

XIV.—REPORT OF EXPERIMENTS FOR DETERMINING THE SMALLEST AMOUNT OF WATER IN WHICH YOUNG SHAD AND EGGS CAN BE KEPT.

BY FRANK N. CLARK.

June 8, 1880, I was requested to conduct a series of experiments at the shad-hatching station at Washington navy-yard, and to use as small a quantity of water as possible both for the eggs and young fish. I accordingly arranged one of the cones with an aëerator attachment for Experiment No. 1.

June 9.—In the morning I placed in Cone No. 1 a portion of the eggs taken the evening before (125,000), and also placed in Cone No. 2 the same number. I commenced on Cone No. 1 by running 35 gallons of water per hour. On Cone No. 2 there were 218 gallons per hour. The aëerator attached to No. 1 was doing the same work the larger amount of water was doing in Cone No. 2. In the course of the day I reduced the amount of water in Cone No. 1 to 23 gallons per hour, and found the eggs had equally as good a motion as with the larger amount of water. The motion of eggs in Cone No. 1 was considered as good as in No. 2.

June 10.—Eggs were examined in both cones and found to be equally as good in Cone No. 1 as in No. 2.

June 11.—Eggs were examined in both cones. In Cone No. 1, with aëerator attachment, I found more fungoid growth on the unimpregnated eggs than in No. 2. They were, however, kept free from the good eggs by the force of air and water. In cones of eggs I have worked for the last few years I have frequently found eggs with the fungoid growth to attach themselves to the good eggs. It was especially so when the water was quite warm. I have always found it necessary in such cases to add a greater flow of water.

June 12.—The fish were all out and appeared in as healthy a condition in Cone No. 1 as in No. 2. So far I have been unable to note any difference in the eggs or in their hatching other than is mentioned in this report. In the evening of this day I removed 25,000 fish from each cone, leaving 75,000 in each of the cones, with same amounts of water (23 and 218 gallons). I find the fish in Cone No. 1 are not forced against the perforated tin edges as in Cone No. 2. Accordingly it is not necessary to attend to them as in No. 2, where it was absolutely necessary to brush the fish away from the edges at least once in an hour to keep them from filling the perforated tin and running over the top of the cone. This I think one great advantage.

June 13.—Fish were examined; found them equally as good in No. 1 as in No. 2. The force of air in Cone No. 1 seems to be rather violent

for the fish. I took the wire cloth from bottom of cone. It made a slight change in the air-bubbles, they were in finer particles.

June 14.—The fish appeared in a healthy condition. At 12 m. I arranged one of the cylinder cans with an aëerator attachment for conducting air and water to the bottom of the can. The water and air passed down through the pipe, and the overflow was through fine perforated tin at the top of the can into the overflow chamber, where the water passed out.

After arranging the can I immediately put into it 50,000 young shad 48 hours old. It had not been running more than ten minutes before I discovered fish were running out the overflow in consequence of the perforated tin at the overflow being too small a surface. I immediately removed the fish and informed Major Ferguson of what had occurred, and gave him my idea of what was wanted for the can. He had the cover of the can made with a larger surface of perforated tin, and this, after putting the 50,000 fish back in the can, I found held the fish.

June 15.—In the morning I discovered the fish in Cone No. 1 appearing weak, in consequence, as I thought, of the violence of air and water forcing them to top of cone, where the air-bubbles would break and throw the fish to one side. In the course of the day I found the fish were dying. In the can, which I shall designate as No. 3, I drew from the bottom of the can about 50 dead fish. The balance of the fish were looking well.

June 16.—There was a thorough examination made of all the different experiments. The fish in cones were found to be in about the same condition as the day before. The can, however, I did not find the same. During the night there had been a stoppage of the water, in consequence of which the fish were found all dead.

June 17.—The fish in Cones Nos. 1 and 2 were five days old. In Cone No. 1, with aëerator attachment, the fish were dying quite fast. My opinion is still the same, that the violence of air-bubbles is too severe for the young fish, and weakens them or wears them out.

June 18.—I arranged another cone (No. 4) with aëerator attachment, and immediately placed in it 100,000 eggs taken the evening before. There was an effort made to use a smaller quantity of water on this cone, but without success. As soon as the water was reduced below 23 gallons per hour the aëerator would not take in air. Thus it will be readily seen the aëerator will not supply the quantity of air with a less amount of water than 23 gallons per hour. This lot of eggs was examined from day to day until all were hatched, and nothing of note occurred different from No. 1.

June 19.—This morning I found the fish in Cone No. 1 all dead. The probable cause was the violence of water and air. The fish in Cone No. 2 were still doing nicely. They were turned loose in the Potomac at 6 p. m. There were 40,000 young shad put in Can No. 3 to again try the aëerator. The fish in Can No. 3 did very well until the third

day, when I found them dying very fast, probably from the impure water caused by the can being closed.

June 22.—I arranged Cone No. 1 with the aëerator attachment, and put in 125,000 eggs taken the evening before. The same amount of water, 23 gallons, was used on this occasion as on the others. Cone No. 4 all hatched and appeared in a very healthy condition. Out of the lot of eggs in Cone No. 4 there were about 90,000 fish, making a very good percentage. I took one-half of these fish and put them in Can No. 5, running a smaller quantity of water than on any of the other cones. There was no aëerator attached to this cone. There were 18 gallons of water per hour running in this cone. These cones were kept running and were examined from day to day until June 25, when the fish were deposited in the Potomac in good condition.

June 26.—On this morning I found the eggs in Cone No. 1 all hatched. The eggs had been examined from day to day; found to be about the same as the cones hatched before. On this day I was directed to discontinue operations at the navy-yard station, to move what fish I had on hand, about 100,000, to the Smithsonian Institution, and to continue my experiments there. The young fish were moved to the Smithsonian on the morning of June 27, where they were placed in cones and cans. In Cone No. 1, with aëerator attachment, I placed 20,000; in Cone No. 2, 20,000; in Can No. 1, with aëerator attachment, 20,000; the balance were placed in Can No. 2. My experiments consisted of one cone with aëerator attachment, running 23 gallons of water per hour; Cone No. 2, with no attachment, running 15 gallons of water per hour. This was afterwards reduced to 10 gallons per hour. In Can No. 1 I ran 15 gallons per hour until the rubber hose conducting the water burst, during the night of June 27, when, of course, the fish all died. In Can No. 2 there was no change of water during the night. The next morning I found the fish all dead. The cones were examined from day to day, and at this writing, July 3, the fish in Cone No. 1 are nearly all dead. The fish in Cone No. 2 are looking well. They are seven days old to-day.

From my experiments I have come to the following conclusions:

When a small quantity of water is to be used in hatching it is absolutely necessary to use the aëerator to introduce the air with the water at the bottom of cones in order to give the eggs the motion desired. In every case where the aëerator was in use, and they were kept until the fifth day, they commenced dying, and in twenty-four or forty-eight hours all were dead. My opinion is that the violence of air-bubbles and water weakened or wore them out. When it is desired to keep the fish in cones for any length of time, and to use a small quantity of water, I should advise that a small quantity of water be run in the cone, as when it is desired to use a limited supply of water a smaller quantity can be used than with the aëerator. In every case the experiment tried with the can in which no change was given the fish proved disastrous in from six to ten hours, according to the quantity of fish in the cans.

WASHINGTON, D. C., *July 3, 1880.*

Record of temperature observations made at Washington, D. C., from June 9, 1880, to July 3, 1880, by Frank N. Clark.

Date.	Cone No. 1.			Cone No. 2.			Cone No. 3.			Cone No. 4.			Cone No. 5.		
	8 a. m.	12 m.	6 p. m.	8 a. m.	12 m.	6 p. m.	8 a. m.	12 m.	6 p. m.	8 a. m.	12 m.	6 p. m.	8 a. m.	12 m.	6 p. m.
1880.															
Wednesday, June 9	72	74	74	72	73	74									
Thursday, June 10	73	74	75	72	73	73									
Friday, June 11	74	75	76	73	73	74									
Saturday, June 12	75	76	77	73	74	75									
Sunday, June 13	76	77	78	75	75	75									
Monday, June 14	76	77	78	75	76	76									
Tuesday, June 15	76	76	77	74	74	74	74	75	75						
Wednesday, June 16	75	76	77	73	74	74	(*)	(*)	(*)						
Thursday, June 17	76	77	78	73	74	75									
Friday, June 18	76	78	79	74	75	76				74	76	77			
Saturday, June 19	76	(*)	(*)	74	74	75	74	75	76	75	76	77			
Sunday, June 20				(*)	(*)	(*)	75	76	77	76	77	77			
Monday, June 21							75	77	78	75	77	78			
Tuesday, June 22	75	76	77				76	(*)	(*)	76	77	78	75	77	78
Wednesday, June 23	76	77	78							75	77	78	75	77	78
Thursday, June 24	75	76	77							75	77	78	75	76	77
Friday, June 25	76	77	77							75	76	77	76	77	77
Saturday, June 26	76	77	78							(*)	(*)	(*)	(*)	(*)	(*)
Sunday, June 27	76	75	75		75	75		75	75						
Monday, June 28	75	76	76	75	76	76	75	(*)	(*)						
Tuesday, June 29	75	75	76	75	76	76									
Wednesday, June 30	75	76	76	75	76	76									
Thursday, July 1	76	76	76	76	76	76									
Friday, July 2	75	76	76	75	76	76									
Saturday, July 3	74	75	75	74	75	75									

NOTE.—The cones were moved to the Smithsonian Institution Saturday evening, June 26

* Fish all dead.

† New eggs.

‡ Fish released.