Pennypack and Ridley creeks (tributaries to the Delaware River) received 1.9 and 1.2 million hickory shad larvae, respectively.

No major mortality occurred due to disruption of flow. Installation of a fluidized bed system in 2008 and closer monitoring of the oxygen injection system resulted in pH and gas

saturation levels that contributed to high survival.

All American and hickory shad larvae cultured at Van Dyke were marked by 4-hour immersion in oxytetracycline. Marks for American shad were assigned based on release site and/or egg source river. All raceway cultured shad examined for marks had marks as intended except for a few specimens that were not marked**.**

RECOMMENDATIONS FOR 2012

1. Disinfect all egg shipments at 50 ppm free iodine.
2. Slow temper eggs collected at river temperatures below 55°F.
3. Routinely feed all larvae beginning at hatch.
4. Continue to hold egg jars on the incubation battery until eggs begin hatching (usually day 7), before transferring to the tanks. Transfer incubation jars to the tanks on day 7 without sunning. Sun the eggs on day 8 to force hatching.
5. Continue to siphon eggshells from the rearing tank within hours of egg hatch.
6. Continue to feed left over AP-100 only if freshly manufactured supplies run out.
7. Use MSXXX jars preferentially to promote egg layering and maintain good egg survival.
8. Continue to collect American shad eggs from the Potomac River as an additional source of out-of-basin eggs.
9. Mark American and hickory shad at 512ppm OTC.
10. Continue using PENNOX 343 (now FDA approved) for marking alosines.
11. Continue to utilize a fluidized bed system, using limestone sand to buffer the Van Dyke source water, neutralize the pH and reduce dissolved aluminum.
12. Continue to record pH, hardness and alkalinity on a regular basis to monitor fish culture water quality.
13. Continue to utilize additional packed column de-gassers to reduce the need for oxygen injection.
14. Continue to measure and record oxygen and nitrogen saturation on a daily basis. Use the

oxygen injection system only when needed and monitor oxygen saturation and larval condition when the system is in use.

15. Mark all tanks of larvae beginning at 11:00AM, to ensure consistency in daily mark application.
16. Consider other options for hickory shad restoration, including direct stocking of eggs or stocking of pre-spawn adults, based on the absence of adult hickory shad in extensive collections conducted at the release sites in 2009 and 2010 by the Philadelphia Water Department.
17. Investigate the potential of increasing egg production at Conowingo Dam by constructing a new tank-spawn facility with the capability of controlling temperatures in order to tank-spawn without the use of hormone injections.
18. Rear raceway cultured juvenile shad in warming pond water regardless of pH.
19. Obtain permission to use the UV microscope at the Northeast Fishery Center in Lamar to view critical otolith specimens.

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FIGURES AND TABLES

Figure 1. American shad eggs incubated at Van Dyke, 1983-2011.

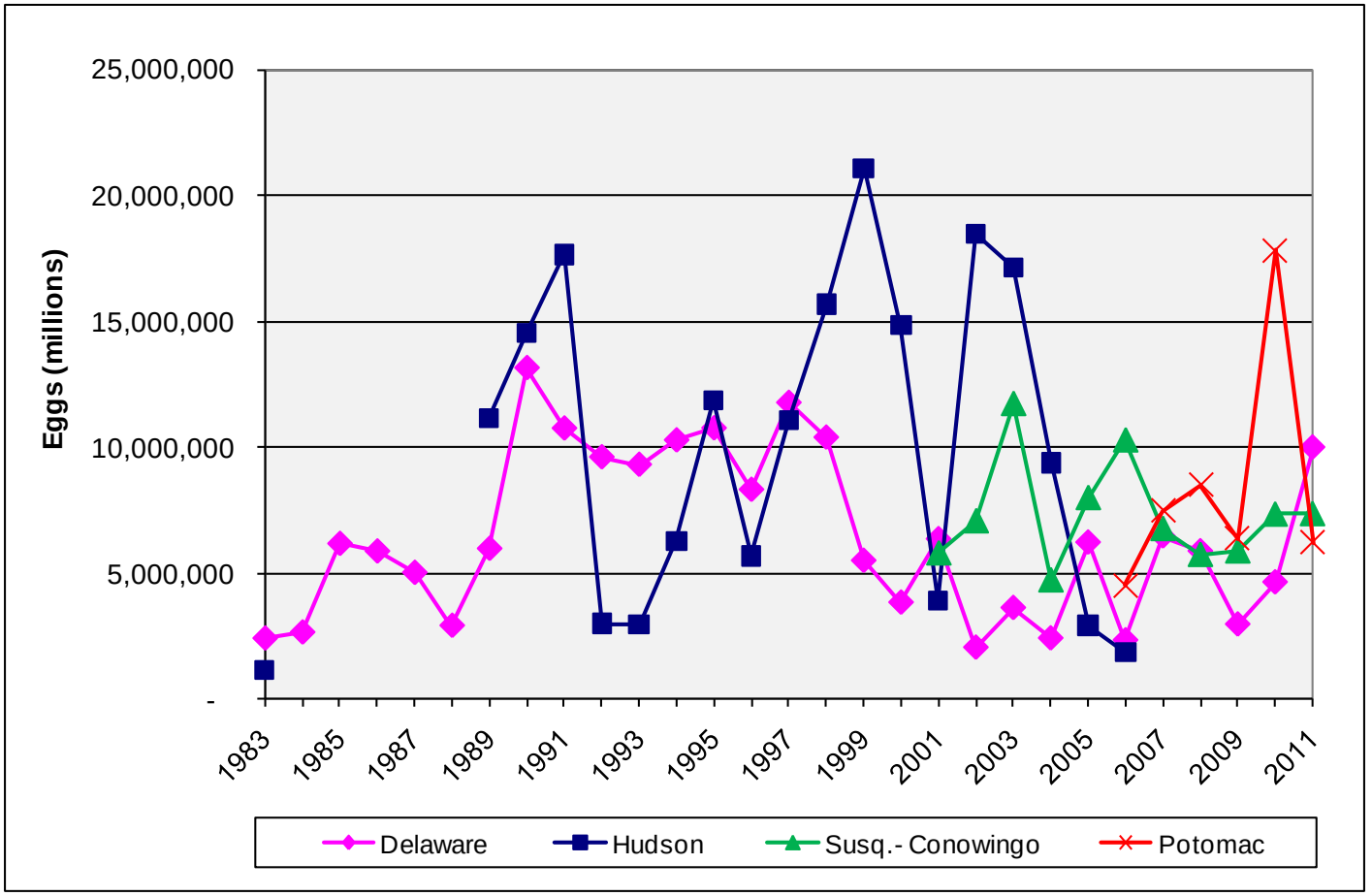

Figure 2. Egg viability (percentage of collected eggs that ultimately hatch) for American shad strip spawning operations on the Delaware, Potomac and Hudson rivers.

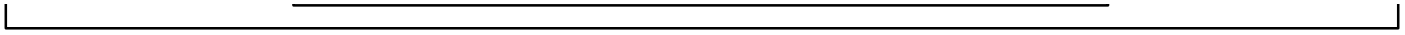

Figure 3a. Survival of American shad larvae, by tank, Van Dyke, 2011 (tanks B1, B4, D2, D3 excluded – see Figure 3b).

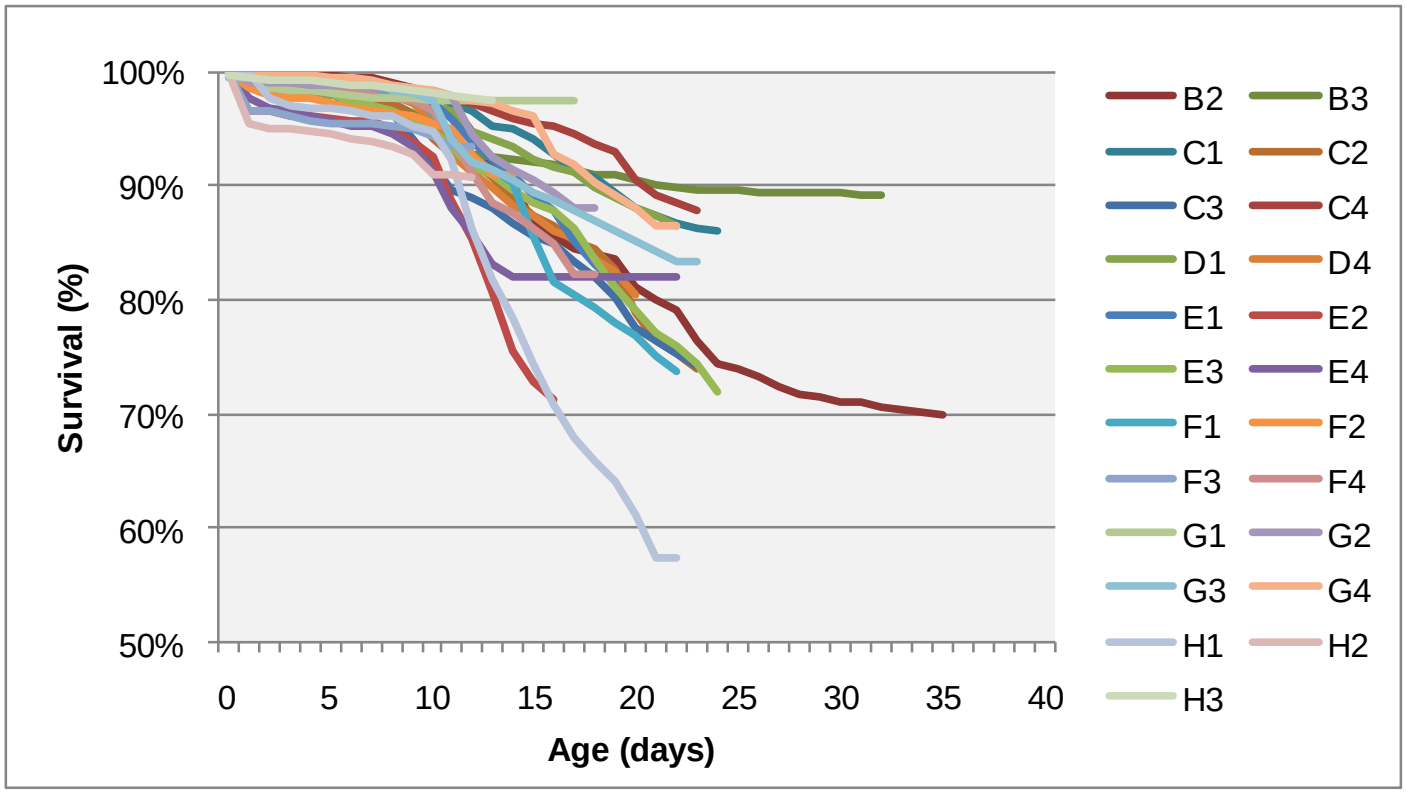

Figure 3b. Survival of American shad larvae in tanks B1, B4, D2 and D3 at Van Dyke, 2011 (B1 was split into D2 @ 19 days of age and B4 was split into D3 @ 4 days of age).

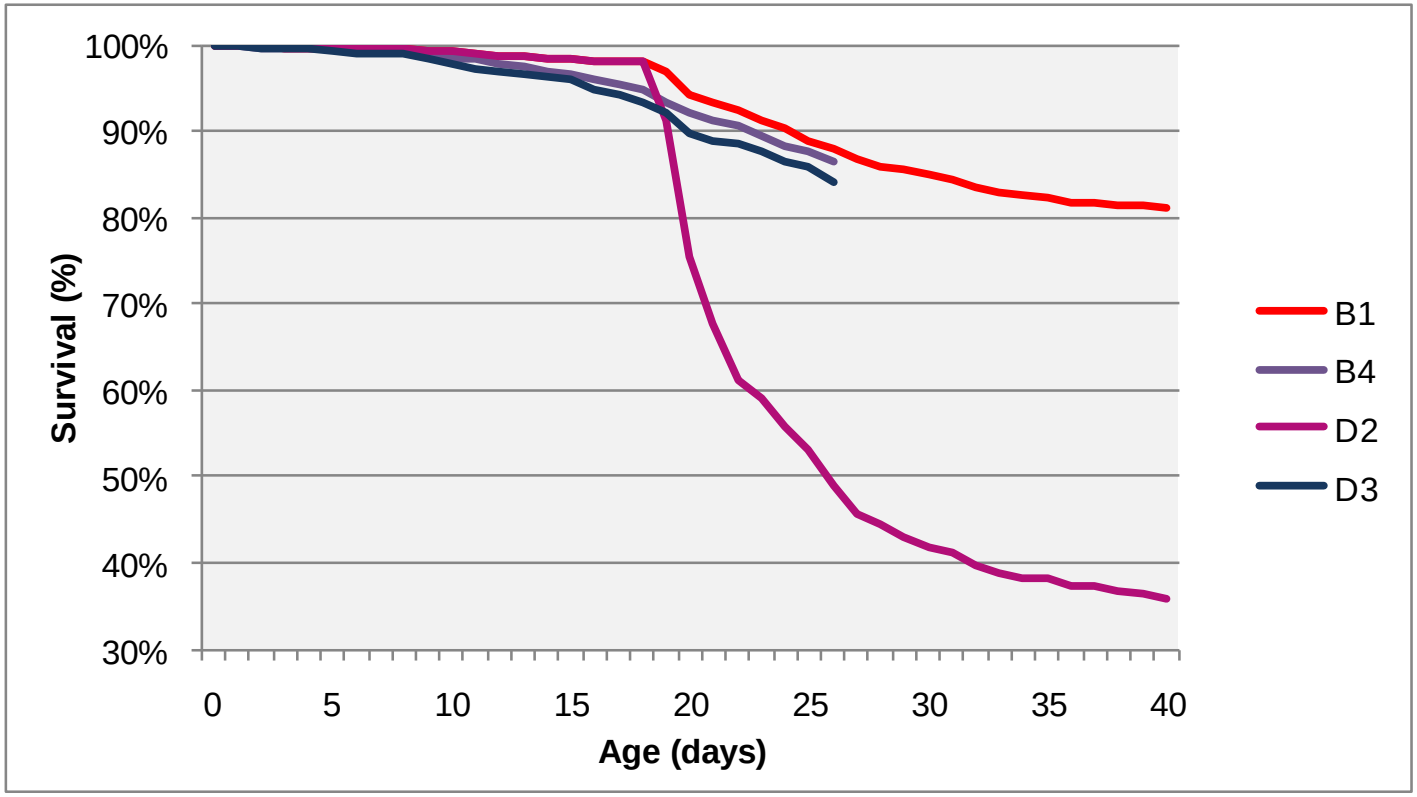

Table 1. Egg shipments received at Van Dyke, 2011.

No.	Species	River	Date Spawned	Date Received	Volume (L)	Eggs	Viable Eggs	Percent Viable
1	American shad	Potomac	4/14/11	4/15/11	19.8	912,775	310,882	34.1%
2	American shad	Potomac	4/25/11	4/26/11	7.1	279,487	94,607	33.9%
3	Hickory shad	Susquehanna	4/26/11	4/26/11	7.9	2,318,069	1,921,383	82.9%
4	American shad	Potomac	4/26/11	4/27/11	5.0	190,917	10,710	5.6%
5	Hickory shad	Susquehanna	4/27/11	4/27/11	7.9	2,911,705	2,321,278	79.7%
6	American Shad	Potomac	4/28/11	4/29/11	10.3	588,455	82,943	14.1%
7	Hickory Shad	Susquehanna	4/28/11	4/29/11	2.8	1,483,827	926,948	62.5%
8	American Shad	Potomac	4/29/11	4/30/11	21.3	987,072	425,302	43.1%
9	American Shad	Potomac	5/1/11	5/2/11	14.8	784,317	473,467	60.4%
10	American shad	Potomac	5/4/11	5/5/11	20.2	861,733	545,721	63.3%
11	American shad	Potomac	5/5/11	5/6/11	17.0	655,675	402,075	61.3%
12	Hickory shad	Susquehanna	5/6/11	5/7/11	5.3	2,357,688	1,720,283	73.0%
13	Hickory Shad	Susquehanna	5/7/11	5/8/11	4.8	3,109,676	2,714,972	87.3%
14	American shad	Potomac	5/8/11	5/9/11	13.4	599,788	207,133	34.5%
15	American shad	Potomac	5/8/11	5/9/11	8.5	356,267	161,594	45.4%
16	American Shad	Susquehanna	5/13/11	5/14/11	12.6	821,265	66,545	8.1%
17	American Shad	Susquehanna	5/14/11	5/15/11	8.5	481,269	94,262	19.6%
18	American Shad	Delaware	5/15/11	5/16/11	5.4	206,148	11,296	5.5%
19	American shad	Susquehanna	5/16/11	5/17/11	20.4	1,273,333	267,067	21.0%
20	American shad	Delaware	5/16/11	5/17/11	8.2	313,374	173,724	55.4%
21	American shad	Delaware	5/17/11	5/18/11	6.0	174,134	101,987	58.6%
22	American Shad	Delaware	5/18/11	5/19/11	5.1	177,242	39,839	22.5%
23	American Shad	Susquehanna	5/19/11	5/19/11	22.0	1,509,191	213,663	14.2%
24	American Shad	Susquehanna	5/21/11	5/21/11	20.8	1,184,690	268,890	22.7%
25	American Shad	Delaware	5/22/11	5/23/11	5.2	197,319	30,010	15.2%
26	American Shad	Susquehanna	5/22/11	5/23/11	7.2	577,542	69,724	12.1%
27	American shad	Delaware	5/23/11	5/24/11	11.4	350,084	68,587	19.6%
28	American shad	Delaware	5/24/11	5/25/11	27.8	1,028,904	584,915	56.8%
29	American shad	Delaware	5/25/11	5/26/11	30.8	1,686,809	215,976	12.8%
30	American Shad	Delaware	5/26/11	5/27/11	17.9	1,442,344	56,338	3.9%
31	American shad	Susquehanna	5/29/11	5/29/11	8.4	974,848	87,788	9.0%
32	American Shad	Susquehanna	5/29/11	5/30/11	6.5	540,475	88,491	16.4%
33	American shad	Delaware	5/30/11	5/31/11	13.1	1,272,730	0	0.0%
34	American shad	Delaware	5/31/11	6/1/11	16.1	1,640,515	43,179	2.6%
35	American shad	Delaware	6/1/11	6/2/11	9.7	670,769	120,650	18.0%
36	American Shad	Delaware	6/2/11	6/3/11	15.2	830,471	20,514	2.5%
Totals			No. of shipments					
	American shad	Potomac	10		137.4	6,216,484	2,714,435	43.7%
		Delaware	13		171.9	9,990,842	1,467,015	14.7%
		Susq.- Conowingo	8		106.4	7,362,615	1,156,431	15.7%
		Grand total	31		415.6	23,569,941	5,337,880	22.6%
	Hickory shad	Susq.- Conowingo	5		28.6	12,180,966	9,604,864	78.9%

Table 2. Annual summary of American shad production, 1976-2011.

Year	Egg Vol. (L)	No. of Eggs (exp.6)	Egg Via-bility (%)	No. of Viable Eggs (exp.6)	No. of Fry stocked (exp.3)		No. of Fingerling stocked (exp.3)	Total stocked (exp.3)	Fish Stocked/ Eggs Rec'd	Fish Stocked/ Viable Eggs
1976	120	4.0	52.0	2.1	518		266	784	0.19	0.37
1977	145	6.4	46.7	2.9	969		35	1,003	0.16	0.34
1978	381	14.5	44.0	6.4	2,124		6	2,130	0.10	0.33
1979	164	6.4	41.4	2.6	629		34	664	0.10	0.25
1980	347	12.6	65.6	8.2	3,526		5	3,531	0.28	0.43
1981	286	11.6	44.9	5.2	2,030		24	2,053	0.18	0.39
1982	624	25.9	35.7	9.2	5,019		41	5,060	0.20	0.55
1983	938	34.5	55.6	19.2	4,048		98	4,146	0.12	0.22
1984	1157	41.1	45.2	18.6	11,996		30	12,026	-	0.73
1985	814	25.6	40.9	10.1	6,960		115	7,075	0.28	0.68
1986	1535	52.7	40.7	21.4	15,876		61	15,928	0.30	0.74
1987	974	33.0	40.7	15.8	10,274		81	10,355	0.31	0.66
1988	885	31.8	38.7	12.3	10,441		74	10,515	0.33	0.86
1989	1220	42.7	60.1	25.7	22,267		60	22,327	0.52	0.87
1990	896	28.6	56.7	16.2	12,034		253	12,287	0.43	0.76
1991	902	29.8	60.7	18.1	12,963		233	13,196	0.44	0.73
1992	532	18.5	68.3	12.6	4,645		34	4,679	0.25	0.37
1993	558	21.5	58.3	12.8	7,870		79	7,949	0.37	0.62
1994	551	21.2	45.9	9.7	7,720	*	140	7,860	0.31	0.68
1995	768	22.6	53.9	12.2	10,930	*	-	10,930	0.43	0.79
1996	460	14.4	62.7	9.0	8,466	*	-	8,466	0.59	0.94
1997	593	22.8	46.6	10.6	8,019		25	8,044	0.35	0.76
1998	628	27.7	57.4	15.9	11,757		2	11,759	0.42	0.74
1999	700	26.6	59.2	15.7	14,412		-	14,412	0.54	0.92
2000	503	18.7	64.8	12.1	10,535		-	10,535	0.56	0.87
2001	423	21.1	35.0	7.4	6,524		7	6,531	0.31	0.88
2002	943	35.6	38.8	13.8	2,589		-	2,589	0.07	0.19
2003	1005	33.0	49.4	16.3	12,742		-	12,742	0.39	0.78
2004	462	17.3	54.0	9.3	5,637		-	5,637	0.33	0.60
2005	372	17.1	36.6	6.0	5,208		1	5,209	0.30	0.87
2006	394	19.0	35.2	6.7	4,945		-	4,945	0.26	0.74
2007	404	20.7	27.7	5.8	2,509		-	2,509	0.12	0.43
2008	441	20.1	28.3	5.7	4,020		-	4,020	0.20	0.71
2009	282	15.2	25.2	3.8	3,073		-	3,073	0.20	0.81
2010	576	29.8	31.8	9.9	5,471		3	5,474	0.18	0.55
2011	416	23.6	22.6	5.3	4,169		9	4,178	0.18	0.78
							Total	**264,619**		
					Total since 1985 (OTC marked)			**233,222**		

*Includes fry reared at Manning Hatchery.

Table 3. American shad eggs used in Pennsylvania's shad restoration program, by egg source.

Year	Hudson Gill Net	Delaware Gill Net	Susquehanna Conowingo Tank Spawn	Susquehanna Lapidum Gill Net	Susquehanna Muddy Run Gill Net	Susquehanna Lamar Tank Spawn	Connecticut Gill Net	Pamunkey Gill Net	Mattaponi Gill Net	James Gill Net	Savannah Gill Net	Columbia Gill Net	Potomac Gill Net	Total
1971				8.42										8.42
1972				7.10										7.10
1973				4.74			4.30	8.45	6.48				34.64	58.61
1974							0.53	9.75	6.80	19.20		8.18	5.56	50.02
1975								1.88		7.15		18.42	5.70	33.15
1976		4.10										54.80		58.90
1977							0.35	4.40	0.57	3.42		8.90		17.64
1978								6.90		10.11		0.00		17.01
1979								3.17		4.99		0.00		8.16
1980								6.73		6.83		0.00		13.56
1981								4.58		1.26		5.78		11.62
1982								2.03		1.25		22.57		25.85
1983	1.17	2.40						5.49		5.91		19.51		34.48
1984		2.64						9.83		0.74		27.88		41.09
1985		6.16						5.28		2.05		12.06		25.55
1986		5.86						5.62		1.07		39.97		52.52
1987		5.01						4.35		0.11		23.53		33.00
1988		2.91						1.92		0.05		26.92		31.79
1989	11.18	5.96						1.91		0.53		23.10		42.68
1990	14.53	13.15				0.33		0.48			0.12			28.61
1991	17.66	10.75				0.30	1.10							29.80
1992	3.00	9.60					5.71			0.17				18.49
1993	2.97	9.30					7.45	1.78						21.50
1994	6.29	10.27					4.09	0.53	0.03					21.22
1995	11.85	10.75												22.61
1996	5.69	8.31				0.41								14.41
1997	11.08	11.76												22.84
1998	15.68	10.38				1.66								27.72
1999	21.10	5.49												26.59
2000	14.88	3.83												18.71
2001	3.92	6.35	5.81			5.05								21.13
2002	18.51	2.04	7.08			7.99								35.62
2003	17.12	3.61	11.72	0.56	0.02									33.04
2004	9.39	2.41	4.74	0.75										17.29
2005	2.92	6.21	8.00										0.00	17.14
2006	1.86	2.33	10.28										4.51	18.98
2007	0.00	6.46	6.77										7.49	20.72
2008		5.87	5.75										8.50	20.12
2009		2.96	5.89										6.38	15.23
2010		4.63	7.34										17.84	29.82
2011		9.99	7.36										6.22	23.57
Total	190.81	191.50	80.75	21.57	0.02	15.74	23.53	85.08	13.88	64.84	0.12	291.62	96.84	1,076.30

Table 4. American shad stocking, 2011.

Date	Tank	Number	Species	Location	Origin	OTC Mark (days)	Age (days)	Size
5/6/11	A1	1,914,188	Hickory shad	Pennypack Creek	Susquehanna	3	4	Fry
5/6/11	A2	1,000,000	Hickory shad	Ridley Creek	Susquehanna	3	4	Fry
5/25/11	A3	1,000	Hickory shad	Ridley Creek	Susquehanna	3,15	21	Fry
5/25/11	A4	199,000	Hickory shad	Ridley Creek	Susquehanna	3,9	14	Fry
5/27/11	A12	500,000	Hickory shad	Octoraro Creek	Susquehanna	3,9	15	Fry
6/1/11	B1	126,956	American shad	Bald Eagle Creek	Potomac	3,6,9,12,15	40	Fry
6/8/11	B2	73,693	American shad	N Br Susquehanna (PA)	Potomac	3,6,9,15	35	Fry
6/8/11	B3	10,000	American shad	N Br Susquehanna (PA)	Potomac	3,6,9,15	32	Fry
6/2/11	B4	150,000	American shad	West Br. Susquehanna R.	Potomac	3,18	26	Fry
6/2/11	C1	300,000	American shad	West Br. Susquehanna R.	Potomac	3,18	24	Fry
6/3/11	C2	251,351	American shad	West Br. Susquehanna R.	Potomac	3,18	23	Fry
6/3/11	C3	236,311	American shad	West Br. Susquehanna R.	Potomac	3,18	23	Fry
6/3/11	C4	253,742	American shad	West Br. Susquehanna R.	Potomac	3,18	22	Fry
6/3/11	D1	131,778	American shad	West Br. Susquehanna R.	Potomac	3,18	22	Fry
6/1/11	D2	64,633	American shad	Bald Eagle Creek	Potomac	3,6,9,12,15	40	Fry
6/2/11	D3	150,000	American shad	West Br. Susquehanna R.	Potomac	3,18	26	Fry
6/6/11	D4	166,681	American shad	Thompsontown	Potomac	3	20	Fry
6/6/11	E1	129,685	American shad	Thompsontown	Potomac	3	19	Fry
6/7/11	E2	114,554	American shad	Millerstown (Rt. 17)	Susquehanna	3,6,9	17	Fry
6/17/11	E3	136,902	American shad	Lehigh	Delaware	9,12,15	24	Fry
6/7/11	E4	218,961	American shad	Millerstown (Rt. 17)	Susquehanna	3,6,9	15	Fry
6/17/11	F1	103,901	American shad	Lehigh	Delaware	9,12,15	22	Fry
6/7/11	F2	194,475	American shad	Millerstown (Rt. 17)	Susquehanna	3,6,9	12	Fry
6/7/11	F3	251,060	American shad	Millerstown (Rt. 17)	Susquehanna	3,6,9	11	Fry
6/17/11	F4	82,562	American shad	Lehigh	Delaware	9,12,15	17	Fry
6/10/11	G1	68,597	American shad	Millerstown (Rt. 17)	Susquehanna	3,6,9	10	Fry
6/17/11	G2	150,000	American shad	Lehigh	Delaware	9,12,15	16	Fry
6/23/11	G3	270,391	American shad	Schuylkill	Delaware	3,6,9,12	22	Fry
6/23/11	G4	147,971	American shad	Schuylkill	Delaware	3,6,9,12	21	Fry
6/23/11	H1	125,000	American shad	Schuylkill	Delaware	3,6,9,12	21	Fry
6/15/11	H2	160,392	American shad	Millerstown (Rt. 17)	Susquehanna	3,6,9	10	Fry
6/23/11	H3	100,000	American shad	Schuylkill	Delaware	3,6,10,12	13	Fry
9/27/11	BS-ICU	9,083	American shad	Lewistown Narrows	various	116*	131*	Fing.

* Mean age at marking and stocking

Table 5. Summary of juvenile Alosines stocked from the Van Dyke Hatchery, 2011.

	Site	Fry	Fingerling
American shad releases	Millerstown (Rt. 17 Bridge)	1,008,039	
	Thompsontown	296,366	
	Lewistown Narrows		9,083
	Juniata River Subtotal	1,304,405	9,083
	North Branch Susquehanna River (PA)	83,693	
	West Banch Susquehanna River	1,473,182	
	Bald Eagle Creek	191,590	
	Susquehanna River Basin Subtotal	3,052,870	9,083
	Schuylkill River	643,361	
	Lehigh River	473,366	
	Total American shad	**4,169,597**	**9,083**
Hickory shad releases	Octoraro Creek	500,000	
	Susquehanna River Basin Subtotal	500,000	
	Pennypack Creek	1,914,188	
	Ridley Creek	1,200,000	
	Delaware River Basin Subtotal	3,114,188	
	Total Hickory shad	**3,614,188**	

Table 6. Summary of marked Alosines stocked in Pennsylvania, 2011.

Number	Size	Immersion mark (days)	Stocking Location	Egg Source	Immersion mark	Immersion Mark Retention (%)	Feed Mark	Feed Mark Retention (%)	Fry Culture	Fingerling Culture
American shad										
1,473,182	Fry	3,18	W. Br. Susq. R.	Potomac	512ppm OTC	100%	-	-	Van Dyke	-
191,590	Fry	3,6,9,12,15	Bald Eagle Creek	Potomac	512ppm OTC	100%	-	-	Van Dyke	
1,008,039	Fry	3,6,9	Juniata R.	Susquehanna	512ppm OTC	100%	-	-	Van Dyke	-
296,366	Fry	3	Juniata R.	Potomac	512ppm OTC	100%	-	-	Van Dyke	-
83,693	Fry	3,6,9,15	N. Br. Susq. R.(PA)	Potomac	512ppm OTC	100%	-	-	Van Dyke	-
3,052,870	Fry	Total Susquehanna River Basin								
473,366	Fry	9,12,15	Lehigh R.	Delaware	512ppm OTC	100%	-	-	Van Dyke	-
643,361	Fry	3,6,9,12	Schuylkill R.	Delaware	512ppm OTC	97%	-	-	Van Dyke	-
1,116,727	Fry	Total Delaware River Basin								
9,083	Fing.	various	Juniata R.	various	512ppm OTC	96%*	single	100%	Van Dyke	Benner Spring
4,178,680		**Total American shad stocked**								
Hickory shad										
500,000	Fry	3	Octoraro Creek	Susquehanna	512ppm OTC	96%	-	-	Van Dyke	-
1,914,188	Fry	3	Pennypack Creek	Susquehanna	512ppm OTC		-	-	Van Dyke	-
1,200,000	Fry	(3), (3,9) & (3,15)	Ridley Creek	Susquehanna	512ppm OTC	**	-	-	Van Dyke	-
3,614,188		**Total Hickory shad stocked**								

* Fingerlings with feed tags had various immersion (fry) tags; 26 of 27 exhibited marks.

** Some hickory shad fry were kept in the hatchery to attempt to feed them. These were given an additional mark. None were retained for mark retention.