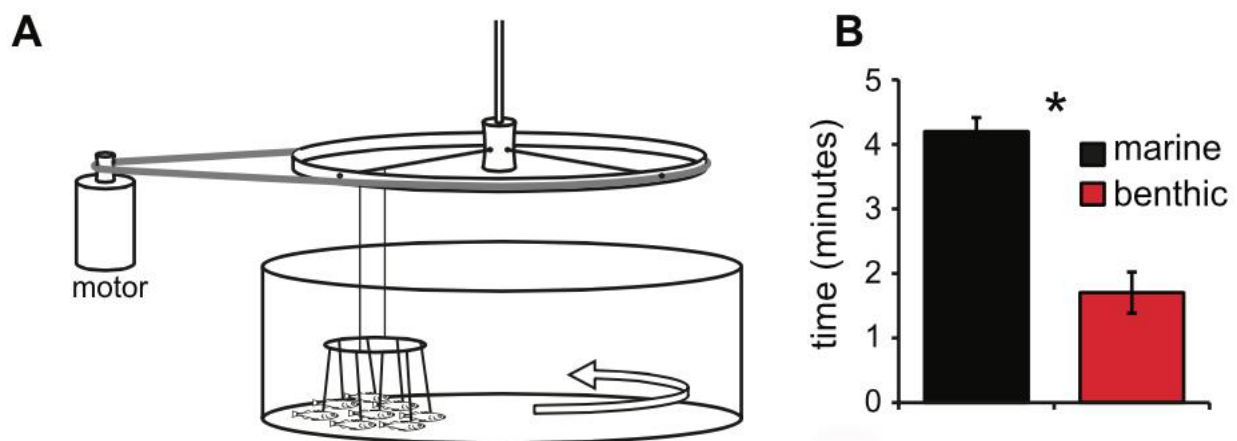




## Schooling Behavior of Stickleback Fish from Different Habitats

### HOW TO USE THIS RESOURCE

Show the figure below to your students along with the caption and background information. The “Interpreting the Graph” and “Discussion Questions” sections provide additional information and suggested questions that you can use to guide a class discussion about the characteristics of the graph and what it shows.



**Caption:** The schooling behavior of threespine stickleback fish (*Gasterosteus aculeatus*) was tested using an artificial fish school model (Panel A). The model consisted of eight stickleback casts attached to a bicycle wheel that was rotated by a motor. As the wheel turned inside a tank, the model fish “swam” around in a “school.” Panel B shows the mean time (in minutes) that real marine (black bars) and freshwater benthic (red bars) stickleback fish introduced into the tank spent schooling with the model fish. The bars represent the means  $\pm 1$  standard error of the mean (SEM). The asterisk represents a significant difference between the two groups.

### BACKGROUND INFORMATION

A team of scientists studied the schooling behavior of threespine stickleback fish (*Gasterosteus aculeatus*) by experimentally testing how individual fish responded to an artificial fish school model. Schooling is a social behavior of fish, in which they congregate in groups as they swim and synchronize their position, direction, and speed. Schooling can be beneficial by making it less likely for individual fish to be caught by predators and increasing the likelihood of finding food. However, schooling also imposes costs such as competition for resources among fish in a school, so if predation is low or fish have other means to escape predators, schooling may not be beneficial. Stickleback fish of the same species can live in very distinct habitats: an open-water marine habitat versus a highly vegetated freshwater benthic habitat. The benthic zone is the area of water closest to the sediment and may be vegetated if sunlight reaches the sediment. Observations of fish in the wild suggested that marine stickleback fish have a strong tendency to school, whereas freshwater benthic stickleback fish are less likely to do so. To test these differences experimentally and to also determine whether schooling is an inherited or learned behavior, the researchers raised marine and freshwater benthic stickleback fish under laboratory conditions: in other words, without the opportunity to learn how to school from their parents. They then placed individual fish in a tank containing an artificial model school (Panel A in the figure) and let them acclimate to the tank for a short period. The researchers then turned on the artificial school model and observed the introduced fish for 5 minutes, measuring the time it spent schooling with the moving artificial school. Experimental trials were conducted with 19 marine stickleback fish and 20 freshwater benthic stickleback fish. The graph in the figure

above (Panel B) shows the average time marine (black bars) and freshwater benthic (red bars) stickleback fish spent schooling.

### INTERPRETING THE GRAPH

Panel B shows the mean time (in minutes) that 19 marine and 20 freshwater benthic stickleback fish spent swimming with the artificial school. The error bars represent means  $\pm 1$  standard error of the mean (SEM). The asterisk in the graph indicates that the difference between the two means is significant. This means that marine stickleback fish spent significantly more time schooling with the model than freshwater benthic stickleback fish did.

**Teacher tip: Explain the concept of the standard error of the mean and statistical significance to your students.**

To estimate whether the difference between two means is statistically significant, researchers sometimes do a quick approximation by multiplying the SEM by 2, which is an estimate of the 95% confidence interval. If the means plus/minus the 95% confidence intervals for each group do not overlap, the difference between the groups might be significant. However, to establish statistical significance, researchers will have to conduct another statistical test, such as a *t*-test.

Because the fish were reared in a laboratory without their parents, their schooling behavior does not appear to be learned, suggesting that the greater tendency for marine stickleback fish to school than freshwater benthic stickleback fish in this experiment is a heritable behavior. In their natural environment, marine stickleback fish have a strong propensity to school as protection from predators, likely because shelter is less available in open marine habitats. In contrast, highly vegetated habitats provide more hiding places and shelter for small fish, which may explain why freshwater benthic stickleback fish are less likely to school. The results of this laboratory experiment, showing a greater tendency toward schooling behavior in marine than in freshwater benthic stickleback fish, are consistent with observations in the wild.

**Teacher Tip: Prompt your students to explain the parts of the graph as applicable:**

- Graph Type: Bar Graph
- X-Axis: The black bar represents marine stickleback fish and the red bar represents freshwater benthic stickleback fish.
- Y-Axis: Time (in minutes) spent following the schooling model
- Error Bars:  $\pm 1$  standard error of the mean (SEM)

### DISCUSSION QUESTIONS

- What do the differences in the means of marine and freshwater benthic stickleback trials tell you about their respective schooling behavior?
- Why is it useful to report the mean time spent schooling instead of data for each individual trial?
- What do the error bars represent?
- The statistical measure of 95% confidence is approximately  $\pm 2$  SEM. Replace the current error bars with bars that represent 95% confidence intervals (i.e., approximately 2 SEM). Explain whether the difference between the black and red bars is statistically significant and why.
- Based on this experiment, do you think that the schooling behavior of the two groups is inherited or based on learned experience? Why?
- Why do you think the two groups exhibit different schooling behaviors in nature?

## SOURCE

Figure 3 from:

Wark, Abigail, *et al.* Heritable differences in schooling behavior among threespine stickleback populations revealed by a novel assay. *PLOS ONE*. 2011. 6(3): e18316.

View Paper: <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0018316>

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