

## FORMATION OF A FALSE ANNULUS ON SCALES OF PACIFIC SARDINES OF KNOWN AGE

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Pacific sardines, *Sardinops caerulea* (Girard), were reared from hatching through the first year of life at the Fishery-Oceanography Center, La Jolla, California. The availability of these fish has allowed the study of growth in length and weight and the formation of accessory ring and annulus on scales of sardine of known age to compare with measurements of field-captured fish.

Sardine eggs were obtained on May 9, 1968, off San Diego, California. They were transferred to the Fishery-Oceanography Center aquarium and placed in a clear, thin-walled polyethylene bag which was suspended in sea water in a 3,500-gallon pool. The polyethylene bag, about 1 meter deep and 1 meter diameter, was used to confine the newly-hatched larvae to a small area of facilitate feeding. An air stone in the bag kept the water gently in motion. Light was constant, provided by a 1,000-watt mercury vapor lamp over the tank.

After 2 days between 16° and 18° C. the eggs hatched into larvae about 4 mm. long. The procedure of feeding changed as the fish grew. The larvae were fed a variety of wild plankton organisms, until the 11th day when their diet was supplemented with live brine shrimp, *Artemia salina*, nauplii. After 28 days the larvae were released into the pool. The food was changed to frozen brine shrimp and size #1 trout food at 52 days. During the first 2 months only a minimum amount of water was added to the pool periodically to flush off the surface scum. At the end of 2 months a constant flow of ambient sea water was maintained in the pool. At the beginning of the third month, the amount of food fed per day was set at 10 percent of the calculated total weight of the fish in the tank; a decision based on a study of food utilization by young anchovy, *Engraulis japonicus* (Temminck et Schlegel), by Takahashi and Hatanaka (1960). The average weight of the fish was obtained from monthly samples and the number of fish estimated until December when they were counted as they were being transferred to another pool.

The larvae were sampled frequently through the first 2 months (Figure 1) to obtain empirical data on their rate of growth. A total of 646 specimens were measured to the nearest half-millimeter SL during this period. From the third month on, samples were measured at 30-day intervals. The laboratory fish were smaller than fish obtained from the Pacific coast bait fisheries during the 1938-39 season (Walford and Mosher, 1943a) through November. After November their lengths were similar.

Two rings formed on the scales during the first year of life of the aquarium reared sardines (Figure 2). The first ring (accessory) formed between August and September 1968. The second ring (annulus) formed between December 1968 and January 1969. Both rings had all of the usual characteristics of an annulus. The second ring was considerably easier to see than the first ring.

Figure 3 illustrates several factors that may be related to formation of the rings. Formation of the accessory ring is associated with the period of maximum growth. Formation of the annulus ring occurs immediately prior to the onset of rapid growth during the late winter 1969. None of the other factors appear to be related to formation of the rings.

At the time of annulus formation the fish were about 7.5 to 8.5 months old and averaged 101 to 105 mm. SL, respectively. Back-calculated  $L_1$  lengths on a random selection of scales from the December through March samples averaged 100.0 mm. SL. However, on their first actual birthdate the sardines averaged 124.5 mm. SL, nearly 25 percent greater actual observed length than their first year back-calculated length. At the time of the accessory ring formation the fish were about 4.5 to 5.0 months old and averaged 81.8 mm. SL.

Other investigators have reported two rings per year on scales taken from similar species. Aikawa (1940) reported that two rings formed on the scales of the Japanese sardines, *Sardinia melanosticta* (Temminck et Schlegel) per year. Davies (1958) found that two rings formed during the first year of life on scales taken from commercially caught South African pilchard, *Sardinops ocellata* (Pappe).

Formation of an accessory ring on scales of laboratory reared Pacific sardines during their first summer of life is cause for concern. If similar accessory rings form on scales of fish in their natural environment, considerable error in assigning ages to fish may result. Preliminary analysis of historical data and re-examination of previously read scales indicates that this type of error in aging has occurred. We are attempting to develop quantitative techniques for distinguishing between accessory rings and annuli.

### ACKNOWLEDGMENTS

I am grateful to Andre Saraspe who deserves special credit for his successful effort in hatching and rearing the sardine larvae through their second month of life. Clark E. Blunt, James E. Hardwick, and John S. MacGregor did the scale reading. I wish to thank William H. Lenarz and Andrew M. Vrooman for

critically reviewing the manuscript. In addition, I wish to express my appreciation to Mary J. Kalin, Ruth Miller, and Nancy Wiley who helped measure the fish samples of the first 2 months, and to Pedro A. Paloma for caretaking duties during the writer's absences at various times.

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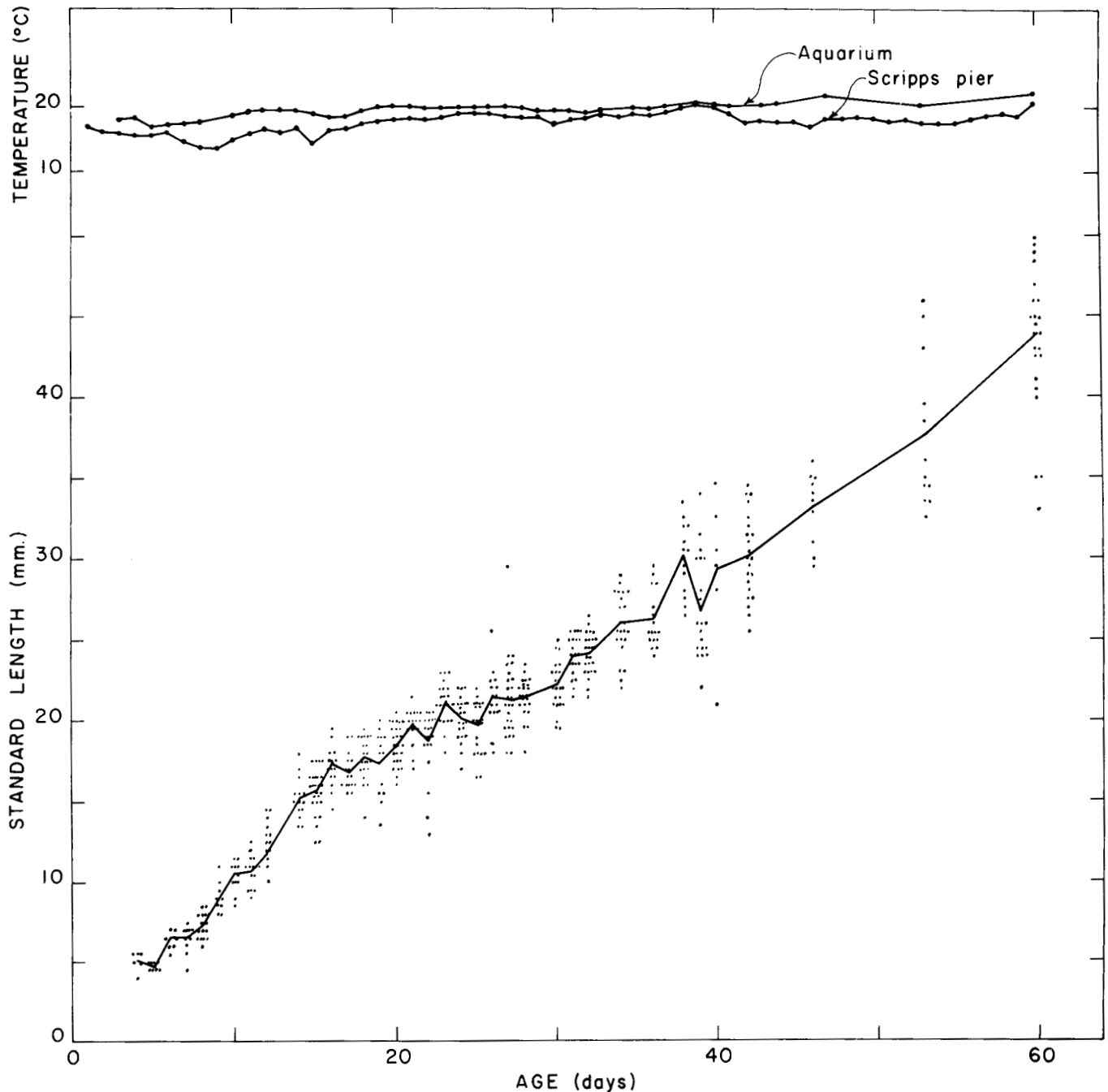


FIGURE 1. Standard lengths of the aquarium reared sardines during the first 2 months of life. The solid line connects the average lengths of the fish sampled on any one day. Scripps pier and the aquarium water temperatures are shown in the upper graph.

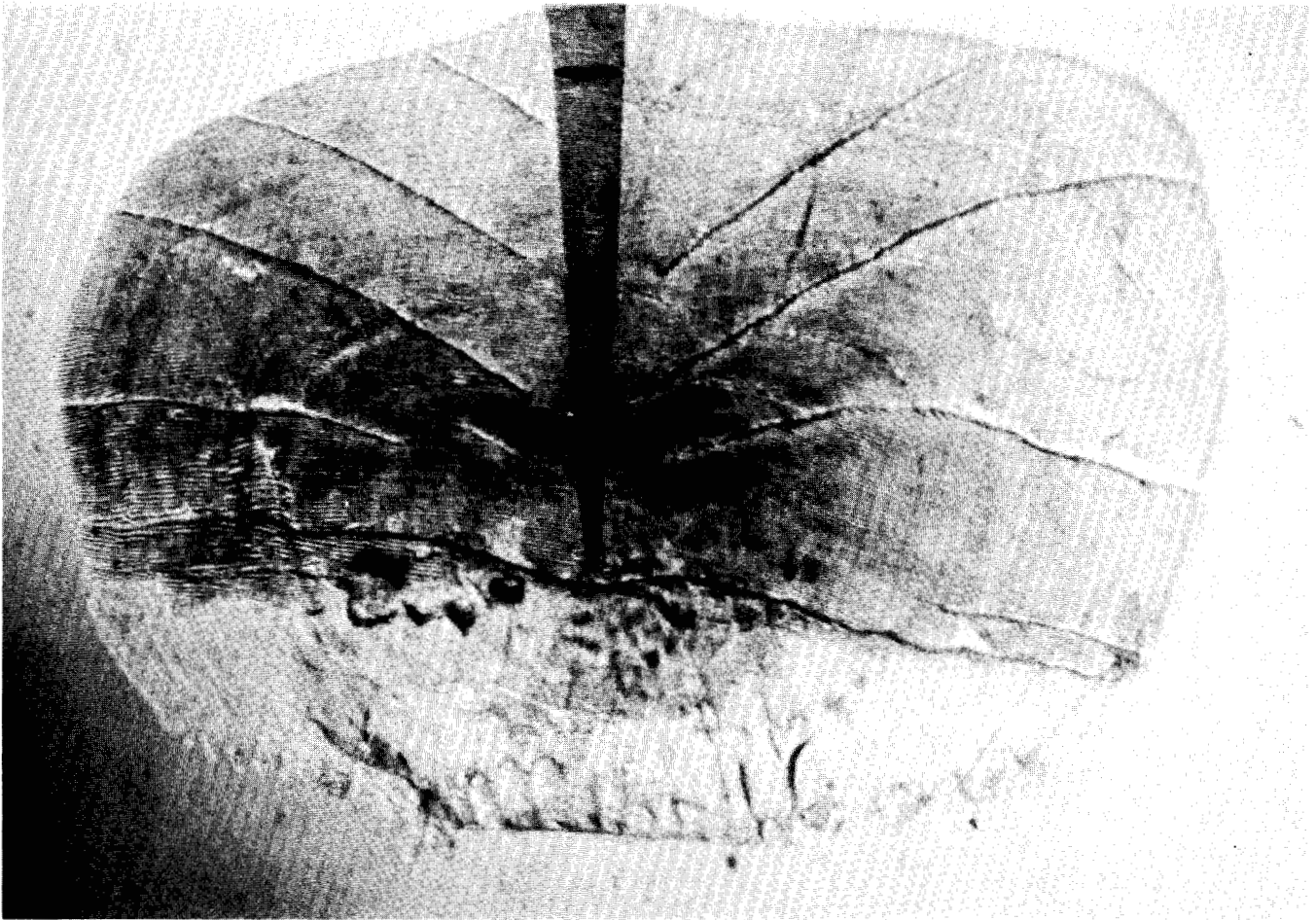


FIGURE 2. A typical scale from one of the aquarium reared sardines sampled in its tenth month of life, March 3, 1969. The dark marks drawn on the scales indicate the accessory check (inner mark) and the first annulus.

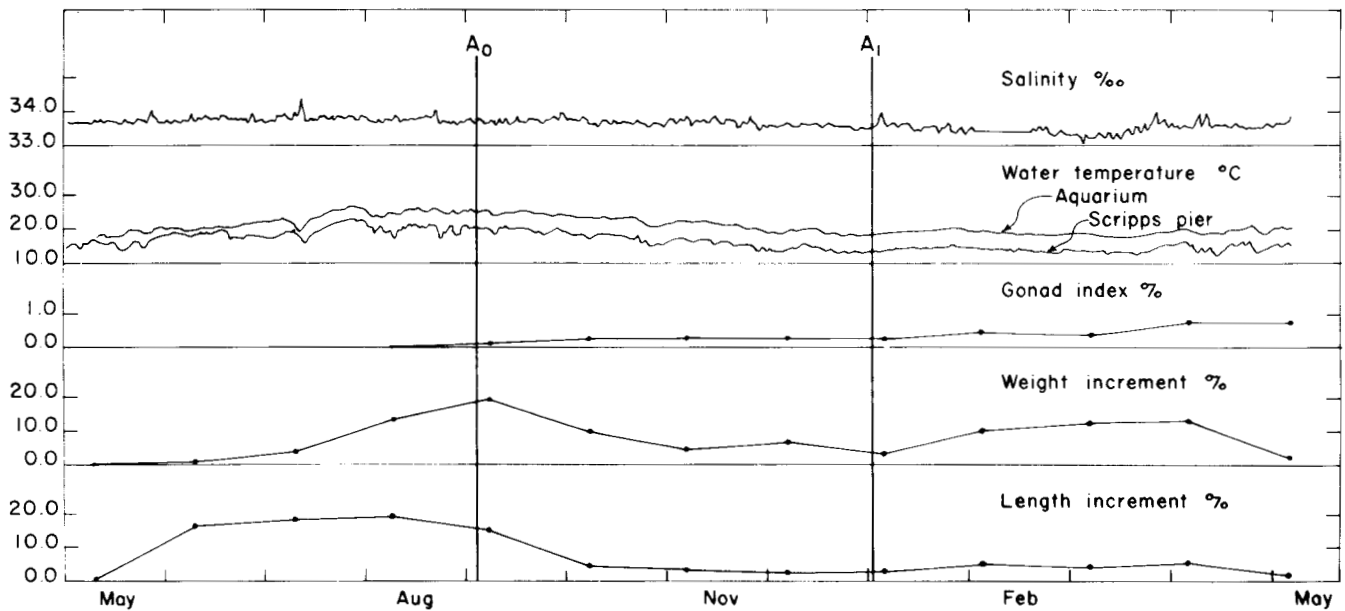


FIGURE 3. Average monthly length increment in percent of the average standard length at the end of 1 year, average monthly weight increment in percent of total weight at the end of 1 year, gonad index (weight of gonad in percent of body weight), along with water temperature and salinity. Periods of formation of the accessory check and the annulus are indicated by the vertical lines  $A_0$  and  $A_1$  respectively.