

JOB II, PART 3. HICKORY AND AMERICAN SHAD SPAWNING TESTS CONDUCTED AT CONOWINGO DAM, SPRING 2011

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INTRODUCTION

The Conowingo Dam West Fish Lift was built in 1972 and has been operated annually during the months of April, May and early June. Initially it was an integral part of the anadromous fish restoration effort, which combined the operation of the West Fish Lift, hand sorting of target species and a fleet of transport trucks to carry American shad and other Alosids to upriver release sites. Since the completion of permanent fish lifts at Conowingo Dam (1991), Holtwood and Safe Harbor Dam (1997), and a fish ladder at York Haven Dam (2000), the role of the Conowingo West Fish Lift changed. Beginning in 2001, the Conowingo West Fish Lift has operated under contract as (1) a source of fishes for special on-site spawning studies to provide the PA Fish and Boat Commission Van Dyke Shad Hatchery with a source of fertilized American shad eggs, (2) provide adult shad for studies conducted by the Maryland Department of Natural Resources at the Manning Hatchery and (3) a source of otoliths and scales from adult American shad to analyze the age structure and origin of returning adult shad. The West Fish Lift when operated 6-8 hours per day and six days per week from late April through early June typically captures 3,000 to 10,000 adult American shad. Most of these fish are in a pre-spawn condition and based on studies at the USFWS Lamar facility many of these fish could be induced to spawn within several days after injection of hormone implants. The advantage of conducting spawning studies on site at Conowingo Dam rather than at a distant hatchery is the elimination of stress associated with lengthy transport times.

Hormone induced hickory shad spawning tests began at the Conowingo West Fish lift in 2003 and were conducted annually through 2008. In 2009 and 2011, hickory shad spawning tests were successfully conducted without the use of hormones. No hickory shad spawning tests were conducted in 2010.

METHODS AND MATERIALS

The methods used to conduct the hormone induced spawning tests at the Conowingo West Fish lift in 2011 were generally similar to those used in the past ten years. Beginning with the 2008 tests and continuing for the 2011 tests, the study plan for the American shad spawning tests was submitted to the U.S. Department of Interior Fish and Wildlife Service Aquatic Animal Drug Approval Partnership Program, Bozeman MT, for approval. The approved American shad study plan for 2011 was assigned Study Number 11-375-11-8. The study protocols for the use of Salmon Gonadotropin-Releasing Hormone Analog (sGnRHa) under the investigational new animal drug (INAD) #11-375 required the use of hormone pellets manufactured solely by Syndel Industries Inc. The smallest dose of sGnRHa available from Syndel was 75ug per pellet and all treatment fish received this dose in the 2011 tests. Other requirements under this INAD included keeping detailed records of hormone inventory, collecting length and weight data on test fish and reporting results to Bozeman, MT. Hormone injected fish that survive the spawning tests also cannot be released back into the river and must be euthanized. In the 2008 spawning tests with hickory and American shad, both species received hormone injections and each species received a separate study number. Since the 2009 and 2011 spawning tests with hickory shad did not include hormone injections, those tests were not subject to the same INAD protocols which applied to the American shad tests.

Spawning tests for both species were conducted in a 10 ft diameter or 12 ft diameter fiberglass tank. These two tanks were assembled on-site at the West Fish Lift in early April and plumbed in a configuration identical to that used since 2001. Both tanks were supplied with approximately 40 gpm of river water through a wall mounted 2-inch fitting. A screened 4-inch PVC drainpipe in the bottom of each tank provided the only exit for the demersal shad eggs and water from the tank. The water level in both spawning tanks was maintained by an external standpipe that also provided a source of water for the rectangular 72 by 36 by 16 inch raised egg collection tank. The calculated volumes for the 10 ft and 12 ft tanks were 6,400 and 9,200 liters respectively. An egg sock fastened to the discharge from the spawning tank prevented the eggs from exiting the egg tank via the standpipe drain that maintained the water level in the egg tank.

The West Fish Lift captures few, if any, hickory shad in a typical year. Shore anglers at the mouth of Deer Creek and electrofishing operations by Maryland Department of Natural

Resources biologists at Lapidum were the source of all hickory shad brood stock for the 2011 tests. Following the transport of hickory shad from Lapidum or Deer Creek by a PA Fish and Boat Commission transport truck, only sex and numbers were recorded before the fish were placed into a spawning tank. The smaller size of hickory shad permits stocking densities of up to 75 fish in the 10 ft tank and 125 fish in the 12 ft tank. The sex ratio in hickory shad spawning tests varied greatly and was based on availability. Stocking densities for American shad were 50 fish in the 10 ft tank and 75 fish in the 12 ft tank. A 3:2 (M/F) sex ratio, if available, was utilized for all American shad tests.

Individual tests with hormone treated American shad lasted 2 to 3 days and were usually terminated following the first large pulse of eggs. With the approval of the Bozeman Montana office, no control fish were utilized in 2011. This request to eliminate controls was prompted by the anticipation of an abbreviated testing season. High river flows in late April and early May delayed the installation of weir and crowder motors on the West Fish Lift and the Lift wasn't operational until May 13th.

Oxygen and temperature were monitored daily in the spawning tanks during each test. The egg sock was examined daily during each spawning test. Following the initial pulse of egg production (usually the second morning after hormone injection) the eggs were removed from the sock and placed into a 10 gal plastic bucket. The eggs were then sieved using a colander with 0.25 in holes to remove scales and other debris. After sieving, the eggs were transferred to a framed nylon net suspended in the egg tank. A No. 20 standard testing sieve was used to transfer the washed eggs from the nylon net into a graduated 2 liter measuring cup. Volume measurements in the field were approximations. The final volume and viability determinations for all shipments were made at the PFBC Van Dyke Hatchery. The packaging of eggs for shipment followed well-established techniques. Up to five liters of water hardened eggs were mixed with 5 liters of river water in double plastic bags. Pure oxygen was introduced into the inner bag before being sealed with tape or rubber band. The bags were placed into marked insulated shipping containers and driven to the Van Dyke Hatchery by PFBC or Normandeu personnel; eggs were always driven to the hatchery on the same day they were collected.

No attempts were made to hand strip American shad following their removal from the spawning tanks. Hormone injected fish that survived to the end of each test were disposed of in an offsite pit. River release of hormone laden fish is prohibited under the INAD agreement.

Shore anglers below the Dam were the source of the 75 American shad utilized to begin the first spawning test. The Conowingo West Fish Lift was the source of the remaining 861 pre-spawned American shad used in this year's spawning tests. All fish were measured for total length and a sub-sample (298) of weights was taken prior to placement of fish into the spawning tanks. Some American shad were kept in oxygenated holding tanks for up to 2 days until a sufficient number of shad needed to stock a spawning tank was collected.

RESULTS

A total of four spawning tests with 378 hickory shad at the West Fish Lift between April 14 and May 12 produced 29.1 liters of eggs (Table 1 and Appendix Table A-1). All but 0.4 liters were shipped to the PFBC Van Dyke Hatchery. The overall viability of the shipped eggs was 78.9% (Mike Hendricks, personal communication) which is above the 62.9% average recorded for seven years of hickory shad spawning tests conducted at the West Lift since 2003 (Table 2). The average volume of eggs produced by each female hickory shad in the 2011 tests (0.208 liters) was slightly lower than the 0.225 liter average recorded from previous tests but the average volume of viable eggs per female in 2011 was above average (Figure 1). Water temperatures ranged from 9.0-16.1°C and oxygen levels were between 9.5 and 12.8 ppm. The overall mortality rate for hickory shad during the four spawning tests was 14.6%.

A total of 15 on-site spawning tests with 936 American shad from 12 May to 7 June produced 116.9 liters of eggs (Table 3 and Appendix Table A-2). Over 106.4 liters of eggs were shipped to the Van Dyke Hatchery and the remaining 10.5 liters were released into the river below Conowingo Dam. The overall estimated viability of the eggs shipped to Van Dyke was 15.7% (Mike Hendricks, personal communication). The total volume of eggs produced per female in 2011 (0.300 liters) was slightly below the average of 0.320 liter observed for the previous ten years (Figure 2). The volume of viable eggs produced per female in the 2011 tests averaged 0.047 liters (Figure 2). Injected fish usually produced the first and largest pulse of eggs within 48 hrs followed by little or no egg production past 72 hrs. Water temperatures and oxygen levels in the spawning tanks were monitored daily and ranged from 18.0 to 24.7°C and 5.0 to 9.2 ppm.

The overall mortality rate for adult American shad during the 2011 tests was 9.4 %. Mortality rates have ranged from 2 to 15% in previous years (Table 4).

SUMMARY

This was the 8th year of hickory shad spawning tests and the 11th year of hormone induced American shad spawning tests at the Conowingo West Fish Lift. Hickory shad continued to outperform the American shad in these tests without the benefit of hormone injections. Hickory shad egg viability in 2011 (78.9%) was the second highest recorded since 2003. The overall viability (15.7%) of the 2011 American shad eggs was near the ten year average of 18.7%. The late start of the American shad tests due to river conditions raised some doubts that a full complement of 15± tests with 936 injected fish could be completed before the end of the American shad runs that typically end in early June. The elimination of control tests and a steady supply of pre-spawn brood stock from the West Lift helped speed up the testing schedule. During the first week of June, river temperature reached 24.0°C and many of the American shad caught at the West Lift were spent, partially spent or in poor physical condition. This combination of conditions resulted in poor egg production for the last three spawning tests

Table1. Summary of egg production data for spawning tests conducted with hickory shad at Conowingo Dam, Spring, 2011

Test #	Start/Stop Date	M/F	Liters of eggs	No. Liters Shipped	Date Shipped
1	4-14/4-21	77/6	0.4	0.0	
2	4-25/4-29	52/38	7.9	7.9	4/26
			7.9	7.9	4/27
3	4-27/4-29	68/52	2.8	2.8	4/29
4	5-5/5-12	45/40	5.3	5.3	5/7
			4.8	4.8	5/8
Totals		242/136	29.1	28.7	
Shipment Date	Liters	Total Eggs	No. Viable Eggs	Percent Viable	
26-Apr	7.9	2,318,069	1,921,383	82.9	
27-Apr	7.9	2,911,705	2,321,278	79.7	
29-Apr	2.8	1,483,827	926,948	62.5	
7-May	5.3	2,357,688	1,720,283	75.0	
8-May	4.8	3,109,676	2,714,972	87.3	
Totals	28.7	12,180,965	9,604,864	78.9	
Total Males			242		
Total Females			136		
Total Fish			378		
Total liters of eggs			29.1		
Mean liters/test.			7.3		
Mean No. of Eggs/ Liter			425,908		
Mean No. of Eggs/Female			88,626		
Mean No. of Viable Eggs/ Female			69,926		

Table 2. Summary of hormone induced spawning trials with hickory shad at Conowingo Dam, 2003-2011.

<i>Year</i>	2003	2004	2005	2006	2007	2008	2009	2011
Start/Finish date	4-15/4-27	4-19/4-26	4-15/4-27	4-11/4-19	4-23/5-1	4-11/4-24	4-13/4-28	4-14/5-12
Tank diameter (ft)	10, 12	10, 12	10, 12	10, 12	12	10,12	10,12	10, 12
Tank volume (liters)	6,400 - 9,200	6,400 - 9,200	6,400 - 9,200	6,400 - 9,200	9,200	6,400 - 9,200	6,400 - 9,200	6,400 - 9,200
No. of test groups	5	4	8	4	3	4	4	4
Total fish	381	349	721	398	384	256	399	378
Males/Females per trial	40/36	48/39	55/34	62/38	59/69	38/26	76/24	61/34
Stocking density (fish/liters)	1/99	1/89	1/78	1/71	1/72	1/75-1/221	1/63-1/107	1/71-1/77
Male:Female ratio	1:0.9	1:0.8	1:0.6	1:0.6	1:1.2	1:0.7	1:0.3	1:0.6
Hormone injected	LHRH _a	sGnRH _a *	None	None				
Liquid, Pellet	L+P	L+P	L+P	L+P	P	P	N/A	N/A
Dose(ug) Male/Female	50/50	50/50	50/50	50/50	25/25	75/75	0	0
Eggs collected (liters)	30.2	33.4	73.8	26.8	27.9	31.1	30.25	29.1
Liters of eggs /Female	0.167	0.215	0.271	0.177	0.135	0.296	0.312	0.214
No. eggs/liter	477,607	405,853	388,208	565,893	459,455	315,233	379,510	425,165
Total no. of eggs shipped	14,423,730	13,555,505	28,727,411	15,165,928	11,532,320	9,803,731	11,480,173	12,180,965
Viability (%)	44.1	46.1	61.4	60.6	69.3	73.6	84.9	78.9
Total number of viable eggs	6,360,865	6,245,259	17,645,251	9,194,583	7,994,797	7,216,392	9,742,474	9,604,864
Total liters of viable eggs	13.3	15.4	45.5	16.3	17.4	22.9	25.7	22.9
Adult mortality rate (%)	14.0	3.7	2.2	22.1	3.1	2.3	4.5	14.6

*Only two of the four test groups received hormone injections

Table 3. Summary of egg production data for hormone(sGnRH α) induced spawning tests conducted with American shad at Conowingo Dam and shipped to the Van Dyke Shad Hatchery, Spring, 2011.

Test Group	Start/Stop Date	Male/Female	Liters Collected	River Release	Release Date	Total Liters Shipped	Date Shipped
1	5-12/5-15	45/30	12.6			12.6	14-May
2	5-13/5-15	30/20	8.5			8.5	15-May
3	5-15/5-17	45/30	9.7			9.7	17-May
4	5-15/5-17	30/20	10.7			10.7	17-May
5	5-17/5-19	45/30	12.5			12.5	19-May
6	5-17/5-19	30/20	9.5			9.5	19-May
7	5-19/5-21	45/30	12.0			12.0	21-May
8	5-19/5-21	30/20	8.8			8.8	21-May
9	5-21/5-24	45/30	7.2			7.2	23-May
10	5-27/5-29	45/30	8.4			8.4	29-May
11	5-28/5-31	30/20	2.6			2.6	30-May
12	5-29/5-31	35/40	3.9			3.9	30-May
12			4.2	4.2	31-May	0	
13	6-3/6-5	29/21	1.6	1.6	5-Jun	0	
14	5-5/6-7	45/30	3.5	3.5	7-Jun	0	
15	6-5/6-7	16/20	1.2	1.2	7-Jun	0	
Totals		545/391	116.9	10.5		106.4	

Shipping Date	Liters Shipped	No. eggs	No. Viable	Viabil.(%)
14-May	12.6	821,265	66,545	8.1
15-May	8.5	481,269	94,262	19.6
17-May	20.4	1,273,333	267,067	21.0
19-May	22.0	1,509,191	213,663	14.2
21-May	20.8	1,184,690	268,890	22.7
23-May	7.2	577,542	69,724	12.1
29-May	8.4	974,848	87,788	9.0
30-May	6.5	540,475	88,491	16.4
Totals	106.4	7,362,613	1,156,430	15.7

Total Males	545
Total Females	391
Total Fish	936
Mean egg vol.(liters) / test group	7.8
Mean No. of Eggs / Liter	69,179
Mean No. of Eggs/Female	20,683
Mean No. of Viable Eggs/ Female	3,247

Table 4. Summary of hormone induced spawning trials with American shad at Conowingo Dam, 2001-2011.

<i>Year:</i>	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Start/Finish date	4-30/6-4	4-24/6-6	4-28/6-5	4-27/5-27	4-27/6-6	4-20/6-3	5-4/5-30	4-25/6-6	4-30/5-29	4-30/5-29	5-12/6-7
Tank diameter (ft)	12	10,12	10,12	10,12	10,12	10,12	10,12	10,12	10,12	10,12	10,12
Tank volume (liters)	9,200	15,600	15,600	15,600	15,600	15,600	15,600	15,600	15,600	15,600	15,600
Number of test groups	10	10	12	10	11	20	14	16*	16*	17*	15
Total fish	599	1,000	1,504	1,055	1,135	1,557	1,504	1010	994	1,075	936
Males/Females per trial	36/24	66/34	75/50	75/50	75/50	47/31	75/50	38/25	37/25	37/25	36/26
Stocking density (fish/liters)	1/153	1/156	1/125	1/125	1/125	1/124	1/125	1/125	1/125	1/125	1/125
Male:Female ratio	3:2	2:1	3:2	3:2	3:2	3:2	3:2	3:2	3:2	3:2	3:2
Hormone injected	LHRHa	sGnRHa	LHRHa	LHRHa	LHRHa	LHRHa	LHRHa	sGnRHa	sGnRHa	sGnRHa	sGnRHa
Liquid, Pellet	P	P	L+P	L+P	L+P	L+P	L+P	P	P	P	P
Dose (ug) Male/Female	75/150	150/150	150/150	150/150	150/150	150/150	25-45/75-95	75/75	75/75	75/75	75/75
Eggs collected (liters)	103	146.8	234	90.4	160.5	169.25	89.6	110.5	98.7	122.2	116.9
Liters of eggs /Female	0.429	0.432	0.387	0.244	0.418	0.270	0.148	0.272	0.318	0.279	0.3
No. eggs/liter	63,140	51,235	51,187	59,775	53,828	60,747	80,638	58,429	60,864	63,699	69,179
Total number of eggs shipped	6,503,420	7,521,346	11,970,764	5,403,660	7,998,778	10,281,444	6,773,594	5,749,467	5,885,504	7,344,503	7,362,613
Viability (%)	33.2	10.1	17.7	20	23.9	21.7	8.9	9.8	23.2	18.2	15.7
Total number of viable eggs	2,159,135	760,935	2,118,852	1,080,732	1,913,801	2,232,459	603,345	526,816	1,366,478	1,334,705	1,156,430
Total liters of viable eggs	34.20	14.85	41.42	18.1	35.6	36.75	7.97	9.64	22.45	20.95	16.72
Adult mortality rate (%)	6.0	3.6	2.0	11.5	3.3	3.5	8.3	10.3	15.0	10	9.4

*Includes 3-4 control groups

Figure 1. Comparison of total hickory shad egg volume (solid line) and viable egg volume (broken line) per female for the spawning tests conducted at Conowingo Dam, 2003-2011. Hickory shad tests were not conducted in 2010.

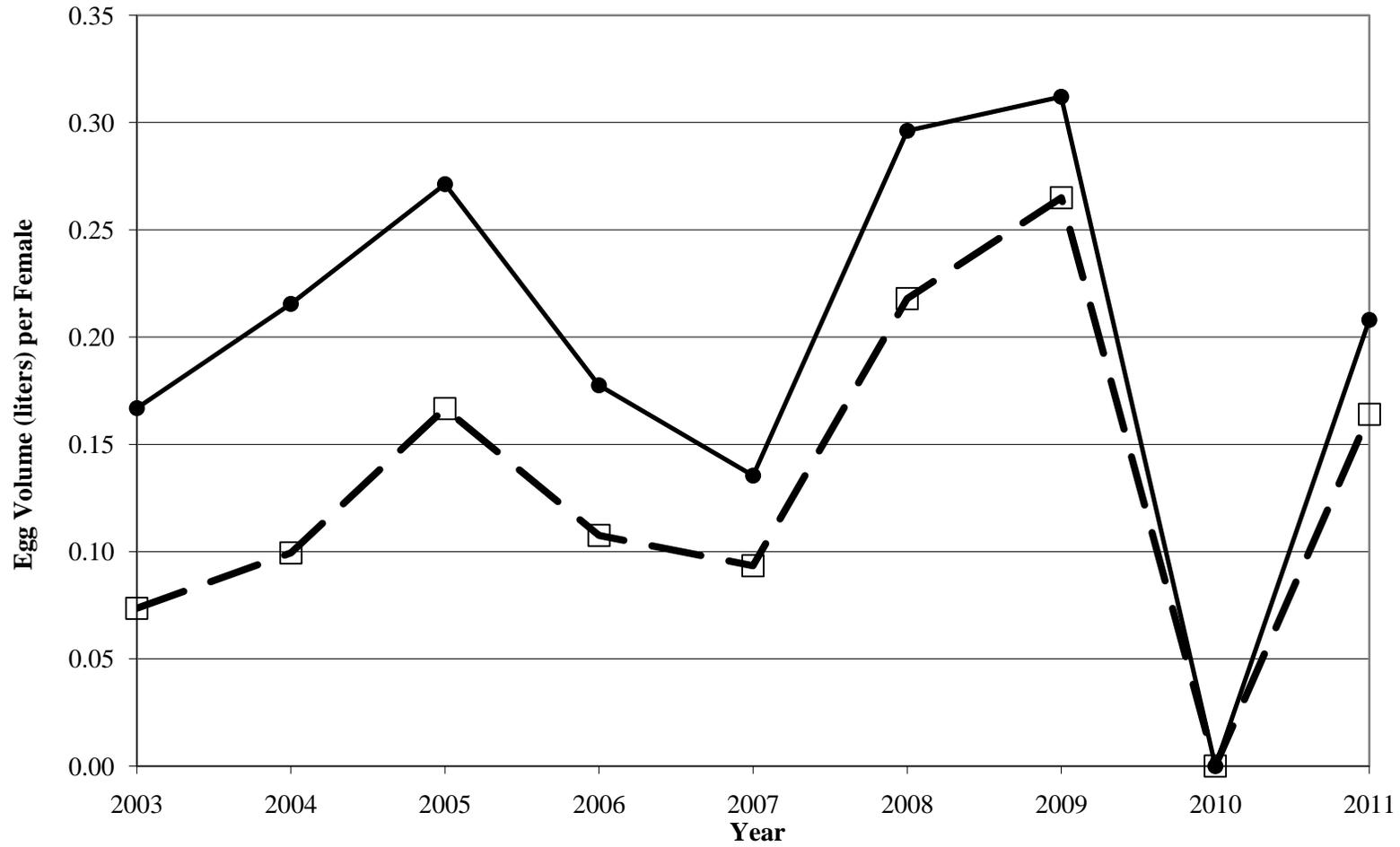
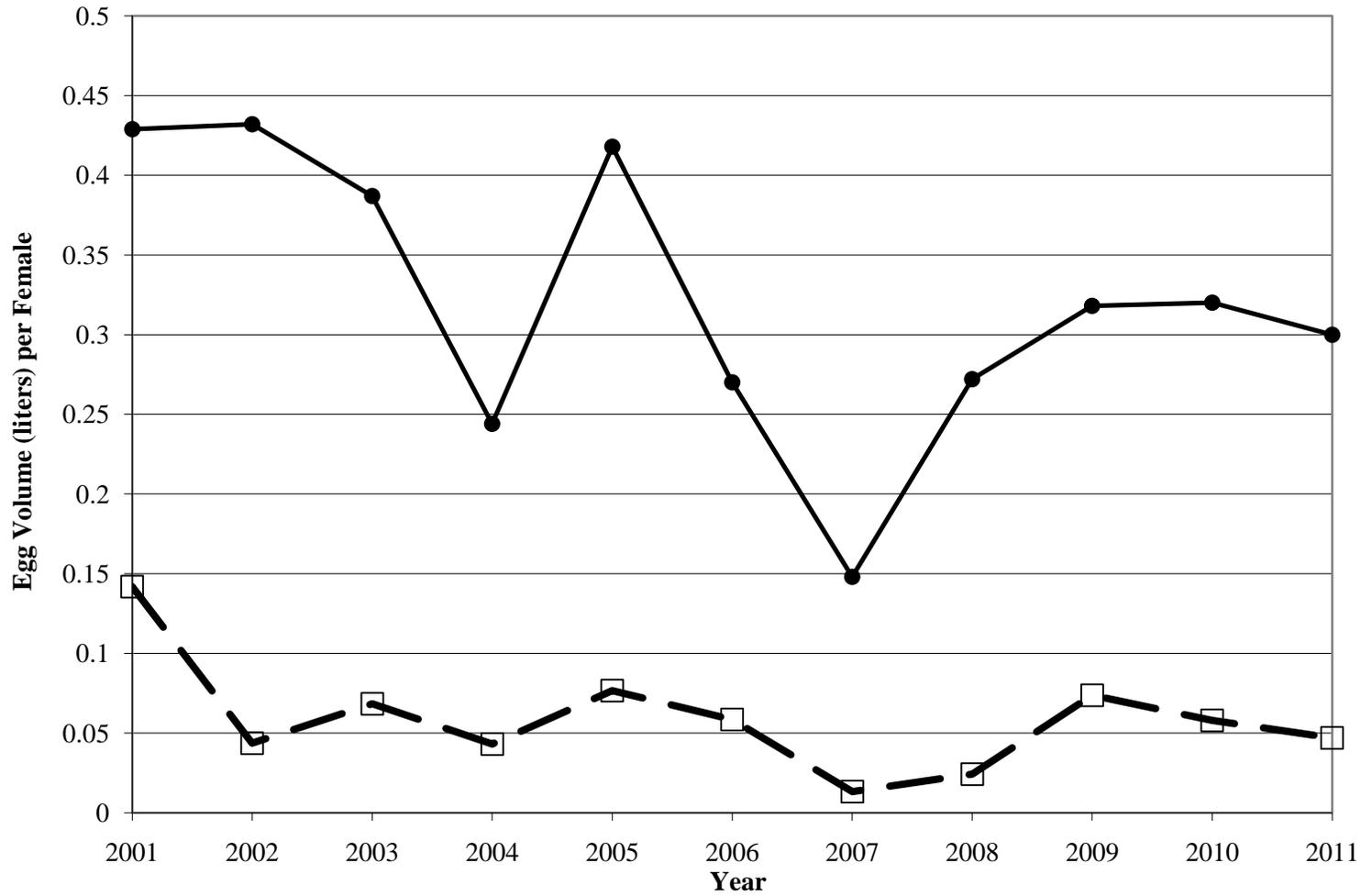


Figure 2. Comparison of total American shad egg volume (solid line) and viable egg volume (broken line) per female for the spawning tests conducted at Conowingo Dam, 2001-2011.



Appendix Table A-1. Individual test group data for hickory shad spawning tests conducted at Conowingo Dam West Fish Lift, 2011.

Test Group 1							
M/F Ratio	77/6					10 ft tank	
Start Date	4/14/11	1600					
End Date	4/21/11	0730					
		Temp.	Oxygen	Eggs	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
4/14/11	1600	13.5	10				
4/15/11	0950	11.9	10.5				
4/15/11	1625	12.7	10.8				
4/16/11	1215	12.2	10.6				7m
4/17/11	1010	12.6	10.6	0.4 kept in sock			1m
4/18/11	1215	11.9	11.1			0.4	1m
4/19/11	1145	10.9	11.8				1f
4/20/11	1420	10.1	12.0				3m
4/21/2011	0725	9.9	12.8				5m, 1f
Test Group 2							
M/F Ratio	52/38					10 ft tank	
Start Date	4/25/11	1500					
End Date	4/29/11	1000					
		Temp.	Oxygen	Eggs	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
4/25/11	1500	14.0	9.5				
4/26/11	0720	13.0	10.3	7.9	7.9		3m
4/27/11	0720	14	10				
4/27/11	1200			7.9	7.9		
4/28/11	0743	16.0	10.2				
4/29/11	0757	16.1	10.5				2m, 3f

Appendix, Table A-1 (continued)

Test Group 3							
M/F Ratio	68/52					12 ft tank	
Start Date	4/27/11	1400					
End Date	4/29/11	1030					
		Temp.	Oxygen	Eggs	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
4/27/11	1400	14.6	10.2				
4/28/11	0740	16	9.8				
4/29/11	0755	16.1	10.6				
4/29/11	1030			2.8	2.8		12m, 15f
Test Group 4							
M/F Ratio	45/40					10 ft tank	
Start Date	5/5/11	1430					
End Date	5/12/11	1550					
		Temp.	Oxygen	Eggs	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/5/11	1435	16	10.4				
5/6/11	0740	14.8	10.4				
5/7/11	0735	14.6	10.4				
5/7/11	0930			5.3	5.3		
5/8/11	0736	14.5	10.7				
5/8/11	0830			4.75	4.75		
5/9/11	0730	15.0	10.4				
5/10/11	0730	15.8	10.2				
5/11/10	0730	16.7	10.1				
5/12/11	0815	17.3	10.1				1m

Appendix Table A-2. Individual test group data for hormone induced American shad spawning tests conducted at Conowingo Dam West Fish Lift, Spring 2011.

Test Group 1							
M/F	45/30	12 ft tank					
Start Date	5/12/11	1300	Dose/fish 75 ug sGnRH α (pellet implant)				
End Date	5/15/11	0945					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/12/11	1500	18.6	9				
5/13/11	0845	18	8.2				
5/14/11	0900	18.3	7.6	12.6	12.6		
5/15/11	0900	18.3	7.6				4m,5f
Test Group 2							
M/F	30/20	10 ft tank					
Start Date	5/13/11	1500	Dose/fish 75 ug sGnRH α (pellet implant)				
End Date	5/15/11	1000					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/13/11	1525	18.2	9.2				
5/14/2011	902	18.3	8.3				
5/15/11	0902	18.3	8.3	8.5	8.5		2f
Test Group 3							
M/F	45/30	12 ft tank					
Start Date	5/15/11	1130	Dose/fish 75 ug sGnRH α (pellet implant)				
End Date	5/17/11	0940					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/15/11	1140	19.5	7.1				
5/15/11	1652	20	6.8				
5/16/11	0032	19.5	7.3				
5/17/11	0940	19.7	8	9.7	9.7		1m, 6f
Test Group 4							
M/F	30/20	10ft tank					
Start Date	5/15/11	1550	Dose/fish 75 ug sGnRH α (pellet implant)				
End Date	5/17/11	1015					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/15/11	1650	20.1	7.9				
5/16/11	0835	19.5	8.6				
5/17/11	0910	19.7	9.1				
5/17/11	1015			10.7	10.7		1m

Appendix Table A-2. (continued)

Test Group 5							
M/F	45/30	12 ft tank					
Start Date	5/17/11	1130		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/19/11	0940					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/17/11	1405	20	8.0				
5/18/11	0842	19.2	7.2				
5/19/11	0900	19.7	7.4	12.5	12.5		1m, 2f
Test Group 6							
M/F	30/20	10 ft tank					
Start Date	5/17/11	1150		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/19/11						
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/17/11	1406	20	8.7				
5/18/11	0845	19.3	8.4				
5/19/11	0902	19.7	8.4				
5/18/11	1000			9.5	9.5		1m, 6f
Test Group 7							
M/F	45/30	12 ft tank					
Start Date	5/19/11	1115		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/21/11	930					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/19/11	1350	20.7	6.8				
5/20/11	0724	18.6	7.4				
5/20/11	1844	18.8	7.5				
5/21/11	0830	17.9	8.4				
5/21/11	0930			12.0	12.0		4f
Test Group 8							
M/F	30/20	10 ft tank					
Start Date	5/19/11	1145		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/21/11	1000					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/19/11	1352	20.5	7.8				
5/20/11	0726	18.6	8.2				
5/20/11	1846	18.7	8.4				
5/21/11	0831	17.9	9.2				
5/21/11	1000			8.8	8.8		3f

Appendix Table A-2. (continued)

Test Group 9							
M/F	45/30	12 ft tank					
Start Date	5/21/11	1115		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/24/11	900					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/21/11	1304	18.8	7.7				
5/22/11	1300	18	8.0				
5/23/11	0756	17.6	8.2				
5/23/11	0900			7.2	7.2		
5/24/11	0730	18	8.0	1.2		1.2	2m, 2f
Test Group 10							
M/F	45/30	12ft tank					
Start Date	5/27/11	1500		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/29/11	1000					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/27/11	1810	21.7	6.8				
5/28/11	0735	21.9	6.7				
5/28/11	1648	23	5.8				
5/29/11	0742	22.9	6.2				
5/29/11	0930			8.4	8.4		2m, 7f
Test Group 11							
M/F	30/20	10 ft tank					
Start Date	5/28/11	1415		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/31/11	900					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/28/11	1650	22.8	7.6				
5/29/11	0745	22.9	7.5				
5/29/11	1235	23.5	7.4				
5/30/11	0735	22.8	7.0	2.6	2.6		
5/31/11	0728	23.2	7.4				2m, 5f
Test Group 12							
M/F	35/40	12 ft tank					
Start Date	5/29/11	1200		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/31/11	1000					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
5/29/11	1233	24	6.0				
5/30/11	0735	22.8	5	3.9	3.9		
5/31/11	0726	23.2	6.2	4.2		4.2	2m, 7f

Appendix Table A-2. (continued)

Test Group 13							
M/F	29/21	10 ft tank					
Start Date	6/3/11	1130		Dose/fish 75 ug sGnRH α (pellet implant)			
End Date	6/5/11	1130					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
6/3/11	1644	24.7	6.1				
6/4/11	0745	23.1	7.1				
6/4/11	1640	24.3	8.4				1f
6/5/11	0730	23.5	7.8	1.6		1.6	7f
Test Group 14							
M/F	45/30	12ft tank					
Start Date	6/5/11	1100		Dose/fish 75 ug sGnRH α (pellet implant)			
End Date	6/7/11	930					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
6/5/11	1336	24.2	6.3				
6/6/11	0733	23.4	5.0				
6/7/11	0630	23.7	6				
6/7/11	0924	24.1	5.6	3.5		3.5	7m, 5f
Test Group 15							
M/F	30/20	10 ft tank					
Start Date	6/5/11	1230		Dose/fish 75 ug sGnRH α (pellet implant)*			
End Date	6/7/11	1030					
		Temp.	Oxygen	Eggs (Liters)	Eggs	River	Morts
Date	Time	(°C)	(ppm)	Collected	Shipped	Releases	Removed
6/5/11	1338	24.1	7.6				
6/6/11	0735	23.7	7.2				
6/7/11	0632	23.8	7.2				
6/7/11	0925	24.1	7	1.2		1.2	1m, 2f

* 14 of 30 males received no hormone injection.