HATCHERY RESEARCH

Idaho Fish & Game

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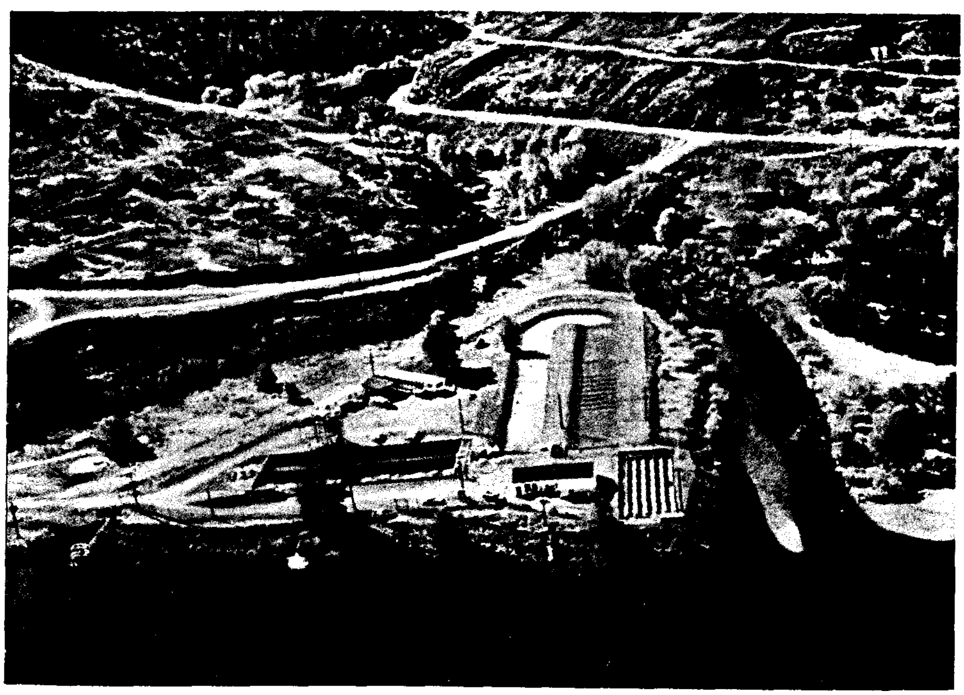
SMALLMOUTH BASS CULTURE AT OXBOW HATCHERY
FEED TRAINING SWIMUP FRY



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ABSTRACT

Controlled raceway spawning of smallmouth bass *(Micropterous dolomieui)* was achieved. Egg production was estimated at five to seven thousand. The resultant fry were incubated through swim-up. An "injector" type feeder was designed and implemented in the feed training of these swimup fry. Due to extenuating circumstances, overall mortality rates were high (98%). However, growth rates were favorable at an average of 0.34mm (0.013") per day.

INTRODUCTION

Oxbow hatchery is a salmon/steelhead mitigation hatchery owned and funded by Idaho Power Company and operated by the Idaho Department of Fish and Game. The primary objective of the Oxbow operation is the trapping and spawning of chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Salmo gairdneri*). Oxbow Hatchery is located at river kilometer 434.5 (RM 270) on the Snake River, 969 kilometers (602 miles) from the Pacific Ocean, at Oxbow, Oregon.

High water temperatures during the summer months do not permit the culture of salmonid fishes at Oxbow. This situation created an opportunity for warm water fish culture research at the station. Smallmouth bass (*Micropterous dolomieui*) was chosen as a reasonable subject for trial and evaluation of an experimental fish culture program.

Smallmouth bass culture is receiving a lot of evaluation and improvements are being made in an attempt to further intensify cultural practices. Most current artificial diet feed training programs utilize bass fry of 20mm or larger. Initially, smallmouth fry are stocked or hatched in fertilized ponds and left to forage naturally until they attain the desired size for training. Currently there is no economically feasible rearing method that allows for the intensive culture of swim-up smallmouth bass fry, utilizing artificial feeding practices (Anderson 1974. Midwest Black Bass Culture 1983).

Oxbow Hatchery does not have a pond system conducive to early rearing of smallmouth bass on a natural diet. Thus the entire program is dependent on the successful feed training of swim-up fry on an artificial diet.

This program had two phases: 1) attempt to spawn smallmouth bass in raceways, and 2) attempt to feed train on an artificial diet. Feed training was broken in two parts: 1) mimic natural zooplankton conditions to achieve a "natural" feeding response and 2) modify this behavior to a more traditional intensive type feeding response.

OBJECTIVES

1. Collect wild smallmouth bass brood stock by electrofishing before natural spawning occurs and hold until water temperature reaches 18°C (64°F).
2. Achieve controlled spawning in concrete raceways on prepared gravel nest boxes.
3. Collect newly hatched fry or eggs and artificially incubate until swim-up.
4. Achieve successive spawnings if possible.
5. Design and implement an "injector" type feeding system that makes food particles appear to be free swimming.
6. Feed train swim-up fry on an artificial diet and rear to 40mm (1.6 in).

MATERIALS AND METHODS

Wild adult smallmouth bass were collected by electrofishing in Oxbow Reservoir of the Snake River on May 17, 1985. Water temperature prior to collection did not exceed 14°C (58°F). Twenty-three bass, consisting of eleven females and twelve males and ranging in size from 177.8 to 381.0mm 7 to 15 in) were collected and held in a concrete raceway 7.7M x .1.8M x deep (25' x 6' x 3'), with a flow of 833 to 1325 liters per minute (220 to 350 gpm).

Artificial nest boxes were made of 1" x 6" lumber 45.7cm (18 in square with 1/2" hardware cloth to keep the gravel in the box. The nest box was equipped with a removable frame on the bottom, covered with nylon window screen and lined with muslin cloth to aid in fry collection (Figure 1). Gravel was screened to achieve uniform substrate size of 2.54 to 5.1cm (1 to 2 in).

A 27.7M x 1.8M x .9M deep (90' x 6' x 3') concrete raceway was divided into nine sections by hanging weighted black plastic sheets that partially barricaded the raceway in an alternate fashion (Figure 2). A nest box was placed in each section .and numbered 1 to 9 respectively. This gave each nest spot .5M^3 (18.0 ft^3) of semi-isolated space and still allowed free fish movement.

An incubation/rearing trough was built from 2" plywood and lined with clear plastic. The trough measured .9M x .45M x .3M deep (3' x 1.5' x 1'). Maximum available flow to the trough was 37.8 liters per minute (10 gpm).

Design, implementation and refinement of a constant delivery feeder was an evolutionary project. The final product is an elevated tank fed' by a variable flow water supply. This tank (30 gallon plastic garbage can) had a single 5.1cm (2 ") PVC outlet pipe in the side. A dry feed. rotating arm type, pan feeder was affixed with the feed delivery hole just above the outlet so feed that dropped into the water was quickly voided via the outlet. This 2" PVC pipe then dropped 1.85M (6') for head pressure and split into two 2.54 cm (1") feeder pipes. The feeder pipe ran the entire length of the trough and were perforated with 4mm (3/16”" holes at 10.2cm (4") intervals to achieve many jetstreams of water throughout the trough (Figure 3). Feed entering the system at the elevated tank outlet mixed evenly and rehydrated while traveling the pipe network.

Rates of food delivery were in extreme excess of any possible consumable quantity. This was done in an attempt to mimic particle densities occurring in heavy concentrations of naturally occurring zooplankton.

Feed was delivered constantly throughout the natural day length. Constant feed delivery resulted in large accumulations of unused food in rearing trough. This was cleaned with a siphon hose daily.

The commercial diet used during this experiment was the standard salmon diet produced by the Rangen Inc. of Buhl, Idaho. This diet was supplemented with freeze dried Calanus Copepods under the MUREX brand name, supplied by the Banyon Pet Food Company, Langly, B.C., Canada.

Figure 1. Spawning nest box detail.

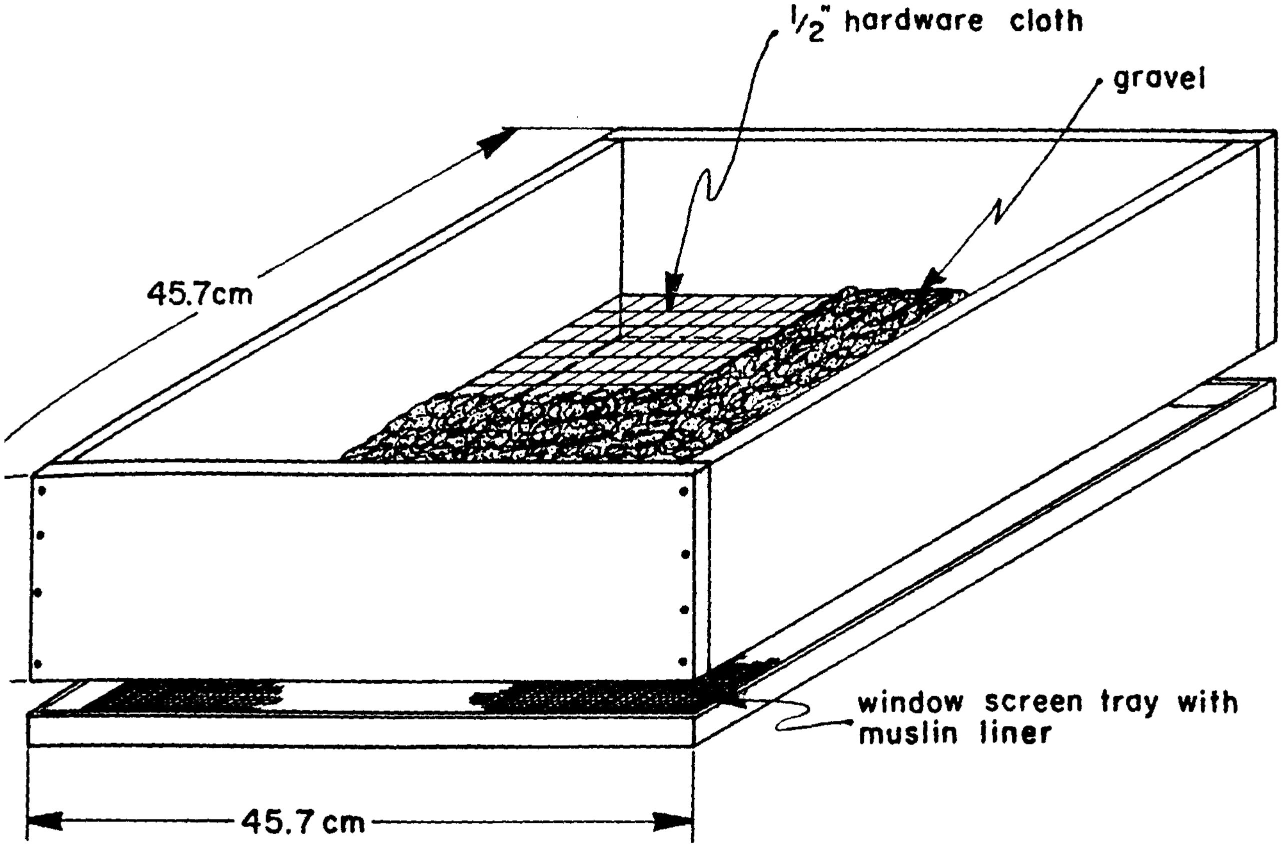


Figure 2. Set-up of spawning raceway.

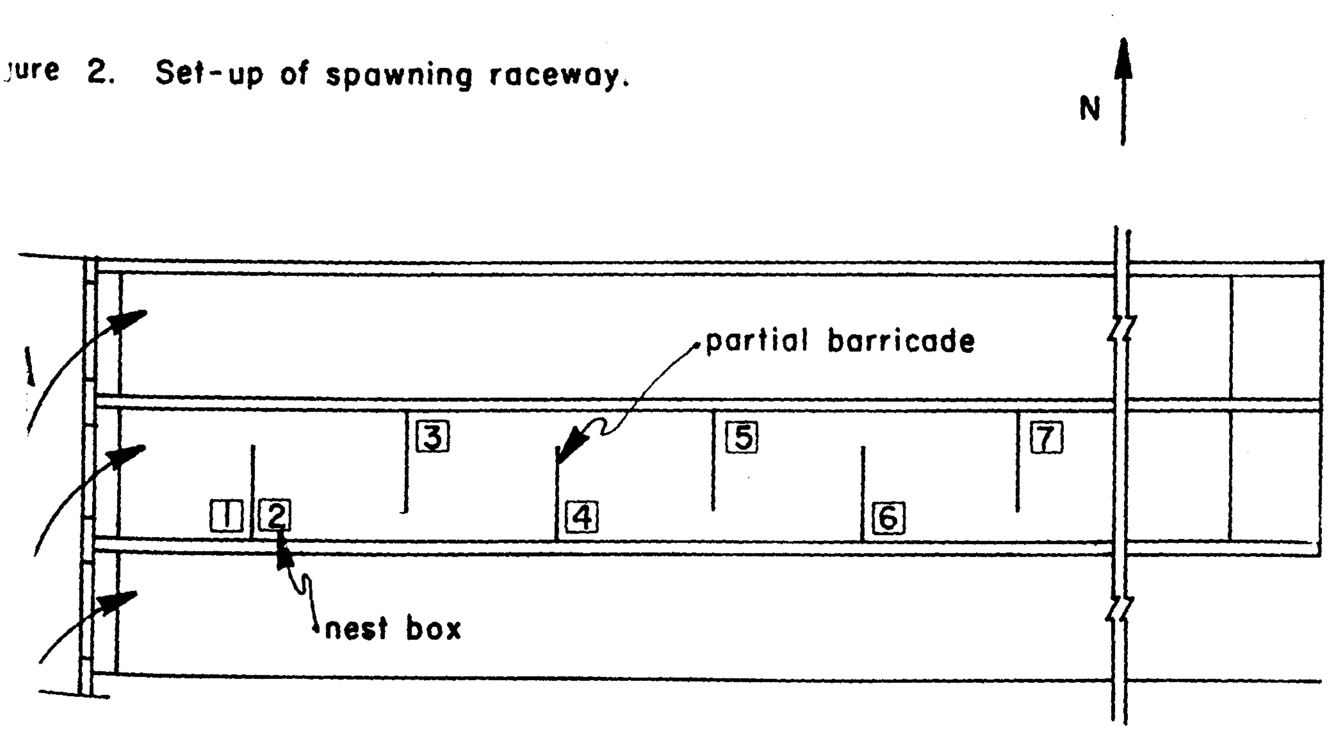


Figure 3. Diagram of feeder system and rearing trough.

Legend:
1. Variable flow water supply
2. Elevated tank
3. Pan feeder
4. Tank outlet (feed enters system)
5. PVC pipe network
6. PVC feed "injector" tubes
7. Screen
8. Rearing trough

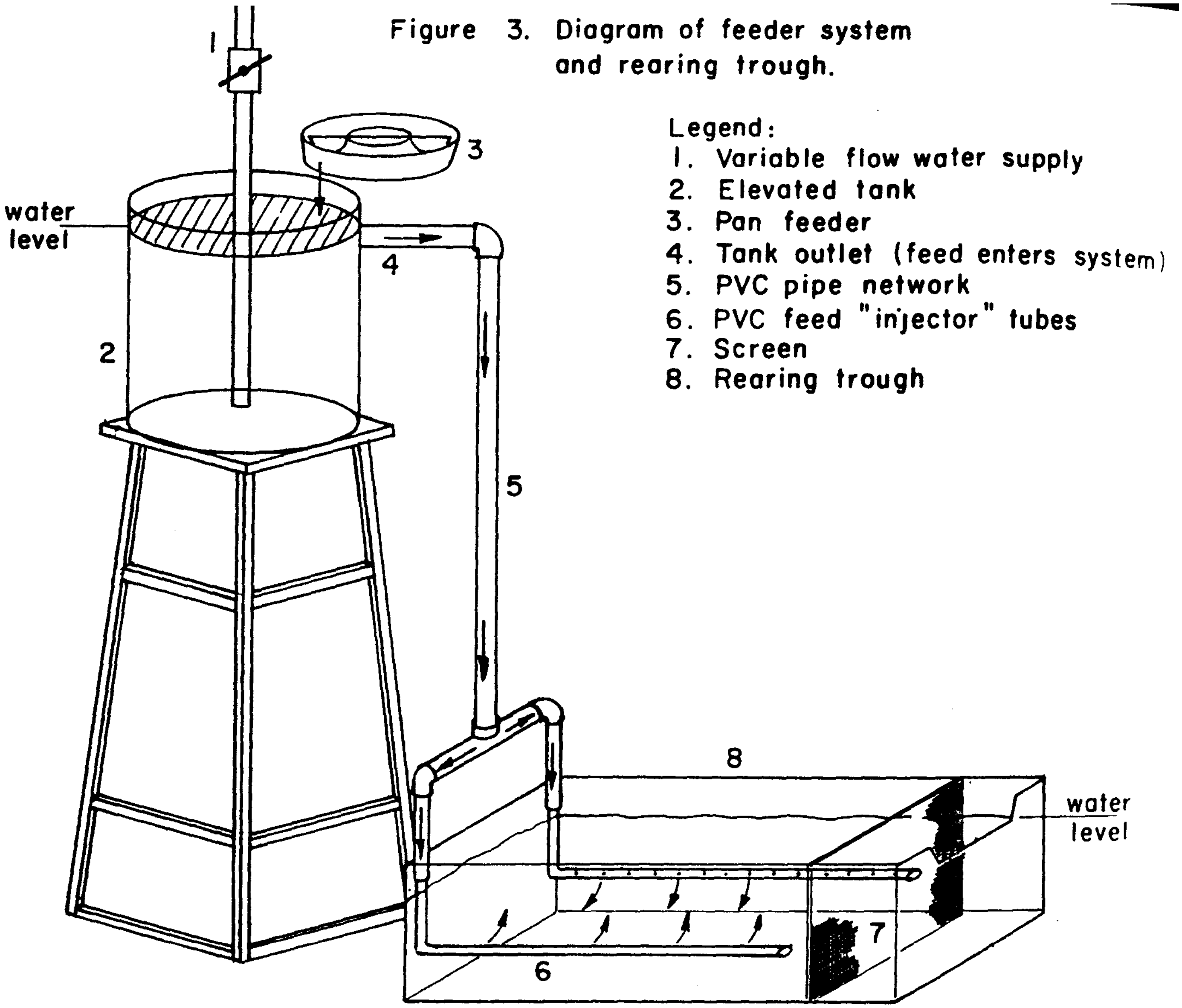
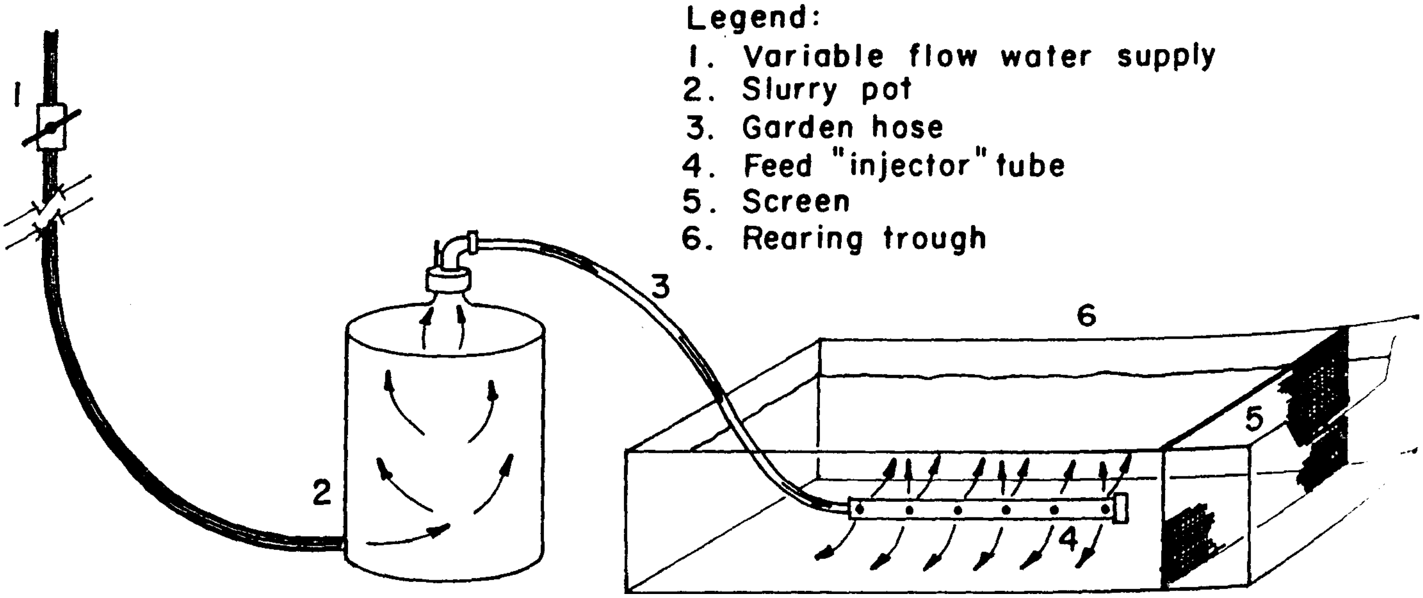


Figure 4. Slurry pot feeder system.

Legend:
1. Variable flow water supply
2. Slurry pot
3. Garden hose
4. Feed "injector" tube
5. Screen
6. Rearing trough



RESULTS

Spawning

The spawning raceway was set up with dividers and nests on June 9. Water temperature was 18°C (64°F), and flow through the raceway was set at 113 liters per minute (30 gpm). On June 10, ten male and eleven female bass were placed in the spawning raceway. On June 12, pre-spawning territorializing was observed. On June 15, eggs were observed in box number 7. Box #7 was nested by the largest male in the raceway. On June 16 eggs were also observed in boxes 3,5,6, and 9. On June 20 the eggs in box #7 hatched and the fry were collected. Upon removal of the muslin tray a large amount of silt and fungus was observed. This condition could have led to high mortality if the newly hatched fry had not been removed shortly after hatching. On June 21, unhatched eggs and newly hatched fry were collected from nests 3,5,6 and 9. Nest 6 was abandoned and fungused so badly that all production was lost. Nest egg volumes ranged from a low of 250 eggs to a high of 1800-2000 eggs. Observations indicate the relative size of the male occupying a nest would correlate to the size of egg clutch, smaller males not being as successful as larger ones.

It is interesting to note that all the nests on the north side of the raceway (morning sun and afternoon shade) were occupied (3,5,7 and 9) while only one on the south side was occupied and it was abandoned (nest 6). All nest boxes were removed from the raceway. On June 23, nest 1 was replaced. The largest male quickly occupied the nest and accumulated a large number of eggs. The eggs developed and hatched, but were not collected soon enough and were lost to fungus.

The number of eggs and fry produced was estimated at 5000 to 7000. These eggs and fry were placed in the rearing trough with the flow rate set at 5.7 liters per minute (1.5 gpm), 2.8 exchanges per hour. Artificial substrate was installed to reduce "bunching up" and possible suffocation. The rearing trough was cleaned daily with a 1/4" rubber siphon hose. Fry that were inadvertently siphoned were collected in a screened bucket and returned to the trough. Mortality was recorded daily.

Feeding

On June 28, fry started to swim-up. Typical feeding behavior patterns were observed upon the introduction of Rangen's Salmon Starter diet through the injector system. Feeding behavior was similar to that of naturally occurring smallmouth bass fry in the Snake River's Brownlee Reservoir (Jim Chandler, personal communication). The flow rate was increased to 11.4 liters per minute (3 gpm), 5.6 exchanges per hour, to increase mixing and prolong the suspension of food particles. On June 29, a marked increase in numbers of swim-up fry was noted. Feeding continued, and fry were observed ingesting food particles. Microscopic stomach analysis on this date showed food in 40 percent (4/10) of the stomachs and food stuff in the remaining 60 percent (6/10) of the fish's intestines. By July 1 all fry were "up".

At this stage of the program the feeder system was in the early stage of development and there were problems in maintaining a constant feed delivery rate. A 37.8 liter (10 gal) in-line "slurry pot" was being used to introduce the feed (Figure 4). The slurry pot was loaded with 500 grams (17.5 oz) of Rangen's Salmon Starter diet per feeding interval. Feeding intervals lasted from two to three hours. During the feeding intervals, mean particle density appeared to he good (water slightly turbid with particles), but initial particle density was extremely high and final particle density was low. There were occasions between feeding intervals when no feed was available for periods of one to two hours. There were usually three to four feeding intervals daily, starting at 7:00 a.m.

The injector tube delivered the food particles in a manner that imitated free-swimming zooplankters. Settling time of the particles was reasonably slow as the water jets kept them moving throughout the trough. Further stomach analysis done on July 4 showed a decrease in feeding activity. Results showed ten percent (1/10) fish with food in the stomach, 70 percent (7/10) with intestinal "glop", and two fish had no feed.

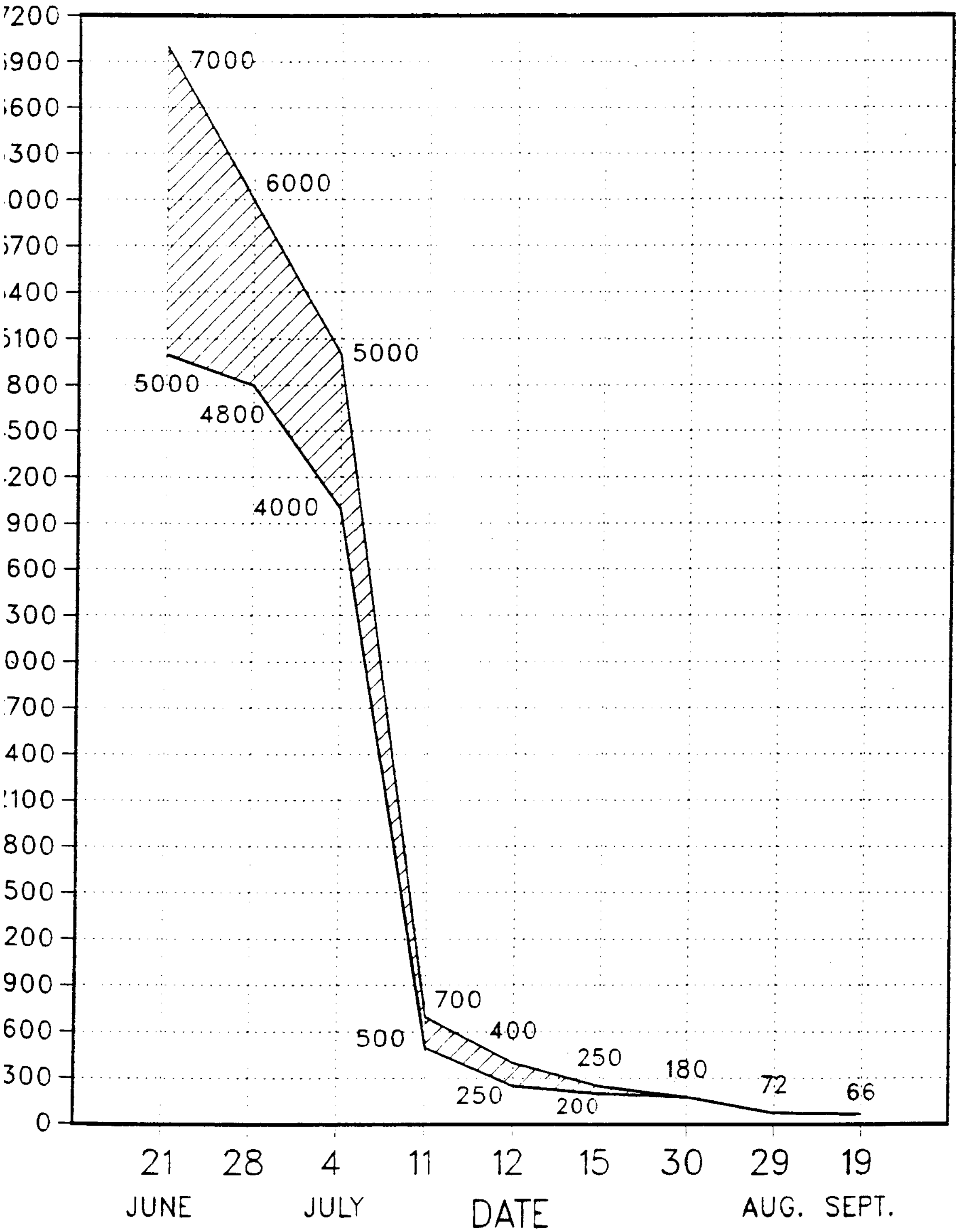
The next few days showed a general deterioration in fish condition. The fish became too weak to eat and eventually too weak to swim as they floated in the current. Stomach analysis done on July 6 showed 50 percent (5/10) of stomachs empty; 30 percent (3/10) with intestinal glop; 10 percent (1/10) with food in the gut and 10 percent (1/10) with a naturally occurring Daphnia sp. in the gut.

By July 11. mortality or morbidity had accounted for nearly 90 percent of the fry. The moribund "floaters" were skimmed from the water surface and discarded. Approximately 600 survivors remained. These fish were still in moderately good condition and were still swimming. These fish were either the last to swim-up or were surviving on the diet. Half of the survivors were moved out to a production raceway 7.7M x 1.8M x 0.3M deep (25' x 6' x 1') with a flow of 113 liters per minute (30gpm). This was done in an attempt to save some fry by allowing for natural forage in river water. None of these fry were recovered.

On July 13 an electric pan-type fry feeder was obtained and the constant delivery feeder system (Figure 3) was built. The diet provided through this feeder was supplemented with krill (Euphasiia pacifica) and freeze dried copepods (Calanus sp.) supplied by the Banyon Pet Feed Co. Krill and copepods were mixed evenly and added to the Rangen diet at 1.4. percent dry weight (10 grams to 700 grams). This diet mixture was introduced via the elevated tank system described earlier. This amount of food lasted an entire ten hour feeding period and achieved an extremely constant delivery rate. Results of the feeder improvement and diet supplementation were noticed by July 14. Visual observations showed fish with distended guts and healthy appearances. Stomach analysis of one of the "feeders" on July 14 showed 16 calanoid copepods. At this time the krill was removed from the diet and a full 1.4 percent copepod were mixed.

By July 15 all moribund fish had been removed and the mortality rate was less than two percent daily. The number of survivors was estimated at 200 (Figure 5).

Figure 5. Survival from swim–up to program termination.
(Shaded area denotes estimations.)



The Rangen diet continued to be mixed with the copepods for two reasons: 1) the diet of copepods alone had a tendency to absorb moisture from the air, become sticky and plug the feeder hole, and 2) as growth continued the fish began to utilize the dry diet and became less dependent on the copepods.

On July 19 the Rangen starter diet was replaced with Rangen's number one fry feed. On July 28 the pan feeder was moved from the position on the elevated tank to a position above the rearing trough. Feed now dropped directly into the water in the rearing trough and no longer traveled the pipe network. The transition in feeding behavior went smoothly with no noticeable effects on growth rates. Fish larger than 20mm (0.8") seemed to adjust better to the different feed delivery than did the smaller fish. This was shown by an increased divergence in size.

On August 19 Rangen number three fry feed was mixed with the Rangen number one feed to provide a larger particle to the larger fish.

Growth

Average length of bass fry at swimup was 9.79mm (0.39") on July 4. Measurements on July 6 showed an average length of 9.46mm (0.37") which may indicate a decline in fish condition. Lengths were again measured on July 22, eight days after the copepods were supplemented in the diet. Average length was 13.0mm (0.51"). Final measurements on September 19 showed an average length of 34.8mm (1.37"). Further growth increment are given in Figure 6 and Table 1.

Table 1 Growth Statistics by Sample Date

Date	No. Sampled (N)	Range (MM)	Average (MM)	Std Dev.
7/4	10	9.6-10.1	9.79	0.196
7/6	10	8.7-10.2	9.46	0.41
7/22	10	10.1-15.2	13.0	1.81
7/30	22	14.0-20.0	16.8	1.69
8/13	28	17.0-33.0	21.7	4.10
8/16	15	19.0-33.0	23.8	5.07
8/29	58	20.0-45.0	29.0	6.58
9/19	43	22.0-56.0	34.8	9.81

During the 75 days of this feeding program (July 6 - Sept 19) the maximum growth rate achieved was 0.62mm (0.024") per day. The minimum growth rate achieved was 0.18mm (0.007") per day. The average growth rate achieved was 0.34mm (0.013") per day.

No attempt was made to calculate feed to growth conversion rates as feed levels were in excess of any possible consumption by the number of fish in this program.

Water temperature averaged 21°C (69°F) during the period July 6 to Sept 9 (Figure 7).

Figure 6. Length frequency by sample date.

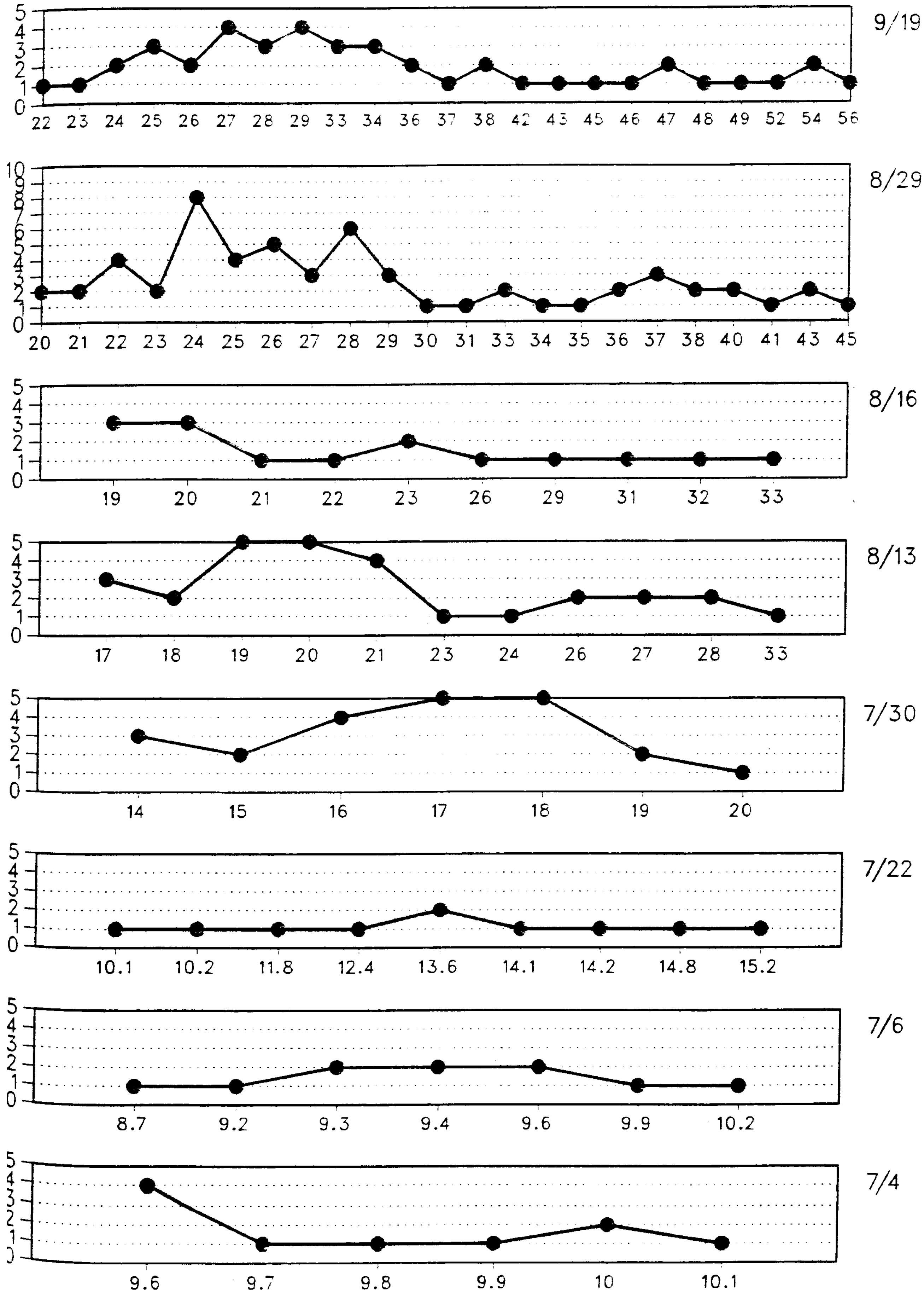
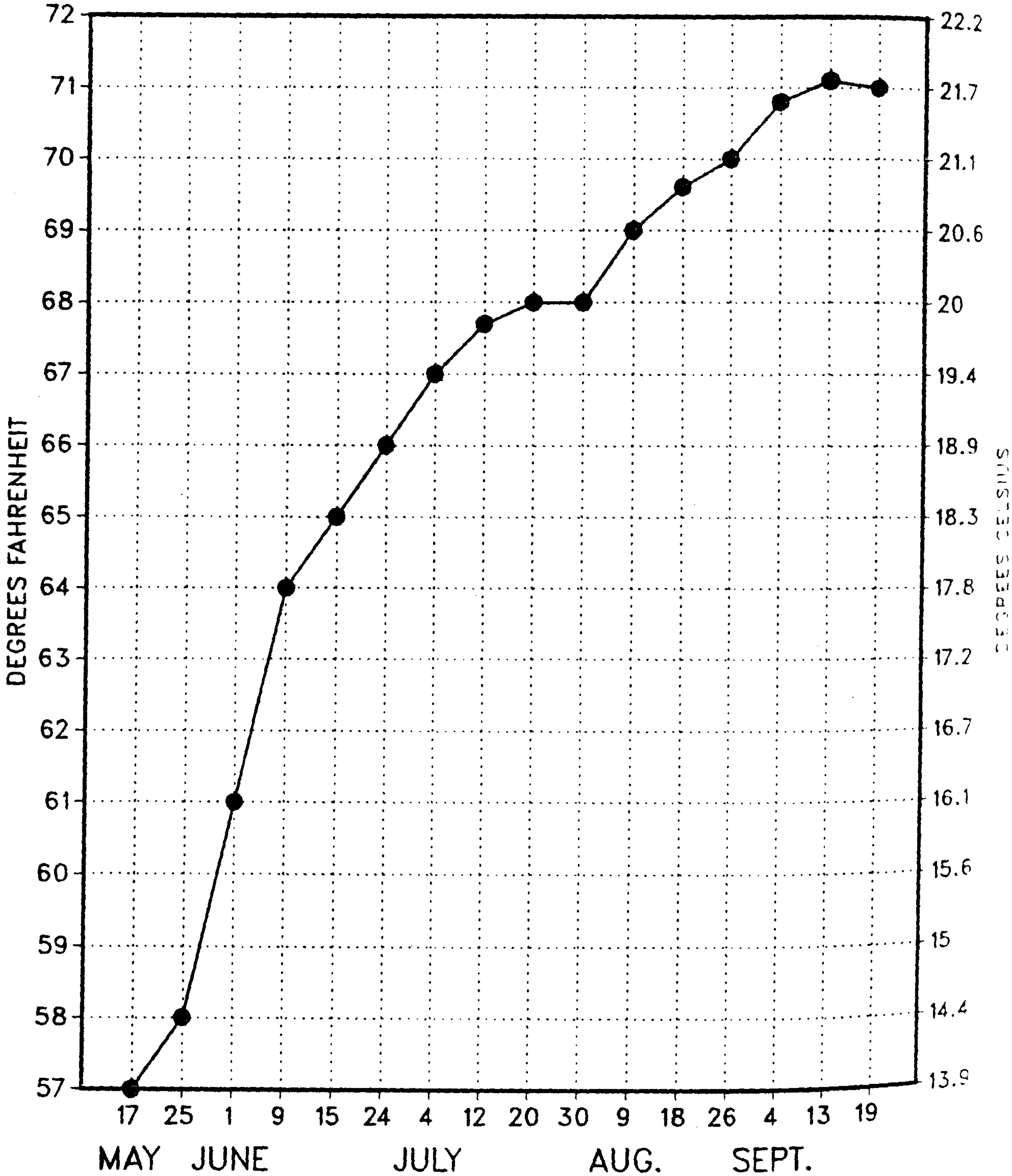


Figure 7. Water temperature profile during project.



DISCUSSION

As a pilot program, this was a large success. Many problems were encountered but more importantly, many questions were answered and most of the developmental problems were solved. With the success of this initial year, additional years should answer production level feasibility questions.

The raceway spawning was moderately successful, as eggs and fry were produced. The size of brood males or the divergence in size may have played a part in spawning success. Males under 203mm (8") were not successful spawners with larger males present. However, the larger males could have spawned all the available females unless the non-nesting males posed a territorial threat and influenced spawning success indirectly.

Egg and fry collection went well. Special care must be taken when observing egg development, not to scare the male off the nest too often as he may abandon it. For this reason it is best to harvest as many nests as possible at the same time (as soon as hatching begins). The muslin lined fry collection trays worked, but they harbored silt, fungus and aquatic insects, all of which may cause production losses if fry are not collected promptly. The eggs that were not yet hatched when collection occurred were removed from the rocks by a gentle washing; no chemicals were needed.

Incubating fry must be cleaned daily as fungus grows rapidly on dead eggs and can quickly damage live fry. Siphoning fungus growths and silt worked well, but occasionally it was necessary to remove the fry from the trough and clean it thoroughly as a prophylactic furgal control method. Egg and pre-swimup fry losses were low.

Development of the constant delivery injector feed system was crucial to the feed training portion of this program. However, the delay in perfecting the system is believed to be one of the reasons for high early fry mortality. Wiggins et al. (1985) states five reasons for feeding success in larval fish: 1) diel variations in feeding intensity, 2) feeding efficiency, 3) food density, 4) food availability and 5) suitability of food. When using the slurry pot to deliver feed, constant food particle densities were not achieved and there were times that food was not available. The other reason for high rates of early fry mortality was the apparent unsuitability of the basic Rangen Diet. Microscopic stomach analysis showed food was ingested, yet fish condition declined. Once a constant delivery rate of a set food particle density was achieved and freeze-dried zooplankton was added to the diet, fish condition improved and growth began.

The price of the MUREX copepods was $36.30/kg ($16.50/lb). This may seem extravagant, however, it requires 16 kilos of live copepods to produce one kilo of freeze-dried (Sadler, personal communication). This must be kept in mind when calculating feed levels, as the copepods require rehydrating before consumption. Rehydration is achieved within the pipe network of the injector feeder. This entire program used .72 kg (1.6 lbs) of freeze-dried copepods while feeding exorbitant levels. I do not believe that supplementing with copepods would be cost prohibitive. Cost of the Rangen diet was $0.306/lb for the swim-up starter and $0.27/lb for the #1 and #3 fry feed (Table 2).

Table 2. Feed and Feed Cost

FEED TYPE	AMOUNT FED	COST PER UNIT	TOTAL COST
Copepods	.72 kg	36.30/kg	26.14*
Rangen Starter	22 lbs	.306/lb	6.73
Rangen #1 Fry	31 lbs	.27/lb	8.37
Rangen #3 Fry	19 lbs	.27/lb	5.13
			$46.37

*Copepods were supplied to this program at no cost.

There can be speculation that the fish surviving at the time when the feeder was improved and the diet was supplemented might have survived without these improvements. Only another production year will answer that question. However, I am confident that future programs using this feeding system and a similar diet supplementation will show favorable results and improved survival. This program, although plagued by high early mortality rates, did show that survival of intensively cultured smallmouth bass from swim-up fry is possible and growth rates are favorable.

RECOMMENDATIONS

This program should be continued.

Spawning operations should utilize larger sized males and possibly only five nests and five males per raceway. Higher numbers of females to males in the raceway should be tried. All nests should be positioned to receive afternoon shade. Successive spawnings should be achieved, as they will greatly increase potential production and provided "back-up" lots if unexpected problems arise.

At least three different rearing troughs should be used (pending sufficient production). These should be fed different concentrations of total food particles with varying concentrations of copepods. Different diets should also be tested. Consideration should also be given to variations of flow rates in the injector feeder. Flows need to be high enough to provide good particle movement, but not high enough to induce elevated stress levels in early swim-up fry.

Fish should be graded as size variation becomes pronounced and feed schedules adjusted accordingly.

ACKNOWLEDGEMENTS

I would like to thank the following people for their assistance in this program: Larry Dunsmoor and Jim Chandler for aiding in broodstock collection, stomach analysis and design consultation; Jim Aamodt for the copepod source and Gene Merritt for helping with the actual construction and pond-side culture.

I would also like to thank Mr Gordon Sadler of the Banyon Pet Food Co., for suppling the freeze dried copepods for this program.

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