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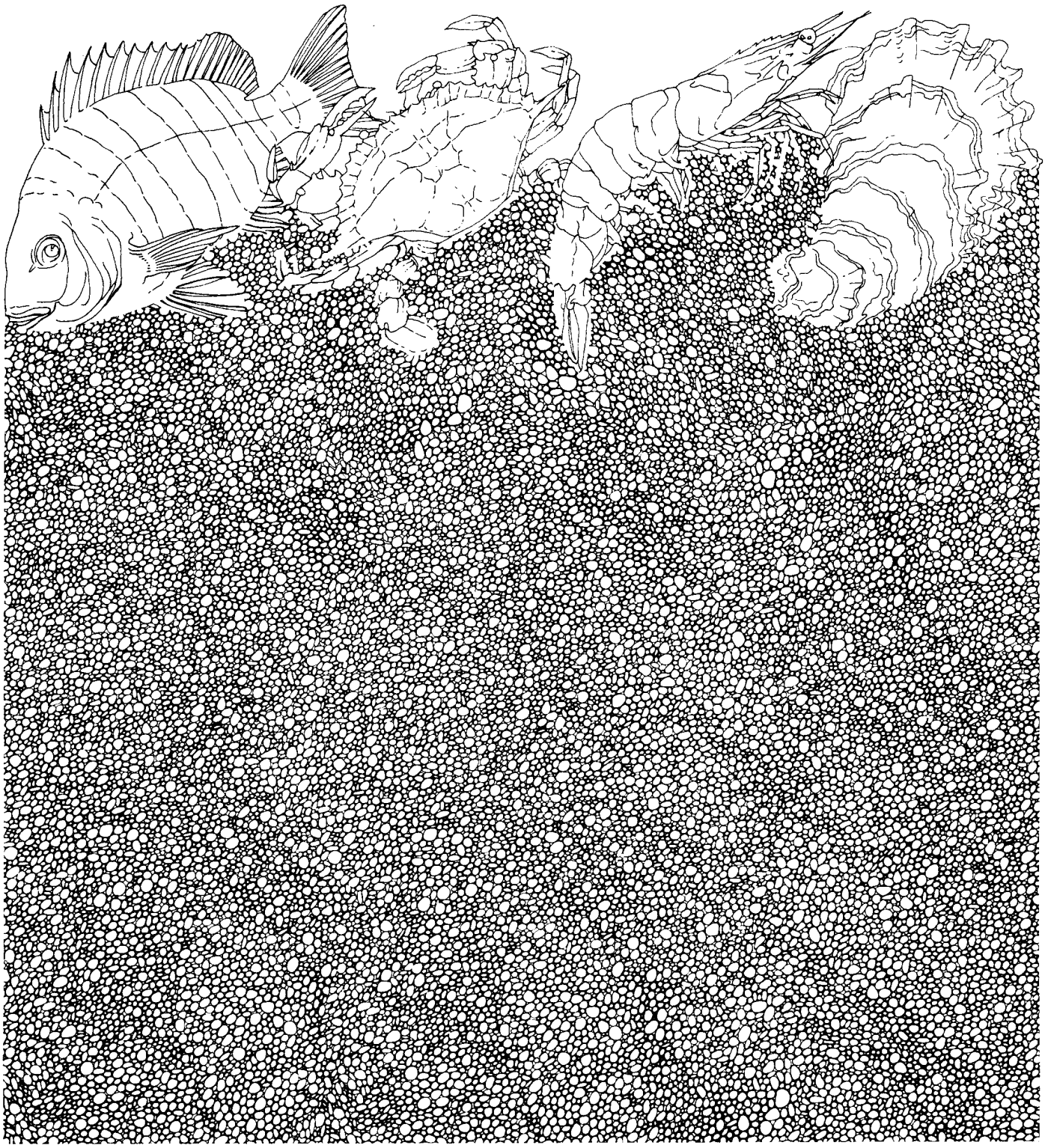

A PRELIMINARY ANALYSIS OF THE EFFECTS OF TEMPERATURE AND SALINITY ON HATCHING OF SPOTTED SEATROUT

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ABSTRACT

The effects of temperature and salinity on hatching of spotted seatrout (Cynoscion nebulosus) eggs were examined. Spotted seatrout embryos obtained from a single hormone-induced spawn were exposed to twenty-five combinations of temperature (20, 23, 26, 29, and 32 C) and salinity (5, 15, 25, 35, and 45 o/oo). Hatching was observed at all temperature and salinity combinations except 45 o/oo, which had no survival at any test temperature. Salinity, temperature, and their interaction significantly affected percent hatch and the percent of unhatched embryos. Hatching success was significantly better in the 15 and 25 o/oo test salinities. Hatching was significantly poorer at the 20 C test temperature. The occurrance of unhatched embryos was significantly higher in the 5 o/oo test salinity. Results indicated successful spawning may be reduced significantly in hypersaline (> 45 o/oo) habitats.

INTRODUCTION

The Spotted seatrout (Cynoscion nebulosus) is an economically important estuarine fish which tolerates a wide range of temperatures and salinities throughout its New York to Tampico, Mexico range (Guest and Gunter 1958). Spawning is generally accepted as occurring from April to September (Hein and Shepard 1979). However, gravid spotted seatrout are present year round in Florida (Stewart 1961), and spawning along the Texas coast may extend from March to November (Pearson 1929, Gunter 1945, Miles 1950, 1951). Therefore, eggs are exposed to a wide range of temperatures and salinities which could affect hatching. Taniguchi (1981) reported spotted seatrout eggs died at 5 o/oo and at > 50 o/oo. However, no studies have been conducted concerning effects of temperature and salinity or their interaction on hatching success of spotted seatrout eggs. The objective of the present study was to determine the effect of 25 temperature-salinity combinations on hatching success of spotted seatrout eggs.

MATERIALS AND METHODS

Embryos for experimentation were obtained by hormone induced strip spawning of one 640-g female using methods of Colura (1974). The spawn was placed in a 3-liter glass bowl and fertilized by a single male using the dry fertilization method (Davis 1953). After fertilization, 1 liter of 25 C Matagorda Bay water with salinity adjusted to 29 o/oo was added to the eggs. The total volume of eggs and water was determined, and three 1-ml aliquots were removed with a Hensen-Stemple pipet. Eggs in each subsample were counted and the total number of eggs was determined by volumetric estimation (Bonn et al. 1976). Eggs were placed in an aerated 37-liter aquarium at 25 C and 29 o/oo salinity. Volume was adjusted so that the aquarium contained approximately 6 eggs/ml. Percent fertilization was determined by examining three samples of approximately 100 eggs each for mitotic division 2 h post-fertilization.

Five replicates of eggs were tested at five temperature (20, 23, 26, 29 and 32 C) and five salinity (5, 15, 25, 35, and 45 o/oo) combinations. Samples containing approximately 30 eggs were taken from the aquarium using a 5-ml Hensen-Stemple pipet. The sample was then filtered through a 63-μm sieve, and eggs washed into each replicate 30-ml plastic container using 25 C water adjusted to test salinities. Test salinities were formulated by mixing filtered Matagorda Bay saltwater with deionized water or artificial sea salts (Fritz Chemical Co., Dallas, Texas) and measured with an S-C-T meter (Model 33, Yellow Springs Instrument Co., Yellow Springs, OH). Salinity was measured in the containers at the beginning and end of the experiment with a temperature compensated salinity refractometer (Aquafauna Biomarine Inc., Hawthorne, CA). Egg containers were supported on racks and placed into a five-compartment water bath system similar to that described by Bumguardner and Maciorowski (1988) to control temperature. Water was maintained within 0.5 C of nominal test temperatures by quartz immersion heaters (Model TH-1000, Sethco Division, Hauppauge, NY) water chillers (Model BHL-842D, Frigid Units, Toledo, OH), and temperature controllers (Model 74, Yellow Springs Instrument Co., Yellow Springs, OH). Temperature was monitored with a telethermometer (Model 46TVC, Yellow Springs Instrument Co., Yellow Springs, OH).

Spotted seatrout eggs incubated at temperatures ≥ 23 C hatch in approximately 16-21 hours (Fable et al. 1977). Accordingly, eggs incubated at 23, 26, 29 and 32 C were maintained for 24 h. Hatching time at 20 C has not been documented, therefore eggs at this temperature were maintained 48 h to assure complete hatch. Replicates of each treatment were preserved individually in 4% buffered formaldehyde. Percent hatch and the percent of unhatched embryos in each replicate were determined using a stereomicroscope at 40X; a mean percent hatch for each treatment was calculated. Eggs were considered developed if the surviving embryos failed to hatch, but were developed within the chorion. Effect of temperature, salinity, and interaction of temperature and salinity on percent hatch and percent of unhatched embryos occuring was examined by two-way analysis of variance. All percentage data were arc-sin transformed prior to analyses to create a normal distribution. The Student-Newman-Kuels test (Sokal and Rohlf 1969) was used to group statistically similar data. Statistical analyses were performed with the Statistical Analysis System (SAS Institute Inc. 1985).

RESULTS

Hatching and embryonic development occurred at all temperature and salinity combinations with the exception of those at 45 o/oo (Tables 1 and 2). No hatching or embryonic development occurred at any temperature when salinities equaled 45 o/oo. Hatching occurred at 5 o/oo but all eggs immediately sank to the bottom of the test containers. Approximately 50% of the eggs, as determined by visual inspection, sank at 15 o/oo. Mean percent hatch improved from 40.2% at 5 o/oo salinity to 64.9% at 15 o/oo salinity, then steadily declined as the test salinities increased (Table 1). Mean percent hatch increased from 31.2% at 20 C to 43.7% at 23 C, and ranged 42.6-38.8% at remaining temperatures. Greatest number of developed but unhatched embryos ($\bar{x}$ = 18.9%) were observed at 5 o/oo salinity (Table 2), mean percent of unhatched embryos observed at the remaining test salinities ranged 0.0-8.3%. Mean percent of unhatched embryos present ranged 2.7-9.2% at the five test temperatures.

Salinity, temperature, and interaction of salinity and temperature significantly affected hatching (Table 3). Mean percent hatch at the 15 (64.9%) and 25 o/oo (57.8%) test salinities were significantly greater than those of other test salinities (Table 1). Mean percent hatch at 20 C (31.2%) was significantly poorer than those at the remaining test temperatures. The mean percent of unhatched embryos present was also significantly affected by salinity, temperature and their interaction (Table 3). A significantly greater mean percentage of unhatched embryos were found at 5 o/oo salinity (18.9%) than were observed at the other test salinities (Table 2). A significantly smaller mean percentage of unhatched embryos were found at 29 C (2.7%) than was observed at the 23, 26 and 32 C test temperatures. The mean percent of unhatched embryos present at the 20 C test temperature was statistically similar to that found at all test temperatures.

DISCUSSION

Temperature and salinity combinations commonly found on the Texas coast during the spotted seatrout spawning season may affect spawning success. Spotted seatrout eggs utilized in this study hatched at 5 o/oo salinity, whereas, Taniguchi (1981) reported no hatching at that salinity. Although hatching did occur at 5 o/oo salinity, eggs sank and under natural conditions might settle into the bottom sediments and not survive. The highest test salinity (45 o/oo) resulted in death of all eggs indicating successful spawning in hypersaline habitats may be reduced. These findings support those of Tanaguchi (1981) who also found hypersaline conditions (> 50 o/oo) prevented hatching of spotted seatrout eggs. Further, Simmons (1957) reported that, based on field collections of juveniles, no spawning occurred in the Laguna Madre, Texas when salinities were > 45 o/oo.

However, care should be exercised in making general conclusions based on results of this study. Embryos utilized in the present study were produced by a single set of Matagorda Bay parents accustomed to salinities ranging approximately 10-25 o/oo (McEachron and Green 1986). This might explain why greatest percent hatching occurred at the 15 and 25 o/oo test salinities. Spotted seatrout populations resident in hypersaline habitats may adapt to the conditions and spawn successfully.

Mean hatch rate was reduced only at the lowest temperature (20 C) suggesting hatching success might be reduced at the beginning and end of the spawning season when temperatures approach 20 C. Brown-Peterson et al. (1988) suggested that 23 C could be the minimum temperature for successful spawning of spotted seatrout, because of their failure to capture ripe fish at lower temperatures.

Unhatched embryos were more common at the 5 o/oo test salinity regardless of temperature. The reason for a significantly greater percent of unhatched embryos at the low test salinity is not clear but may be common for sciaenids in general. May (1975) reported unhatched eggs of Bairdiella sp. were most common at low test salinities (10-20 o/oo). He postulated that reduced salinities increased the incidence of malformations, resulting in embryos being physically unable to break through the chorion.

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Table 1. Mean (± SD) percent hatch of spotted seatrout eggs exposed to different temperature-salinity combinations (n=125). Means lacking a letter in common are significantly different from each other ($P < 0.05$).

Salinity (o/oo)	Temperature (C) 20	23	26	29	32	Mean (± SD) % hatch at test salinity
5	21.3 ± 16.6	61.2 ± 8.7	44.0 ± 26.2	42.7 ± 5.2	31.5 ± 13.7	40.2 ± 19.9 A
15	73.0 ± 8.4	59.5 ± 12.2	62.8 ± 7.6	65.2 ± 7.8	64.0 ± 24.3	64.9 ± 13.2 B
25	53.6 ± 9.4	49.9 ± 16.8	58.2 ± 12.5	59.7 ± 13.4	67.7 ± 10.0	57.8 ± 13.1 B
35	7.9 ± 6.2	47.7 ± 15.5	39.5 ± 10.0	45.4 ± 11.6	30.9 ± 26.9	34.3 ± 20.5 A
45	0.0	0.0	0.0	0.0	0.0	0.0
Mean (± SE) % hatch at test temperature	31.2 ± 29.7B	43.7 ± 25.5A	40.9 ± 26.1A	42.6 ± 24.8A	38.8 ± 30.1A	

Table 2. Mean (± SD) percent unhatched embryos in spotted seatrout eggs exposed to different temperature-salinity combinations (n=125). Means lacking a letter in common are significantly different from each other ($P < 0.05$).

Salinity (o/oo)	Temperature (C) 20	23	26	29	32	Mean (± SD) unhatched embryos at test salinity
5	32.3 ± 3.9	4.1 ± 2.9	19.9 ± 18.9	12.5 ± 12.1	25.9 ± 10.9	18.9 ± 14.5A
15	0.0	9.8 ± 14.1	5.7 ± 4.7	0.0	6.1 ± 13.5	4.3 ± 9.1C
25	0.0	8.7 ± 6.9	6.0 ± 8.8	0.00	0.8 ± 1.7	3.1 ± 5.9C
35	3.5 ± 4.5	18.3 ± 10.5	14.3 ± 9.2	0.8 ± 1.9	4.2 ± 4.3	8.3 ± 9.4B
45	0.0	0.0	0.0	0.0	0.0	0.0
Mean (± SE) % unhatched embryos at test temperature	7.2 ± 13.1AB	8.2 ± 10.0A	9.2 ± 11.9A	2.7 ± 7.1B	7.4 ± 12.2A	

Table 3. Analysis of variance of percent hatched and unhatched embryos of spotted seatrout eggs exposed to different temperature-salinity combinations.

Source	Hatched			% Unhatched embryos		
	F	df	P	F	df	P
Temperature (T)	4.6	4	0.0018	5.3	4	0.0007
Salinity (S)	165.2	4	<0.0001	32.8	4	<0.0001
T X S	3.6	16	<0.0001	4.1	16	<0.0001

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