MONTANA

DEPARTMENT OF

FISH, WILDLIFE AND PARKS

REPORT ON SUBMERGED FEEDING SYSTEMS FOR DOMESTIC BROWN TROUT

by

JIM DRISSELL, FISH CULTURIST
BIG SPRINGS TROUT HATCHERY
DEPT. OF FISH, WILDLIFE AND PARKS
LEWISTOWN, MONTANA

JUNE 19, 1987

INTRODUCTION

Because brown trout have a tendency to stay near the bottom of raceways in hatcheries, it can be difficult to feed them using dry feeds which tend to float. If the feed could be released near the bottom of the raceways, perhaps these fish would better utilize the food.

Submerged feeding systems enable feed to be released near the bottom of raceways, and have been used successfully for feeding brown trout fry at other hatcheries (Messamer, 1985. See attached Wyoming report at end of this report.). This report is on an experiment conducted during the winter of 1986-1987 at the indoor facility of Big Springs Trout Hatchery. The experiment compared the performance of domestic brown trout fed using submerged feeding systems versus hand feeding.

PROCEDURE

Three lots of eyed brown trout eggs were received from Spring Creek Trout Hatchery, a private trout hatchery outside of Lewistown, during November 1986. These eggs were from hatchery brood stock which have not been mixed with wild brood stock for at least six generations, thus the eggs are from a domestic brown trout stock. Numbers per ounce are as follows:

MONTANA

DEPARTMENT OF

FISH, WILDLIFE AND PARKS

LOT NUMBER	NUMBER/OUNCE
L980886LB1 (lot #1)	252
L980886LB2 (lot #2)	241
L980886LB3 (lot #3)	227

Eggs from lot #1 were split evenly in two raceways, R9 and R10. Eggs from lot #2 and lot #3 were put in two separate raceways, R11 and R12 respectively.

Feeders were used on R10 and R11, while R9 and R12 were hand fed. The study was duplicated and results were compared between R9 and R10 (because these raceways both contained lot #1 eggs, and had approximately the same number of fish in each), and between R11 and R12.

Feed used was a $\frac{1}{2}$ and $\frac{1}{2}$ mixture of Sterling Silver Cup feed and Biostarter feed. Feed was measured out daily and fed every hour through the working day. Amount of feed was calculated the same way for each raceway, feeding daily a percent of the total fish weight in each raceway. A feed chart was established using information from a dry feed chart and a Biodiet feed chart to change the percent of feed fed daily as the fish grew. Feed amounts were changed when sample counts of fish were taken. Feed sizes were changed according to charts for both dry feeds and Biodiet feeds. While feed was released near the bottom of raceways R10 and R11, R9 and R12 were fed by hand, throwing the feed hard onto the surface of the water to break the surface tension, allowing the feed to sink.

Samples were taken from each raceway to get the number of fish per pound, total lengths, and condition factor. Number of fish per pound were calculated about every six days while total lengths and condition factors were calculated three to four times during the experiment. Both feeders and raceways were cleaned at the end of each working day.

MATERIALS FOR FEEDERS

The feeders were modified from the design used at the Clark's

MONTANA
DEPARTMENT OF
FISH, WILDLIFE AND PARKS

Fork Hatchery in Wyoming, operated by the Wyoming Game and Fish Department. Feeders were constructed of 4 inch PVC pipe, 10 feet long, cut lengthwise to create 4 inch wide troughs. The basic idea is to have an open stream of water in which feed could be mixed with the water, which would then be released near the bottom of the raceway. A water supply pipe was constructed with four outlets to release water evenly in the trough. Water flows through the trough and into ten feeder tubes which lead to the bottom of the raceway. Cost of each feeder was approximately $48.00. For future use, feeder tubes could be constructed from ½ inch PVC pipe instead of 5/8 inch vinyl tubing. This would save about $11.00 and would be sturdier in design. See figure 2 for design.

RESULTS

Data collected during the experiment are shown in tables 1 through 4, and figure 1. The results in both sets of experiments (R9 and R10, R11 and R12) are similar. In both sets, results showed little difference between hand feeding and using the feeders until the fish reached about 1.58 inches or 700 fish per pound, shortly after a feed change from Biostarter #2 to Biostarter #3. At this point the hand fed fish started to do better than fish fed using the feeders. An even greater difference in ΔL and conversions were noticed between R9 and R10 shortly after changing feed from Silver Cup #1 to Silver Cup #2, with hand fed fish doing better.

Errors may have occurred during sampling due to the small sizes of the fish. Total lengths were hard to measure due to transparent caudal fins in smaller fish. Water weighed with the fish samples may have caused errors in sample weights.

Since the submerged feeding system worked at Clark's Fork Hatchery in Wyoming, it is puzzling it did not improve the growth of brown trout during this experiment. Perhaps one reason is because these brown trout were from domestic brood stock, while the brown trout used at Clark's Fork Hatchery were from wild brood stock. These domestic brown trout started to surface feed after a couple weeks of feeding. This may have reduced the efficiency of the feeders since they release feed near the bottom of the raceway. A repeat experiment with wild brown trout may help to answer this question. Since the efficiency of the feeders was reduced as feed size and fish size increased, perhaps the feeders should only be used for initial feeding of brown trout.

MONTANA
DEPARTMENT OF
FISH, WILDLIFE AND PARKS

TABLE 1 LOT #1 IN RACEWAY 9, HAND FED
TOTAL FISH = 46,812 ± 1,960

DATE	FISH/LB.	FISH/LB. σ_{n-1}	AVERAGE LENGTH (INCHES)	LENGTH σ_{n-1}	CONDITION FACTOR ($\times 10^{-4}$)	FOOD FED (LB.)	TOTAL FISH WEIGHT (LB.)	WEIGHT GAIN (LB.)	CONVERSI
12/13/86	3,044	82.8					15.38		
12/17/86	2,410	58.1	1.07	0.064	3.360	4.09	19.42	4.04	1.01
12/22/86	1,866	74.8				5.85	25.09	5.67	1.03
12/26/86	1,423					5.63	32.90	7.81	0.72
12/29/86	1,290	60.7	1.33 (ΔL = 0.022)	0.087	3.280	5.19	36.29	3.39	1.53
1/3/87	1,020	19.9				9.78	45.89	9.60	1.02
1/7/87	877	29.9				9.51	53.38	7.49	1.27
1/12/87	702	30.3	1.62 (ΔL = 0.021)	0.109	3.340	14.19	66.68	13.30	1.07
1/19/87	506	18.5				19.44	92.51	25.83	0.75
1/23/87	422	15.4				16.17	110.93	18.42	0.88
2/2/87	332	13.9	2.13 (ΔL = 0.024)	0.170	3.130	47.21	141.00	30.07	1.57
AVERAGE			ΔL = 0.023						1.09

MONTANA
DEPARTMENT OF
FISH, WILDLIFE AND PARKS

TABLE 2 LOT #1 IN RACEWAY 10, USING FEEDER
TOTAL FISH = 52,440 ± 2,680

DATE	FISH/LB.	FISH/LB. σ_{n-1}	AVERAGE LENGTH (INCHES)	LENGTH σ_{n-1}	CONDITION FACTOR ($\times 10^{-4}$)	FOOD FED (LB.)	TOTAL FISH WEIGHT (LB.)	WEIGHT GAIN (LB.)	CONVERSION
12/13/86	3,175	235.3					16.52		
12/17/86	2,305	152.6	1.11	0.053	3.184	3.97	22.75	6.23	0.64
12/22/86	1,852	141.4				6.01	28.32	5.57	1.08
12/26/86	1,519					5.77	34.52	6.20	0.93
12/29/86	1,281	81.4	1.34 (ΔL = 0.019)	0.093	3.270	5.22	40.94	6.42	0.81
1/3/87	1,055	15.5				9.86	49.71	8.77	1.12
1/7/87	900	31.5				9.29	58.27	8.56	1.09
1/12/87	745	23.2	1.59 (ΔL = 0.018)	0.129	3.318	13.79	70.39	12.12	1.14
1/19/87	606	15.2				18.30	86.53	16.14	1.13
1/23/87	532					14.09	98.57	12.04	1.17
2/2/87	456	23.3	1.86 (ΔL = 0.013)	0.160	3.408	41.38	115.00	16.43	2.52
AVERAGE			ΔL = 0.016						1.30

USING FEEDER

TABLE 3 LOT #2 IN RACEWAY 11, "
TOTAL FISH = 64,343 ± 4,742

MONTANA
DEPARTMENT OF
FISH, WILDLIFE AND PARKS

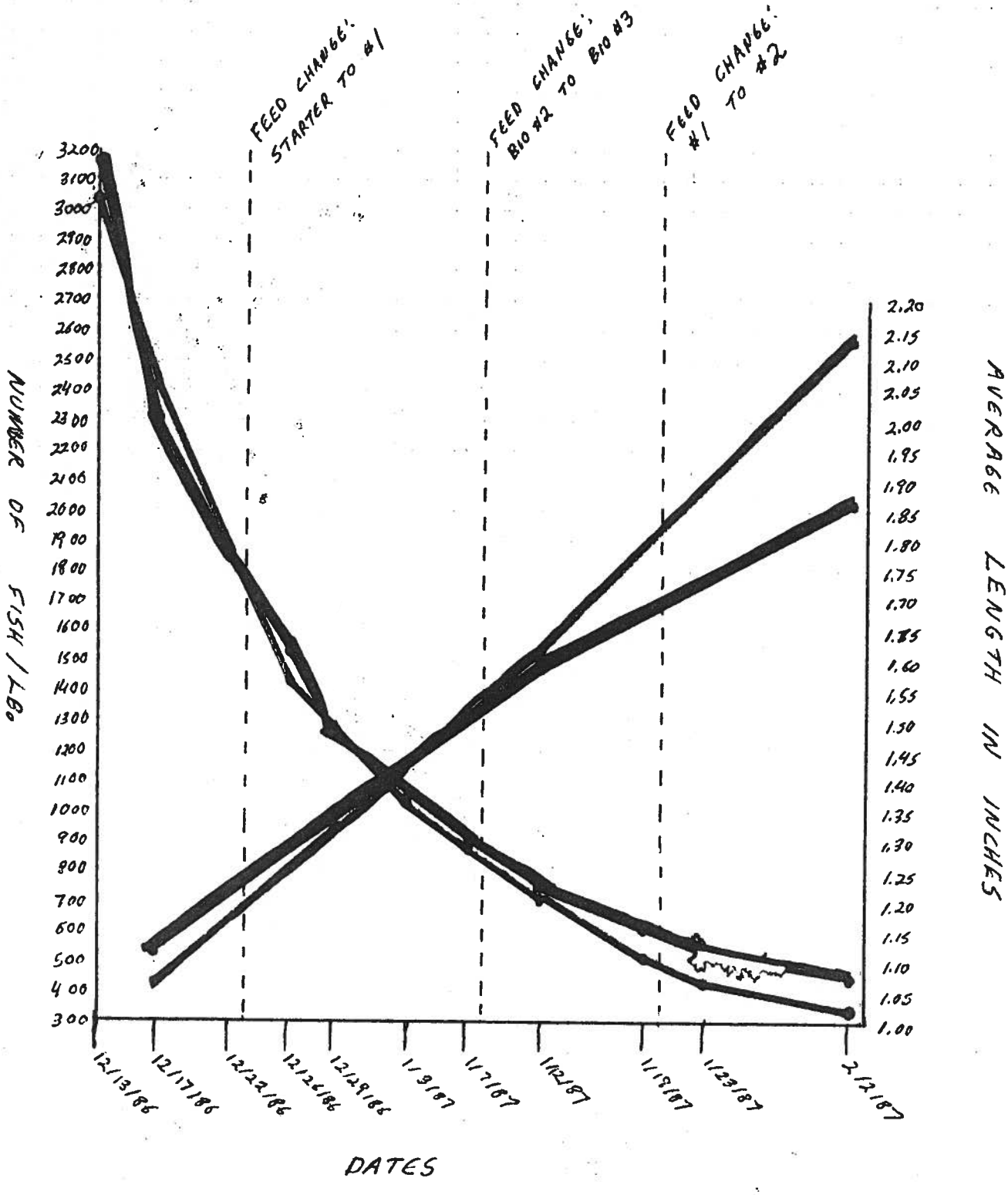
DATE	FISH/LB.	FISH/LB. σ_{n-1}	AVERAGE LENGTH (INCHES)	LENGTH σ_{n-1}	CONDITION FACTOR ($\times 10^{-4}$)	FOOD FED (LB.)	TOTAL FISH WEIGHT (LB.)	WEIGHT GAIN (LB.)	CONVERSION
12/22/86	2,568	60.8					25.06		
12/26/86	2,135					6.29	30.14	5.08	1.24
1/2/87	1,601	67.1	1.25	0.059	3.160	14.17	40.19	10.05	1.41
1/7/87	1,313	63.5				11.89	49.00	8.81	1.35
1/13/87	1,024	31.7	1.44 (ΔL = 0.017)	0.088	3.298	13.97	62.83	13.83	1.01
1/19/87	833	59.4				20.03	77.24	14.44	1.39
1/23/87	760	36.4				15.61	84.66	7.42	2.10
2/3/87	518	11.7	1.82 (ΔL = 0.018)	0.014	3.224	43.95	124.21	39.55	1.11
AVERAGE			ΔL = 0.018						1.27

TABLE 4 LOT #3 IN RACEWAY 12, HAND FED
TOTAL FISH = 46,360 ± 2,155

MONTANA
DEPARTMENT OF
FISH, WILDLIFE AND PARKS

DATE	FISH/LB.	FISH/LB. σ_{n-1}	AVERAGE LENGTH (INCHES)	LENGTH σ_{n-1}	CONDITION FACTOR ($\times 10^{-4}$)	FOOD FED (LB.)	TOTAL FISH WEIGHT (LB.)	WEIGHT GAIN (LB.)	CONVERSION
12/26/86	3,583						12.94		
1/2/87	2,198	70.7	1.15	0.062	2.992	5.72	21.09	8.15	0.70
1/7/87	1,829	46.0				6.51	25.35	4.26	1.53
1/13/87	1,400	31,4	1.33 (ΔI = 0.016)	0.087	3.060	7.77	33.11	7.76	1.00
1/19/87	1,092	29.3				11.24	42.45	9.34	1.20
1/23/87	853	42.2				9.10	54.35	11.9	0.76
2/3/87	603	20.3	1.74 (ΔI = 0.020)	0.140	3.138	29.74	76.88	22.53	1.32
AVERAGE			ΔL = 0.018						1.10

FIGURE 1 LOT #1 IN RACEWAYS 9 AND 10
DATES VERSUS NUMBER/LB. AND LENGTH



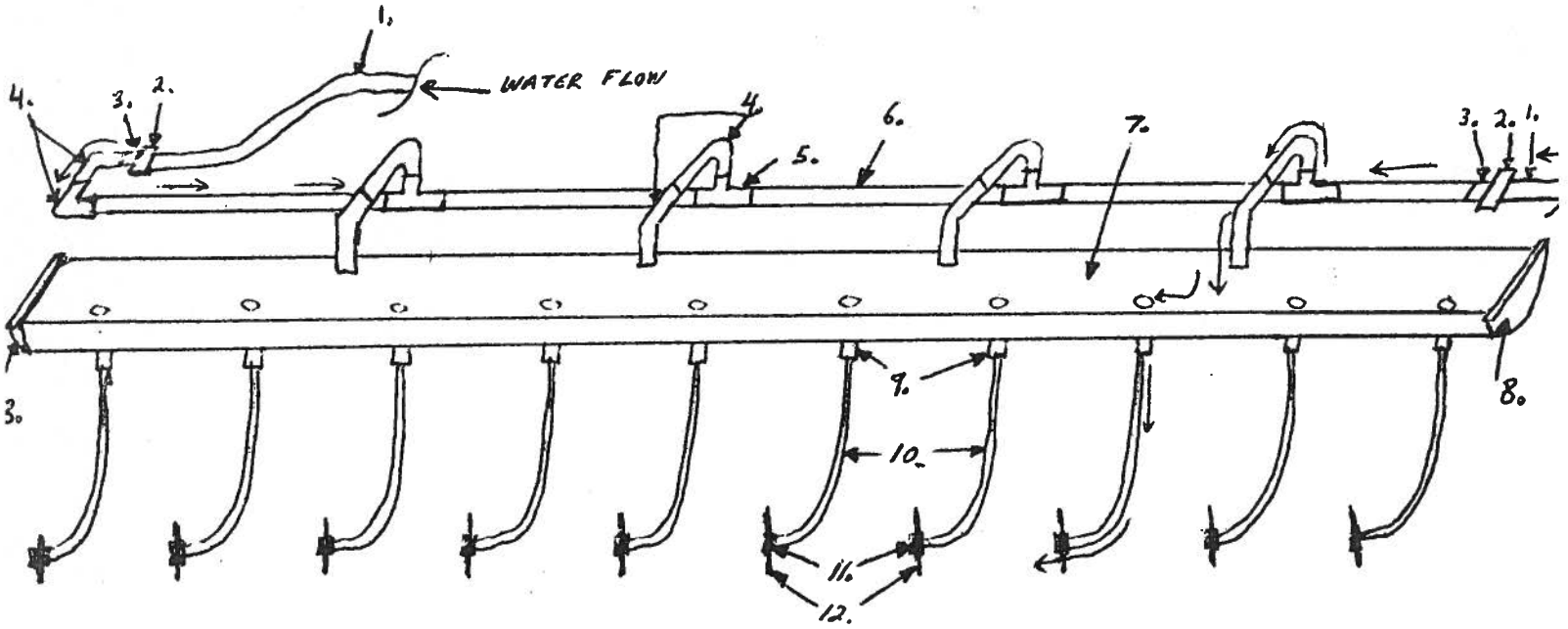
KEY:
- FISH/LB. FOR RACEWAY 9, HAND FED
- FISH/LB. FOR RACEWAY 10, USING FEEDER
- LENGTH FOR RACEWAY 9, HAND FED
- LENGTH FOR RACEWAY 10, USING FEEDER

MONTANA

DEPARTMENT OF

FISH, WILDLIFE AND PARKS

FIGURE 2 DESIGN OF FEEDER



1. garden hose for water supply
2. 3/4" brass pipe thread to hose thread coupler
3. 3/4" PVC to pipe thread coupler
4. 3/4" PVC street 90's
5. 3/4" PVC tees
6. 3/4" PVC pipe, 10 feet
7. 4" SD40 PVC pipe, 10 feet, cut lengthwise
8. 4" SD40 PVC end caps, cut in half
9. $\frac{1}{2}$" PVC couplers
10. 5/8" clear vinyl tubing
11. 3/8" electrical clamps, used to weight down tubing
12. 3/4" washers, used to weight down tubing

Wyoming Game & Fish Department
Fish Division
Administrative Report

A SUBMERGED FEEDING SYSTEM FOR BROWN TROUT (Salmo trutta)

by
Raymond K. Messamer
Fish Culturist
Clark's Fork Hatchery

Personnel:
Don Peterson, Superintendent
Paul Kretschmar, Asst. Superintendent
Gerald Linsdau, Leland McDonald

November 2, 1985

INTRODUCTION:

When Rauch, Mandis, and Harris (1983) reported on the development of a submerged feeding system for brown trout fry at the 18th Annual Meeting of the Colorado/Wyoming Chapter of the American Fisheries Society in Fort Collins, the possible application of the technique for large production lots of browns seemed very likely. Subsequently, in the fall of 1984, two similar feed delivery systems were constructed for testing at Clark's Fork Hatchery.

Brown trout represent a significant portion of the annual fish production efforts of the Fish Culture Section, and as such are a major concern in hatcheries across the state. Their erratic behavior and performance characteristics are well known, and prompted the initiation of this experiment.

METHODS AND PROCEDURES:

Testing was conducted on a large lot of brown trout (693,000), which originated as eggs from wild stock spawned in Soda Lake near Pinedale. The eyed eggs were received at Clark's Fork in December of 1984. Testing began January 4, 1985, shortly after the fry were dumped into rearing tanks from the hatching baskets. The entire lot was trained to feed on Biodiet starter for 10 days prior to dumping.

In summarizing the results of their original experiment, Rauch, Mandis, and Harris (1983, p.53) reported "...removal of human interference during feeding by use of automatic feeders did not conclusively demonstrate a growth benefit except when submerged feed delivery systems were also used." Because of this assertion, it was decided that the testing of the impact of human interference during feeding would not be a part of this experiment. The major factors tested were 1) the submerged feed delivery system and 2) the relative effectiveness of two readily available starter diets, the USFWS SD-9 and Biodiet. Two feeders were constructed using the basic design and components reported by Rauch, Mandis, and Harris, with one major difference; the feeders were hand operated rather than automatically operated.

Four parallel rearing tanks containing equal numbers of brown trout fry (approximately 53,000 each) were set aside for the experiment. One tank was hand-fed the SD-9 diet, one was fed with the submerged delivery system and SD-9 diet, a third tank was hand-fed with Biodiet, and the fourth was fed Biodiet with the submerged delivery system. All four tanks were fed an excess of feed to insure optimal opportunity for

all individuals to receive feed. Feeding an excess to swimup fry is a standard practice at Clark's Fork.

Initial weight and length samples were taken, weight samples were again taken after 18 days, and weight and length samples were taken when the experiment concluded on January 31st. At this time the bulk of this lot of fish was transferred to the Speas Hatchery (see Table 1).

RESULTS:

Mortality rates over the duration of the experiment show a marked difference in performance of the two feeds tested (Table 2). Both test groups which were fed Biodiet suffered approximately half the mortality experienced in the SD-9 groups. Length frequency distributions also show significant differences in the pe formance of the feeds; both groups of Biodiet fish showed much more uniform growth than did those fed with the SD-9 diet (Table 1).

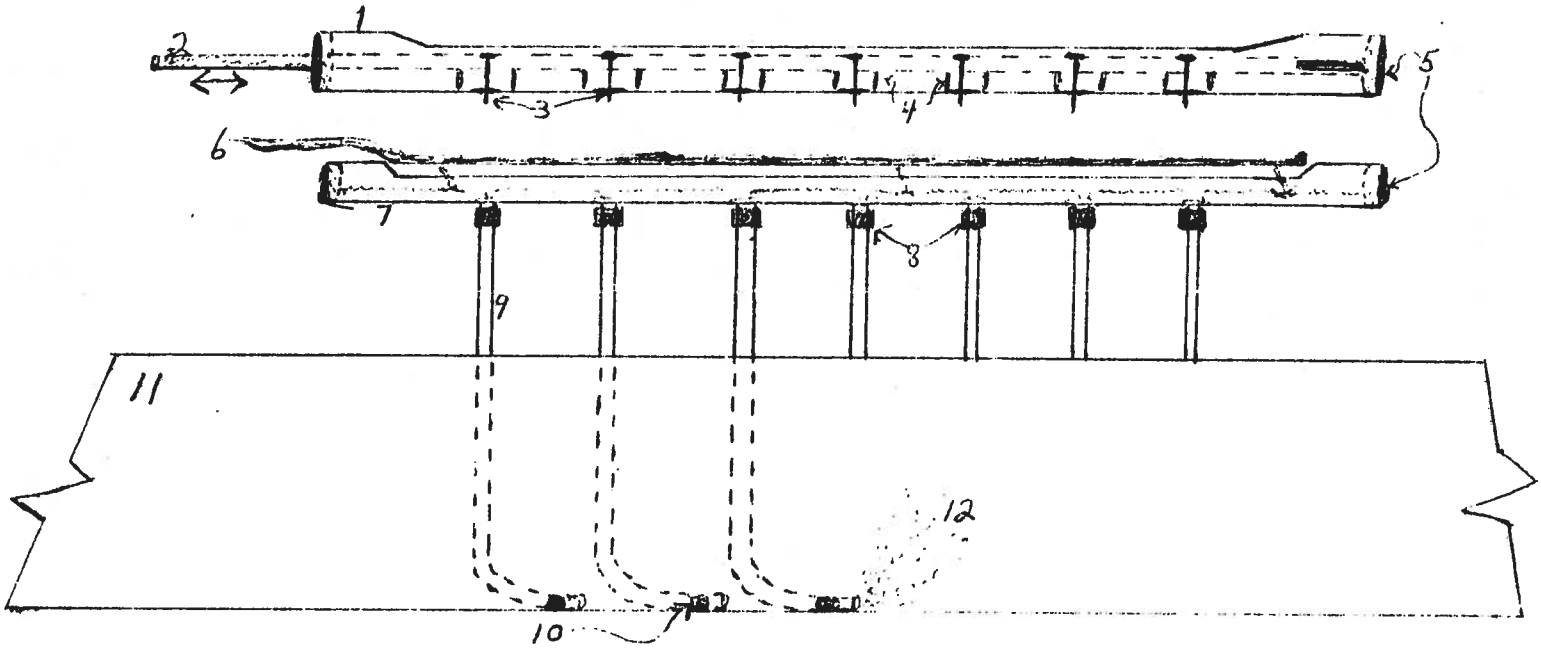
Weight samples taken on January 21 after 18 days into the experiment exhibited exactly the results that were hypothesized. The largest group were those being fed the Biodiet via the submerged delivery system, followed by the hand-fed Biodiet group, the submerged delivery SD-9 group, and finally the hand-fed SD-9 group showed the slowest growth. However, when the experiment was concluded, weight samples showed that this trend had essentially been reversed. Both lots being fed the SD-9 diet had surpassed the growth of the fish being fed Biodiet by a significant amount (Table 1).

SUMMARY AND RECOMMENDATIONS:

The results of this experiment seem to generally reinforce the conclusions reached by the originators of the submerged feed delivery system for brown trout (Rauch, Mandis, & Harris, 1983). Both groups of fish fed with this system outperformed their hand-fed counterparts both in mortality rates and in increased growth for the first portion of the experiment. The reversal of growth patterns noted at the end might be explained with a comparison of food particle sizes between the two diets. It appears as though the much smaller Biodiet particles became increasingly difficult for the growing fish to locate and consume once the average size passed a certain point. Other factors may have entered the picture, but this seems to be the most logical point.

The lower mortality rate and more uniform growth rates of the Biodiet fish lead to the following recommendations: brown trout at Clark's Fork Hatchery should in the future be fed Biodiet starter, with the submerged delivery system if possible, for approximately two weeks (14-18 days) after dumping, at which time the regular SD-9 starter feed should be utilized, or a switch to the next larger Biodiet size should be made. The use of Biodiet should be completely phased out by the time the fish reach approximately 1400/lb., to keep the cost of feed from becoming prohibitive. The initial benefits realized from this feeding procedure should carry over into later life stages, helping to produce what should be a healthier and more uniform lot of fish, with minimal hatchery induced selection taking place.

FIGURE I.



SUBMERGED FEED DELIVERY SYSTEM

Operation and construction of submerged delivery feeders: conduit slider with attached nails and sheet metal pushers drops feed through slots when the slider is pushed or pulled by hand. Feed drops directly into water in the feed delivery system; water and feed are flushed down through the feed delivery tubes to the bottom of the rearing tank. Small air bubbles which attach to many feed particles cause some feed to rise through the water column after delivery.

1) Feeder body (3 in. PVC pipe)
2) Slider rod (1/2 in. aluminum conduit)
3) Nails to keep feeder slots open
4) Push plates (sheet metal) force feed toward slots
5) Both assemblies are stoppered with wooden plugs
6) Water hose with three outlet slots to assure uniform flow
7) Submerged delivery system (2 1/2 in. PVC pipe)
8) Rubber hose stop collars anchor delivery tubes in place
9) Delivery tubes (3/8 in. plastic hose
10) Weights hold delivery tubes down on bottom of rearing tank
11) Rearing Tank
12) Feed rising in water column

TABLE I.

WEIGHT AND LENGTH SAMPLES

GROUP	NUMBER/LB.	AVG. L. (MM).	RANGE (MM)	% DEVIATION FROM MEAN
Initial Samples	5,000	22.50	21-26	± 11
21 JAN				
Bio-Hand	2,216	---	---	---
Bio-Feeder	2,136	---	---	---
SD9-Hand	2,384	---	---	---
SD9-Feeder	2,264	---	---	---
31 JAN				
Bio-Hand	1,986	30.88	27-37	± 16.2
Bio-Feeder	1,836	30.52	26-35	± 14.7
SD9-Hand	1,722	32.16	26-39	± 20.2
SD9-Feeder	1,672	30.96	24-38	± 19.2

TABLE 2.

TOTAL MORTALITY

GROUP	% OF GROUP	GROUP SIZE	NUMBER
Bio-Hand	0.45	53,000	238
Bio-Feeder	0.49	"	261
SD9-Hand	0.98	"	517
SD9-Feeder	0.88	"	466

LITERATURE CITED:

Rauch, G., T. Mandis, and L.E. Harris. 1983. Preliminary investigation of feeding preferences of brown trout (Salmo trutta): manner of feeding and diet effects. Proc. 18th Ann. Mtg. Colo./Wyo. Chptr., Amer. Fish. Soc., pp. 48-53.