

AMERICAN SHAD SPAWNING TESTS CONDUCTED AT CONOWINGO DAM, SPRING 2013

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, 2012 or 2013 by Normandeau Associates, Inc. In 2013, Maryland Department of Natural Resources (MDDNR) utilized one of our spawning tanks at Conowingo Dam for two late season hickory shad trials using no hormones because of issues they were having at the Manning Hatchery.

METHODS AND MATERIALS

The methods used to conduct the hormone induced spawning tests at the Conowingo West Fish lift in 2013 were generally similar to those used in the past thirteen years. Beginning with the 2008 tests and continuing for the 2013 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 2013 was assigned Study Number 11-375-13-005. 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 2013 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 American shad 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 (Figure 1). 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.

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 2013. This request to eliminate controls was prompted by the anticipation of an abbreviated testing/spawning season.

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 Normandeau 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 that is in effect.

The Conowingo West Fish Lift was the source of all 968 pre-spawned American shad used in this year's spawning tests. All fish were measured for total length and a sub-sample (307) 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 sixteen on-site spawning tests with 968 American shad from 30 April to 28 May produced 131.8 liters of eggs (Table 1 and Appendix Table A-1). A total of 125.7 liters of eggs were shipped to the Van Dyke Hatchery and the remaining 6.1 liters were released into the river below Conowingo Dam. The overall estimated viability of the eggs shipped to Van Dyke was 21.3% (Table 1). The total volume of eggs produced per female in 2013 (0.341 liters) was slightly above the average of 0.320 liter observed for the previous ten years (Figure 2). The volume of viable eggs produced per female in the 2013 tests averaged 0.069 liters (Figure 2) and was the fifth highest volume since 2001. 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 16.2 to 21.5°C and 4.5 to 10.2 ppm, respectively. The overall mortality rate for adult American shad during the 2013 tests was 5.7%. Mortality rates have ranged from 2 to 15% in previous years (Table 2).

SUMMARY

This was the 13th year of hormone induced American shad spawning tests at the Conowingo West Fish Lift. The overall viability (21.3%) of the 2013 American shad eggs was above the ten year average of 18.4% (Table 2). The elimination of control tests enabled sixteen spawning test groups to be completed from the West Lift. Nearing the end of May, river temperature reached 21.0°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, along with exhaustion of the hormone supply, resulted in termination of West Fish Lift operations and American shad spawning trials.

TABLES AND FIGURES

Table 1.

Summary of egg production data for hormone(sGnRHa) induced spawning tests conducted with American shad at Conowingo Dam and shipped to the Van Dyke Shad Hatchery, Spring, 2013.

| Test Group | Start/Stop Date | Male/Female | Liters Collected | River Release | Release Date | Total Liters Shipped | Date Shipped |
|-------------------|------------------------|--------------------|-------------------------|----------------------|---------------------|-----------------------------|---------------------|
| 1 | 4-30/5-2 | 45/30 | 12.1 | | | 12.1 | 2-May |
| 2 | 4-30/5-2 | 26/17 | 10.5 | | | 10.5 | 2-May |
| 3 | 5-2/5-5 | 45/30 | 9.6 | | | 9.6 | 4-May |
| | | | 2.1 | 2.1 | 5-May | | |
| 4 | 5-2/5-5 | 30/20 | 13.1 | | | 13.1 | 4-May |
| 5 | 5-6/5-8 | 30/20 | 6.9 | | | 6.9 | 8-May |
| 6 | 5-8/5-10 | 30/20 | 7.2 | | | 7.2 | 10-May |
| 7 | 5-10/5-12 | 30/20 | 5.8 | | | 5.8 | 12-May |
| 8 | 5-16/5-19 | 45/30 | 9.5 | | | 9.5 | 18-May |
| 9 | 5-19/5-21 | 45/30 | 8.5 | | | 8.5 | 21-May |
| 10 | 5-20/5-22 | 30/20. | 8.0 | | | 8.0 | 22-May |
| 11 | 5-21/5-23 | 45/30 | 7.2 | | | 7.2 | 23-May |
| 12 | 5-22/5-24 | 30/20 | 7.8 | | | 7.8 | 24-May |
| 13 | 5-23/5-26 | 45/30 | 5.5 | | | 5.5 | 25-May |
| 14 | 5-24/5-26 | 30/20 | 4.0 | 4.0 | 26-May | | |
| 15 | 5-26/5-28 | 30/20 | 5.6 | | | 5.6 | 28-May |
| 16 | 5-26/5-28 | 45/30 | 8.4 | | | 8.4 | 28-May |
| Totals | | 581/387 | 131.8 | 6.1 | | 125.7 | |

| Shipping Date | Liters Shipped | No. eggs | No. Viable | Viabil.(%) |
|----------------------|-----------------------|------------------|-------------------|-------------------|
| 2-May | 22.6 | 1,245,337 | 250,923 | 20.1 |
| 4-May | 22.7 | 1,108,767 | 184,051 | 16.6 |
| 8-May | 6.9 | 461,438 | 64,740 | 14.0 |
| 10-May | 7.2 | 400,362 | 71,944 | 18.0 |
| 12-May | 5.8 | 275,330 | 34,035 | 12.4 |
| 18-May | 9.5 | 557,506 | 36,527 | 6.6 |
| 21-May | 8.5 | 525,942 | 170,641 | 32.4 |
| 22-May | 8.0 | 474,901 | 173,205 | 36.5 |
| 23-May | 7.2 | 510,802 | 59,638 | 11.7 |
| 24-May | 7.8 | 445,626 | 69,546 | 15.6 |
| 25-May | 5.5 | 314,224 | 106,281 | 33.8 |
| 28-May | 14.0 | 866,257 | 307,028 | 35.4 |
| Totals | 125.7 | 7,186,492 | 1,528,559 | 21.3 |

| | |
|------------------------------------|---------------|
| Mean egg vol.(liters) / test group | 8.5 |
| Mean No. of Eggs / Liter | 57,172 |
| Mean No. of Eggs/Female | 18,570 |
| Mean No. of Viable Eggs/ Female | 3,950 |

Table 2.

Summary of hormone induced spawning trials with American shad at Conowingo Dam, 2001-2013.

| <i>Year:</i> | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|--------------------------------|-------------|--------------------|-------------|-------------|-------------|-------------|-------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| 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 | 4/24/5-31 | 4-24/5-28 |
| Tank diameter (ft) | 12 | 10,12 | 10,12 | 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 | 15,600 | 15,600 |
| Number of test groups | 10 | 10 | 12 | 10 | 11 | 20 | 14 | 16* | 16* | 17* | 15 | 8 | 16 |
| Total fish | 599 | 1,000 | 1,504 | 1,055 | 1,135 | 1,557 | 1,504 | 1010 | 994 | 1,075 | 936 | 481 | 968 |
| 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 | 36/24 | 36/24 |
| 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 | 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 | 3:2 | 3:2 |
| Hormone injected | LHRHa | sGnRH _a | LHRHa | LHRHa | LHRHa | LHRHa | LHRHa | sGnRH _a |
| Liquid, Pellet | P | P | L+P | L+P | L+P | L+P | L+P | P | 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 | 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 | 64.5 | 131.8 |
| 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 | 0.338 | 0.341 |
| 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 | 63,054 | 57,172 |
| 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 | 3,827,377 | 7,186,492 |
| Viability (%) | 33.2 | 10.1 | 17.7 | 20 | 23.9 | 21.7 | 8.9 | 9.8 | 23.2 | 18.2 | 15.7 | 24.6 | 21.3 |
| 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 | 941,595 | 1,528,559 |
| 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 | 14.93 | 26.74 |
| Adult mortality rate (%) | 6.0 | 3.6 | 2.0 | 11.5 | 3.3 | 3.5 | 8.3 | 10.3 | 15.0 | 10 | 9.4 | 10.7 | 5.7 |

*Includes 3-4 control groups

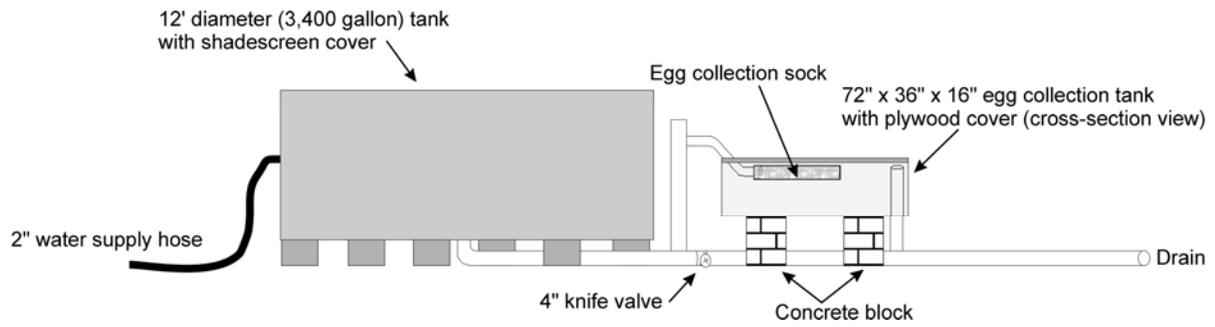


Figure 1

Schematic of tank spawning system used at Conowingo Dam West Fish Lift.

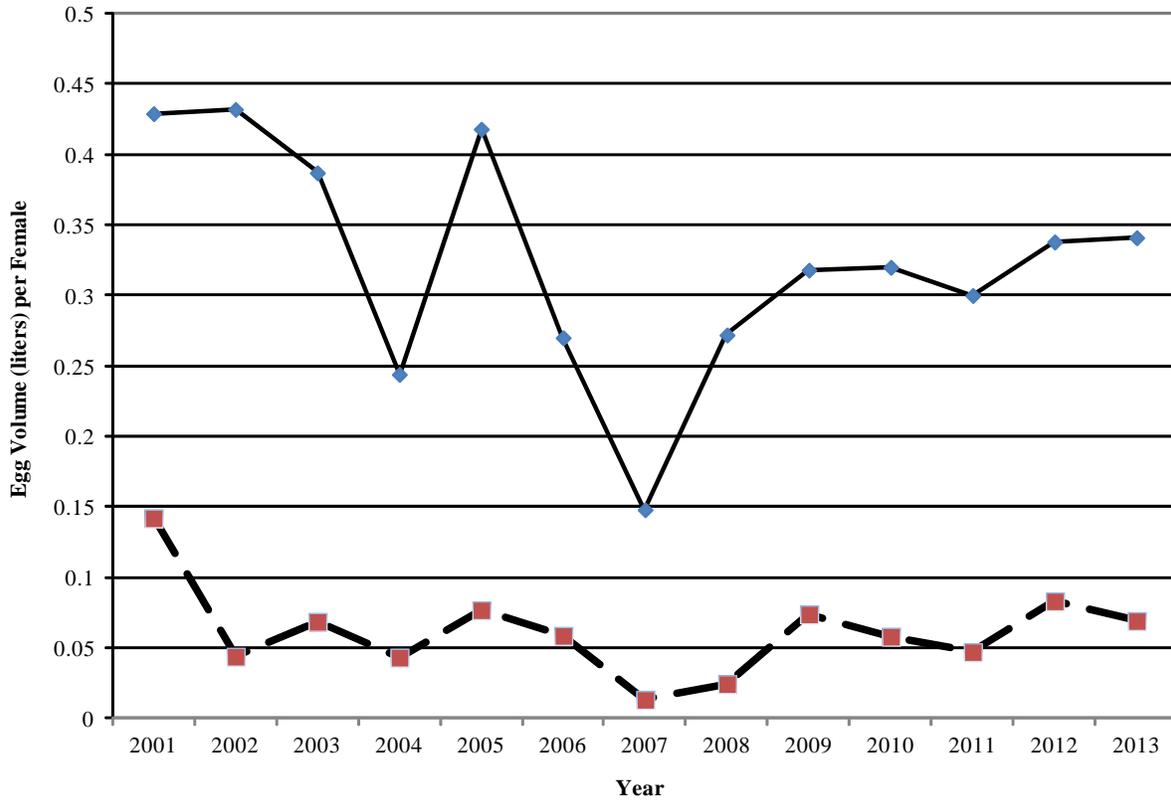


Figure 2. Comparison of total American shad egg volume (solid line) and viable egg volume (broken line) per female for the spawning tests conducted at Conowingo Dam, 2001-2013.

APPENDIX A

Appendix Table A-1.

Individual test group data for hormone induced American shad spawning tests conducted at Conowingo Dam West Fish Lift, Spring 2013.

| Test Group 1 | | | | | | | |
|---------------------|---------|------------|---|-------------------------|--------------|----------------|---------------|
| M/F | 45/30 | 12 ft tank | | | | | |
| Start Date | 4/30/13 | 1000 | Dose/fish 75 ug sGnRH _a (pellet implant) | | | | |
| End Date | 5/2/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 4/30/13 | 1120 | 16.2 | 8.0 | | | | |
| 4/30/13 | 1800 | 16.2 | 8.2 | | | | |
| 5/1/13 | 0900 | 16.4 | 9.0 | | | | |
| 5/1/13 | 1545 | 17.0 | 8.3 | | | | |
| 5/2/13 | 0900 | 16.5 | 8.7 | 11.8 | 11.8 | 0 | 6f |

| Test Group 2 | | | | | | | |
|---------------------|---------|------------|---|-------------------------|--------------|----------------|---------------|
| M/F | 26/17 | 10 ft tank | | | | | |
| Start Date | 4/30/13 | 1030 | Dose/fish 75 ug sGnRH _a (pellet implant) | | | | |
| End Date | 5/2/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 4/30/13 | 1120 | 16.2 | 9.5 | | | | |
| 4/30/13 | 1800 | 16.2 | | | | | |
| 5/1/13 | 0900 | 16.2 | 9.6 | | | | |
| 5/1/13 | 1545 | 17.0 | 9.0 | | | | |
| 5/2/13 | 0900 | 16.5 | 9.0 | 10.2 | 10.2 | 0 | 0 |

| Test Group 3 | | | | | | | |
|---------------------|--------|------------|---|-------------------------|--------------|----------------|---------------|
| M/F | 45/30 | 12 ft tank | | | | | |
| Start Date | 5/2/13 | 1000 | Dose/fish 75 ug sGnRH _a (pellet implant) | | | | |
| End Date | 5/5/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/2/13 | 1330 | 17.6 | 8.2 | | | | |
| 5/2/13 | 1545 | 17.8 | 8.2 | | | | |
| 5/3/13 | 0930 | 17.0 | 7.9 | | | | |
| 5/3/13 | 1645 | 17.6 | 7.7 | | | | |
| 5/4/13 | 0830 | 17.2 | 8.1 | 9.8 | 9.8 | 0 | |
| 5/5/13 | 0900 | 17.2 | 8.3 | 2.1 | | 2.1 | 1m;1f |

Appendix Table A-1.

Continued.

| Test Group 4 | | | | | | | |
|---------------------|--------|------------|---|-------------------------|--------------|----------------|---------------|
| M/F | 30/20 | 10 ft tank | | | | | |
| Start Date | 5/2/13 | 1100 | Dose/fish 75 ug sGnRHa (pellet implant) | | | | |
| End Date | 5/5/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/2/13 | 1330 | 17.5 | 8.2 | | | | |
| 5/2/13 | 1545 | 17.5 | 8.5 | | | | |
| 5/3/13 | 0930 | 17.0 | 8.9 | | | | |
| 5/3/13 | 1645 | 17.5 | 7.3 | | | | |
| 5/4/13 | 0830 | 17.5 | 9.0 | 13.3 | 13.3 | 0 | |
| 5/5/13 | 0900 | 17.2 | 9.3 | | | | 0 |

| Test Group 5 | | | | | | | |
|---------------------|--------|------------|---|-------------------------|--------------|----------------|---------------|
| M/F | 30/20 | 10 ft tank | | | | | |
| Start Date | 5/6/13 | 1000 | Dose/fish 75 ug sGnRHa (pellet implant) | | | | |
| End Date | 5/8/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/6/13 | 1430 | 17.5 | 10.2 | | | | |
| 5/6/13 | 1600 | 17.8 | 9.8 | | | | |
| 5/7/13 | 0925 | 18.0 | 9.1 | | | | |
| 5/7/13 | 1605 | 18.4 | 8.2 | | | | |
| 5/8/13 | 0830 | 18.1 | 8.6 | 6.8 | 6.8 | 0 | 3f |

| Test Group 6 | | | | | | | |
|---------------------|---------|------------|------------------------|-------------------------|--------------|----------------|---------------|
| M/F | 30/20 | 10 ft tank | | | | | |
| Start Date | 5/8/13 | 1015 | Dose/fish 75 ug sGnRHa | | | | |
| End Date | 5/10/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/8/13 | 1155 | 18.4 | 7.8 | | | | |
| 5/9/13 | 0830 | 18.2 | 8.0 | | | | 1m |
| 5/9/13 | 1500 | 19.2 | 7.2 | | | | 0 |
| 5/10/13 | 0815 | 18.8 | 7.8 | 7.0 | 7.0 | 0 | 1f |

Appendix Table A-1.

Continued.

| Test Group 7 | | | | | | | |
|---------------------|---------|------------|---|-------------------------|--------------|----------------|---------------|
| M/F | 30/20 | 10 ft tank | | | | | |
| Start Date | 5/10/13 | 1000 | Dose/fish 75 ug sGnRH α (pellet implant) | | | | |
| End Date | 5/12/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/10/13 | 1015 | 19.2 | 7.0 | | | | |
| 5/11/13 | 0916 | 20.0 | 7.8 | | | | |
| 5/11/13 | 1810 | 20.0 | 7.5 | | | | |
| 5/12/13 | 0830 | 19.8 | 7.4 | 5.6 | 5.6 | 0 | 2m;2f |

| Test Group 8 | | | | | | | |
|---------------------|---------|------------|---|-------------------------|--------------|----------------|---------------|
| M/F | 45/30 | 12 ft tank | | | | | |
| Start Date | 5/16/13 | 1030 | Dose/fish 75 ug sGnRH α (pellet implant) | | | | |
| End Date | 5/19/13 | 0930 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/16/13 | 1500 | 19.0 | 7.9 | | | | |
| 5/17/13 | 0915 | 18.0 | 7.5 | | | | |
| 5/17/13 | 1615 | 18.9 | 7.4 | | | | |
| 5/18/13 | 0750 | 17.9 | 7.5 | 9.2 | 9.2 | | |
| 5/19/13 | 0920 | 18.0 | 7.0 | | | 0 | 1m;3f |

| Test Group 9 | | | | | | | |
|---------------------|---------|------------|---|-------------------------|--------------|----------------|---------------|
| M/F | 45/30 | 12 ft tank | | | | | |
| Start Date | 5/19/13 | 1100 | Dose/fish 75 ug sGnRH α (pellet implant) | | | | |
| End Date | 5/21/13 | 0830 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/19/13 | 1630 | 18.4 | 7.0 | | | | |
| 5/20/13 | 0930 | 18.8 | 6.6 | | | | |
| 5/20/13 | 1630 | 19.3 | 7.0 | | | | |
| 5/21/13 | 0830 | 19.0 | 6.0 | 8.6 | 8.6 | 0 | 2m;2f |

Appendix Table A-1.

Continued.

Test Group 10

| M/F | 30/20 | 10 ft tank | | | | | |
|------------|---------|------------|---|-------------------------|--------------|----------------|---------------|
| Start Date | 5/20/13 | 1000 | Dose/fish 75 ug sGnRH _a (pellet implant) | | | | |
| End Date | 5/22/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/20/13 | 1630 | 19.3 | 6.7 | | | | |
| 5/21/13 | 0900 | 19.0 | 5.7 | | | | |
| 5/21/13 | 1500 | 20.0 | 6.0 | | | | |
| 5/22/13 | 0830 | 20.2 | 6.9 | 8.1 | 8.1 | 0 | 1f |

Test Group 11

| M/F | 45/30 | 12 ft tank | | | | | |
|------------|---------|------------|------------------------------------|-------------------------|--------------|----------------|---------------|
| Start Date | 5/21/13 | 1100 | Dose/fish 75 ug sGnRH _a | | | | |
| End Date | 5/23/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/21/13 | 1500 | 20.0 | 6.7 | | | | |
| 5/22/13 | 0830 | 20.2 | 6.1 | | | | |
| 5/22/13 | 1445 | 21.0 | 6.0 | | | | |
| 5/23/13 | 0900 | 21.0 | 6.1 | 7.0 | 7.0 | 0 | 4f |

Test Group 12

| M/F | 30/20 | 10 ft tank | | | | | |
|------------|---------|------------|---|-------------------------|--------------|----------------|---------------|
| Start Date | 5/22/13 | 1100 | Dose/fish 75 ug sGnRH _a (pellet implant) | | | | |
| End Date | 5/24/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/22/13 | 1445 | 21.0 | 6.8 | | | | |
| 5/23/13 | 1700 | 21.2 | 6.3 | | | | |
| 5/24/13 | 0900 | 21.0 | 6.9 | 7.3 | 7.3 | 0 | 3f |

Appendix Table A-1.**Continued.**

| Test Group 13 | | | | | | | |
|----------------------|---------|---------------|---|-------------------------------|-----------------|-------------------|------------------|
| M/F | 45/30 | 12 ft tank | | | | | |
| Start Date | 5/23/13 | 1100 | Dose/fish 75 ug sGnRHa (pellet implant) | | | | |
| End Date | 5/26/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/23/13 | 1700 | 21.2 | 6.0 | | | | |
| 5/24/13 | 0900 | 20.8 | 6.5 | | | | |
| 5/24/13 | 1615 | 21.5 | 6.8 | | | | |
| 5/25/13 | 0845 | 20.2 | 7.7 | 6.0 | 6.0 | 0 | 1f |
| 5/26/13 | 0815 | 19.7 | 7.8 | | | | 3m;9f |

| Test Group 14 | | | | | | | |
|----------------------|---------|---------------|---|-------------------------------|-----------------|-------------------|------------------|
| M/F | 30/20 | 10 ft tank | | | | | |
| Start Date | 5/24/13 | 1130 | Dose/fish 75 ug sGnRHa (pellet implant) | | | | |
| End Date | 5/26/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/24/13 | 1615 | 21.5 | 6.9 | | | | |
| 5/25/13 | 0845 | 20.2 | 8.2 | | | | |
| 5/26/13 | 0815 | 19.7 | 8.0 | 4.0 | 0 | 4.0 | 2f |

| Test Group 15 | | | | | | | |
|----------------------|---------|---------------|------------------------|-------------------------------|-----------------|-------------------|------------------|
| M/F | 30/20 | 10 ft tank | | | | | |
| Start Date | 5/26/13 | 1030 | Dose/fish 75 ug sGnRHa | | | | |
| End Date | 5/28/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/26/13 | 1320 | 20.8 | 8.0 | | | | |
| 5/28/13 | 0830 | 19.8 | 6.3 | 5.5 | 5.5 | 0 | 2m;1f |

Appendix Table A-1.

Continued.

| Test Group 16 | | | | | | | |
|----------------------|---------|---------------|-----------------|-------------------------------|------------------------|-------------------|------------------|
| M/F | 45/30 | 12 ft tank | | | | | |
| Start Date | 5/26/13 | 1145 | | | Dose/fish 75 ug sGnRHa | | |
| End Date | 5/28/13 | 0900 | | | | | |
| Date | Time | Temp. (°C) | Oxygen (ppm) | Eggs (Liters) Collected | Eggs Shipped | River Releases | Morts Removed |
| 5/26/13 | 1320 | 20.5 | 7.4 | | | | |
| 5/28/13 | 0830 | 19.8 | 4.5 | 8.3 | 8.3 | 0 | 4f |
