UNITED STATES GOVERNMENT

Memorandum

Memorandum

Denver, Colorado
DATE: October 6, 1978

TO : Chairman, Fish Screening Facility Task Force

FROM : Laboratory Testing Coordinator

SUBJECT: FY78 Progress Report

Introduction

Report REC-ERC-75-6, "Hydraulic Model Study of a Fish Screen Structure for the McClusky Canal," describes laboratory development of a 40-mesh, self-cleaning, sloping screen to filter fish eggs and larvae from the McClusky Canal. That study did not use live organisms to verify the filtering capability of the 40-mesh screen. Subsequent review by the International Joint Commission (IJC) raised several questions which could be resolved only by additional laboratory and field studies.

Objectives

The objectives of the laboratory study are:

1. Determine the effectiveness of various size screens to stop the passage of fertilized eggs, eyed eggs, sac fry, and swim-up fry of rainbow smelt, carp, gizzard shad, and Utah chub. Additional species may be studied if warranted. Each species will be studied under various hydraulic conditions.

2. Determine the hydraulic characteristics of screen sizes tested to determine what modifications of the existing structure are required.

3. Test the effectiveness of the seal design.

4. Determine the impact of debris on screening effectiveness and hydraulic efficiency.

5. Augment design recommendations for field test facility and for field tests, based on laboratory test results.

Testing Procedures

Culturing of eggs and larvae. - Testing concentrated on rainbow smelt and common carp. The spawning season for gizzard shad coincided with heavy testing with rainbow smelt; therefore, the former species was not included in this year's testing.

Attempts to hold and spawn Utah chub in the laboratory were not successful. Special aquariums were purchased to allow holding the fish under carefully controlled environmental conditions. Utah chub were collected at Flaming Gorge Reservoir in Wyoming and rushed to Denver by tank truck. The fish were in good condition on arrival, and within a few weeks of spawning. Unfortunately the fish were very sensitive to the stresses associated with holding. All fish died before spawning was possible. Other investigators have reported similar difficulties. In 1979, fish will probably be spawned in the field, the eggs will be shipped to Denver, and hatching and rearing will be attempted here. Research is needed in determining the size and other characteristics of chub eggs and larvae, as well as techniques for handling adult fish.

Carp were collected locally and some difficulty was encountered in finding spawning male and female pairs. Hot weather apparently influenced the fish to remain in deeper, cooler waters where they were inaccessible to collection by beach seining. Collection permits have been obtained which will allow more flexibility in searching for and collecting adult fish next year.

Attachment 1 describes the culturing of rainbow smelt eggs and larvae and the results of testing in the full-scale sectional model (table 1). A similar report will be prepared for carp and Utah chub. The methods for introduction and sampling of the eggs and larvae for both smelt and carp are also described in attachment 1.

Characterisitics of the screens used in the testing are given in the following table:

Mesh	Wire diameter (in)	Opening width (mm)	Percent open area
40	0.008	0.432	46.2
50	0.009	0.279	30.3
50	0.0075	0.318	39.1
60	0.0075	0.234	30.5

Rainbow smelt was the most critical species with respect to average size, as shown in the table on the following page.

	Smelt	Sample size	Carp	Sample size	Chub	Sample size
Mean egg diameter (mm)	1.14	450	1.40	10	2.00	5
Mean larvae length, one 1 day after hatching (mm)	6.45	81	5.12	14	5.30	3
Mean larvae head width (mm)	0.83	81	0.72	14	0.82	3
Mean widest larvae width (mm)	0.83	81	0.93	14	1.10	3

The table also shows that Utah chub are larger than carp or smelt; therefore, their exclusion from the testing does not change conclusions with respect to required screen size.

This table, when compared to the previous table on screen size, suggests that even the 40-mesh screen should be able to exclude the eggs and larvae of rainbow smelt. However, smelt and carp eggs and larvae appear to be sufficiently flexible to allow their passage (intact) through openings considerably smaller than their smallest dimension.

Results of Sectional Model Tests

Figure 1 shows the full-scale sectional model. The model includes conduits for subsurface introduction of eggs and larvae, a 3-foot by 10-foot section of screen, and a plankton net apparatus for collecting and concentrating material which passes through the screen.

Both table 1 (rainbow smelt) and table 2 (common carp) show the passage of both eggs and larvae through the range of screen sizes. There is no consistency in the data. The comments for the 60-mesh runs state that attempts were made to reseal the screens. The conclusion was reached that the silicone rubber seal around the upstream and side edges of the screen (figure 2) was inadequate and that eggs and larvae, though excluded by the screen, were passing through the seal. The numbers of undamaged eggs and larvae recovered gave weight to this conclusion. Because of the uncertainty in the results of the full-scale sectional model tests, it was decided to take another approach. However, FY78 tests on the sectional model were not lost; methods of introducing, collecting, and sampling eggs and larvae were developed.

Standpipe Tests

A standpipe apparatus (figures 3 and 4) was fabricated to allow better controlled testing of the filtration capability of the various screens. A head of 2 feet 3 inches was applied to the screen, which was sealed immediately above a 1-1/4-in orifice plate. The head on the screen exceeded the maximum drop of 2 ft expected for the prototype screen. The orifice plate, in a 4-in plexiglass pipe, caused the pipe above the orifice to flow full. The discharge was passed through a plankton net. Material collected after test runs of 45 minutes duration was

examined, as with the sectional model tests. The use of the standpipe was an outgrowth of Milo Bell's suggestion to test the passage of eggs and larvae through hypodermic needles of varioussizes. To our knowledge, it is a unique approach.

Test results are shown in table 3. With the exception of three headless smelt larvae, no material passed the 60-mesh screen. Carp eggs and larvae and smelt eggs did not pass the 50-mesh screen; however, 11 smelt larvae passed. The results of the 40-mesh tests eliminated that screen from further consideration for smelt so it was not tested with carp. Tests with carp may be conducted later to obtain general research data.

Conclusions

1. Results of the full-scale sectional model tests suggest that the seal between the screen and the model walls allowed the passage of eggs and larvae. Therefore, the data on filtration capability are unreliable. The sectional model tests developed techniques for introducing, collecting, and sampling the eggs and larvae.

2. Rainbow smelt is the critical species with respect to average size.

3. Standpipe tests showed that eggs of neither smelt nor carp will pass 40-, 50-, or 60-mesh screens. Smelt larvae will pass both 40- and 50-mesh screen; with the exception of three headless larvae, they did not pass 60-mesh screen. Carp larvae will not pass 50- and 60-mesh screen (40-mesh may be tested later).

4. It is our opinion that the use of a sloping, fine-mesh screen, as originally conceived, remains a viable approach to filtering eggs and larvae from the McClusky Canal flow.

Recommendations

1. Perform standpipe tests with 70-mesh screen, 0.0065-in wire.

2. If standpipe tests indicate 100 percent filtration efficiency, proceed with sectional model tests, taking extreme care with the side seals. Recommend 70-mesh screen for field testing.

3. If 100 percent efficiency is verified, proceed with testing for hydraulic efficiency, mechanical seals, basket concept, self-cleaning, and mechanical cleaning.

N. L. King

Attachment

Copy to persons on attached sheet.

Noted OCT 13 1978
Howard J. Cohan
Chief, Division of Research

Copy to: Commissioner, Attention: 107 (Seaman)
Regional Director, Sacramento, California, Attention: Ken Lentz
Regional Director, Billings, Montana, Attention: 210 (Verzuh)
Project Manager, Bismarck, North Dakota, Attention: 400 (Knoll)

Blind to: 1520
1522
1522 (Roline)
1522B (Jackson)
1530
1530 (King)
1531
1531 (Johnson)
✓1532
252 (DeLapp)
274 (Starbuck)
1500
934

Note for 1522B (Jackson): Please see that Lee Mills receives a copy of this progress report.

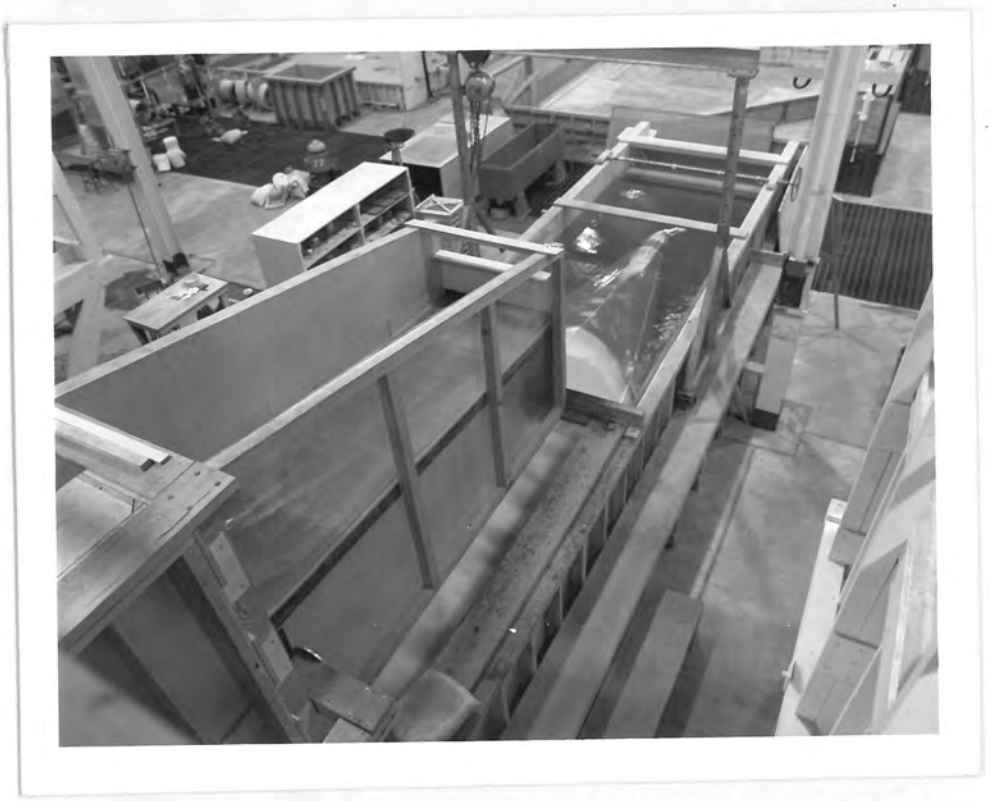

Figure 1. - Overall view of full-scale section model, looking downstream. Plankton net is visible in tailbox.

Figure 2. - Screen in sectional model. Flow is from left to right.

Figure 3

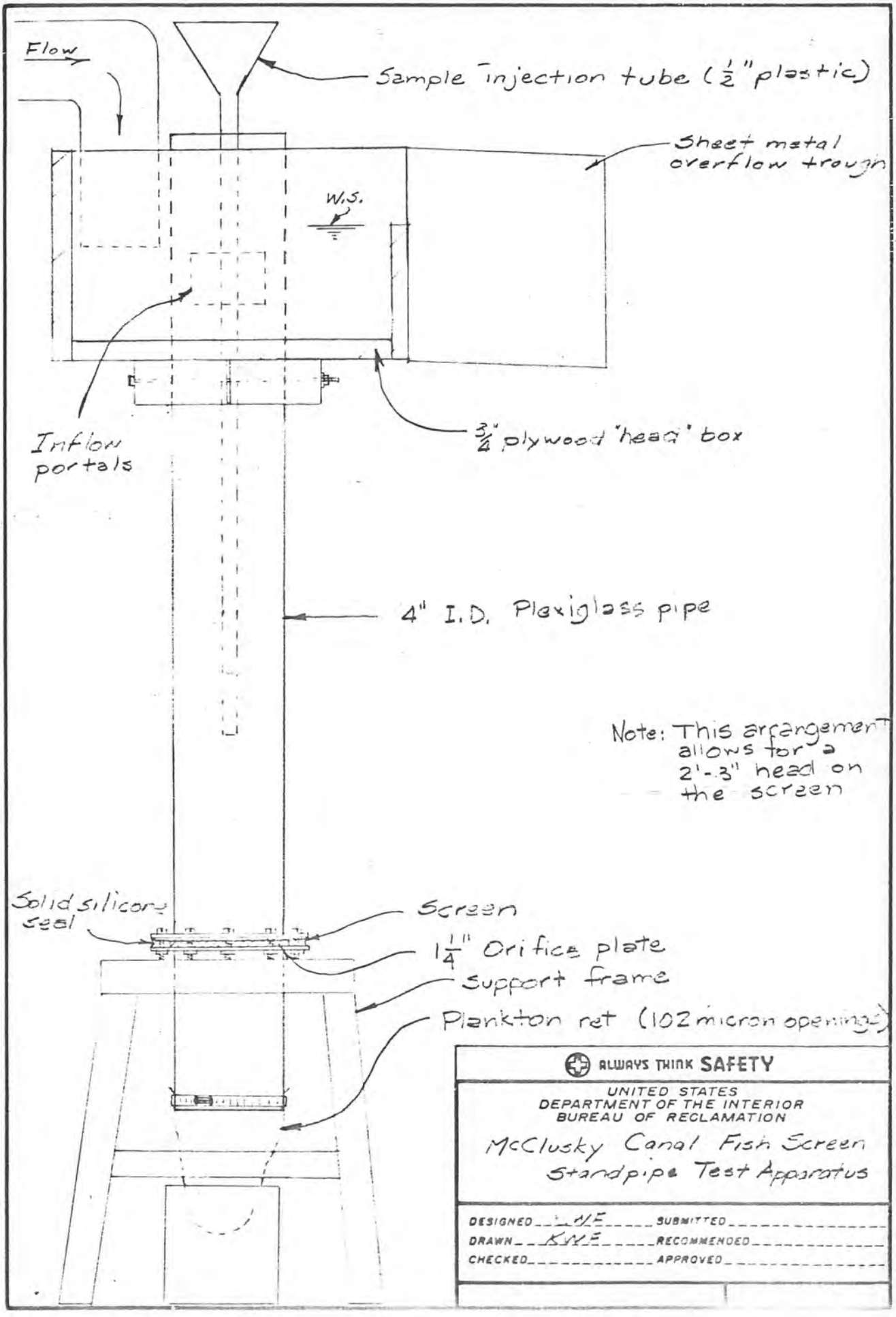
Flow
Sample injection tube (½" plastic)
Sheet metal overflow trough
W.S.
Inflow portals
¾" plywood "head" box
4" I.D. Plexiglass pipe
Note: This arrangement allows for a 2'-3" head on the screen
Solid silicone seal
Screen
1¼" Orifice plate
Support frame
Plankton net (102 micron openings)
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
McClusky Canal Fish Screen
Standpipe Test Apparatus
DESIGNED LWE SUBMITTED
DRAWN KWE RECOMMENDED
CHECKED APPROVED

Figure 4. - Standpipe test apparatus.

Table 1 - Results of sectional model tests with smelt

Screen (mesh)	Date	Discharge (ft^3/s)	Length of test (min)	Sample tested [1]		Sample recovered in plankton net						Comments
				Eggs	Larvae	Whole eggs	Egg cases	Damaged eggs	Whole larvae	Headless larvae	Damaged larvae	
40	4-29	18	15	100	100	100			88			Recovery test [2]
40	5-1	18	30	5,000	500	24	64		2	10		
50	5-3	18	120	10,000	~1,000,000	~400			~36	~600		Larvae in sump [3]
50	5-4	18	45	30,000	15,000	464	9		31	340		
60	5-6	17.6	45	5,000	30,000	17	18		20	39	26	
60	5-6	9	45	5,000	30,000	3	13		7	8	10	
60	5-8	18	45	0	0	2	3		2	2		Control test
60	5-9	3	45	30,000	15,000	1	1		2		2	
60	5-9	12	45	30,000	15,000	20	14		40	9		Ogee approach Resealed
60	5-10	12	45	30,000	15,000	3	0		0	0		Ogee approach Resealed
60	5-11	17	45	10,000	15,000	0	3		0	4	3	Resealed
60	5-11	18	15	100	100	90	22		104			Recovery test
60	5-12	3	45	10,000	15,000	0		2	1 [4]	0		Resealed
50	5-12	9	45	30,000 (preserved)	50,000 (preserved)	0	2	2	0	8		Resealed

1/ Numbers of organisms introduced into the headbox of the model.
2/ All test organisms were introduced under the screen directly into the plankton net.
3/ Hatching of a number of eggs took place during the night of May 3, 1978, and larvae were found to be in the sump water.
4/ This whole larva presumably passed by the silicone rubber seals of the screen.

Table 2 - Results of sectional model tests with carp

Screen (mesh)	Date	Discharge (ft^3/s)	Length of test (min)	Sample tested		Sample recovered in plankton net						Comments
				Eggs	Larvae	Whole eggs	Egg cases	Damaged eggs	Whole larvae	Headless larvae	Damaged larvae	
50	6-16	12	45	2,000 1/	0	0	0	0	0	0	0	
50	6-16	17	45	4,000 1/	4,000	0	1	0	0	4	0	
50	6-20	17	45	4,000	3,500 2/	0	0	0	0	0	0	
50	6-21	12	45	4,000	3,500 2/	0	1	0	0	1	0	
50	6-22	3	45	4,000	4,000 2/	0	0	0	0	0	0	
40	6-23	3	90	4,000 2/	4,000 2/	0	many	0	2	>50	0	One whole larva without tail
40	6-23	18	45	4,000 1/	4,000	2	many	1	0	>120	0	
40	6-26	18	45	4,000 2/	4,000	0	several	0	0	3	1	
40	6-27	18	45	4,000 2,3/	4,000	0	many	0	0	1	0	
60	6-28	17	45	4,000 2,3/	6,000	2	few	0	0	1	0	One flat possibly dried larva
60	6-29	3	45	2,000 2/ 2,000 2,3/	4,000	1	several	0	0	0	2	Smashed heads with tails
60	6-30	3	45	4,000 2,3/	4,000	1	0	0	0	0	0	
60	6-30	18	45	4,000 2,3/	4,000 2/	0	0	1	2	0	1	Smashed tail

1/ Eyed eggs.
2/ Preserved in formaldehyde.
3/ Unfertilized eggs.

Table 3 - Results of standpipe tests

Screen (mesh)	Date	Length of test (min)	Sample tested		Sample recovered in plankton net						Comments
			Eggs 1/	Larvae 1/	Whole eggs	Egg cases	Damaged eggs	Whole larvae	Headless larvae	Damaged larvae	
			Carp:								
60	7-7	45	100	100	0	0	0	0	0	0	
60	7-7	45	100	100	0	0	0	0	0	0	
60	7-11	45	100	100	0	0	0	0	0	0	
60	7-11	45	100	100	0	0	0	0	0	0	
60	7-12	45	100	100	0	0	0	0	0	0	
			Smelt:								
60	7-12	45	100	100	0	0	0	0	0	0	
60	7-19	45	100	100	0	0	0	0	0	0	
60	7-20	45	100	100	0	0	0	0	1	0	≈ 1.5-mm length
60	7-21	45	100	100	0	0	0	0	0	0	One insect larva
60	7-21	45	100	100	0	0	0	0	0	0	
			Smelt:								
60	9-1	45	100	100	0	0	0	0	2	0	
60	9-1	45	100	100	0	0	0	0	0	0	
60	9-1	45	100	100	0	0	0	0	0	0	
60	9-1	45	100	100	0	0	0	0	0	0	
60	9-1	45	100	100	0	0	0	0	0	0	
			Carp:								
50	8-25	45	100	100	0	0	0	0	0	0	
50	8-25	45	100	100	0	0	0	0	0	0	
50	8-25	45	100	100	0	0	0	0	0	0	
50	8-28	45	100	100	0	0	0	0	0	0	
50	8-28	45	100	100	0	0	0	0	0	0	
			Smelt:								
50	8-22	45	100	100	0	0	0	1	1	0	
50	8-22	45	100	100	0	0	0	0	1	1 *	* head
50	8-23	45	100	100	0	0	0	1 *	2	0	* one eye
50	8-23	45	100	100	0	0	0	0	1	1 *	* head
50	8-23	45	100	100	0	0	0	0	0	1 *	* head
			Smelt:								
40	8-7	45	100	100	0	0	0	4	0 *	2	* various pieces
40	8-7	45	100	100	0	0	0	2	0 *	5	
40	8-8	45	100	100	0	0	0	2	0 *	2	
40	8-8	45	100	100	0	0	0	0	0 *	2	
40	8-9	45	100	100	0	0	0	3	0 *	3	

1/ Preserved, not live, material.

ATTACHMENT 1

UNITED STATES GOVERNMENT

memorandum

Memorandum
Denver, Colorado
August 4, 1978

DATE:

REPLY TO ATTN OF: Head, Environmental Sciences Section

SUBJECT: Progress Report on the Culturing of Rainbow Smelt Eggs and Larvae and the Testing of the Model for the McClusky Canal Fish Screen Structure

TO: Research Division Coordinator, McClusky Canal Fish Screen Studies, Attention: 1530

THROUGH: Chief, Applied Sciences Branch

Applied Sciences Referral No. 78-2-10

Investigations by: R. A. Roline and J. S. Thullen

Introduction

In response to the memorandum dated November 25, 1977, from Robert H. Madsen, Regional Director, Billings, Montana, the first phase of laboratory testing has been completed concerning the McClusky Canal fish screen structure to be located near Bismarck, North Dakota.

The primary objective of this study was to obtain Rainbow Smelt eggs and larvae for testing, and to determine the screen mesh size to be effective and hydraulically most efficient in removing 100 percent of the eggs and larvae that could conceivably be introduced into the canal system.

Methods and Materials

Adult Rainbow Smelt and eggs were shipped by commercial airlines to the Denver laboratory, as shown in the following schedule:

Date	Numbers shipped	Source
April 4, 1978	~100 adults	French River Hatchery, Minnesota
April 13, 1978	~300,000 recently fertilized and eyed-eggs	Cornell University, Ithaca, New York
April 22, 1978	51 adults	New Hampshire
April 26, 1978	~280 adults	Lake Sakakawea, North Dakota
April 27, 1978	~1,000,000 eyed-eggs and ~100 adults	New Hampshire

The adult smelt were held until spawning (artificially or naturally) in a 1140-L circular flow-through fiberglass tank at 11 °C (figure 1) and in a 684-L flow-through fiberglass tank at 16 °C (figure 2).

Fertilized eggs were incubated in two commercial flow-through incubators (figure 3) with fine-mesh polyester trays used in place of the standard screens. Standard treatment rates of formalin and malachite green were used in the treatment of fungus.

One incubator had a water source of 11 °C as the other source was 16 °C. Eyed-eggs incubated at 11 °C hatched in 13 days as those incubated at 16 °C hatched in 6 days. Larvae were held for testing in a 684-L fiberglass tank at 16 °C and in 638-L aquaria at 18 °C with gentle aeration present in both systems.

Both live and dead eggs and recently hatched live smelt larvae were used in all testing except during the May 16 test of the 50 mesh screen (table 1) in which preserved organisms were used. All test organisms were introduced into the headbox of the model at three depths (surface, 0.3 m, 0.6 m) through 5-cm PVC tubes except during the 3-ft^3/s test in which all organisms were introduced at the surface of the flow.

The model was operated for varying lengths of time (table 1) and the plankton net was washed twice immediately following each test run. The sample collected from the plankton net was stained with a 1 percent Rose Bengal solution for easier identification and the sample was then counted and preserved with formalin.

The use of Neutral Red stain and Evan's Blue stain has not proven satisfactory as yet in determining live from dead organisms collected in the plankton net.

The screen was washed after each test using a garden hose and all organisms and other debris were preserved with formalin and stored.

The plankton net was thoroughly dried between tests in an attempt to eliminate any possible contamination from previous runs.

Results and Discussion

A summary of the testing thus far can be seen in table 1.

The testing program began with an evaluation of the collection procedure by running a recovery test using 100 eggs and 100 larvae (figures 4 and 5). The test organisms were introduced under the screen directly into the plankton net during a waterflow of 18 ft^3/s. As table 1 indicates 100 percent of the eggs were recovered and 88 percent of the larvae. Further into the testing another recovery test was run, using 100 eggs and 100 larvae. In that test nearly 100 percent of the eggs and larvae were recovered. The numbers of organisms introduced in the second recovery test are only approximations due to the fact that there may

have been some eggs and larvae remaining in the headbox from previous tests. However, it is quite certain the collection procedure was adequate.

Beginning with the 2.13-m 40 mesh screen (0.007 wire) panel, approximately 0.5 percent of the total number of eggs and larvae introduced into the headbox of the model passed through the screen or by the seals, and were collected in the plankton net. The 3.05-m 50 mesh screen (0.009 wire) panel was installed for the next two test runs. Since the number of larvae introduced into the headbox was an approximation, a specific percent recovery cannot be determined. However, a large number of both intact eggs and larvae were collected in the plankton net.

The installation of the 3.05-m 60 mesh screen (0.0075 wire) panel began a series of tests examining various waterflow rates and various numbers of test organisms introduced into the headbox. It seemed that lower flows had a greater effect on limiting numbers of organisms collected in the plankton net than did the subsequent installation of an ogee approach section to inhibit the driving force of the water on the screen. These results may have been due to a leak in the seal around the screen panel which would have been more pronounced at higher flows. After extreme care was taken in resealing the screen in the model, the number of eggs and larvae collected in the plankton net dropped substantially. Only one intact larva was collected in the plankton net in three tests using various flow rates and numbers of organisms. This larva is presumed to have passed by the seals. An additional test using the 50 mesh screen allowed no passage of either preserved eggs or larvae.

Both the 50 and 60 mesh screens seem to be effective in removing any possible fish eggs and larvae from the canal system provided all seals around the screen are completely secure and watertight.

A short 16-mm movie is available of the testing procedure as well as a number of slides and prints of various aspects of the study.

8/16/78

Attachments

Copy to: 1522
1522 (Roline)
1522 (Thullen)
1522B (Jackson)
1531 (Johnson)

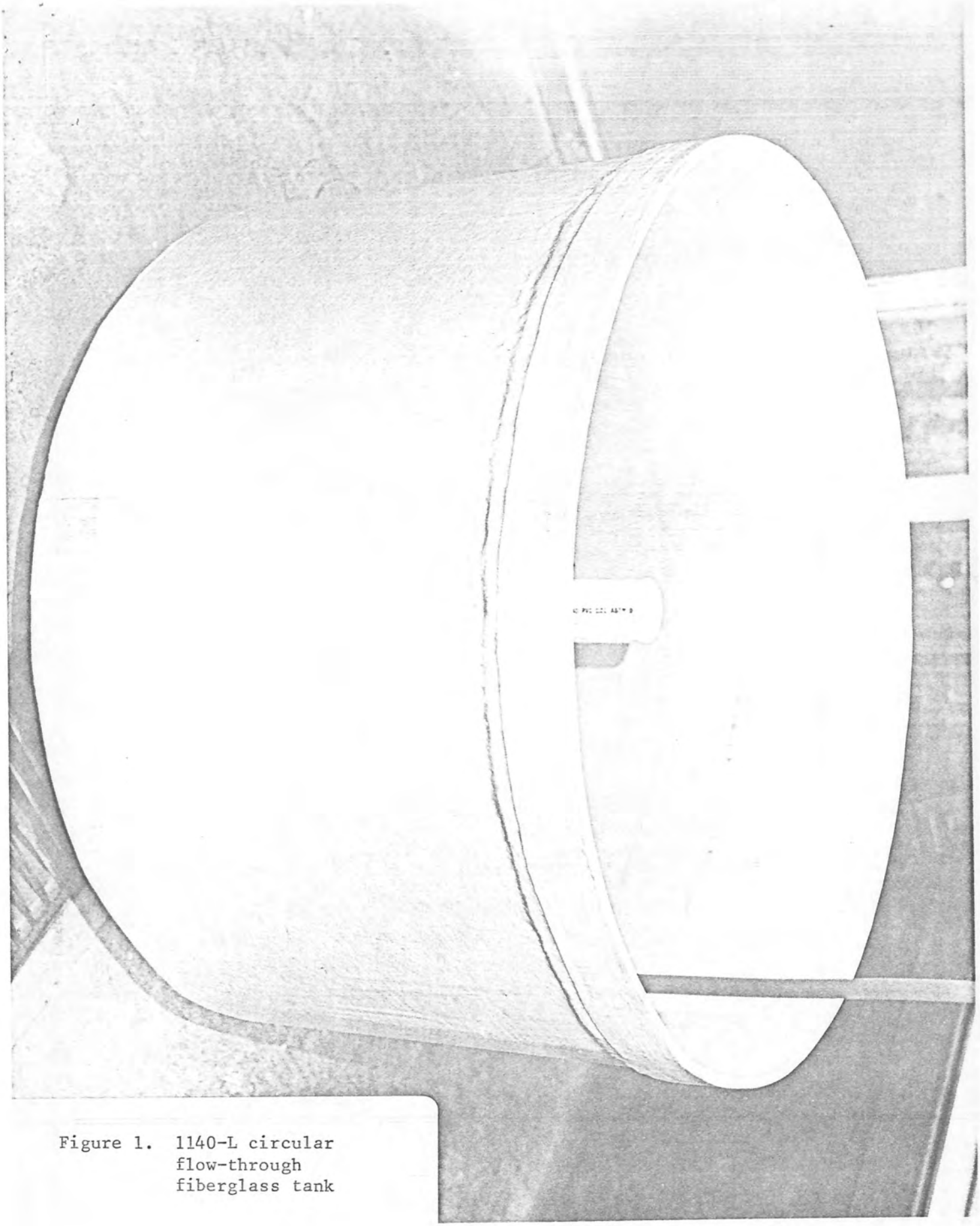

Figure 1. 1140-L circular flow-through fiberglass tank

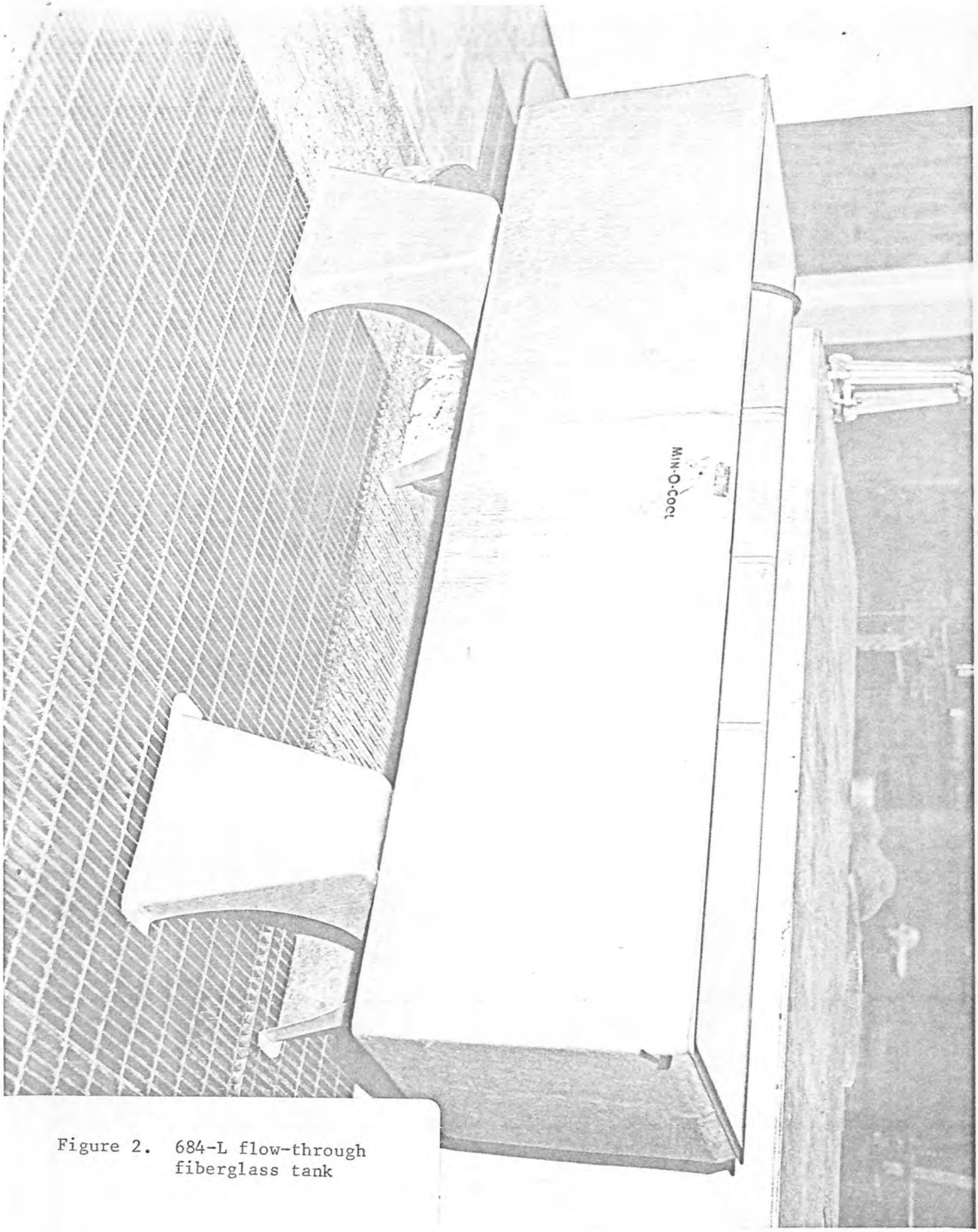

Figure 2. 684-L flow-through fiberglass tank

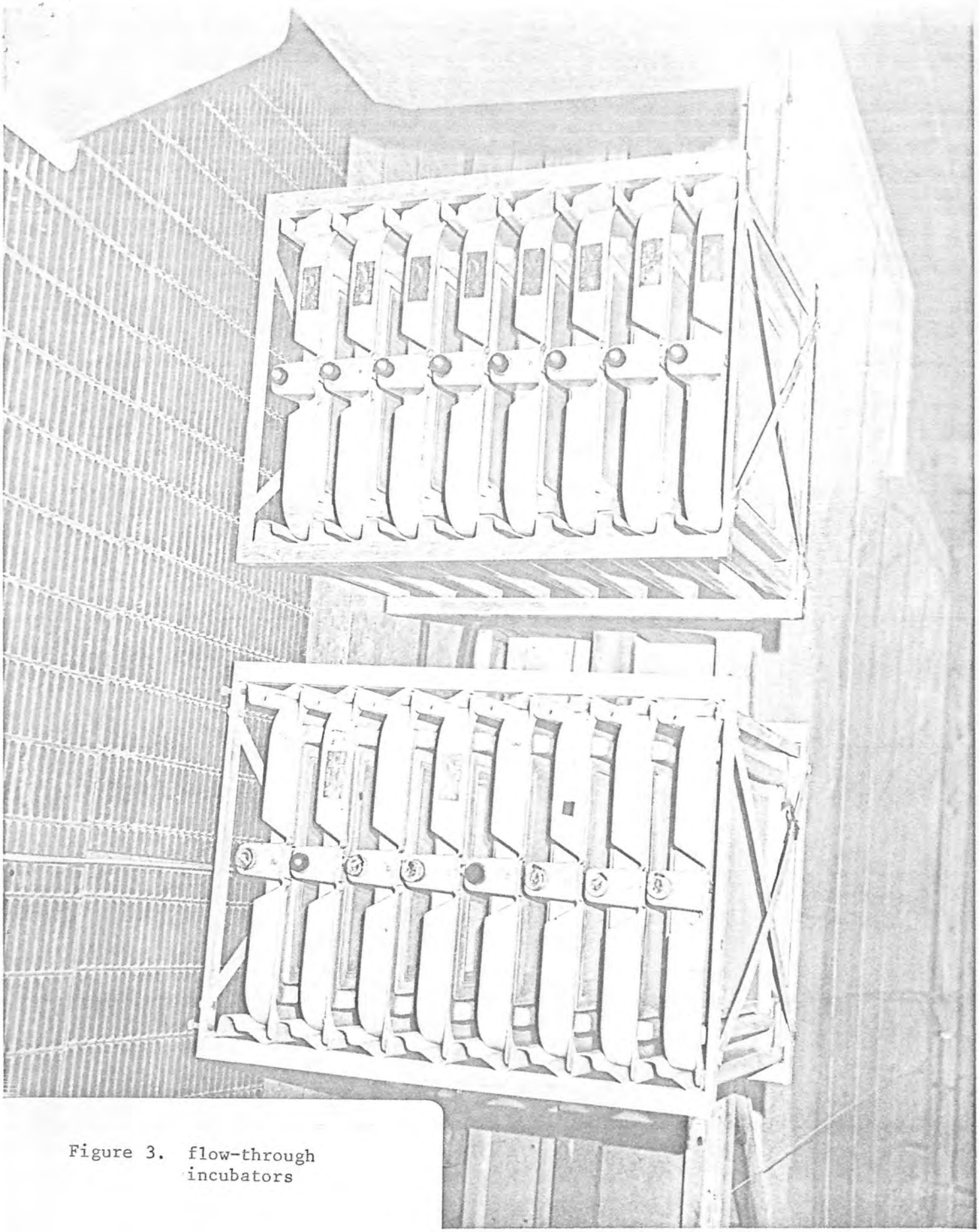

Figure 3. flow-through incubators

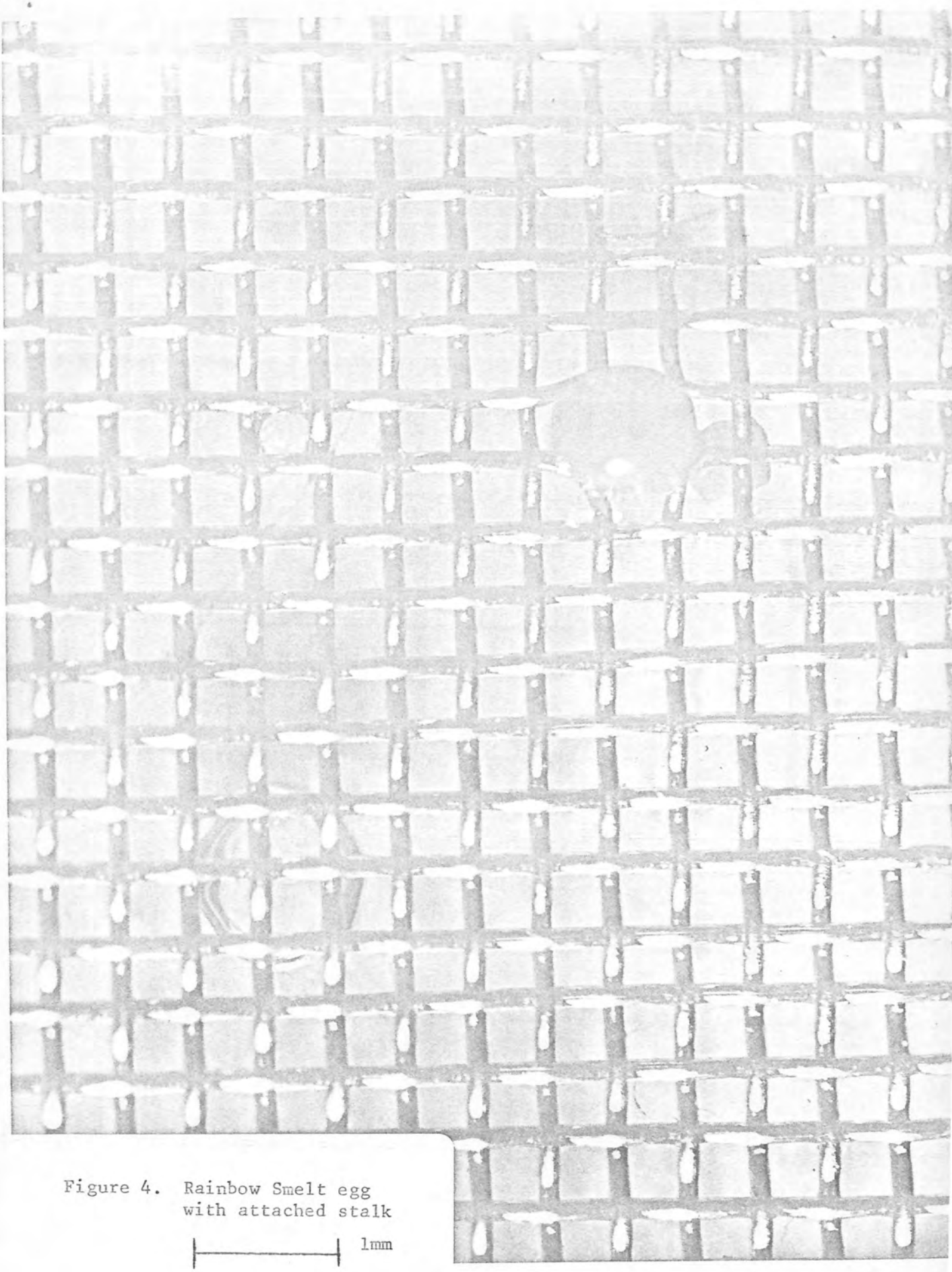

Figure 4. Rainbow Smelt egg with attached stalk

1mm

Figure 5. Rainbow Smelt larvae

1mm