# The Fish Kill Mystery

## Using Case Studies in the Middle School Classroom

*by Christy Heid, Barbara Biglan, and Margaret Ritson*

Case studies are an excellent method for engaging middle school students in the current work of scientists. Students learn to think like scientists as they decide how to investigate the dilemma presented in the case study. The National Science Education Standards' Content Standard for Science as Inquiry indicates that for the middle grades, understandings about scientific inquiry increase in complexity beyond those standards for the elementary grades (NRC 2000). Students in middle school should understand that scientific explanations emphasize evidence; have logical, consistent arguments; and use scientific principles, models, and theories. Through the case study, middle school students learn

to use their skepticism to raise legitimate questions about scientific investigations and explanations.

One such case study, the Fish Kill Mystery, was of particular interest because it takes place at a popular vacation spot—the beaches of North Carolina. The original case came from the National Center for Case Study Teaching in Science at the University at Buffalo (Kosal 2003). We modified the case for use in the middle school classroom. The modifications included breaking the case into smaller "chunks" to fit in a 45-minute class period and creating recording sheets, as well as journal-entry and discussion stopping points. We designed a series of questions to follow each "chunk."

This activity became part of the existing curriculum unit on the environment and ecology. We do a unit that focuses on model rivers and how water has sculpted the land over thousands of years. It also focuses on the impact that humans and industries have on our water systems (George 1991), from toxic dumps to where dams should be built. The Fish Kill Mystery fits with the water systems unit.

## Day 1: Introducing the case

The Fish Kill Mystery took place in the Pamlico estuary in North Carolina in the 1990s when billions of fish, predominantly Atlantic menhaden, were being killed in estuaries all along the eastern coast of the United States. We introduced the case study to students by reading its beginning section involving three young people who suddenly had their trip to the beach interrupted by the horrible stench of hundreds of dead fish. Students focused on the following questions to help them gather their thoughts on the Fish Kill Mystery:

- Where does this take place?
- What is the geography of this area?
- What were the volunteers at the cleanup doing?
- What sources of evidence could they gather at this site?
- What other sources of evidence do you think they should consider?
- At this time, what do you think killed the fish?

Once students had time to reflect on the questions individually, they worked in small groups of four to six to brainstorm which evidence, such as a reading of the amount of oxygen in the water, they should gather to determine why the fish died. Each small group used chart paper to display the five types of evidence they thought were most important. Their work was hung around the classroom and students participated in a silent "gallery walk" to read the other groups' proposed sources of evidence. (Depending on the time available and classroom dynamics, a student from the group that developed each poster could be posted at the display to answer viewers' questions.) After the gallery walk, students defended their choices, provided a rationale for their importance, and then the class, by consensus, chose the top seven sources of evidence for the class to focus on. Many students have pet fish and know how important it is to have aeration pumps bubbling oxygen

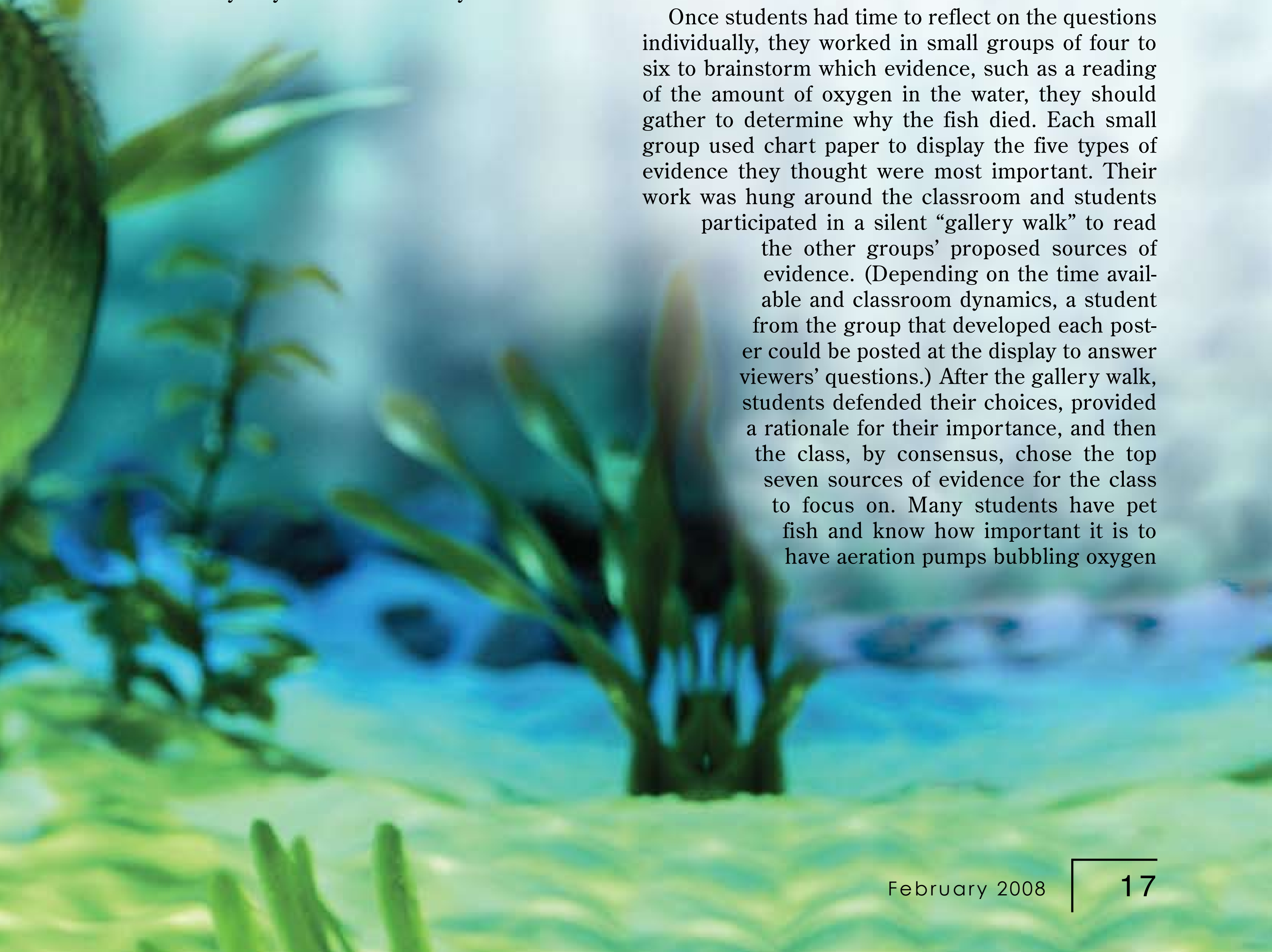

**FIGURE 1** Test results

| Water sample | Dissolved oxygen level (ppm) | | |
|---|---|---|---|
| | Trial 1 | Trial 2 | Average |
| Phil's Creek | 4 | 4 | 4 |
| Max's Creek | 5.5 | 2.5 | 4 |
| Phil's Pond | 6 | 6 | 6 |
| Pearson's Creek | 4 | 6 | 5 |
| Duck Lake | 4 | 4 | 4 |

in the water because fish are dependent on oxygen to survive. This led to the idea of testing oxygen levels in local water sources to determine typical dissolved oxygen levels in local bodies of water. Several students took containers home to collect water samples from local creeks, ponds, or rivers. Students were encouraged to share information about the project with parents and seek parental permission before venturing to local streams. If teaching in an urban setting where natural water sources are limited, the teacher can take responsibility for securing samples.

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Students work in groups to design posters of the sources of evidence their group has chosen to investigate.

## Day 2: Testing the water

We began the second day's lesson by having students answer the following question in their science journal: "Do different bodies of water have the same level of dissolved oxygen? Explain." One student wrote the following in her journal: "I don't think that all bodies of water have the same dissolved oxygen level because different animals and organisms live in different bodies of water and maybe they need more or less oxygen. Also, maybe cleaner waters have higher or lower oxygen levels than dirtier waters." Another student answered the question posed by writing the following: "No, because salt water has more salt, so the salt takes up more room. Now there's less room for oxygen." Students then shared their ideas with the class.

Students worked in pairs to test the dissolved oxygen of the samples of water students had brought in, commercially prepared field trip test kits. Test kits contained multiple water tests in addition to dissolved-oxygen, such as temperature, pH, phosphate, nitrate, and turbidity. The dissolved-oxygen test consists of dissolving two tabs in a small tube filled to the top with the sample water, without any air to affect the dissolved-oxygen reading of the sample. After waiting five minutes for the color to develop in the tube, the color is compared to the dissolved-oxygen color chart. Depending on the color of the sample—clear, pink, or orange—the dissolved-oxygen level is determined to be either 0, 4, or 8 ppm, respectively. The kits cost $54.95 and include materials for 25 dissolved-oxygen tests. The dissolved-oxygen testing materials (10 tests, two tablets per test, $19) may also be purchased separately from science supply companies if you have previously purchased the tubes and color charts required for the dissolved-oxygen tests.

Each group tested a different water sample, performing two trials on each sample. Students shared their results by adding their group's data to the class data table displayed on the chalkboard. The results of the tests for one class are shown in Figure 1. Our tests were completed in the winter, so tests showed that the dissolved oxygen of samples was higher for the class that met at the beginning of the day, compared to the class at the end of the day, which tested the water after it had reached room temperature. Students recorded what they learned about dissolved oxygen in their journals. One student wrote: "The temperature of the water also effects how much oxygen it can hold. Warm water can't hold as much oxygen as cooler water." From the case study, students learned that a dissolved-oxygen level of 2 mg/L (2 ppm) or less is harmful to fish. Next, we viewed dissolved-oxygen maps of the Pamlico estuary and nearby rivers (DENR) during various days during the year (see Resources). The class discussed that the dissolved-oxygen content in these bodies of water decreased during the course of the summer, which students attributed to the increase in temperature of the water due to the hot summer days. The dissolved-oxygen maps of the estuary for the summer compared to the winter also reinforced the difference in dissolved- oxygen levels due to the temperature.

We concluded there was not enough of a decrease in the dissolved-oxygen level to kill the fish, which was also verified in that days' reading of the case study. At the end of the lesson, students answered the following question in their science journal for homework: "Using the information from the portion of the Fish Kill Mystery we read today about the dissolved- oxygen level readings of the estuary, why don't the scientists think the dissolved-oxygen levels in the estuary led to the fish kill? Write a new hypothesis for what killed the fish." Students had some very creative ideas including that the fish had been bitten by other fish or had eaten something harmful.

## Day 3: Food webs

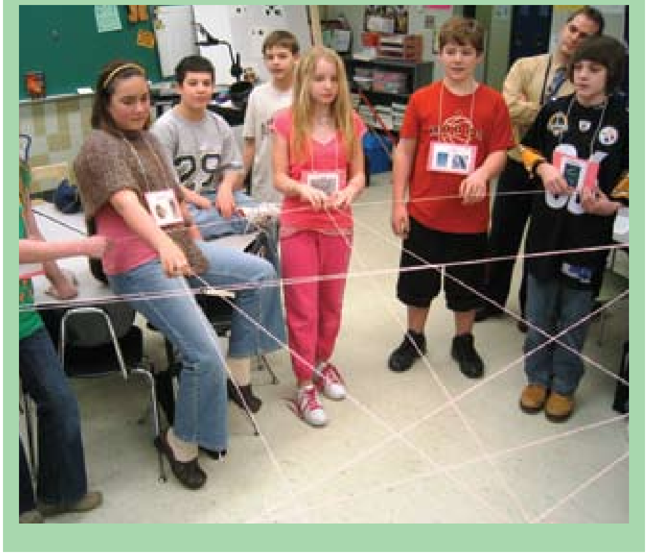
On the third day we discussed students' new hypotheses and why the dissolved-oxygen level in the estuary did not lead to the fish kill because it was not low enough to be harmful. Next we chose to test the fish diet because students hypothesized that the fish might have eaten something that made them die. The predominant type of dead fish in this example was the Atlantic menhaden. To understand what Atlantic menhaden eat, we looked at the food web of an estuary. We found some interactive food webs for estuaries online, such as FEMAP at the College of William and Mary (see Resources). To prepare for this food-web activity (Kostalos 1990), the instructors made 13 cards, each for a different member of the estuary food web. The instructors researched the members of the estuary food web at various sites on the internet, however, students could also have researched members of the estuary food web and prepared their own cards for this activity.

Students share the results of dissolved-oxygen tests of local water sources.

On the front of the card was a picture of the animal or organism living in the estuary and on the back was a description of it. Our list was not exhaustive but included a random selection of estuary food-web members: humans, Atlantic menhaden, phytoplankton, pfiesteria, striped bass, bluefish, gray trout, tuna, sandbar sharks, seabirds, anchovies, sea turtles, and crabs. The members of the estuary food web were chosen randomly. However, key members such as Atlantic menhaden and pfiesteria should not be excluded because menhaden were the predominant fish that were killed in the estuaries and the dinoflagellette, pfiesteria was the culprit (Kosal 2003). For example, the card for Atlantic Menhaden is as follows:

*I am a blue-black fish with bronze-colored fins.*
*I grow to be 15 inches long.*
*I like to eat plankton and microscopic organisms such as pfiesteria.*
*I am a favorite food of striped bass, bluefish, sea trout, tuna, and sharks.*
*I am very important to the United States fish industry, providing fish meal, fish oil, and fish solubles and bait for other fisheries.*

**FIGURE 2** Students make a food web of the estuary



Half of the class was chosen to be a member of the estuary food web since we had prepared a limited number of cards, however, more cards could be made so that an entire class could participate as members of the estuary food web. Each student, acting as a member of the estuary food web, read their description to the class so students not participating in the food web as an animal or organism could assist with designing the food web. An arbitrary student was chosen to start the estuary food web by holding one end of a ball of string. The student chose one animal or organism in the food web that was directly connected as prey or predator and passed the ball of string to that student while still holding on to one end. The person holding the ball of string then chose one animal or organism in the food web that was directly connected as prey or predator and passed the ball of string to that student while still holding on to the piece of string. As the ball of string was passed around it unwound to form a web joining members of the food web (see Figure 2).

Next, we looked at the effect of the fish kill on the food web by removing the menhaden and following the food web to see what other animals were affected. To represent this visually using the string food web just created, we had the student playing the part of the menhaden let go of the string. The members of the estuary food web directly connected to menhaden would consequently let go of their part of the string since if menhaden died they would either die off from lack of food with menhaden no longer available or overpopulate the estuary if menhaden was their predator. This would continue as each subsequent member of the food web was affected by the death of the menhaden fish. The activity worked well with students playing a member of the estuary food web, as they were more likely to be concerned with how losing just one part of the food web could be detrimental to everyone.

## Day 4: Learning from scientists

On the fourth day of the Fish Kill Mystery unit, students read the remainder of the case study as a play. This portion of the case study was a conversa-

Students read their parts for the Fish Kill Play tion among a professor, his graduate students, and the three young people who were originally on their way to the beach. Students enjoyed reading the various parts of the discussion and the remainder of the class listened intently to discover how the fish were really killed.

## Day 5: Wrap-up

On the final day students discussed why the Fish Kill Mystery has taken so long for scientists to solve—the dangerous toxin in pfiesteria that killed billions of fish in the 1990s is just now being identified (Engelhaupt 2007). Pfiesteria is a mysterious killer since it is usually not toxic and doesn't produce a visible algae bloom when it is toxic, as does the common "red tide." We discussed pfiesteria's unique behavior that required scientists to use red lights when working with the toxin because it was so unstable in white light. Students also learned about weather conditions prior to the fish kill, such as Hurricane Fran of 1996, which may have triggered the pfiesteria toxin to be released. Scientists were also baffled by the sudden disappearance of fish kills after 1999 (Engelhaupt 2007).

## Conclusion

One of the main outcomes of the case study is that students learn how to think and act like scientists. Our outcomes were evident in feedback received from a survey evaluating what they learned from the case study. One student noted the importance of data collection: "When you are gathering data, every bit of information counts." Another student noted that a scientist must try many methods before achieving the end result: "You have to try all kinds of different things to get your answer." Students also expressed how much they enjoyed the case study. For instance, one student wrote her favorite part was "trying to figure out what killed the fish because I love trying to figure things out." Another important lesson students learned from this case study was "that it took a long time to find out what killed the fish." Often we provide students with "canned" experiments in which there is one expected outcome, unlike real science where years of research are devoted to solving a particular problem. We hope to incorporate this lesson again each year, possibly adding additional reading about the struggles Dr. JoAnn Burkholder faced in her research to uncover the deadly dinoflagellate pfiesteria from the captivating book *And the Waters Turned to Blood: The Ultimate Biological Threat* (Barker 1997). ■

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## Resources

Dissolved-oxygen maps of the Pamlico estuary—*www.esb.enr.state.nc.us/NeuFolder/images/060708do.gif.*

Interactive food webs for estuaries—*www.fisheries.vims.edu/multispecies/femap/foodweb.htm.*

*The Fish Kill Mystery* (National Center for Case Study Teaching in Science)—*www.sciencecases.org/fishkill/fishkill.asp.*

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