FY80 PROGRESS REPORT

(FISH SCREENING FACILITY TASK FORCE)

DANNY KING

PAP-408

PAP-408

D-1532
FILE

United States Department of the Interior
WATER AND POWER RESOURCES SERVICE
ENGINEERING AND RESEARCH CENTER
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DENVER, COLORADO 80225

IN REPLY REFER TO D-1530
565.

Memorandum

To: Chairman, Fish Screening Facility Task Force, Billings, Montana

From: Laboratory Testing Coordinator

Subject: FY80 Progress Report

INTRODUCTION

The primary conclusion from testing in FY79 was that the 70-mesh screen with rectangular inflatable seals would provide 100 percent efficiency in filtering whole eggs and larvae. Testing in FY80 centered on acquiring data for further verification of this conclusion and in testing to develop details of the final design. Considerable laboratory work was accomplished in support of the field testing at Turtle Lake.

ACQUISITION OF EGGS AND LARVAE FOR TESTING

Appendix I gives details of the program of acquisition and culturing of adult fish, eggs, and larvae during FY80. Sufficient eggs and larvae of rainbow smelt were obtained to complete the testing for that species.

Success in transporting adult gizzard shad was considerably improved over FY79; however, mortality in the laboratory was a major problem and insufficient eggs and larvae were obtained. Testing with eggs and larvae of the gizzard shad is of critical importance, because the eggs and larvae are the smallest of the four species under consideration.

Utah chub were successfully captured and transported and are surviving in the laboratory. However, spawning did not provide adequate eggs and larvae for testing. Adults are being held over with accelerated simulated seasonal changes to allow spawning early in 1981.

A hot weather induced fish kill nearly eliminated the carp being held for spawning, so testing for that species was also unsuccessful. Both the chub and carp have eggs and larvae considerably larger than the other two species; therefore, their inclusion in the testing program is not critical. The data which have been obtained, plus intuition based on the relative sizes, leads to the conclusion that the eggs and larvae of Utah chub and common carp will not pass the 70-mesh screen.

Appendix II describes an apparatus and technique for photographing and sizing eggs and larvae.

FILTRATION TESTING

A potential problem of leakage past improperly vulcanized splices in the inflatable seals was partially resolved by a manufacturer modification, and can be fully resolved in seals for the prototype structure.

A question raised late in 1979 concerned possible damage which could occur to whole eggs and larvae in the turbulent boil below the screen. Such damage would mask the results, in that recovery of pieces of eggs and larvae might imply that whole specimens had passed the screen.

Tables 1 through 5 in Appendix 1 summarize filtration tests accomplished during FY80. As noted earlier, supplies of eggs and larvae for Utah chub, gizzard shad, and common carp were inadequate to complete testing for those species. However, in the limited number of tests, plus the complete series for rainbow smelt, <u>no pieces</u> of eggs or larvae were recovered below the screen. The 70-mesh screen with inflatable seals is obviously completely effective in blocking the passage of eggs and larvae. All that remains is to round out the documentation for the most critical species, gizzard shad.

FLOW CAPACITY OF THE SCREEN

Differences were noted between the flow capacity in the field test facility and that in the laboratory test facility. An 80-mesh screen, with a percent open area nearly equivalent to the laboratory 70-mesh screen, was used in the field during 1979. Maximum capacity achieved through the 12.5-foot-long screen was 20 ft^3/s. For two 3-foot-wide panels this resulted in a unit discharge capacity of 3.33 ft^3/s per ft. The maximum long term capacity was 15 ft^3/s, or 2.50 ft^3/s per ft. These unit discharges are considerably lower than the laboratory unit discharge of 5.0 ft^3/s.

Laboratory tests examined the effects of mesh size, backup screen configuration, and approach channel depth. Neither backup screen configuration nor approach channel depth were found to make a significant contribution to the capacity difference. Some of the difference is suspected to be attributable to differences in the discharge coefficients of the 70- and 80-mesh apertures, although no conclusive data have been developed. There is a possibility that roughening due to corrosion causes a reduced capacity in the field test facility. However, the major reason for lower capacity in the field than in the laboratory is believed to be clogging.

Flow deflectors were developed to deflect water moving along the screen frames back onto the screens. This prevents loss of water off the downstream end.

TESTS REGARDING SCREEN HOLDDOWN

Observation of screen panels showed that the screen holddown rods on the frame tended to bow out of the retaining groove. Also, there was a tendency to shear the screen during installation.

A test apparatus, figure 1, was assembled to determine the pullout limits for various holddown configurations in both horizontal (parallel to the plane of the screen) and vertical (perpendicular to the plane of the screen) directions.

Table 1 summarizes the test results. Figure 2 shows the configurations of plates numbers 1 and 2 listed in the table. The decision was made to continue the use of the circular monel rod in the field test facility, but to double the number of retaining screws, to give a screw spacing of approximately 3.5 inches. No problems have been experienced with pullout; however, the design is being reexamined for the possibility of simplifying the screen installation procedure and reducing the potential for screen shear.

VERIFICATION OF SCREEN INTEGRITY

This activity falls into two categories: (1) determination of wear or damage to the screen during operation and (2) verification of adherence to specifications for newly installed screens.

The first category requires visual examination of magnified photographs taken before and after a test period of field operation. A control system has been developed so that the before and after photographs are taken of identical areas of the screen. Data recorded from this examination are then subjected to statistical analysis to determine change trends.

Results to date show significant reduction of the wire diameters in the field test facility phosphor bronze screen because of corrosion. The decision has been made to eliminate the phosphor bronze screen from further consideration. Both upper screens in the field test facility are now monel.

A task group was assembled to brainstorm methods for verifying the integrity of newly installed screens. A long list was developed of potential methods which were broadly classified as optical-visual, tracers, electrical, sound, surface tension, and jet penetration. After considerable discussion and some experimentation and analysis, the following methods were chosen for further examination.

1. Visual examination of the screen surface, enhanced by oblique lighting

2. Videotaped scanning, with subsequent monitoring of the videotape

3. Utilization of surface tension to detect flaws in the screen material

The last method shows enough promise to warrant further development. A test tank will be fabricated to accommodate a full screen panel, figure 3. Water is added to the reservoir in small increments to gradually increase the air pressure under the screen. Inconsistencies in the screen surface appear as bubbles in a liquid film applied to the upper surface of the screen.

DEVELOPMENT OF A FAIL-SAFE MONITORING AND ALARM SYSTEM

Figure 4 schematically represents a system configuration including regulators, valves, switches, and alarms to ensure that the pneumatic seals will remain properly inflated, or if damage occurs, an alarm will cause immediate shutdown. It is essential to note that a second, lower screen will involve a completely separate air system and complete redundancy will be provided.

BIOLOGICAL GROWTH ON THE SCREENS

A memorandum to D. L. King from the Head, Environmental Sciences Section dated April 21, 1980, details the results of laboratory examination of screen samples exposed to field waters. The samples clearly show growth-inhibiting characteristics of phospher bronze as compared to stainless steel. Monel which also contains copper, but at a lesser percentage, has uncertain growth retardant characteristics. Neither phosphor bronze nor monel showed problems of biological growth in the field test facility where spray cleaning has a significant effect.

TESTS TO DEVELOP CLEANING APPARATUS

Laboratory testing involved definition of required nozzle type, diameter, spacing, angle, and pressure to effectively remove algae and other debris from the screens.

Initially, some concern was expressed that sediment might be making a major contribution to clogging of the screen at the field test facility. However, sediment concentration was insignificant except during initial startup when some material was scoured from the supply canal. Analysis showed the maximum size of the sediment to be about 80-mesh. Therefore, clogging should be insignificant for a 70-mesh screen, unless the screen was already partially plugged by algae. The sediment was comprised of abrasive minerals; therefore, some long-term abrasion of the screen might be expected. Sediment in the cleaning spray might have a more serious impact.

The primary clogging is due to algae and becomes serious during the summer when blooms occur in the system upstream.

Laboratory experiments concluded that No. 40 nozzles, operating at 40-50 lb/in^2, with 40^o divergence in the spray, and mounted 3-3/4 to 4 inches from the screen should be used for cleaning the upper screen from the underside. A similar arrangement cleans the lower screen from either the top or under side. The design is still under adjustment through field testing.

Twelve tests were run in the laboratory with spray cleaning of the top side of the upper screen, and with eggs and larvae from a filtration test run remaining on the screen. No recognizable pieces of eggs or larvae were recovered below the screen.

FY81 TESTING PLANS

Laboratory testing in FY81 will concentrate on:

1. Verification of screen filtration capability for eggs and larvae of gizzard shad. Attempts will again be made to obtain test specimens from North or South Dakota. Testing may also occur at the TVA laboratory at Norris, Tennessee, which is near a source of gizzard shad at Oak Ridge National Laboratory.

2. Develop the surface tension technique for verifying screen integrity.

3. Produce a documentary videotape of laboratory and field testing.

4. Test for the potential use of polyester screen materials.

5. Determine the hydraulic implications of increasing the spacing between the upper and lower screens from 1 foot up to 3 feet.

6. Investigate the possible use of and durability of various screen repair techniques.

7. Conduct tests as needed to assist in evaluation and development of spray cleaning systems.

Danny L. King

Enclosures

Copy to: Project Manager, Bismarck, North Dakota, Attention: 400 (Knoll)

Blind to: D-1522
D-1522 (Grabowski)
D-1522B (Jackson)
D-1530
D-1530 (King)
D-1531
D-1531 (Johnson)
D-1532
D-1533
D-252 (Nelson)
D-274 (Starbuck)

Note to D-1522B (Jackson): Please see that Mills receives a copy of the memorandum.

DLKing:mjs

Figure 1. - Test Apparatus to Determine Pullout Limits of Various Holddown Configurations

ALTERNATIVE RETENTION PLATE PLACEMENT

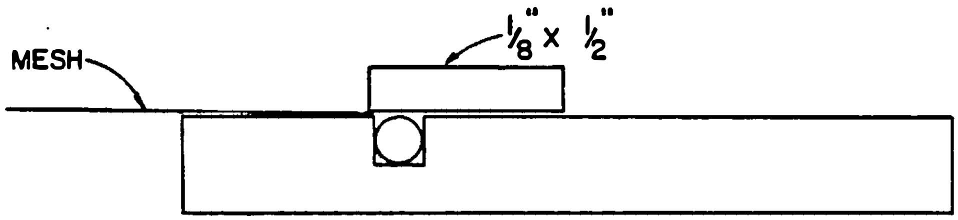


PLATE NO. 1

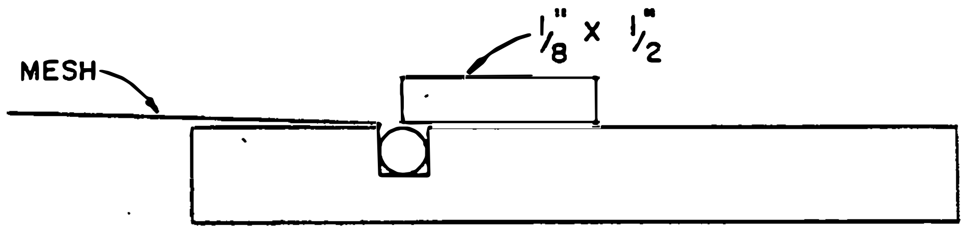
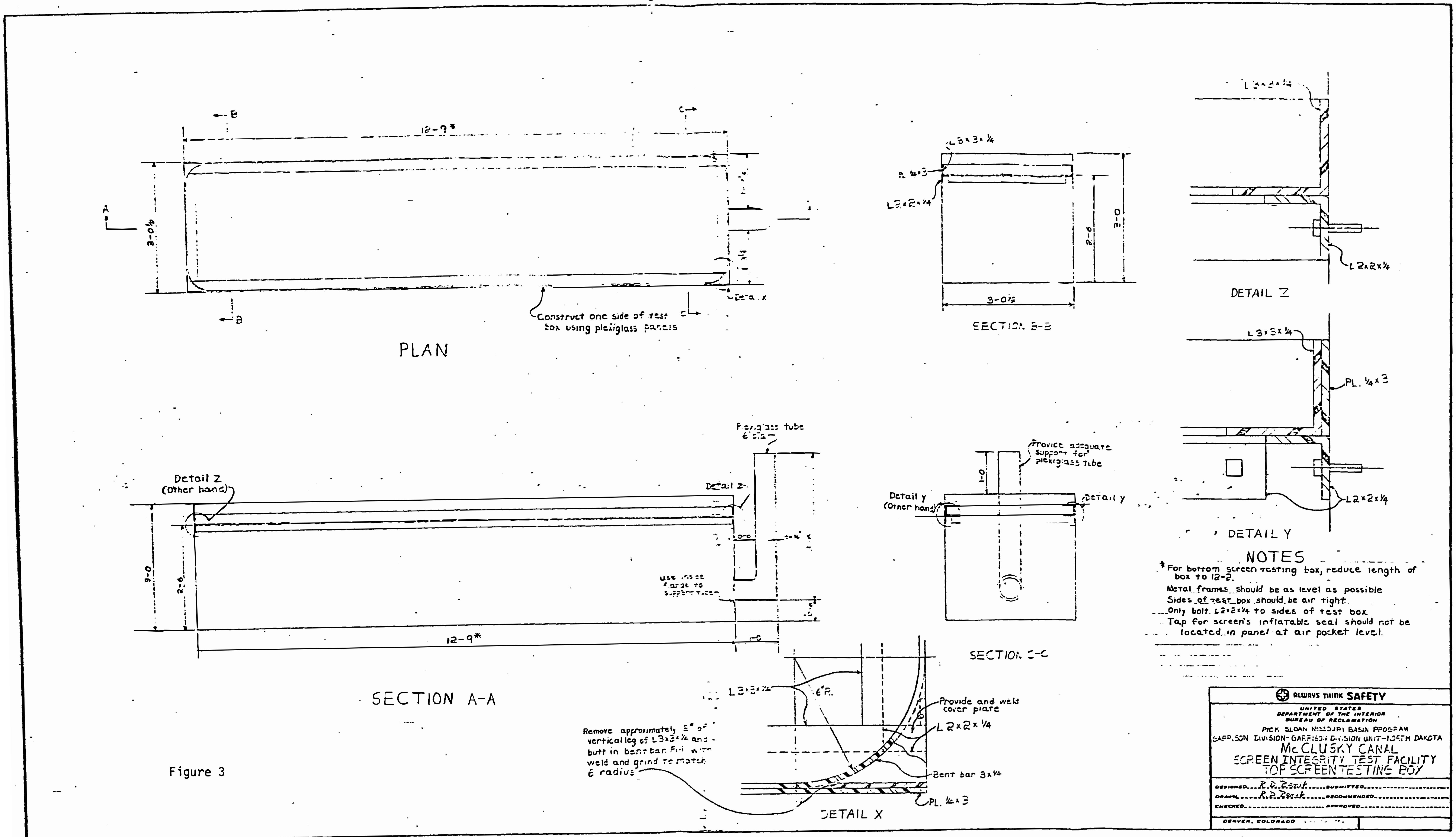


PLATE NO. 2

Figure 2



PLAN
12-9*
3-0½
Construct one side of test box using plexiglass panels
SECTION B-B
L3×3×¼
L2×2×¼
3-0½
2-6
3-0
DETAIL Z
L2×2×¼
SECTION A-A
Detail Z (Other hand)
Detail Z
Plexiglass tube 6" dia.
3-0
2-6
12-9*
SECTION C-C
Provide adequate support for plexiglass tube
1-0
Detail y (Other hand)
Detail y
DETAIL Y
L3×3×¼
PL. ¼×3
L2×2×¼
DETAIL X
L3×3×¼
6" R.
Provide and weld cover plate
L2×2×¼
Bent bar 3×¼
PL. ¼×3
Remove approximately 3" of vertical leg of L3×3×¼ and butt in bent bar. Fill with weld and grind to match 6 radius
NOTES
* For bottom screen testing box, reduce length of box to 12-2.
Metal frames should be as level as possible
Sides of test box should be air tight.
Only bolt L2×2×¼ to sides of test box.
Tap for screen's inflatable seal should not be located in panel at air pocket level.
ALWAYS THINK SAFETY
UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION
PICK SLOAN MISSOURI BASIN PROGRAM
GARRISON DIVISION-GARRISON DIVISION UNIT-NORTH DAKOTA
McCLUSKY CANAL
SCREEN INTEGRITY TEST FACILITY
TOP SCREEN TESTING BOX
DESIGNED R.D. Zorik SUBMITTED
DRAWN R.D. Zorik RECOMMENDED
CHECKED APPROVED
DENVER, COLORADO

Figure 3

SCHEMATIC DRAWING OF PNEUMATIC SEAL AIR SUPPLY LINE CONTROLS AND FITTINGS

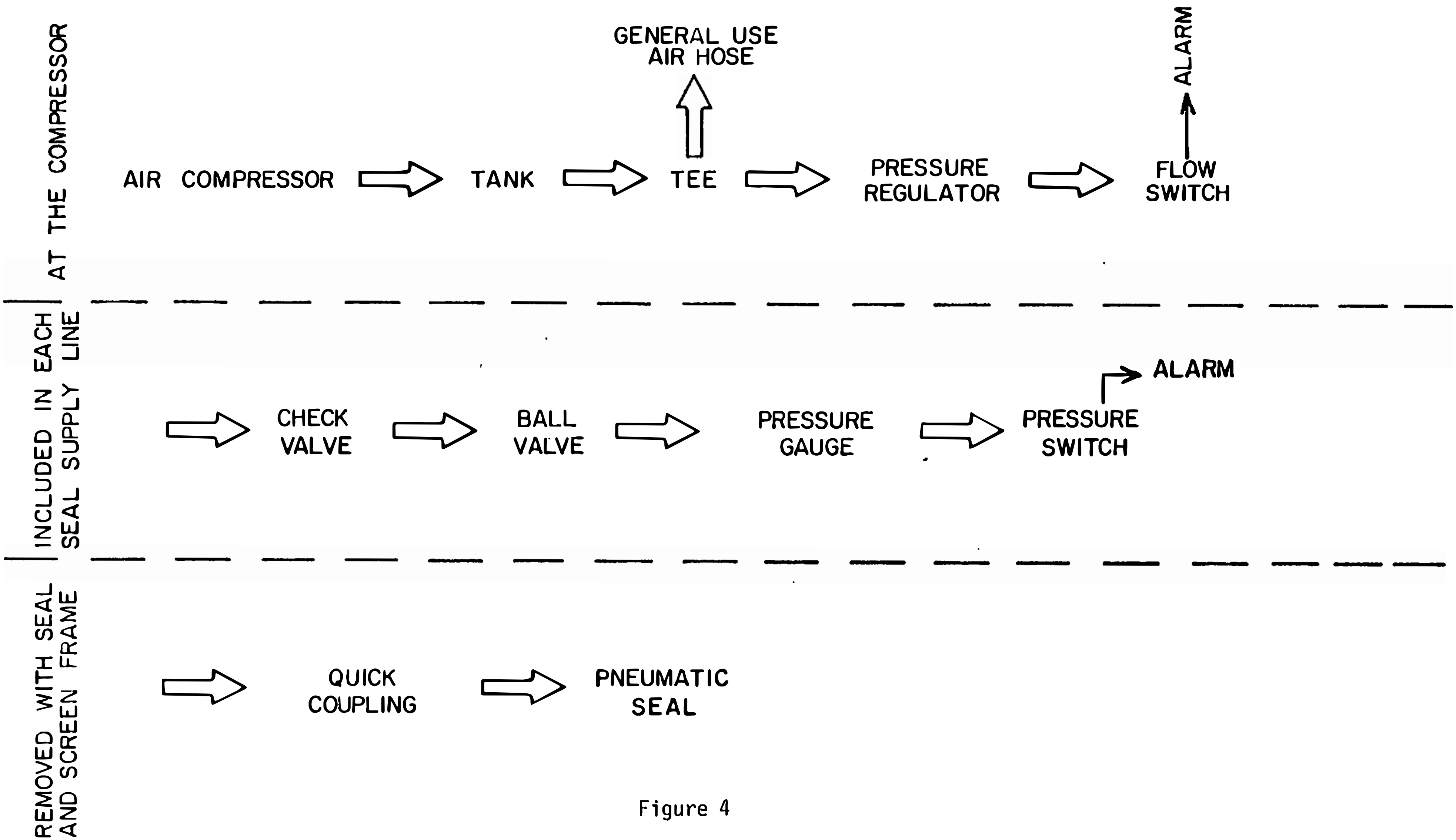


Figure 4

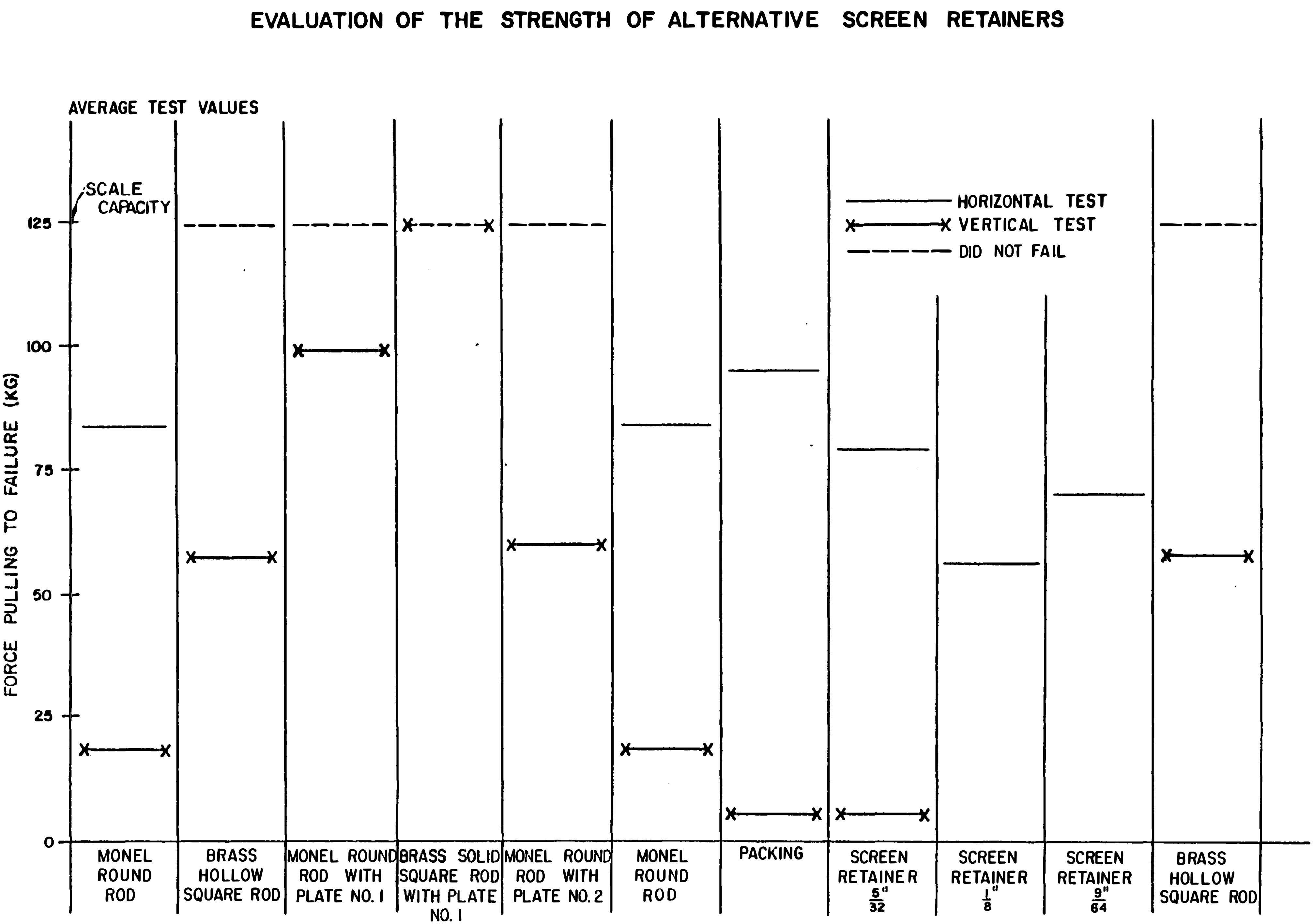

EVALUATION OF THE STRENGTH OF ALTERNATIVE SCREEN RETAINERS
AVERAGE TEST VALUES
FORCE PULLING TO FAILURE (KG)
SCALE CAPACITY
125
100
75
50
25
0
HORIZONTAL TEST
VERTICAL TEST
DID NOT FAIL
MONEL ROUND ROD
BRASS HOLLOW SQUARE ROD
MONEL ROUND ROD WITH PLATE NO. I
BRASS SOLID SQUARE ROD WITH PLATE NO. I
MONEL ROUND ROD WITH PLATE NO. 2
MONEL ROUND ROD
PACKING
SCREEN RETAINER 5"/32
SCREEN RETAINER 1"/8
SCREEN RETAINER 9"/64
BRASS HOLLOW SQUARE ROD

Table 1

APPENDIX I

OPTIONAL FORM NO. 10
JULY 1973 EDITION
GSA FPMR (41 CFR) 101-11.6

D-910

UNITED STATES GOVERNMENT

Memorandum

Memorandum
TO : Chief, Applied Sciences Branch 12/18/80

Denver, Colorado
DATE: December 4, 1980

FROM : Head, Environmental Sciences Section

SUBJECT: Fish Acquisition and Culture for McClusky Canal Fish Screen Studies - FY80

Applied Sciences Referral Memorandum No. 81-2-5

Investigations by: S. J. Grabowski

INTRODUCTION

During FY80, laboratory tests on a sectional model of the McClusky Canal fish screen were continued at the Water and Power Resources Service Engineering and Research Center, Denver, Colorado. The rationale for and methods employed in the testing program were described previously (FY79 Progress Report). This memorandum will describe acquisition and testing of four fish species during FY80.

FISH ACQUISITION AND CULTURING

Rainbow Smelt

Rainbow smelt (*Osmerus mordax*) were obtained from several sources including commercial fishermen and State fish and game agencies.

On March 18, 1980, we obtained 59 rainbow smelt from Mr. Jerry Peterson, a fishery biologist with the Michigan Department of Natural Resources in Escanaba. These fish did not tolerate shipment very well; many were in distress upon arrival in Denver and 50 died within 2 days. No spawn was obtained from the remaining nine fish. These fish were collected in pound nets set through the ice and had been pulled rapidly from a depth of about 50 feet.

On March 25, 1980, we received another shipment of 60 smelt from Escanaba. We obtained a small number of eggs from the smelt, enough to conduct one filtration run and three recovery runs on April 23 and 24. None of these eggs hatched.

On April 11, 1980, we received 125 smelt of about 400 collected by MSPO Biology Branch personnel in Beaver Bay, North Dakota. Survival of these smelt was good, although egg production was low. We obtained sufficient eggs to conduct five filtration runs. Most of the moribund fish or mortalities were ripe females. The active surviving fish were most often males or spent females. This situation was observed in some other shipments of smelt as well. The smelt less able to survive handling and shipment seemed to be ripe females. Attempts were made to spawn moribund females, with limited success.

The remaining 275 Beaver Bay smelt were placed in a concrete raceway at Garrison Dam National Fish Hatchery. These fish were allowed to spawn over burlap mats placed on the bottom of the raceway. About 15 egg-covered burlap mats were shipped to the E&R Center on April 15. These were placed in two Heath incubators, one with a water temperature of 40 °F and the other with a temperature of 48 °F. The eggs maintained at 48° F hatched between May 3 through 6, and the larvae were used for recovery and filtration tests. The smelt eggs maintained at 40 °F, to reduce the rate of development, delay hatching and extend the screen testing period, began showing increased mortality around the beginning of May. On May 10 these eggs were moved to another incubator with a temperature of 48 °F. Few of these eggs hatched.

On April 24, 1980, we received about 200 North Dakota smelt collected in the Parshall Bay area of Lake Sakakawea. Again, the majority of dead or moribund fish were ripe females. We attempted spawning moribund fish on April 25 but although the eggs looked good, they all were dead by May 1. We also received smelt eggs on moss from the Maine Department of Inland Fisheries and Wildlife on April 24. These eggs began hatching May 6 and provided larvae for the majority of the filtration runs conducted this year.

On May 2, the Vermont Fish and Game Department shipped us several thousand smelt eggs on a burlap mat. These hatched in about 2 weeks and provided larvae for recovery runs.

On May 5, personnel from the French River Hatchery near Duluth, Minnesota shipped 100 adult smelt to the E&R Center. As was the case last year, the majority of these smelt were males. We did not obtain sufficient eggs from this lot of fish for testing. We also received additional smelt eggs on burlap from North Dakota. These eggs had been in the raceway at Garrison Dam Hatchery at 34 to 37 °F. Most of the eggs were dead upon arrival and almost complete mortality had occurred within a few days.

The New Hampshire Fish and Game Department was unable to supply smelt eggs this year. A poor smelt run due either to an unusually dry year or to inherent biological factors in the smelt population in Lake Winnisquam itself lead to such low egg production that New Hampshire Fish and Game Department could not meet its own requirements for smelt eggs.

Best hatching success and larvae production came from the Maine smelt eggs attached to moss, followed by North Dakota smelt eggs spawned on burlap, shipped to Denver, and incubated in a Heath incubator with a water temperature of 48 °F. The possibility of extending the active testing period somewhat by delaying hatching of several lots of smelt eggs did not work out as hoped. At least with rainbow smelt we observed greater egg mortality during prolonged low temperature incubation with consequent poor hatching success.

Utah Chub

On May 22, 1980, we picked up 212 prespawning adult Utah chub (Gila atraria) collected in Flaming Gorge Reservoir, Wyoming by Wyoming Game and Fish Department and Utah Cooperative Fishery Unit personnel. We transported these fish to Denver and experienced no mortality in shipment. After the chub were acclimated to laboratory conditions, they were checked for ripeness. Most males were ripe and were given a top caudal fin clip. Over a period of about 1 month attempts were made to induce spawning of ripe fish using an injection of Carp pituitary and clomiphene citrate, according to a procedure developed by Utah Cooperative Fishery Unit personnel. We were moderately successful in obtaining eggs by this procedure. We completed several runs with eggs and larvae thus obtained. We were also able to obtain some eggs from female chub collected in Strawberry Reservoir, Utah, and shipped to Denver.

We presently are maintaining about 50 Utah chub at a winter temperature and photoperiod regime in an attempt to shorten the normal 1-year reproductive cycle to about 9 months. We were successful in compressing the reproductive cycle of six Flaming Gorge Reservoir and six Hebgen Lake chub to 9 months by manipulating temperature and photoperiod. These 12 experimental fish were injected in mid- and late-March 1980, and eggs from several females were incubated. The larvae and eggs were used for a test run on March 25. We will attempt this again this year with a larger number of chub.

In June 1980 we sent 15 adult chub and the spawn from 1 female to the La Crosse National Fishery Research Laboratory to use for fish egg and larvae toxicologic experiments. The eggs did not survive shipment. The adults survived shipment but succumbed within 2 weeks. We plan to provide La Crosse with additional chub this year to complete toxicologic studies.

This year chub were hauled very successfully using 0.2 and 0.5 percent NaCL to reduce osmoregulatory stress, 2.0 mg/L quinaldine to calm the fish, an antifoam compound, bacteriocidal agent (furacin), and gaseous oxygen. No hauling mortality occurred.

Gizzard Shad

Gizzard shad (Dorosoma cepedianum) were obtained from seven different locations this year. Except for shad collected by gill netting in Ute Reservoir near Logan, New Mexico, hauling mortality was low. Shad were collected by electrofishing gear by fish and game agencies in Nebraska, Kansas, and Oklahoma. Shad from New Mexico were collected coincidental to the walleye spawn taking operation. These particular fish were in a gill net for several hours and showed signs of extreme cutaneous hemorrhage. No shad were collected in a trap net set for 2 days in a normally productive location in Ute Reservoir. Shad from Prewitt Reservoir in northeastern Colorado were collected by large mesh gill nets set for a maximum of 30 minutes. Some of these shad were ripe and provided eggs for testing. None of the attempts to obtain shad larvae were successful.

Gizzard shad are extremely sensitive fish and difficult to maintain in captivity.

The McClusky Canal fish screen consultants recommended that we obtain and test shad eggs and larvae from Lake Mitchell, South Dakota. Water and Power Resources Service therefore contracted with the South Dakota Cooperative Fishery Research Unit in Brookings to collect about 1 million shad eggs and ship these to the E&R Center. Extensive efforts over several months by fishery unit personnel yielded only a few ripe female shad, but literally hundreds of ripe males. In early July we traveled to Mitchell, South Dakota, to observe shad collection personally and transport any collected fish back to Denver. None of the females among the 75 shad collected were ripe. Ovaries of several sacrificed females were small, hard, compact, and undeveloped. Ovaries of other shad examined during the season by Fishery Unit personnel looked the same. Shad in Lake Mitchell either completed spawning before collection efforts began or it was not a "typical" year there. Local residents and the conservation officer reported seeing none of the usual early morning spawning activites of shad this year as they have in previous years. Fish and Wildlife Service personnel in Genoa, Wisconsin, collected no shad during their routine fishery surveys this spring, although shad were numerous in past years. Unusual or abnormal winter conditions or low water levels may be responsible in part for the unusual situation associated with shad in the upper midwest in the FY80. Fishery Unit personnel gill netted shad in deep water in Lake Mitchell in mid-August. The ovaries looked the same as those examined earlier.

We received two shipments of mixed gizzard shad and threadfin shad eggs from Oak Ridge National Laboratory. The eggs were attached to cotton cloth or nitex netting material. None of the eggs hatched. Personnel at ORNL indicated that they had problems with hatching shad eggs this year and had to terminate some experiments because of poor hatching success.

Carp

About 50 common carp (*Cyprinus carpio*) were held over the winter in a pond on the Federal Center. The Colorado Division of Wildlife collected carp in Marston Lake and provided the Service with about 43 fish in June. These fish were prespawning adults. Carp were placed in a holding pond behind the greenhouses and monitored regularly for sexual development. Imminent spawners were placed in a 4- by 8-ft wire cage for easy access. On June 24, before most of the confined fish spawned, 101 fish, mostly gravid females, died in a fish kill in the pond. Several days of unseasonably warm weather preceded the fish kill and probably contributed in part to the kill. The Division of Wildlife cooperated in the collection of 51 additional carp from Barr Lake on June 27. We had poor success in obtaining eggs from these fish collected late in June. The unfortunate fish kill of gravid carp prevented us from completing a full series of filtration and recovery runs with carp eggs and larvae.

LABORATORY TESTING RESULTS

We were not able to complete an entire series of test runs with all four species. The number of filtration and recovery runs completed for each fish species are summarized in table 1. Detailed information regarding each test run for each species are included in tables 2, 3, 4, and 5.

Consultants to the McClusky Canal Fish Screen Task Force have indicated that we should consider the testing of rainbow smelt eggs and larvae completed. They also indicated that on the basis of the size of eggs and larvae of Utah chub and carp compared to rainbow smelt, testing of these two species can be considered completed. They recommended that laboratory testing in FY81 concentrate on gizzard shad. There is a strong possibility that testing of gizzard shad eggs and larvae can be conducted at the TVA laboratory in Norris, Tennessee, with eggs supplied by Oak Ridge National Laboratory personnel. We plan to pursue this possibility.

Grabowski
15 Dec 80

N.E. Otto

Table 1. - Summary of tests completed on the McClusky Canal Fish Screen sectional model at the E&R Center

Species	Type of run		Q(ft³/s) 3	9	15
Rainbow smelt	Recovery	Eggs	1	1	1
		Larvae	2	3	3
	Filtration		8	8	8
Utah chub	Recovery	Eggs			
		Larvae	1	1	1
	Filtration		1	3	1
Common carp	Recovery	Eggs	1	1	1
		Larvae			
	Filtration		2	2	1
Gizzard shad	Recovery	Eggs			
		Larvae			
	Filtration		1	1	1

Table 2. - Live rainbow smelt tests - rectangular inflatable seal

Screen mesh size	Date	Discharge (ft³/s)	Length of test (min)	Approximate sample size: Eggs	Approximate sample size: Larvae	Number of organisms recovered in plankton net: Whole eggs	Egg cases	Damaged eggs	Whole larvae	Headless larvae	Damaged larvae	Stain	Source
70	4-21-80	9	45	10,000		0	0	0				Neutral red	North Dakota
70	4-22-80	13	45	10,000		0	0	0				Fast green	North Dakota
70	4-22-80	9	45	10,000		0	0	0				Toluidine blue O	North Dakota
70	4-22-80	1/ 3 2.6	45	10,000		0	0	0				Neutral red	North Dakota
70	4-23-80	3	45	10,000		0	0	0				Toluidine blue O	Michigan
70	4-23-80	15	45	2/ *		82		10				Neutral red	Michigan
70	3/ 4-23-80	9	45	*		92	4/ 12	4				Fast green	Michigan
70	4-24-80	3	45	*		91		8				Neutral red	Michigan
70	5-03-80	15	45		*				34	55		Neutral red	North Dakota
70	5-03-80	9	45		*				53	29		Toluidine blue O	North Dakota
70	5-30-80	3	45		*				84	8		Toluidine blue O	North Dakota
70	5-04-80	15	45		*				59	30		Toluidine blue O	North Dakota
70	5-04-80	9	45		*				81	13		Fast green	North Dakota
70	5-04-80	15	45		10,000				0	0	0	Neutral red	North Dakota
70	5-06-80	9	45		10,000				0	0	0	Toluidine blue O	Maine
70	5-06-80	3	45		10,000				0	0	0	Fast green	Maine
70	5-07-80	15	45		10,000				0	0	0	Toluidine blue O	Maine
70	5-07-80	3	45		10,000				0	0	0	Neutral red	Maine
70	5-07-80	15	45		10,000				0	0	0	Fast green	Maine

Table 2. - Live rainbow smelt tests - rectangular inflatable seal (continued)

Screen mesh size	Date	Discharge (ft^3/s)	Length of test (min)	Approximate sample size		Number of organisms recovered in plankton net						Stain	Source
				Eggs	Larvae	Whole eggs	Egg cases	Damaged eggs	Whole larvae	Headless larvae	Damaged larvae		
70	5-08-80	9	45		10,000				0	0	0	Toluidine blue O	Maine
70	5-08-80	9	45		10,000				0	0	0	Neutral red	Maine
70	5-08-80	15	45		10,000				0	0	0	Fast green	Maine
70	5-08-80	3	45		10,000				0	0	0	Toluidine blue	Maine
70	5-09-80	3	45		10,000				0	0	0	Neutral red	Maine
70	5-09-80	9	45		10,000				0	0	0	Fast green	Maine
70	5-09-80	15	45		10,000				0	0	0	Toluidine blue O	Maine
70	5-09-80	15	45		10,000				0	0	0	Neutral red	Maine
70	5-10-80	3	45		10,000				0	0	0	Fast green	Maine
70	5-10-80	9	45		5,000				0	0	0	Toluidine blue O	Maine
70	5-15-80	9	45		*				64	13		Neutral red	Vermont
70	5-15-80	15	45		*				57	29		Toluidine blue O	Vermont
70	5-16-80	3	45		*				68	14		Fast green	Vermont
70	5-16-80	9	45		6,000				0	0	0	Neutral red	Vermont
70	5-19-80	3	45		10,000				0	0	0	Neutral red	Vermont

1/ During the 45 minute min, the flow gradually decreased to 2.6 ft^3/s.
2/ * Recovery Test - Introduced 100 eggs or larvae under the screen panel.
3/ After this run, during washdown a small tear was observed in the watertight bag near the upper rear corner. The tear was repaired before additional tests were conducted.
4/ These 12 pieces were stalk remnants from egg cases.

Table 3. - Live Utah chub tests - rectangular inflatable seal

Screen mesh size	Date	Discharge (ft^3/s)	Length of test (min)	Approximate sample size		Number of organisms recovered in plankton net						Stain	Source
				Eggs	Larvae	Whole eggs	Egg cases	Damaged eggs	Whole larvae	Headless larvae	Damaged larvae		
70	3/25/80	9	45	10,000	10,000	0	0	0	0	0	0	Neutral red	Wyoming
70	5/30/80	15	45	10,000		0	0	0				Toluidine blue O	Wyoming
70	6/5/80	3	45	10,000	10,000	0	0	0	0	0	0	Neutral red (larvae) Fast green (eggs)	Wyoming
70	7/10/80	9	45	10,000		0	0	0				Neutral red	Wyoming
70	7/14/80	9	45		8,000				0	0	0	Neutral red	Wyoming
70	7/14/80	9	45		1/ *				93			Fast green	Wymong
70	7/14/80	15	45		*				93			Toluidine blue O	Wyoming
70	7/14/80	3	45		*				83			Neutral red	Wyoming

1/ * Recovery test - Introduced 100 larvae under the screen panel.

Table 4. - Live carp tests rectangular inflatable seal

Screen mesh size	Date	Discharge (ft^3/s)	Length of test (min)	Approximate sample size		Number of organisms recovered in plankton net						Stain	Source
				Eggs	Larvae	Whole ~~eggs~~	Egg cases	Damaged eggs	Whole larvae	Headless larvae	Damaged larvae		
70	6/16/80	3	45	10,000		0	0	0				Toluidine blue O	Colorado
70	6/16/80	15	45	10,000		0	0	0				Neutral red	Colorado
70	6/16/80	9	45	10,000		0	0	0				Fast green	Colorado
70	6/17/80	9	45	10,000		0	0	0				Toluidine blue O	Colorado
70	6/17/80	3	45	10,000		0	0	0				Neutral red	Colorado
70	7/17/80	15	45	* 1/		69		12				Neutral red	Colorado
70	7/17/80	3	45	*		79		10				Toluidine blue O	Colorado
70	7/17/80	9	45	*		91		0				Fast green	Colorado

1/ * Recovery test - introduced 100 larvae under the screen panel.

Table 5. - Live gizzard shad tests - rectangular inflatable seal

Screen mesh size	Date	Discharge (ft^3/s)	Length of test (min)	Approximate sample size		Number of organisms recovered in plankton net						Stain	Source
				Eggs	Larvae	Whole eggs	Egg cases	Damaged eggs	Whole larvae	Headless larvae	Damaged larvae		
70	6/13/80	15	45	10,000		0	0	0				Neutral red	Colorado
70	6/13/80	9	45	10,000		0	0	0				Fast green	Colorado
70	6/13/80	3	45	10,000		0	0	0				Neutral red	Colorado

APPENDIX II

Memorandum

Memorandum

Denver, Colorado

TO : Laboratory Testing Coordinator, McClusky Canal Fish Screen Studies

DATE: December 2, 1980

FROM : Stephen J. Grabowski, Research Fishery Biologist

SUBJECT: A Photographic Method to Measure Fish Eggs

INTRODUCTION

Consultants to the McClusky Canal Fish Screen Task Force recommended measuring freshly spawned eggs of the four critical fish species (rainbow smelt, Utah chub, common carp, and gizzard shad) to determine egg size of one species in relation to other species and to the openings in the wire cloth fish screen. Measurements could be obtained using a microscope equipped with an ocular micrometer, but this is a time-consuming process. Fish eggs imbibe water during water hardening and generally increase in size up to the time of hatching. Since all freshly spawned eggs could not be measured simultaneously, the eggs measured early would be smaller in average diameter than eggs measured later. Recently spawned eggs should then be the smallest and most critical size that would challenge a fish screen.

To provide an accurate and rapid method for determining the diameter of recently spawned fish eggs, a photographic method was developed. The concept was based on the procedure used to photograph the screen material used at the field test facility. Details of the developmental process will be covered in another report.

METHODS AND MATERIAL

Suitable photographic equipment for use in photographing fish eggs and larvae was suggested by E&R Center photographers and included a Nikon FM camera body, a 55-mm, f/3.5 micro lens, two Nikon PK-13 lens extension tubes, and a Vivitar 215 flasn unit. A 1/4-inch piece of white plexiglass on top of the flash unit served to diffuse the flash. The laboratory shops fabricated a suitable copy stand which allowed the placement of the flash unit 7 inches below the bottom of a stage made of 1/4-inch white plexiglass. Fish eggs were placed on a clean glass 1- by 3-inch microscope slide and placed on the stage. When the eggs were in focus, the distance from the eggs to the end of the micro lens was about 1-5/8 inches. A 5-mm round ocular micrometer was placed next to the slide on the stage. About one-third of the micrometer disk was ground off parallel with the scale to increase the area of the microscope slide that could hold fish eggs and thus increase the sample size (fig. 1). Since the thickness of the glass slide and the micrometer disk were similar, the plane of the micrometer scale was approximately the same as the plane of the fish eggs.

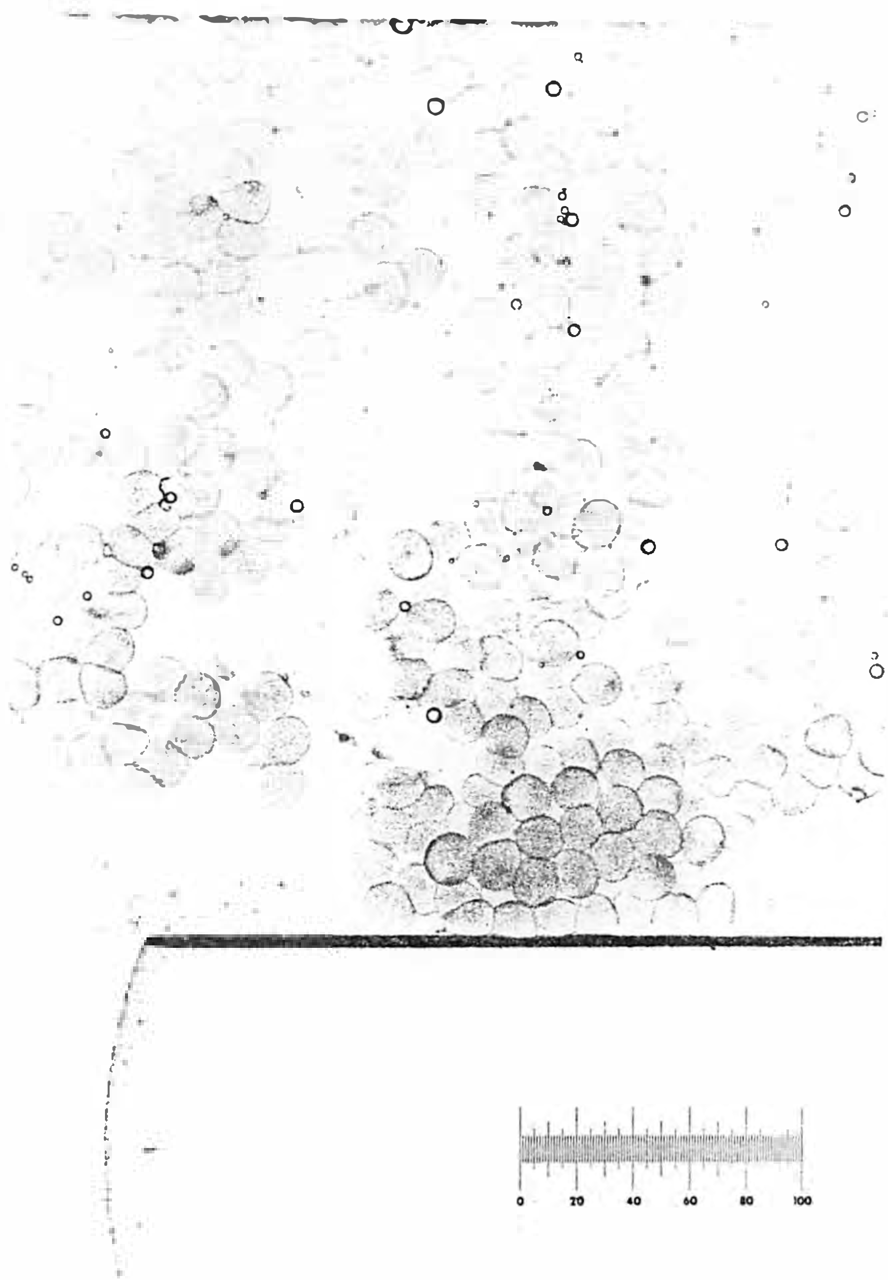


Figure 1. Recently spawned rainbow smelt eggs with 5-mm scale.

Ilford FP4 black-and-white film, ASA 125, was used almost exclusively for photographing the fish eggs. On a few occasions Kodak PX 135 Plus-X pan film, ASA 125, was used. Generally, 8- by 10-inch photographic enlargements made from the Ilford film were sharper and clearer than those from Kodak film. Shutter speed was always kept at 1/60 second, and three photographs of each set of eggs were taken at F/22, F/16, and F/11 to bracket the correct exposure. A record of each photograph containing essential information was maintained. Magnification of eggs and scale was about 12-13 times. Contact sheets were made of all photographs and the most suitable exposures were selected for enlargement.

A fine-point pair of mechanics dividers were used to measure the diameter of fish eggs on the 8- by 10-inch enlargements. The points of the dividers were placed across the egg being measured. When the opening of the dividers was exactly the diameter of the egg, the opening width was measured directly from the enlarged 5-mm scale in the photograph. This value was recorded as the diameter of that egg. Uncrowded, undistorted, "normal looking" eggs were measured by this procedure.

To verify the accuracy of the enlargements and, therefore, of the method, 30 grade 25 chrome steel balls, 1/16 inch (0.0625 inch = 1.5875 mm) in diameter were photographed (fig. 2), then three individuals independently measured the diameters of the steel balls from 8- by 10-inch photographic enlargements. They also measured the steel balls using a Bausch and Lomb binocular dissecting microscope equipped with a 0.0 to 0.2 ocular micrometer calibrated so that 0.20 = 2.0 mm.

RESULTS AND DISCUSSIONS

Eggs from three species of fish (rainbow smelt, Utah chub, and common carp) were measured. No gizzard shad eggs were measured.

Freshly spawned rainbow smelt eggs averaged 0.82-mm to 0.93-mm in diameter. In fish from Parshall Bay, North Dakota (fig. 3), slight correlation of average egg diameter with size of female was apparent. One large female from Beaver Bay had eggs smaller in diameter than expected from those measured from Parshall Bay (table 1). Eggs that had been incubating on burlap were larger than freshly spawned eggs. A 30-minute time series of photographs taken of fertilized eggs of a 180-mm Beaver Bay female smelt showed that the egg diameter increased from 0.98 to 1.06 mm during the 30-minute period (table 2).

Freshly spawned Utah chub eggs (fig. 4) were generally larger than rainbow smelt eggs. Chub eggs averaged from 0.99 to 1.34 mm in diameter among eggs spawned from chub collected in Flaming Gorge Reservoir in mid-May 1980 (table 3). The lot of eggs that averaged 0.99 mm in diameter contained some eggs that were not completely ripe, which may have reduced the average diameter somewhat.

The diameter of eggs from several Flaming Gorge Reservoir and Hebgen Lake Utah chub held over the winter in the laboratory and spawned in March 1980 averaged from 1.28 to 1.41 mm (table 4).

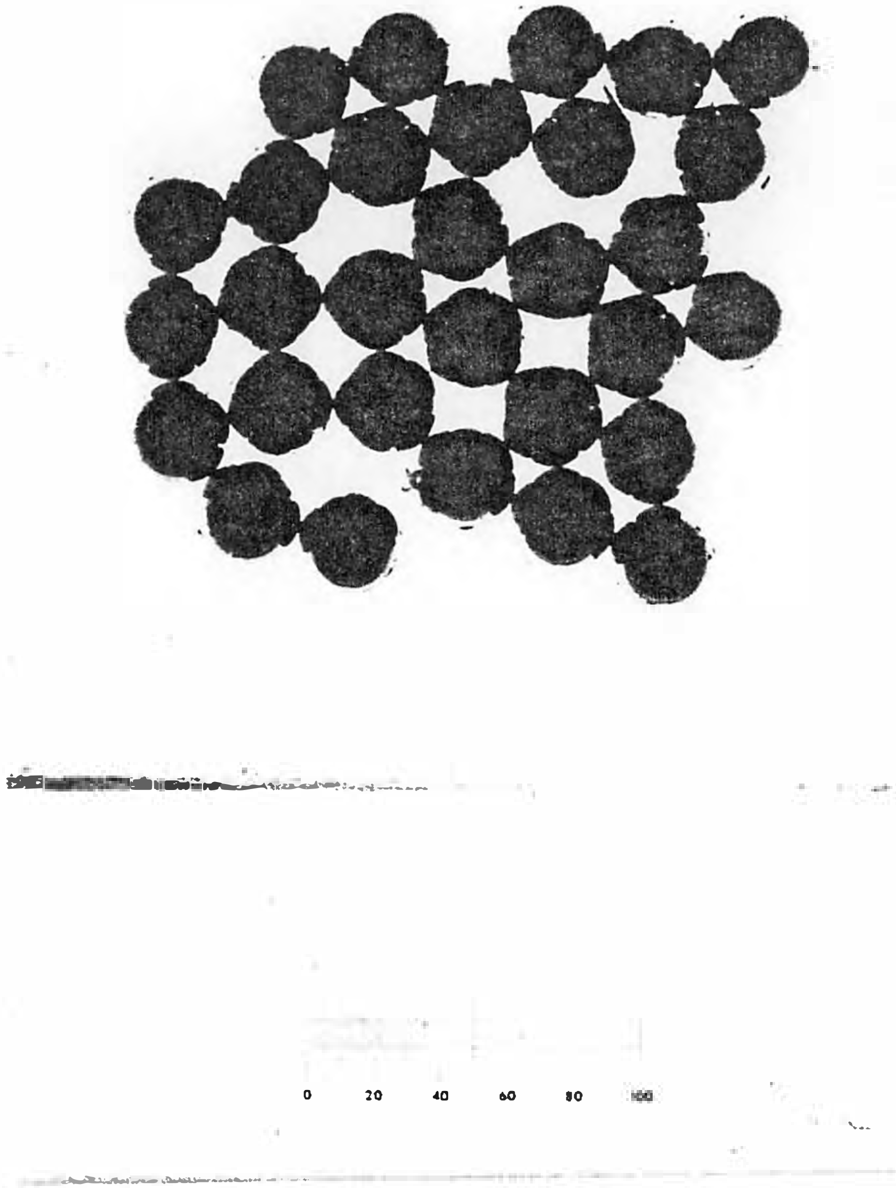


Figure 2. Chrome steel balls and 5-mm scale. Ball diameter 1.5875 mm.

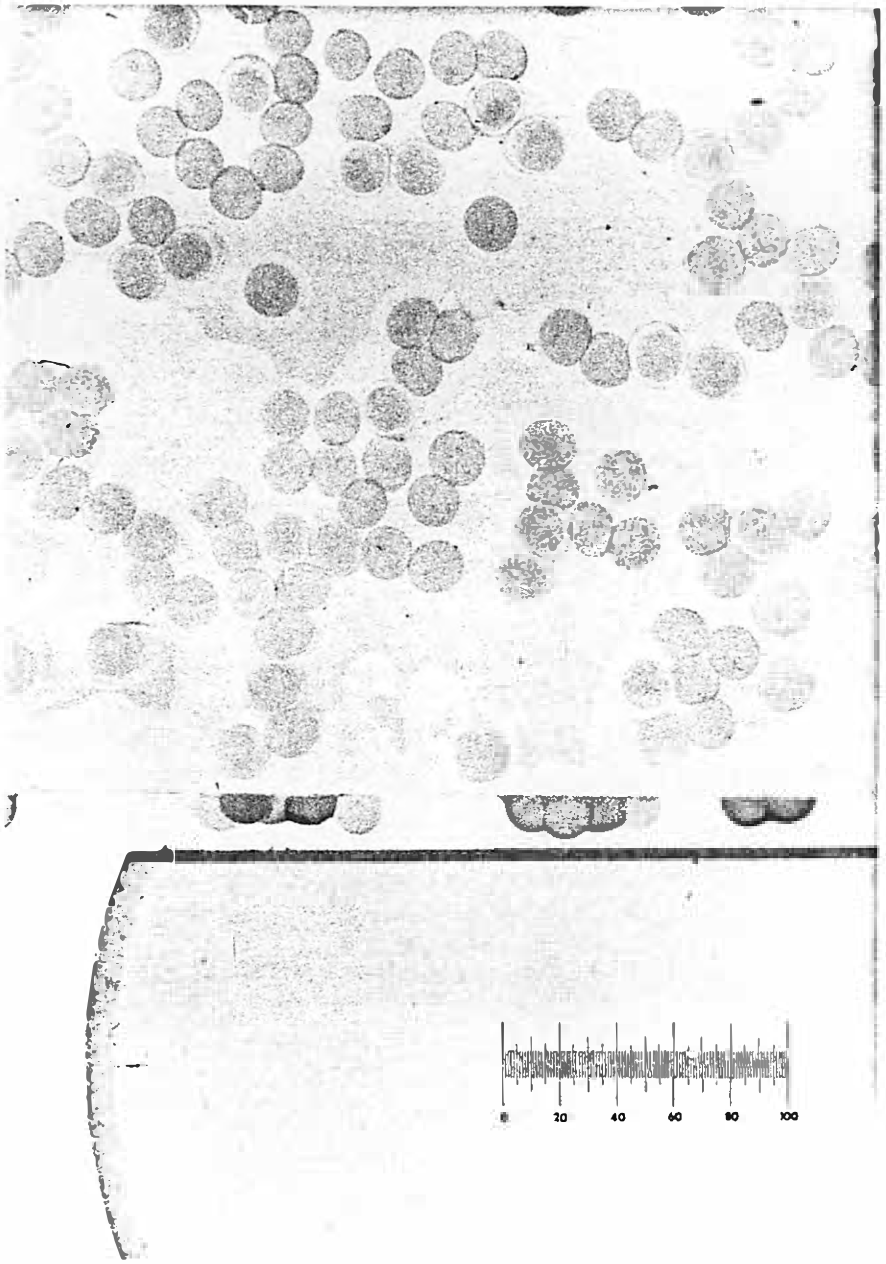


Figure 3. Fertilized eggs of a recently spawned Parshall Bay, North Dakota smelt.

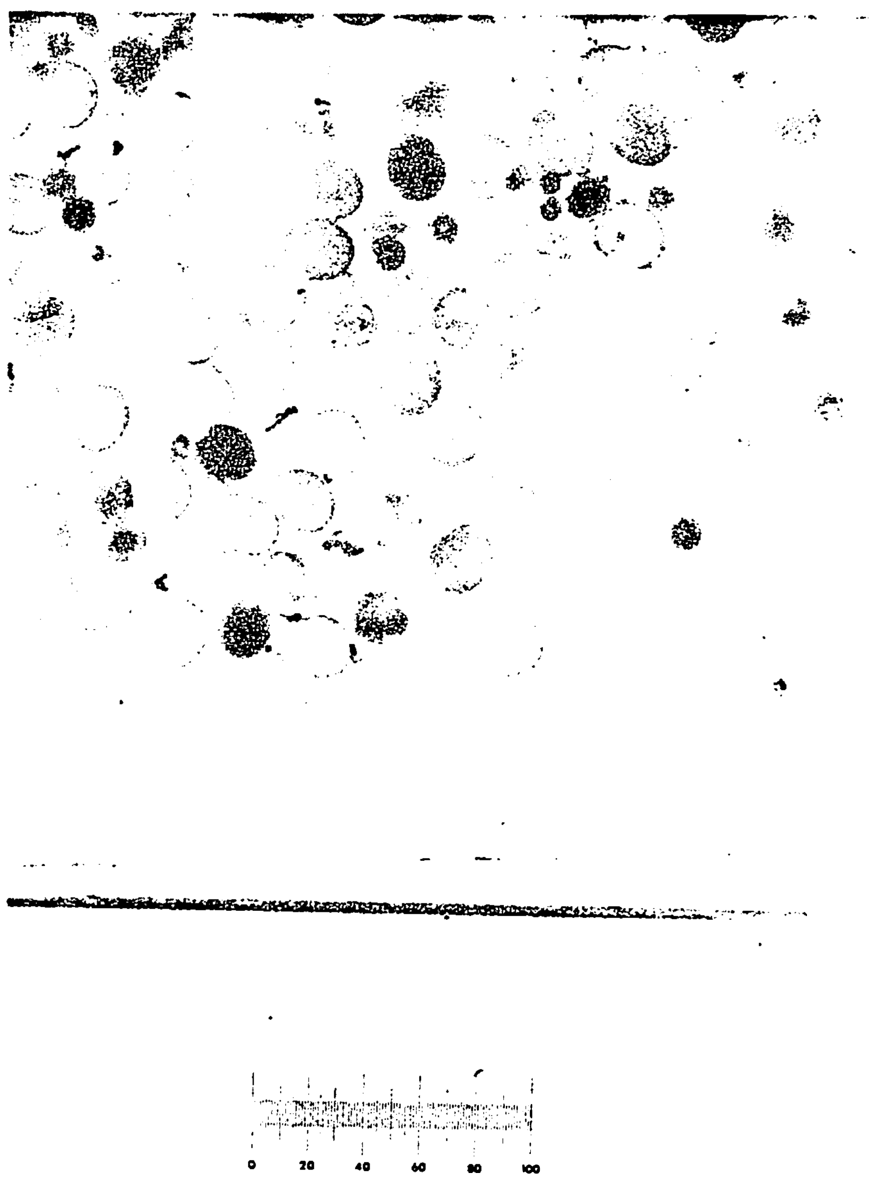


Figure 4. Unfertilized Utah chub eggs spawned 2 minutes prior to photographing.

Table 1. - Average diameter and range of eggs of several rainbow smelt

Date	Source	Length	Diameter (range)	n
April 12	Beaver Bay, North Dakota	173	0.85 (0.75-0.95)	40
April 24	Parshall Bay, North Dakota	137	0.82 (0.75-0.85)	10
		143	0.80 (0.75-0.90)	15
		143	0.84 (0.80-0.90)	20
		146	0.90 (0.90)	10
		146	0.93 (0.90-0.95)	10
May 2	Vermont (on burlap)		1.01 (0.90-1.15)	20
May 14	Beaver Bay, North Dakota (on burlap)		1.09 (0.95-1.15)	20

Table 2. - Increase in diameter of fertilized smelt eggs over a 30 minute period. Female = 180 mm in length

Date	Time	Egg diameter (range)	n
April 12	1248	0.98 (0.90-1.05)	20
	1254	0.98 (0.85-1.05)	20
	1306	0.98 (0.90-1.05)	30
	1311	1.02 (0.95-1.10)	30
	1318	1.06 (1.00-1.10)	30

Table 3. - Average diameter and range of eggs of several Flaming Gorge Reservoir Utah chub

Date	Length (mm)	Mass (g)	Diameter (range)	n
April 28	230	178	1.08 (0.95-1.25)	20
	245	201	1.01 (0.95-1.10)	40
	245	244	1.16 (1.05-1.30)	20
April 29	200	124	0.99 (0.95-1.05)	15
	210	172	1.24 (1.15-1.30)	20
	220	155	1.34 (1.10-1.65)	20
	232	197	1.23 (1.15-1.30)	20

Table 4. - Average diameter and range of eggs from several Utah chub induced to spawn in the laboratory in March 1980

Date	Source (mm)	Length (mm)	Egg diameter (range)	n
March 25	Hebgen Lake	290	1.41 (1.30-1.55)	20
March 19	Flaming Gorge Reservoir	246	1.28 (1.05-1.50)	10
		250	1.37 (1.15-1.60)	15
		265	1.40 (1.35-1.45)	10

These chub had been subjected to wintertime temperature and photoperiod conditions in the laboratory for about 3 months, then subjected to springtime temperature and photoperiod conditions, and were induced to spawn in mid-March by using injections of carp pituitary and clomiphene citrate. The fish held over the winter were larger than the fish collected in May in Flaming Gorge Reservoir. Egg diameter was also greater. Among these four chub the longer fish had a larger average egg diameter.

Freshly spawned carp eggs (fig. 5) were also larger in average diameter than rainbow smelt eggs. Average diameter of eggs from several carp measured in early June ranged from 1.11 to 1.35 mm (table 5). The lengths of these carp were inadvertently not recorded.

Table 5. - Average diameter and range of eggs of three carp measured in June 1980.

Date	Egg diameter (range)	n
June 3	1.35 (1.25-1.45)	15
June 3	1.11 (1.00-1.20)	25
June 10	1.31 (1.20-1.45)	50

We were not able to photograph any freshly spawned gizzard shad eggs this year. We had received some threadfin shad eggs from personnel at Oak Ridge National Laboratory, but these eggs were nearly ready to hatch and, therefore not recently spawned. We will attempt to photograph freshly spawned gizzard shad eggs from fish collected in several locations in 1981.

Thirty steel balls were measured independently by three individuals from an 8- by 10-inch photographic enlargement as well as with a microscope. The nominal size of the steel balls was 1.5875 mm. The size obtained by microscopic measurement ranged from 1.581 to 1.590 mm, while the size obtained from the 8- by 10-inch enlargement ranged from 1.588 to 1.597 mm (table 6).

The average diameter of chrome steel balls measured under the microscope was nearly identical with the nominal size stated by the manufacturer. The average diameter measured from an 8- by 10-inch photographic enlargement was 0.37 percent greater than the manufacturer's stated size. This photographic method of measuring the diameter of fish eggs or the size of other small objects seems to be a valid approach.

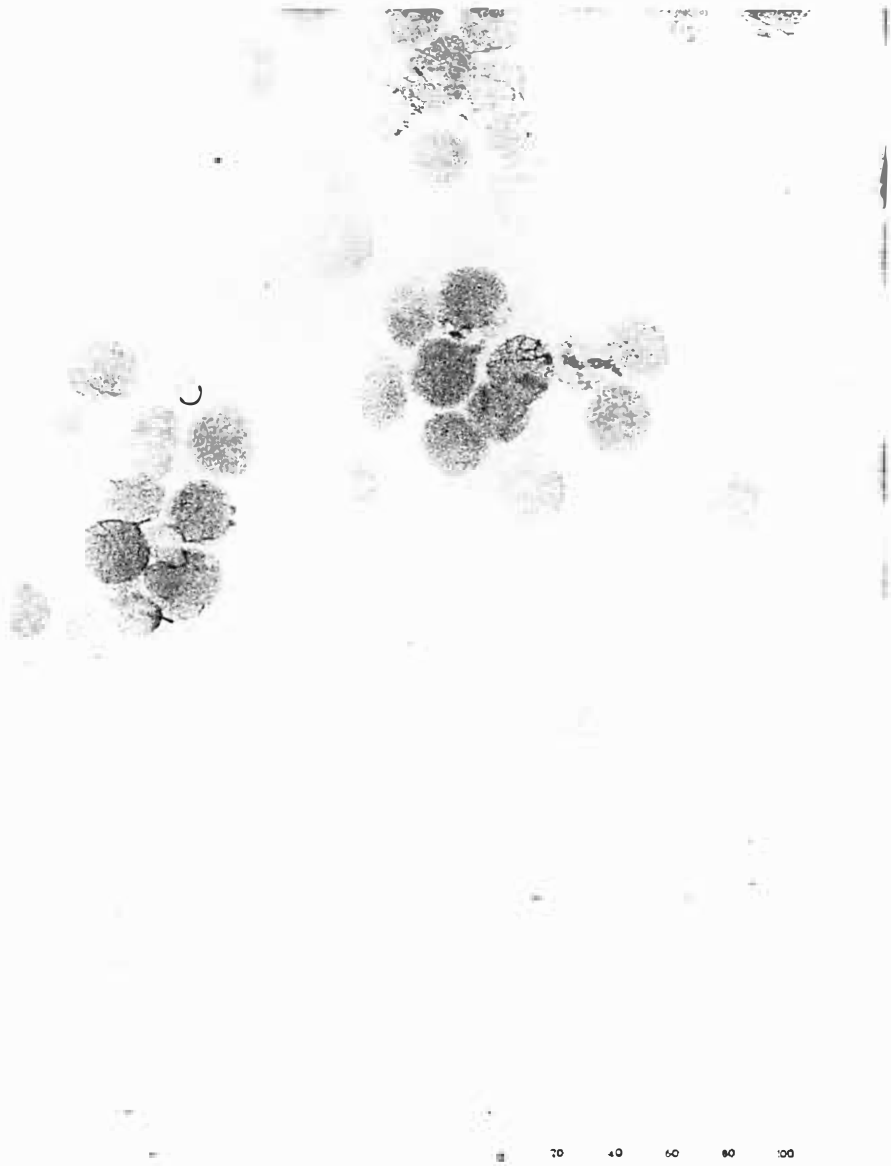


Figure 5. Unfertilized carp eggs spawned 3 minutes prior to photographing.

Table 6. - Comparison of the average diameter of 30 grade 25 chrome steel balls measured independently by three individuals using a microscope and the 8- by 10-inch photographic enlargement. Nominal ball diameter = 1.5875 mm

Individual	Microscope		Photograph	
	$\bar{x}$ (mm)	Range (mm)	$\bar{x}$ (mm)	Range (mm)
1	1.590	1.58-1.60	1.588	1.57-1.60
2	1.581	1.58-1.59	1.595	1.58-1.62
3	1.591	1.58-1.60	1.597	1.59-1.60
	1.587		1.593	