RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES.

Serial No.1684
(D.c.9)

ICNAF Res.Doc. 66-68

ANNUAL MEETING - JUNE 1966

Orientation of juvenile herring (Clupea harengus) to temperature and salinity

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Experiments have been conducted at the Bureau of Commercial Fisheries Biological Laboratory at Boothbay Harbor to determine the response of juvenile herring to temperature and salinity as an aid to predicting their movements near the coast of Maine. Specimens were obtained from the catches of local fishermen, transported alive to the laboratory and stored in large wooden tanks. The experimental apparatus was a rectangular fiberglass tank 5.5 meters in length, 30 x 40 centimeters in section, and was divided into three compartments by a pair of plexiglass panels equipped with sliding doors. The temperature or salinity in either end compartment could be controlled by adding heated sea water or fresh water.

Each experiment consisted of a series of trials wherein a group of fish were given the choice of two temperature (or salinity) alternatives. The fish were released from the center compartment and allowed to select the end of the tank where the conditions were most to their liking. With each successive trial the two alternatives were reversed with respect to the right and left ends of the tank. The number and percentage of fish present in each compartment was observed and recorded at 15-minute intervals for two hours on each trial. The averages for six to twelve trials were calculated, and

the differences between the mean percentages on the warm end (right and left) and the cool end (right and left) were tested by analysis of variance for significance. Several ranges of temperature choices were offered the fish. Groups of fish previously adapted to three temperature levels (3°, 7-9°, and 15°C) were investigated separately.

As shown graphically in Figure 1, the herring adapted to 3° showed a strong preference for mean temperatures of 5.8-5.9°C over 2.6-2.8°C; they showed a weak, but significant, preference for a mean temperature of 5.3° over 10.0°. The preferred temperature for these cold adapted fish was thus estimated to be about 6-7°C. The herring adapted to 7-9° showed a strong preference for 9.8°-10.2°C over 7.2°-7.5°, and an equally strong preference for 11.2-11.3° over 14.2°-14.8°, and therefore the preferred temperature for these fish was estimated at about 10°. Herring adapted to 15°C showed a strong preference for 9.7°-9.8° over 6.3°-6.8°, indifference between 11.5°-11.7° and 14.7°-14.8°, and a strong preference for 14.9° over 18.6°-18.7°. The preferred temperature was estimated as being about midway between 11.5° and 15° or about 13°C. Unfortunately, in several experiments the herring showed a strong bias for the left end of the tank; by reversing the direction of the temperature differential from left to right with each experimental trial, however, the temperature effects could be separated from the bias effects in the statistical analysis.

Other experiments showed that prior adaptation as brief as one hour could modify the temperature preference. When fish are exposed to a broad range of temperature conditions, the selected temperature eventually reverts to a value independent of prior adaptation. In Fig. 2 this value is shown where the curve of preferred temperatures intersects the diagonal; that is, at the point where adaptation temperature and preferred temperature are equal. With the experimental herring, this appears to be about 12°C.

Similar experiments were done to determine the preference of herring for salinity. At low temperatures (below 12°C) the herring showed significant preferences for salinites above 29 o/oo. At warmer temperatures, they preferred salinities less than 29 o/oo, but given choices at several levels below this (down to 15 o/oo) the herring showed only indifference. Prior adaptation to low salinity reversed the preference at low temperatures to below 29 o/oo. The natural environment of herring along the Maine coast is predominantly one of high salinity, seldom less than 25 o/oo, hence the question of salinity preference below this level is largely irrelevant.

Although the responses of herring to temperature and salinity may be only a small part of the total complex of factors governing herring movements, the known behavior of the juvenile herring along the Maine coast seems to be in essential accord with the experimental results. When the inshore waters cool in the fall, the herring tend to move offshore into deeper water where winter temperature is slightly warmer than the shallow water near the land. In the spring,

the inshore waters become warmer than those offshore, and the young herring occupy these waters throughout the warm season. During the warmest part of the summer, some evidence is available from tagging experiments which indicates that the herring move away from areas where the temperature is 15° or higher towards cooler water.

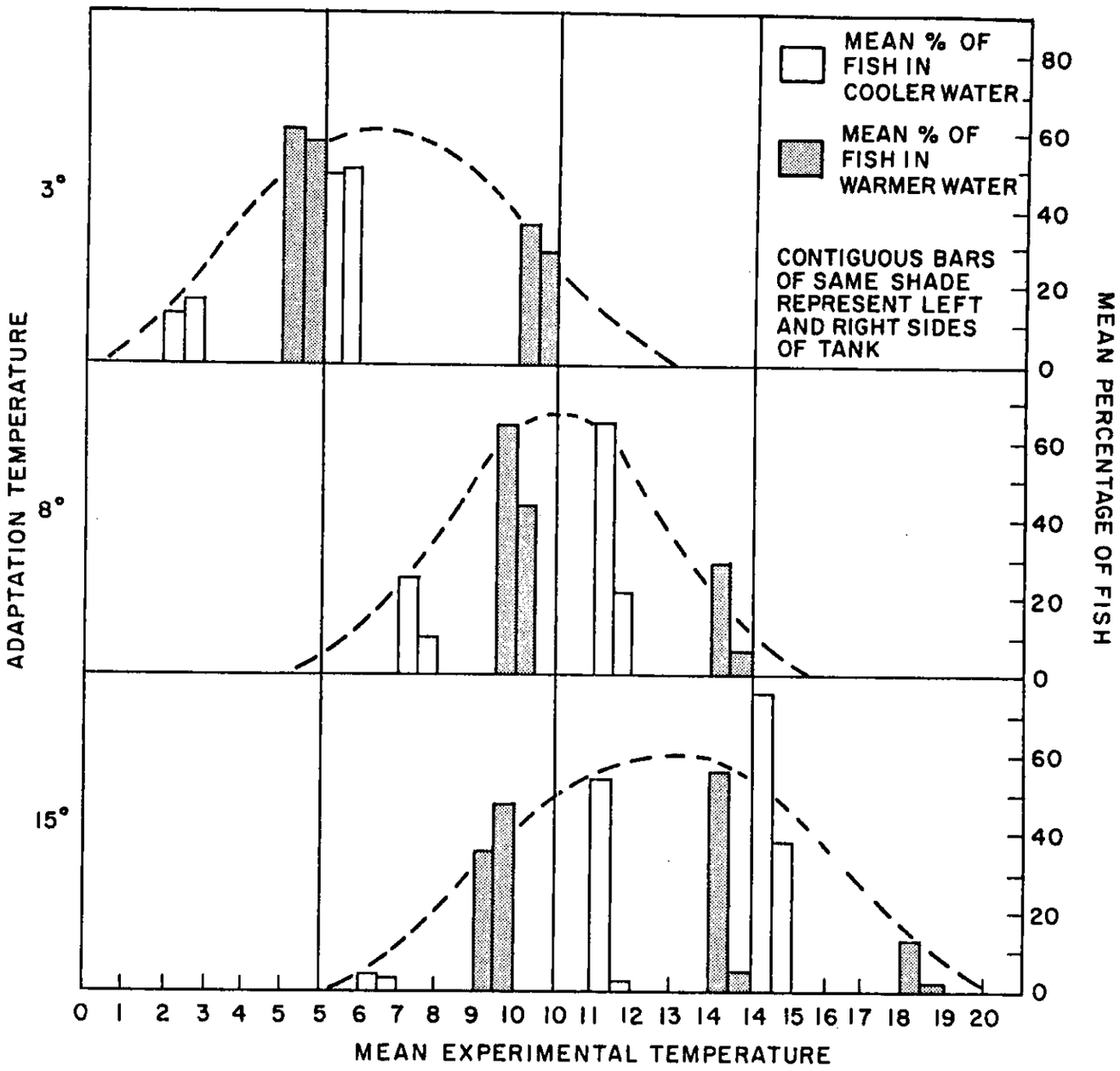

Figure 1. The temperature preference of juvenile herring at three levels of prior temperature adaptation. The height of the bars in each block represents the degree of preference between two temperature alternatives. The dashed lines indicate the estimated zone of temperature preference.

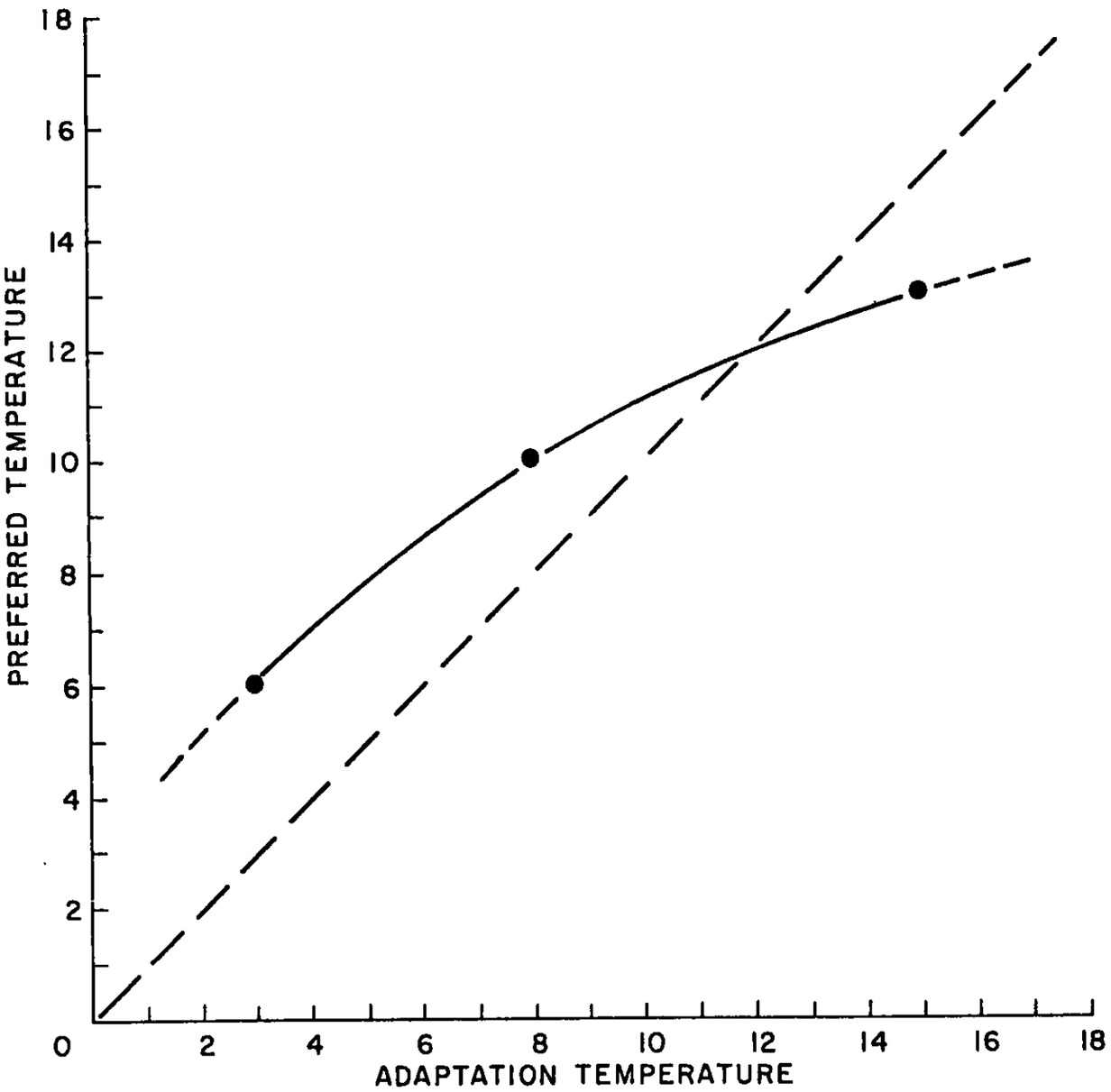

Figure 2. Relationship between prior temperature adaptation and the preferred temperature of juvenile herring. The intersection of this curve with the diagonal (where adaptation temperature - preferred temperature) represents the final temperature.

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Corrigendum to ICNAF Res.Doc.66/68

Please add to this document the following title which was inadvertently omitted when the document was initially produced and distributed:

"Orientation of Juvenile Herring (*Clupea Harengus* L.) to Temperature and Salinity"