SURVIVAL OF RAINBOW TROUT EGGS AND ALEVINS IN FLUCTUATING FLOWS

An Interim Report

by

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ABSTRACT

Fluctuations in water level of the Colorado River below Glen Canyon Dam may influence several aspects of the early life history of rainbow trout that presently support a blue-ribbon fishery. Despite regular observation over many years of active spawning in the river, recruitment of naturally spawned trout into the fishery appears to be unusually low. If fluctuations in water level reduce hatching success of eggs or reduce survival of sacfry (alevins) in the gravel or free-swimming fry once they emerge, this may contribute to the observed low recruitment. Field observations and both field and laboratory experiments suggest that exposure of eggs for periods of $\leq$ 10 hrs per day appears to have little effect on mortality. Exposure of eggs for $\geq$ 6 hrs per day shortens the hatching time, and exposure for 15 hrs reduces survival. Exposure of alevins for $\geq$ 6 hrs per day decreases survival. In addition to period of daily exposure, slope of the shoreline may influence the survivorship of alevins by altering the rates at which water drains from sediments. Young, recently-emerged trout are probably displaced downstream when changing water levels expose near-shore cover and areas of little or no current, sweeping them into fast current against which they cannot swim.

INTRODUCTION

Mark-recapture studies by the Arizona Game and Fish Department have demonstrated that the renown trout fishery in the Colorado River between Glen Canyon Dam and Lees Ferry is maintained primarily by stocking; there is little natural recruitment although successful construction of redds (nests) and successful production of fertilized eggs occur widely. We proposed that fluctuating water levels may affect three stages in the early life history of trout: eggs, alevins (fry remaining in redds and retaining the yolk sac), and free-swimming fry.

This research addresses three questions:

1. What is the effect of fluctuating water levels and associated exposure on hatching of rainbow trout eggs?
2. What is the effect of fluctuating water levels and associated exposure on survival of alevins (sac fry)?
3. What is the probable fate of fry after they emerge from nests (redds) in the gravel?

Research was initiated in Summer 1990 with descriptive field studies at Lees Ferry. These studies selected field sites, examined composition of gravels on and off known spawning areas, and measured temperature fluctuations above and below ground along a transect reaching from below the low water line to above the high water line.

During Fall-Spring 1991-1992, laboratory experiments were conducted to assess hatching of eggs and survival of alevins exposed to air for known periods (0,3,6,11,12,15 hrs). Similar experiments were later conducted in the field to determine the applicability of laboratory results to field conditions.

During Summer 1991, a single mark-recapture study on free-swimming fry (actually small fingerlings) was conducted to assess tendencies of fry to remain in proscribed areas under fluctuating flows. The techniques used for this study proved ineffective; a modified approach to the latter question has been devised for future test.

In the summaries below, we outline methods, identify the nature of data or samples collected, and identify preliminary results. An extension to Summer 1992 for completion of the study was granted due to an incapacitating injury to the Research Assistant during Summer 1991.

FIELD TEMPERATURE MEASUREMENTS

Question: How does air temperature affect substrate temperatures along a gravel bar?

Methods: Thermometers were strapped to metersticks at 10, 30 and 100 cm above the substrate along two transects at the 8-mile study site. Sampling points on each transect were: 1 m below the water line, at the waterline, and 5 m, 17.3 m and 26.1 m above the waterline. An additional sampling point was 40 m above the water line in desert vegetation, well beyond the immediate influence of the river. A YSI temperature meter was buried 11 cm below the surface along one of the transects in order to assess variations in subsurface conditions. This method of measurement was subsequently discarded in favor of several buried, continuously recording thermographs.

Results/Discussion: The temperatures recorded at 10 cm above the surface were slightly cooler than the temperatures at 30 and 100 cm. However, the range between the maximum and the minimum temperature was similar. Intergravel temperatures change more slowly than air temperatures and do not exhibit severe fluctuations over short periods.

Table 1. Summary of results from one transect at 8-mile site, 14-15 September 1990. Upper table: conditions at 10, 30 and 100 cm above surface at various positions along transect; lower table: conditions 10 cm below surface of gravel relative to 100 cm above surface.

	RANGE		
Position	**100 cm**	**30 cm**	**10 cm**
1 m below water line	18-26	15-24	13-20
water line	18-26	15-24	14-23
5 m above water line	18-26	16-24	16-23
26 m above water line	18-26	17-24	16-22
40 m above water line	18-26	...	...

Table 1 (continued).

TIME	TEMPERATURES AIR (at 1 m)	GRAVEL	AIR-GRAVEL
2000	25	19	6
2100	24	18	6
2200	24	18	6
2300	24	17	7
2400	26	17	9
0100	22	17	5
0300	21	15	6
0400	26	16	10
0500	20	15	5
0600	18	15.5	2.5
0700	20	14	6

LABORATORY EXPERIMENTS

Question: How does exposure affect the hatching success of rainbow trout eggs and the survival of the alevins?

Methods: Two Living Stream refrigerate, recirculating stream tanks were employed to answer this question. Each stream tank contained three cages; each cage had three levels, each of which was exposed for a different period each day. Four Whitlock-Vibert boxes (a commercially-available, plastic box designed to serve as hatching chambers for salmonid eggs) were placed on each level and surrounded by gravel collected at Lees Ferry. In the pilot experiment, each box contained 100 eggs; in subsequent experiments, each box contained 25 eggs. The cages were mounted on a pulley system so that each level could be exposed for known periods that simulated fluctuating flows at Lees Ferry.
The eggs and alevins are checked every other day. Eggs were scored as hatched, unhatched but viable, or dead; alevins were scored as dead or alive.

Pilot Experiment

Results: We restrict our considerations to fate of eggs during the first 11 days of the experiment (Table 2). By that day, hatching was much lower in the Control (0 hrs exposure per day) than in Treatments with 6 and 12 hours exposure per day. The percent of remaining eggs that were viable was also larger for the Control and 6 hour exposure than for the 12 hour exposure.

Table 2. Example of data from pilot experiment, including percent of eggs hatched by day 11 and percent of eggs remaining on day 11 that were viable.

	EXPOSURE		
	0 hrs	6 hrs	12 hrs
Percent hatch	24%	35%	92%
Percent eggs viable	100%	92%	32%

Experiment A

Results: The percent hatch was determined on the third and fourth day of the experiment (Table 3). Controls (0 hrs exposure per day) had lower percent hatch than exposure of 6 and 12 hours per day. As in the pilot experiment, extended exposure decreased the time to hatching.

Table 3. Percent of eggs hatched on days 3-4 of experiment A. Experiment was subsequently terminated due to loss of alevins from Whitlock-Vibert boxes.

	EXPOSURE		
	0 hrs	6 hrs	12 hrs
% hatch (Tank 1)	30%	27%	51%
% hatch (Tank 2)	23%	27%	47%

Experiment B

Results: Eggs subjected to 11 hours of exposure per day hatched sooner than at 6 and 0 hours exposure (Table 4). Heavy mortality began almost immediately in sacfry exposed for 11 hrs per day. After two weeks, many fewer sacfry remained alive after 11 hours of exposure than at 6 and 0 hrs. After almost three weeks of exposure, all sacfry exposed 100 hrs per day had died and the number of sacfry remaining alive at 6 hours of exposure was less than that of the control (Tables 1 and 2).

Table 4. Example of data from experiment B. Upper panel: percent of eggs hatched by days of the experiment for different levels of exposure (hours per day); lower panel: percent of hatched sacfry that remained alive on various days of the experiment.

	PERCENT HATCH ON DAY:						
Exposure	4	5	7	8	13	14	18
0 hrs	26	76	99	100	100	100	100
6 hrs	17	56	100	100	100	100	100
11 hrs	76	85	98	100	100	100	100

Table 4 (continued).

PERCENT OF SACFRY ALIVE

0 hrs	100	100	100	98	98	98	97
6 hrs	100	100	100	100	91	91	30
11 hrs	100	83	56	49	47	18	0

Experiment C

Results: Of eggs that hatched, those subjected to 15 hours of exposure per day tended to hatch sooner than those at 3 and 0 hours exposure; however, approximately 15% of these eggs failed to hatch. Exposure for 0-3 hrs appears to have had little effect on viability of sacfry. At 15 hrs exposure, mortality was complete almost immediately after hatching.

Table 5. Example of data from experiment C. Upper panel: percent of eggs hatched by days of the experiment for different levels of exposure (hours per day); lower panel: percent of hatched sacfry that remained alive on various days of the experiment.

PERCENT HATCH ON DAY:

Exposure	6	7	9	10	13	14	21	22	27
0 hrs	3	3	3	8	45	78	100	100	100
3 hrs	5	5	5	8	40	61	97	100	100
15 hrs	9	37	86	86	0	0	0	0	0

PERCENT OF SACFRY ALIVE

0 hrs	.	.	.	.	100	100	100	100	86
3 hrs	.	.	.	.	100	100	100	99	94
15 hrs	.	17	0	0	0	0	0	0	0

FIELD EXPERIMENTS

Survival of eggs and alevins

Experiments were conducted at both the 8 mile and 13.5 mile study sites to test applicability of laboratory data to field conditions. Whitlock-Vibert boxes, each loaded with 25 Bellaire-strain rainbow trout eggs, were placed at 4 water levels representing different periods of exposure under normal dam operating conditions: 1000 cfs level, 0 hrs exposed per day; 5000 cfs, 6 hrs; 10,000 cfs, 10 hrs; 15,000 cfs, 15 hrs. These periods of exposure in the field matched the 0, 6, 11-12 and 15 hrs of exposure in laboratory experiments.

Results: Hatching in all treatments at both sites began between days 7 and 12. By day 21, mortality of eggs and any hatched alevins was complete at both sites for both the 10,000 cfs and 15,000 cfs replicates. At the same time, samples at the 5000 cfs level differed markedly between the two sites: mortality was almost complete at the 13.5 mile site, but was only 15-50% at the 8 mile site. The difference may be due to slope of the shore. The 13.5 mile site is much steeper and may experience more rapid intragravel draining of water than does the 8 mile site.

Fate of emerged fry

Based on a single mark-recapture experiment, recently-emerged juvenile fish appear to be swept downstream or otherwise lost with large fluctuations in water level. Approximately 1000 large fry (60-70 mm total length, twice the size of naturally spawned fry present in the river [25-35 mm TL]), were released near shore at the 8 mile study site at approximately 1600 hrs. Triplicate seine hauls were made at the release site between 2115 and 2200 hrs. Hauls were in quiet water near submerged weed beds; 33 marked fry and 1 naturally-spawned fry were captured. A large aggregation of fry of the size released were observed adjacent to a submerged weed bed but beyond the reach of seine or electrofishing equipment. Additional seine hauls 100 m upstream produced no fry. Three seine hauls 100 m below the release site produced a single marked fish. Thus, in locally calm water under rising or stable water conditions, many released fish maintained their position.

All seine hauls were repeated at 0700-0730 the next morning. The areas previously seined, which included areas of sand and fine sediments with fully to partially exposed macrophytes, were exposed completely; seine hauls were across clean to lightly-sedimented cobble and gravel, through fast-flowing water, and onto a sand/gravel shore. No fish were collected in seine hauls. Electroshocking for a total of 194 seconds of woody debris imbedded in the sediments produced 2 marked and 2 unmarked trout; 4 additional fish were seen, 2 of which were the size of naturally spawned fry. No additional fish were seen offshore of the study area.

Seine hauls were again repeated at 1300 hrs, after water had returned to levels similar to those encountered during the previous night's successful collections. No trout were collected. Observers also drifted approximately 150 m over weed beds where the large aggregation of released trout had been seen the night before; only 2 fish of the size of stocked trout were observed.

PRELIMINARY CONCLUSIONS

Exposure for periods of $\leq$ 10 hrs per day appears to have little effect on mortality of eggs.
Exposure for 15 hrs per day increases egg mortality.
Exposure for $\geq$ 6 hrs per day shortens the hatching time for eggs.
Exposure for $\geq$ 6 hrs per day decreases survival of hatched alevins (sacfry)
Laboratory and field experiments produced similar results, suggesting that predictions made from simple laboratory experiments are generally applicable to the field.
Shoreline slope may influence the survivorship of alevins.
Young trout are probably displaced downstream when changing water levels expose near-shore cover and areas of little or no current.