EFFECTS OF SUSPENDED SEDIMENT ON THE DEVELOPMENT AND HATCHING SUCCESS OF YELLOW PERCH AND STRIPED BASS EGGS

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ABSTRACT

Yellow perch and striped bass eggs were incubated in suspensions of different concentrations of natural, fine-grained sediments. The results showed that in the laboratory concentrations of up to 500 mg/l did not significantly affect the hatching success of yellow perch or striped bass eggs, but that concentrations of 1000 mg/l did significantly affect their hatching success.

INTRODUCTION

There is a vast literature on the effects of sediments on organisms (see, for example, the bibliography by Sherk and Cronin, 1970), but very little of it deals with the effects of natural, fine-grained suspended sediments on the development and hatching success of fish eggs (Schubel and Wang, 1973). In 1971 the Chesapeake Bay Institute initiated a series of laboratory studies to determine the effects of different concentrations of natural, fine-grained suspended sediments on the development and hatching success of eggs of some of the important fishes of the Chesapeake Bay region.

This report summarizes some of the results of experiments conducted with yellow perch (*Perca flavescens*), and striped bass (*Morone saxitilis*) eggs. In each experiment, eggs from a single female were distributed among a control suspension, and several testing suspensions. The testing suspensions were made by enriching the control with different amounts of natural, fine-grained sediment. Concentration of the testing suspensions ranged from 50 to 1000 mg/l. The concentration of the control was always less than 10 mg/l.

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MATERIALS AND METHODS

It was necessary to develop a system for maintaining and renewing uniform suspensions of different concentrations of fine-grained sediments in a series of testing tanks. The apparatus that was devised has been described in some detial by Schubel, et al. (1972). Each experimental unit consisted of a testing tank with agitator, a feeder resvoir with agitator, and a mechanism for the automatic, periodic addition of replacement suspension from the feeder reservoir to the testing tank, Fig. 1. Fifteen gallon aquaria were used as testing tanks, 30 gallon plastic barrel liners as feeder reservoirs, and vertically reciprocating perforated plates driven by gear motors as the agitators to keep the particles in suspension. It was desirable to have the motion of the aquarium agitator plate as gentle as possible to minimize possible physical effects of the stirring on the eggs. It had to be vigorous enough, however, to keep the particles in suspension. The appropriate amplitude and frequency

of plate motion are achieved by appropriate linkage and motor speed selection. A total travel of 10 cm and an 18 RPM motor were used. This combination produces a mean plate speed of about 3 cm/sec.

A renewal time of approximately 24 hours was selected for gradual, complete replacement of each aquarium suspension to avoid any buildup of undesirable waste products. This time interval precluded renewal by continuous flow because of sedimentation that occurred in the plumbing lines with the very low continuous flow rates dictated by the 24 hour renewal time. Replenishment was accomplished by periodic slug additions of 1150 ml to each aquarium every 30 minutes. This intermittent flow was produced with electric pinchcocks programmed from a 30 minute repeat cycle time switch.

The testing aquaria were partially immersed in a constant temperature bath set at the average temperature on the spawning grounds. The temperature of each of the two baths could be controlled independently, and each bath held five testing aquaria--a control and four testing tanks. The temperature of the feeder suspensions was not controlled. The thermal mass of the periodic additions of feeder suspensions that a constant temperature was easily maintained. The testing suspensions were aerated throughout the experiments. suspensions were aerated throughout the experiments.

Natural, fine-grained Chesapeake Bay bottom sediments were used in the experiments. The sediment was fractionated by settling to select particles with settling velocities less than about 5 x 10-3cm/sec (Schubel and Wang, 1973). Appropriate masses of this material were then added to water from the spawning grounds to produce suspensions of the desired concentrations--50, 100, 500, and 1000 mg/l. Water from the spawning grounds that had settled for 48-72 hours was used as the control suspension. The concentration of total suspended solids in the control was always less than 10 mg/l, and was generally less than 5 mg/l. The procedures for preparing the suspensions have been described in detail by Schubel and Wang (1973). The concentration of suspended sediment in each aquarium was monitored by removing small, 200 ml, volumes of suspension every 4-6 hours. These samples were filtered through pre-weighed 0.6 pore diameter membrane filters, desiccated, reweighed, and the concentration in mg/l calculated.

For the yellow perch experiments, naturally spawned egg masses were collected from the upper reaches of several of the small tributaries to the Chesapeake Bay. All striped bass eggs used in the study were artificially fertilized. For each striped bass experiment a female was stripped-out into a finger bowl and fertilized with the milt from several males. The eggs were left in the milt for approximately five minutes and rinsed thoroughly with water from the spawning grounds. All eggs were placed in insulated ice chests for transportation to the field laboratory. During transport, the water was aerated. At the laboratory, the eggs were held in a constant temperature bath.

To begin an experiment, four or five sub-samples of 100 - 500 eggs each were withdrawn from the sample of eggs from a single female, placed in specially constructed hatching boxes, and distributed among the aquaria containing the different testing suspensions. In the case of striped bass, the desired numbers of viable eggs were individually withdrawn from the sample with a large pipette. For yellow perch, an egg mass was cut into the desired number of sections, and the pieces were distributed among the aquaria.

The hatching boxes were made by replacing the plastic bottoms of standard aquarium store breeding traps with nylon screen. The largest mesh size that would still retain the eggs was selected. The hatching boxes floated freely in the aquaria.

During the course of an experiment dead eggs were removed from the boxes, counted, and preserved. Periodically, a few eggs were extracted from each hat-

ching box, examined microscopically for any morphological evidence of aberrant development, photographed, and preserved in formalin for later study. Upon termination of each experiment, the absolute hatching success was determined for the sub-sample of eggs put into each box at the start of the experiment. The absolute hatching success is defined as that fraction of eggs. initially placed in the box that hatched. Relative hatching successes were also calculated. The relative hatching success of a sub-sample is defined as the absolute hatching success of that sub-sample divided by the absolute hatching success of the control sub-sample--the sub-sample of eggs incubated in the control suspension. Both the absolute and relative hatching successes are expressed as percentages.

Larvae were examined microscopically for any morphological evidence of aberrant development, and preserved in formalin for later study.

RESULTS AND DISCUSSION

Five experiments were conducted with yellow perch eggs, Table 1. A two-way analysis of variance was run on the combined absolute hatching successes to determine whether the different suspensions had a statistically significant effect on hatching success. Before the analysis was made, the data were transformed with the standard arcsin transformation. In the statistical analysis each fish was considered a block, and each suspension, including the control suspension, was considered a treatment. The results of the analysis show that the differences in hatching success among the five treatments are not significant. Comparisons of the results for each of the four test suspensions with the control suspension show that only in the 1000 mg/l suspension did the eggs have a significantly (at the 90% lovel) lower hatching success than in the control suspension. There was no morphological evidence of abnormal development in any of the suspensions.

Five experiments were also run with striped bass eggs, Table 2. A two-way analysis of variance shows that the differences in hatching success among the various treatments, including the control treatment, are significant at the 95% level. Comparisons of the results for each of the four test suspensions with the results for the control suspension show that only the 1000 mg/l suspension produced a significant decrease in hatching success. This effect was however, highly significant (99.9% level). There was no morphological evidence of abnormal egg development in any of the suspensions tested.

In similar experiments with yellow perch and striped bass eggs, Schubel and Wang (1973) reported that suspensions of fine-grained sediments with concen-'trations of up to 500 mg/l—the highest concentration they studied--had no significant effect on hatching success of eggs of either of these species.

In summary, our experiments show that in the laboratory suspensions of natural, fine-grained sediment with concentrations of up to approximately 500 mg/l had no statistically significant effect on the hatching success of either yellow perch or striped bass eggs. Concentrations of 1000 mg/l however, did result in significantly lower hatching success of eggs of both of these species. These results should be transferrable to relatively well-mixed, natural environments. In nature, concentrations of suspended sediment as great as 1000 mg/l are relatively rare, even in areas of dredging activity.

We have also investigated the effects of suspended sediment on the larvae of these species, but the data have not been analyzed.

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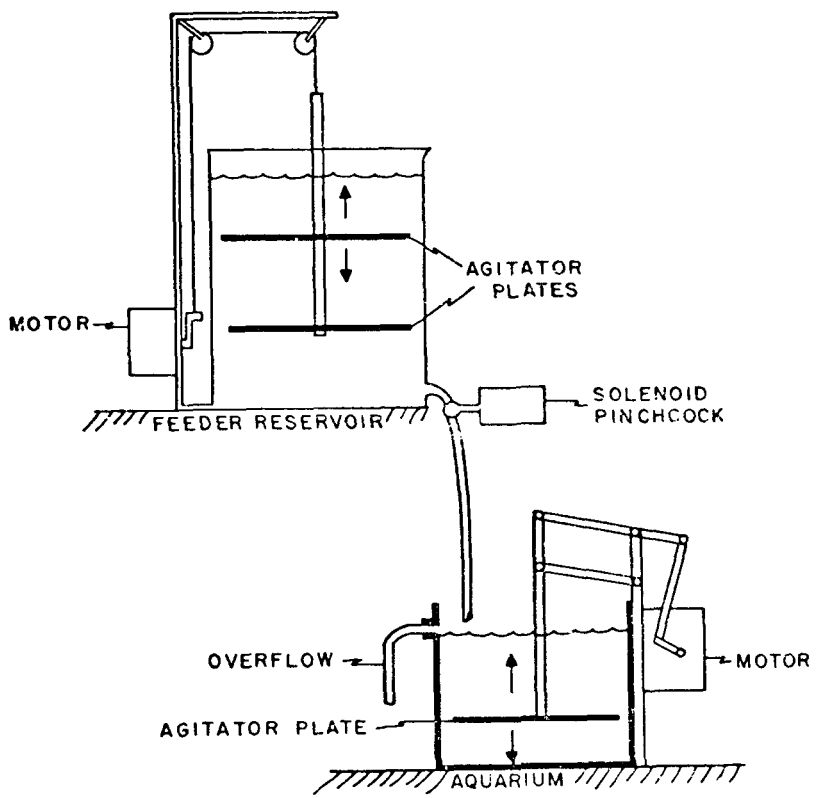

Figure 1. Apparatus used for maintaining and renewing uniform suspensions of fine-grained sediments.

Table 1. Hatching Success of Yellow Perch (*Perca flavescens*) Eggs Incubated in Suspensions of Different Concentrations of Natural, Fine-Grained Sediments.

Expt.	Developmental Stage at Start of Experiment		Hatching Success (%) Control		50 mg/l		100 mg/l		500 mg/l		1000 mg/l	
1	Gastrula	Absolute	494/506	= 98	493/497	= 99	412/432	= 95	545/591	= 92	472/512	= 92
		Relative	100		102		98		94		94	
2	Gastrula	Absolute	283/307	= 92	304/345	= 88	312/389	= 80	510/601	= 85	289/340	= 85
		Relative	100		96		87		92		92	
3	1 & 2 cell stage	Absolute	191/194	= 98	392/423	= 93	148/159	= 93	160/250	= 64	297/305	= 97
		Relative	100		95		95		65		99	
4	Mid-embryo	Absolute	498/508	= 98	503/510	= 99	483/500	= 97	501/517	= 97	513/535	= 96
		Relative	100		101		99		99		98	
5	8 to 16 cell stage	Absolute	155/161	= 96	198/205	= 97	227/316	= 72	290/302	= 96	97/180	= 54
		Relative	100		101		75		100		56	

Table 2. Hatching Success of Striped Bass (*Morone saxitilis*) Eggs Incubated in Suspensions of Different Concentrations of Natural, Fine-Grained Sediments.

Expt.	Developmental Stage at Start of Experiment		Hatching Success (%) Control	50 mg/l	100 mg/l	500 mg/l	1000 mg/l
1	Early embryo	Absolute	91/109 = 84	103/120 = 86	72/101 = 71	67/105 = 64	41/120 = 34
		Relative	100	102	85	76	40
2	Early gastrula	Absolute	177/190 = 93	118/136 = 87		88/102 = 86	109/155 = 70
		Relative	100	94		92	75
3	Early embryo; head & tail bud	Absolute	120/213 = 56	84/214 = 39	135/222 = 61	116/220 = 53	118/219 = 54
		Relative	100	70	109	95	96
4	Early embryo; almost tail-free	Absolute	87/101 = 86	83/111 = 75	101/120 = 84	68/107 = 64	74/107 = 69
		Relative	100	87	98	74	80
5	Late gastrula to early embryo	Absolute	164/204 = 80	136/209 = 65	157/221 = 71	141/208 = 68	153/215 = 71
		Relative	100	81	89	85	89