TIEE

Teaching Issues and Experiments in Ecology - Volume 1, January 2004

ISSUES – FIGURE SET

Bleaching in coastal Florida
©- Reef Relief, www.reefrelief.org)

What's Killing the Coral Reefs and Seagrasses?

Charlene D'Avanzo [1] and Susan Musante [2]

1 - School of Natural Sciences, Hampshire College, Amherst, MA, 01002 cdavanzo@hampshire.edu

2 - Education and Outreach Program Manager, The American Institute of Biological Sciences, Washington, D.C. 20005, smusante@aibs.org

Figure Set 5: Eutrophication and Anoxia

Purpose: To help students construct the series of events linking nutrient loading to coastal waters and anoxic events.
Teaching Approach: "Jigsaw"
Cognitive Skills: (see Bloom's Taxonomy) — knowledge, comprehension, interpretation, application, synthesis, evaluation
Student Assessment: diagram quiz

BACKGROUND

Eutrophication (organic matter increase in water) is a crucial problem in marine and freshwaters worldwide. Coastal waters in particular receive large loadings of N and P (mainly from agriculture and sewage) which in turn stimulates growth of phytoplankton and macroalgae. This increase in primary production can result in anoxia and hypoxia (oxygen concentration > 2 ppm) when bacteria and other aerobes use up ambient oxygen to metabolize this pulse of organic carbon. "Fish kills" (large kills of fish and other animals) and death of corals and seagrasses can occur during anoxic events.

The basic biological concepts manifested by eutrophication include nutrient uptake by primary producers, aerobic bacterial metabolism, and effects of low oxygen on aerobes. Even though students may understand these concepts separately, for many linking them to predict effects of nutrient enrichment in the Florida Bay and Keys is difficult. The jigsaw allows students to focus on each concept separately in one group and then in a second group they put the pieces together.

STUDENT INSTRUCTIONS

Questions for Students In First Jigsaw Grouping

Jigsaw Group A (Figures 5A-1 and 5A-2). To begin, someone in your group should volunteer to read the following individual and groupwork directions:

* Individual and Groupwork Directions: Individually examine Figures 5 A-1 and 5 A-2; take your time to first describe the figure (parameters and scale on each axis, the symbols, the overall pattern) and then attempt to interpret them. Be sure to read through the "explanations of the graphs" below. When each person in your group has finished doing this, carefully discuss each figure together. Make sure that each person truly understands the data, the axes, the symbols, the pattern, your interpretations. Now figure out how to explain these graphs to other students who will not have seen them before. What confused you at first? Show and explain these. What are the most important points you need to make? Make sure you can explain these clearly. Anticipate problems and questions they may have. Don't finish until each person in your group feels comfortable teaching this material in the next grouping.

* Explanation of the Graphs: Figure 5A-1 is a compilation of data from 4 types of ecosystems in the U.S. In this case "input" is amount (a mole is the molecular weight of an element in grams) of nitrogen (N) and phosphorous (P) going into each square meter of that ecosystem in a year. Make sure you understand the scale of the axes. What does this figure show? Which ecosystem receives the highest loading of the nutrients N and P? Why might this be?

* Figure 5A-2 shows the relationship between input of the nutrient N and the concentration of chlorophyll in phytoplankton in estuaries around the world. Chlorophyll is a main plant pigment and it is a good measure of the biomass of phytoplankton in water. Phytoplankton ("wandering plants") are microscopic plants that are the base of the food chain in the ocean. Note the scales on the axes.

* After you figure out each graph separately, relate them to each other. Why would estuaries be receiving high loadings of the nutrients N and P? Using what you know from Figure 5A-2, what would you predict about phytoplankton biomass in estuaries receiving high loads of N and P? Why might this be a problem?

Jigsaw Group B (Figures 5B-1 and 5B-2). To begin, someone in your group should volunteer to read the following individual and groupwork directions:

* Individual and Groupwork Directions: Individually examine Figures 5B-1 and 5B-2 and the "explanation of the graphs". Take your time to first describe the figure (parameters and scale on each axis, the symbols, the overall pattern) and then attempt to interpret them. When each person in your group has finished doing this, carefully discuss each figure together. Make sure that each person truly understands the data, the axes, the symbols, the pattern, your interpretations. Now figure out how to explain these graphs to other students who will now have seen them before. What confused you at first? Show and explain these. What are the most important points you need to make? Make sure you can explain these clearly. Anticipate problems and questions they may have. Don't finish until each person in your group feels comfortable teaching this material to other students in the class.

* Explanation of the Graphs: Figure 5B-1 is data from the waters in the Florida Bay collected during June and July. There are 3 stations that are progressively farther from shore - Port Pine (an artificial canal system with houses around it), Pine Channel (a seagrass meadow farther out), and Lodge Key (an offshore reef area about 6 miles from shore). The researchers measured the nutrient ammonium (NH4+) in micromoles (a mole is the molecular weight of an element in grams) and also the pigment chlorophyll in 2 water samples collected at each station on each date. Chlorophyll is a main plant pigment and it is a good measure of the biomass of phytoplankton in water. Phytoplankton ("wandering plants") are microscopic plants that are the base of the food chain in the ocean. Figure 5B-2 is from a different study by the same researchers. They measured ammonium and the concentration of dissolved oxygen in many water samples in near-shore waters of the Florida Keys during summer months. Oxygen values of 2 mg/l or less are considered "hypoxic" and deadly for many aerobic animals; values of 0 mg/l indicate anoxia which means that there is no oxygen in the water.

* After you figure out each graph separately, try to relate them to one another. There is a series of events taking place here. These data show that nutrient concentrations can increase in coastal waters like Florida Bay. What could cause this increase? Think about what the Pine point channel probably looks like; this may give you a clue. Imagine collecting water samples at the Port Pine site. When ammonium concentrations reach high levels, what would you expect happens to chlorophyll concentrations? Why? How might an increase in ammonium affect oxygen levels? How might this in turn be related to chlorophyll concentration (phytoplankton biomass)? Why can elevated plant matter in the water result in low oxygen?

Jigsaw Group C (Figure 5C). To begin, someone in your group should volunteer to read the following individual and groupwork directions:

* Individual and Groupwork Directions: Individually examine Figure 5C; take your time to first describe the figure (parameters and scale on each axis, the symbols, the overall pattern) and then attempt to interpret them. Be sure to read through the "explanations of the graphs" below. When each person in your group has finished doing this, carefully discuss each figure together. Make sure that each person truly understands the data, the axes, the symbols, the pattern, your interpretations. Now figure out how to explain these graphs to other students who will now have seen them before. What confused you at first? Show and explain these. What are the most important points you need to make? Make sure you can explain these clearly. Anticipate problems and questions they may have. Don't finish until each person in your group feel comfortable teaching this material in the next grouping.

* Explanation of the Graph: Figure 5C is a 3 dimensional plot of oxygen dissolved in water (units are mg/l which is equivalent to parts per million or ppm; percent is parts per hundred), salinity parts per thousand or ppt) and tide in meters. The data are from one location - Port Pine Channel - which is close to shore and to houses. The scientist collected literally thousands of data points with an instrument that automatically measured these 3 parameters very frequently. Three-D plots are not easy to figure out, so take your time with this one.

Questions for Students In Second Jigsaw Grouping (all groups have one A, one B, and one C person)

* Each A, B, and C person should take a few minutes and explain your figure(s) to your other group members. Patiently teach them what your data show.

* Finally, your group should use your combined knowledge to explain why nutrient loading into the Florida Bay region results in loss of corals, seagrasses, fish and other organisms,

* Hint: a main focus of your second group will be to explain the low oxygen in Florida Bay, so this is an important figure for everyone to understand. It will be easier to look at 2 of the variables at a time. When salinity is low, what happens to oxygen? Which is the independent and which is the dependent variable (e.g. what causes what)? Why might oxygen change like this when salinity changes? If you and your group do not know why this likely happens, just make sure that you can the "what" and then focus on the "why" in your next group. The other students will have clues that will help you understand this. Now look at the effect of tide on oxygen and salinity and see how they relate.

FIGURES

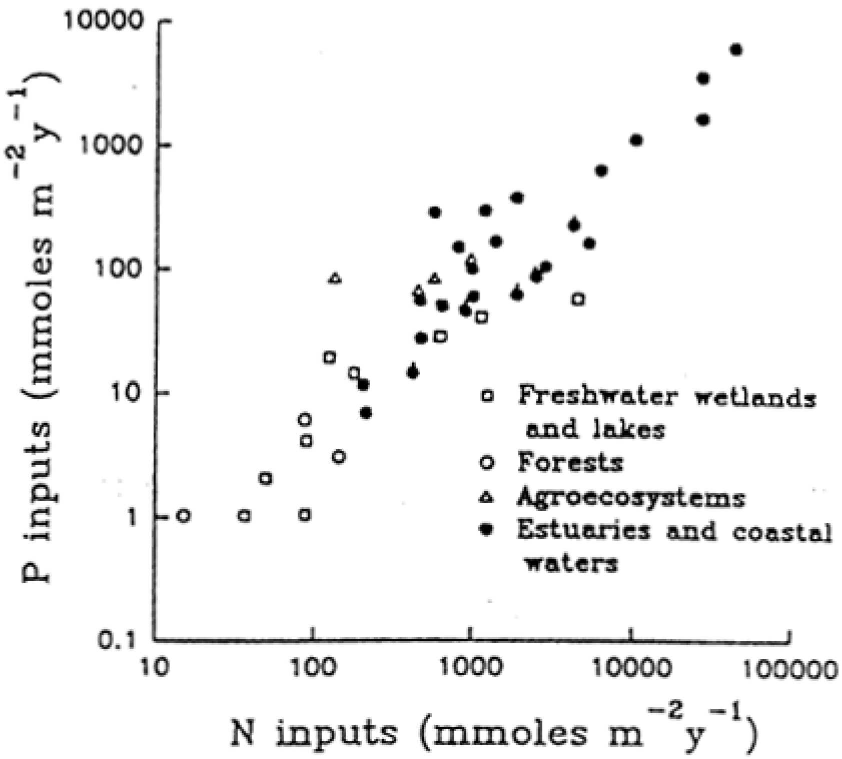

Figure 5A-1. Nitrogen (N, millimoles per square meter per year) and phosphorus (P) loadings to different types of ecosystems (from Nixon, School of Oceanography, URI).

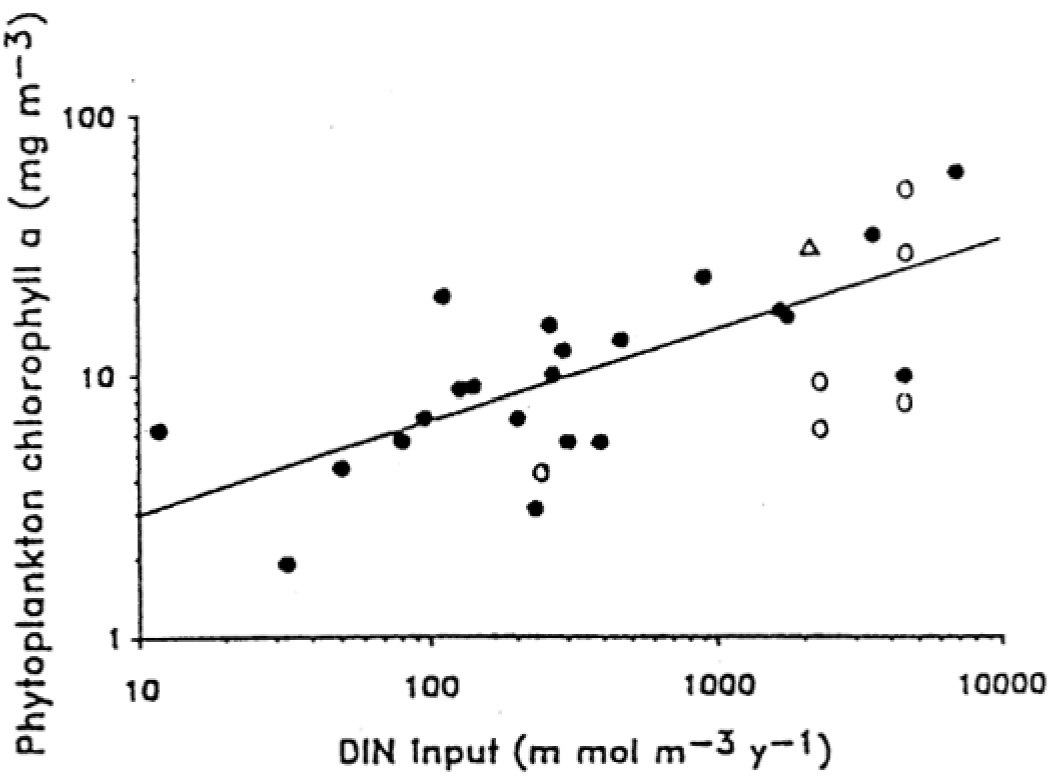

Figure 5A-2. Relationship of dissolved inorganic nitrogen (ammonium and nitrate in millimoles per cubic meter per year) and annual cholophyll (milligrams per cubic meter) in seawater (from Nixon, School of Oceanography, URI and I. Valiela, Marine Biological Laboratory, Woods Hole, MA).

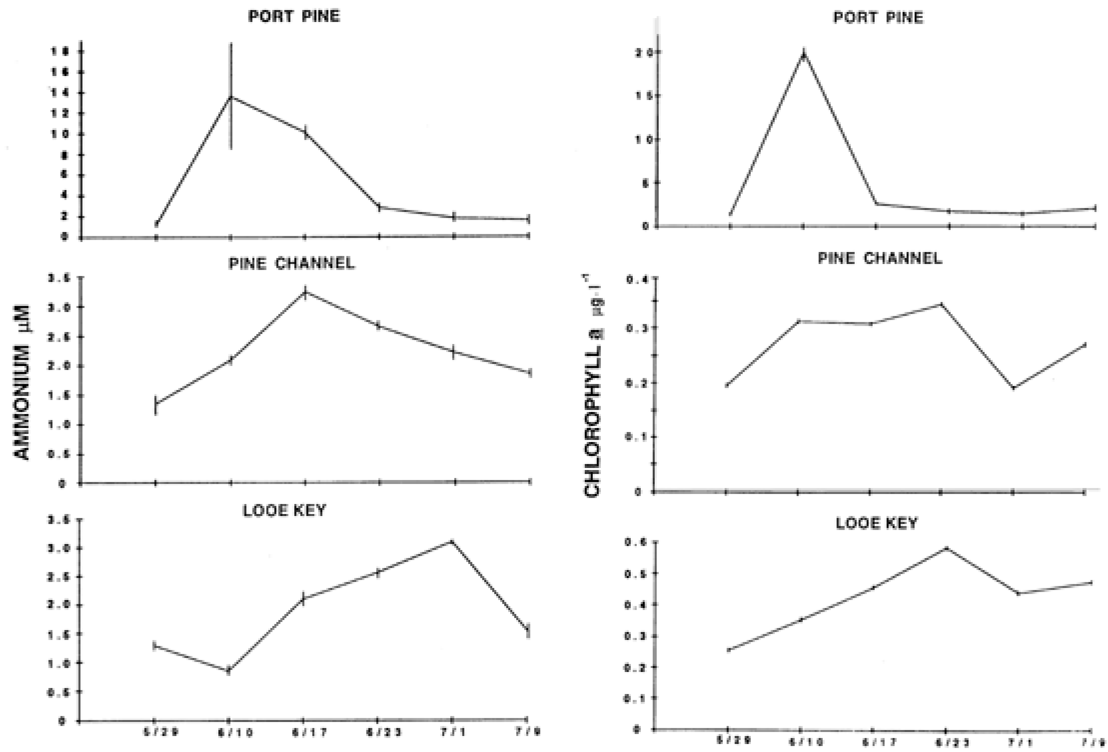

Figure 5B-1. Ammonium concentration (in micromoles; left panel) and chlorophyll a (micrograms/liter; right panel) in 3 sites in the nearshore waters of the Florida Keys between May and July, 1992 (from LaPointe, B. E., and W. R. Matzie. 1996. Effects of stormwater nutrient discharges on eutrophication processes in nearshore waters of the Florida Keys. Estuaries 19: 422-435).

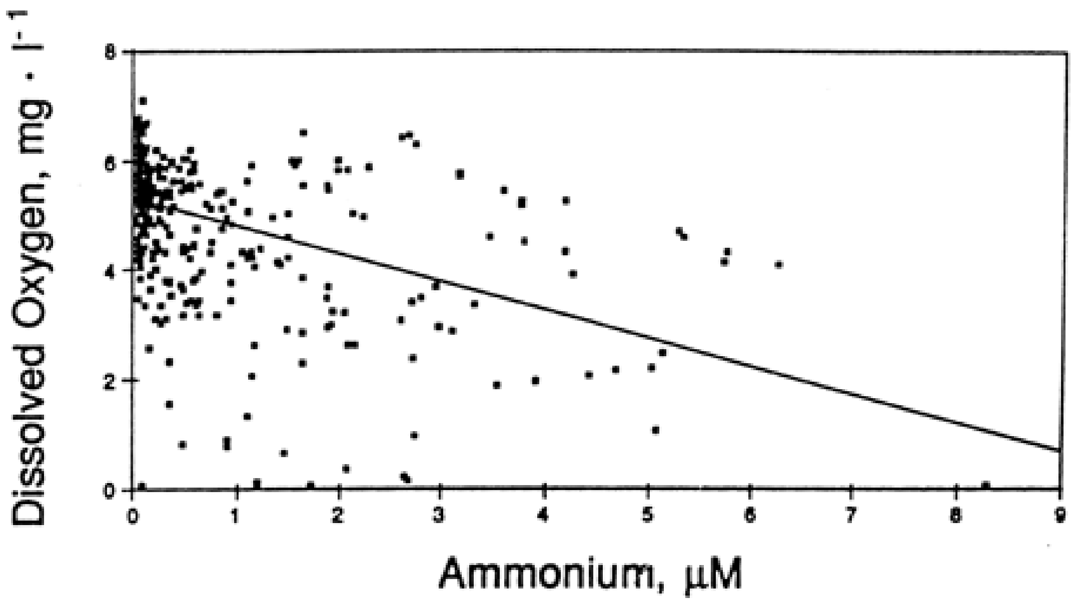

Figure 5B-2. Negative correlation of water column dissolved oxygen (milligrams/liter) at dawn and ammonium (micromoles) in near-shore waters off the Florida Keys (from LaPointe, B. E., and M. W. Clark. 1992. Nutrient inputs from the watershed and coastal eutrophication in the Florida Keys. *Estuaries* 15: 465-476).

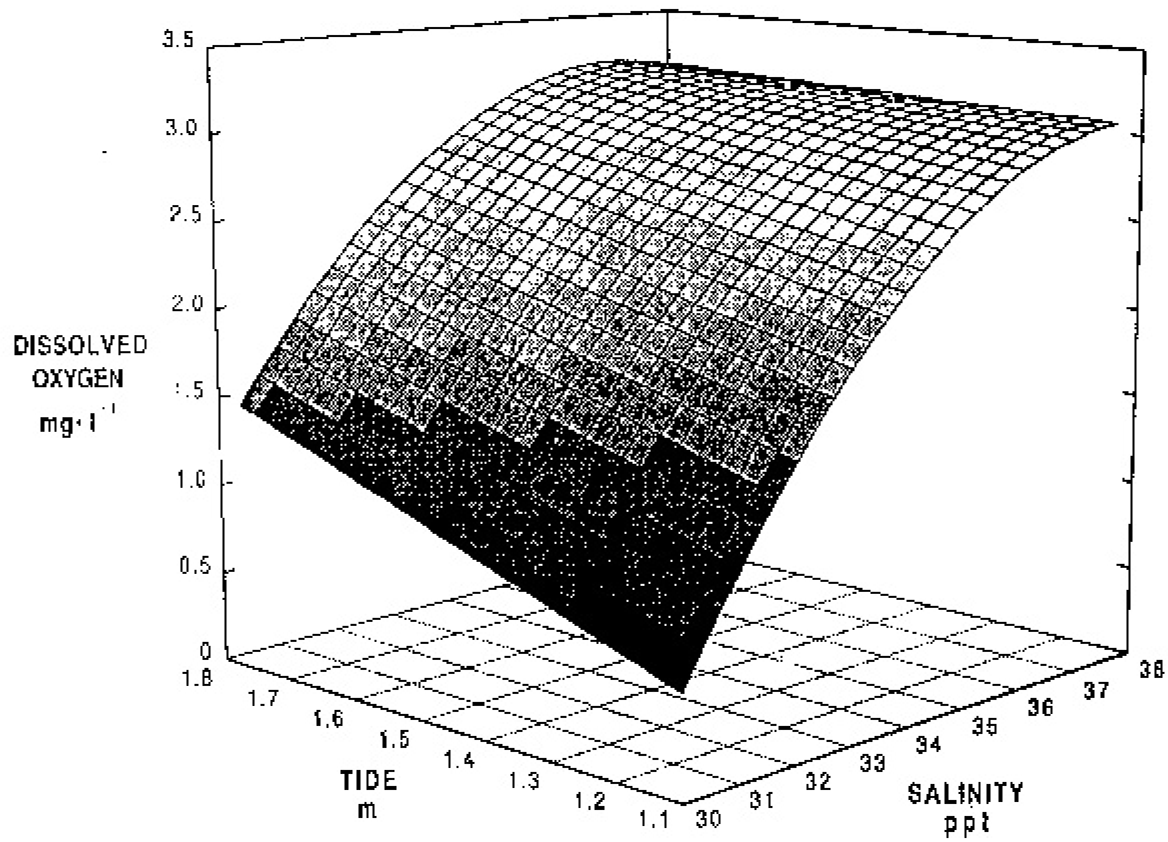

Figure 5C. 3D plot of dissolved oxygen (milligrams/liter) versus tide (meters) and salinity (parts per thousand - ppt) at Port Pine Channel. Number of samples = 4343 (from LaPointe and Matzie 1996).

NOTES TO FACULTY

In this jigsaw, there are 3 subsets of information. Using a class of 30 as an example, divide the class into 6 subgroups of 5 students. Give 2 groups Figure 5A plus accompanying information (below), 2 groups 5B, and 2 groups 5C. Allow these students enough time to look at their figures and background information individually and then with their team members. The goal is for each student to understand their topic clearly enough so that they can teach it to another student. Then, rearrange the groups so that there are 10 groups with an A, B, and C student in each one. Again, give the second grouping time so that students can explain their figure and questions they may have without feeling rushed. The final question for this group is to use their combined knowledge to explain why nutrient loading into the Florida Bay region results in loss of corals, seagrasses, fish and other organisms. That's what makes it a "jigsaw" - the pieces are reassembled to solve the puzzle.

This may be a challenging problem for both groupings of your students. You of course are the best judge of how much time they will need. It would be best to do this jigsaw during class time when you are available to help students and when they are all present. If you cannot use up this much time, the first group could meet outside of class and the second in class. When it is not possible for students to meet in person, groupwork via computer is an alternative.

If your students are unfamiliar with units such as “micro” and “milli, log scales, and moles you should explain this to them ahead of time or in a hand-out reference for the groups. You will also need to explain – or have them reason out - that farming, sewage treatment, and septic systems are common sources of N and P for many water bodies if you anticipate that few students will know this.

You should explain the units for oxygen and salinity in your next group. In air oxygen concentrations are much higher than in water and we measure air oxygen in units of percent (pph) as opposed to ppm in water. The concentration of oxygen dissolved in water depends on the water temperature and the salinity; as temperature and salinity increase, the amount of oxygen “at saturation” decreases. Saturation is an easy concept to understand; if you place a bucket of water in a room, the water in “Saturated” with oxygen when the flux rate of oxygen in and out of the water are the same.

The salinity units are even easier. Students probably know from experience that seawater is denser than freshwater because you float more easily in the ocean than in a lake. Seawater is denser because of the salt (mostly NaCl) that is dissolved in it. Again, the units for salinity are parts per thousand. Explain to them that the ocean is about 30 ppt which is the same as 3 percent (parts per hundred).

Student Assessment: Diagram quiz.

Draw a sketch or diagram demonstrating how nutrient loading leads to anoxic conditions.

Evaluating an Issue: How do you know whether it is working?

On-going (also called formative) evaluation of the approaches your are using is critical to the success of student-active teaching. Why try out new ideas if you don't know whether or not they are working? This is a brief overview of formative evaluation. For more information, go to the Formative Evaluation essay in the Teaching Section.

Course Goals:

Formative evaluation only works if you have clearly described your course goals - because the purpose of the evaluation is to assess whether a particular technique is helping students reach these goals. For instance, most of us have "learn important ecological concepts and information" as a course goal. If I reviewed the nitrogen cycle in a class, for evaluation I might ask students to sketch out a nitrogen cycle for a particular habitat or system. Each student could work alone in class. Alternatively, I might ask students to work in groups of 3 and give each group a different situation (e.g. a pond receiving nitrate from septic systems, an organic agricultural field, an agricultural field receiving synthetic fertilizer). The students could draw their flows on a large sheet of paper (or an overhead transparency) and present this to the rest of the class.

The Minute Paper:

Minute papers are very useful evaluative tools. If done well they give you good feedback quickly. Minute papers are done at the end of a class. The students are asked to respond anonymously to a short question that you ask. They take a minute or so to write their response in a 3x5 card or a piece of paper. You collect these and learn from common themes. In the next class it is important that you refer to one or two of these points so that students recognize that their input matters to you. The UW - FLAG site (www.wcer.wisc.edu/nise/cl1/flag/) gives a good deal of information about using minute papers including their limitations, how to phrase your question, step-by-step instructions, modifications, and the theory and research behind their use.