

The Effect of Minimum Temperature on the Survival of Larval Atlantic Menhaden, *Brevoortia tyrannus*

INTRODUCTION

Experiments were performed at Beaufort, North Carolina, from January to April 1964, to ascertain the effect of low temperatures on survival of Atlantic menhaden larvae. Field studies by the Bureau of Commercial Fisheries in Delaware and North Carolina showed that larval menhaden were present in collections from October to May and abundant from December through March. June and Chamberlin (1959) reported that larvae occurred in abundance outside the river mouths after hatching at sea, and entered the estuaries during winter and spring months. However, larvae were absent from the plankton tows when water temperatures went below 3.0 C. Thus, entry of menhaden larvae into the estuary apparently can be affected by water temperature. Kinne (1963) considered temperature a primary factor governing survival and distribution of marine animals.

COLLECTIONS OF EXPERIMENTAL STOCK

Larval menhaden, 17 to 34 mm total length, were collected in Beaufort Harbor with a 1-m plankton net of 0.9-mm braided nylon mesh attached to a Chesapeake Bay-type crab float, 120 by 90 by 40 cm, lined with plastic screen. The cod end of the net was connected by a stainless-steel clamp to an 8-cm pipe that projected from one end of the float. The net, tied to a bridge near the center of the channel, was fished at night during flood tide. The tidal current swept several species of larval fish through the net and into the float. Once the current started to slack, few larvae entered the net.

The larvae were attracted to the surface of the crab float with a 6-v marine lantern, then dipped into 10-liter plastic buckets. Larvae were transported to the laboratory within 20 minutes and since exposure to air causes death, they were kept in water at all times during the transfer. Little sloshing was permitted in the buckets as this action also may cause death. The menhaden were separated from other fishes in the laboratory.

EQUIPMENT AND PROCEDURE

Three tanks, painted with nontoxic black Inertol¹, held larvae prior to their transfer to an acclimation tank. A standpipe maintained the water depth at 20 cm in each of two smaller tanks, 60 by 130 cm and suitable for holding 300 larvae. Water depth was maintained by a standpipe at 25 cm in a larger tank, 80 by 120 cm, suitable for holding 400 larvae.

Salt water from Beaufort Harbor, pumped through a filter of glass wool and marble chips to remove silt and organisms, flowed continuously into the holding tanks and kept the water temperature in these tanks approximately the same as in the harbor.

The acclimation tank, a converted chest-type freezer lined with Fiberglas¹ and painted with Inertol, was suitable for holding 150 larvae. It was divided into two sections, each measuring 60 by 60 cm, with water depth maintained at 23 cm. The water temperature

was held constant by a mercury regulator. The regulator controlled an electronic relay that either activated a 500-w immersion heater or a solenoid valve that controlled the coolant in coils embedded in the walls of the freezer.

Three separate Fiberglas chambers, each measuring 80 by 80 cm and filled with water to a height of 28 cm, were used to test larvae. Temperature was controlled as in the acclimation tank except that the cooling coils were exposed directly to the water in each chamber. A wooden frame in each chamber supported four polyethylene 10-liter buckets containing larvae. These buckets were filled with 8 liters of water and submerged until the water level in the buckets was the same as the chamber. Temperature of the water in each chamber was recorded continuously with a thermograph.

Compressed air was used to oxygenate and stir the water in the acclimation tank, the Fiberglas chambers, and the polyethylene buckets. Dissolved oxygen, checked periodically in all containers, ranged from 80% to 95% saturation. Once each day newly hatched brine shrimp were fed to all larvae.

Larvae were subjected to test temperatures they might encounter in the estuary to determine the relation between survival time and temperature. Larvae were acclimated for 12 hours or longer at temperatures of 7.0, 10.0, 12.5, 15.0, and 20.0 C. For each test, 10 larvae were placed in each of four polyethylene buckets at the acclimation temperature, or a total of 40 larvae. The buckets were immersed in the Fiberglas chambers held at preset temperatures. The water in the buckets reached temperature equilibrium within 2 to 3 hours. Each test was continued until 50%, or more, of the larvae died. A median value, expressing 50% survival time, was calculated from the combined four replications. Each series of tests included temperatures between 0.0 and 6.0 C by half-degree intervals. However, in the 10.0 C acclimation series, a test at -1.0 C also was included, and in the 15.0 C series, 7.0 and 8.0 C tests were made. A control bucket with 10 larvae was aerated and kept at room temperature for each test.

In all tests, salinities were measured by a conductivity bridge and adjusted to $24 \pm 1\%$

¹ The Bureau of Commercial Fisheries neither recommends nor disapproves the products referred to in this paper.

TABLE 1.—Number of hours to 50% mortality of menhaden larvae exposed to different temperatures

Acclimation temperature Celsius	Test temperature C							
	-1.0	0.0	0.5	1.0	1.5	2.0	2.5	3.0
7.0	—	8.5	11.5	13.0	33.5	38.5	40.5	37.5
10.0	4.4	5.2	9.0	5.3	16.7	20.4	23.0	33.2
12.5	—	4.2	7.0	9.6	13.4	17.9	17.7	36.0
15.0	—	3.4	6.4	6.0	4.5	14.5	10.0	23.4
20.0	—	2.1	—	—	—	3.2	—	—

Acclimation temperature Celsius	Test temperature C							
	3.5	4.0	4.5	5.0	5.5	6.0	7.0	8.0
7.0	77.0	96.0	>137.5	>137.5	—	—	—	—
10.0	46.0	26.8	132.7	130.0	>144.0	>144.0	—	—
12.5	39.2	45.0	60.0	132.0	216.0	>216.0	—	—
15.0	18.9	45.7	36.4	140.0	140.0	70.0	82.8	>169.0
20.0	—	11.2	—	—	—	—	—	—

by the addition of distilled water. Evaporation was reduced by a Plexiglas¹ cover over each bucket.

Overhead, pink, 40-w fluorescent tubes gave continuous lighting. Perlmutter and White (1962) recommended pink lights for fish hatcheries after concluding that the strong emission of visible blue light by cool-white fluorescent tubes caused a high mortality among brook trout eggs.

In those experiments where all larvae died, the lengths of larvae were examined to determine if there was any relation between the size of larvae and the length of time the larvae survived. Experiments were run so that observations could be made prior to and following the time of 50% mortality. Larvae were considered dead when no body movement occurred or could be induced. If larvae revived when removed from the water, they were returned to their test bucket.

RESULTS AND DISCUSSION

Behavior of larvae in test buckets followed a definite pattern. As they became chilled they lost equilibrium, floated and twitched erratically, and finally settled on the bottom. A response could be initiated by touching these larvae with a probe. Larvae that apparently were dead could be removed from the water and warmed; if still alive, heart pulsations or muscle reflexes occurred.

Table 1 lists the number of hours that larvae survived before a 50% mortality occurred. Generally, larvae acclimated at cooler temperatures survived longer at a given test temperature than those acclimated at warmer temper-

atures. Due to equipment failure and subsequent repair, some of the larvae from the 15.0 C acclimation series were in holding and acclimation tanks for a month or longer. Ordinarily, larvae were kept in these tanks for 2 weeks or less. The uneven results in the 15.0 C acclimation series may be due to holding larvae an extended time or possibly are characteristic of larvae acclimated at this temperature. Only three tests could be completed in the 20.0 C acclimation series.

In several cases during equipment failure, the water temperature dropped to near freezing for several hours. Approximately one-third of the larvae that were exposed to this low temperature for less than 3 hours recovered when warmed to room temperature.

Length frequencies of larvae from those experiments in which all larvae died indicated no relation between the size of larvae and survival time.

With few exceptions, larvae acclimated at 7.0 C survived 0.0 to 4.0 C approximately 1.5 to 3.5 times longer than those acclimated at warmer temperatures and the survival time increased with increased test temperature. There was a marked difference in the survival time of larvae acclimated at different temperatures and tested at 4.5 C. Larvae acclimated at 7.0 and 10.0 C survived over twice as long as those acclimated at 12.5 or 15.0 C. Larvae survived equally well at 5.0 C for all acclimation temperatures. Those tested at 5.5 C and above survived for approximately 6 days or more, except for larvae acclimated at 15.0 C. Larvae from the 15.0 C series showed poor

survival at 6.0 and 7.0 C, possibly due to holding larvae more than a month. Larvae in the control buckets did not die during any experiment. On the basis of these data, it appears that acclimation temperature is more important to the survival of larvae at test temperatures less than 5.0 C than it is at 5.0 C and above.

The experiments conducted in the laboratory partially explain the absence of menhaden larvae in plankton collections taken when water temperatures were below 3.0 C. Whether the larvae were killed or avoided the cold water in the estuaries has not been determined.

LITERATURE CITED

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