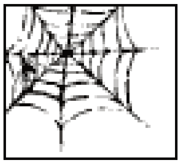
The Volunteer Monitor

The National Newsletter of Volunteer Water Quality Monitoring
Vol. 5, No. 1, Spring 1993



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Special Topic: School-Based Monitoring

"Students and Teachers never look at the river the same way again. It becomes a living thing. Students have told me they thought the river was just water between two banks' before the project."

- Geoff Dates
  River Watch Network

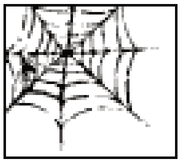
"The first day we did the testing, I told the students, What's neat about this is we're starting this today and it's going to do on forever.'"

- Glenn Tremblay
  science teacher

Co-Editors: GREEN (Global Rivers Environmental Education Network)

For more information, see How to Be Part of GREEN in this issue.

The following articles appear in this edition of *The Volunteer Monitor:*



About The Volunteer Monitor

The Volunteer Monitor newsletter serves as a networking tool and information source for volunteer environmental monitoring groups nationwide. It strives to represent the diversity and scope of citizen monitoring activities and to facilitate the exchange of ideas, monitoring methods, and practical advice.

Subscribing

Subscriptions to *The Volunteer Monitor* are free. To be added to the mailing list, write to the address below.

Reprinting Articles

Feel free to reprint or excerpt material from *The Volunteer Monitor.* None of the material is copyrighted. Please remember to give credit to both the newsletter and the article's author.

Participating

The newsletter is your tool for information sharing. You can:

- Suggest article topics. What would you like to learn more about?
- Write an article or a letter to the editor.
- Publicize what you have to offer-books, videos, manuals, etc.
- Contribute technical tips.

Rotating Co-Editors

The Volunteer Monitor has a permanent editor and volunteer editorial board. In addition, a different monitoring group serves as co-editor for each issue. This unique structure ensures stability while at the same allowing a variety of viewpoints to be represented.

Address all correspondence to: Eleanor Ely, editor, 1318 Masonic Avenue, San Francisco, CA 94117; telephone 415/255-8049 (9 a.m. - 5 p.m. Pacific time).

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Back Issues

The following back issues are available:

- Fall 1991 (special topic: Biological Monitoring; limited supply available)
- Spring 1992 (special topic: Monitoring for Advocacy)
- Fall 1992 (special topic: Building Credibility)

To obtain back issues, or additional copies of this issue, please send a self-addressed stamped envelope, 9 x 12 or larger, to the address below. First-class postage is 52¢ for one issue, $0.98 for two, and $1.44 for three. For $2.90, you can get up to 15 copies. For larger orders, please call for shipping charges.

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CORRECTION

In the last issue of *The Volunteer Monitor*, the telephone number for *NPS News-Notes* was incorrectly listed as 202/ 260-1517. That is actually their fax number. The correct phone number is 202/ 260-3665. Apologies for any inconvenience this may have caused.

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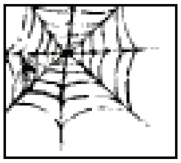
From the Editor

Everyone who worked on producing this issue of *The Volunteer Monitor* was amazed at the number of students and teachers who are monitoring water quality. And the programs represented in these pages are just the tip of the iceberg. From small projects conducted by a single teacher and class, to watershed-wide, statewide, or even international networks, many thousands of students laden with kits and nets are out testing the quality of their local waters.

Why so many? Time and again, teachers describing the value of water monitoring use the same two expressions: "hands-on" and "real-world." Monitoring is hands-on because it allows students to do actual scientific research; as one students said, "It makes science three-dimensional." And it's real-world because it extends the classroom into the community, giving students a chance to provide a useful service and bringing them face to face with social issues. Monitoring projects lend themselves perfectly to the goal of environmental education - to develop a citizenry that works for positive changes in the environment.

One topic noticeably absent is how to fund a school-based monitoring program. That's because the next issue of *The Volunteer Monitor* (Fall 1993) will focus on obtaining funding, as well as other types of support, for all types of water quality monitoring projects. The co-editing group for that issue will be Maryland Save Our Streams.



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Staff at *The Volunteer Monitor*

Editor: Eleanor Ely

Co-editing group for each issue changes: GREEN (Global Rivers Environmental Education Network).

Graphic Designer: Brien Brennan

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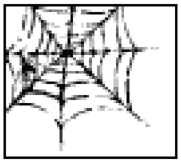

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Getting Help Online

On March 18, 1993, students at Oakmont Regional High School in Ashburnham, Massachusetts, logged onto EcoNet, entered a GREEN conference called "gr.monitoring," and sent out a call for help.

"We need help," they wrote. "We are involved in testing a stream near our school for detergent contamination. . . . Are there any of you who have done this? If so, what types of tests did you do?"

Four days later, GREEN founder Bill Stapp entered this response into the same conference: "We have not been testing directly for detergents - but rather for total phosphates that may be coming from detergents and other sources. Detergents are not quite the problem that they used to be. . . ."

And on April 1, high school teacher Deb Reinke logged on and added the following advice: "In the past, detergents had a higher phosphorus content. Now phosphorus content in detergents is regulated. . . . Use the phosphate test. You should also check the DO and BOD. If there are many phosphates in the water, you will have an algae bloom. . . ."

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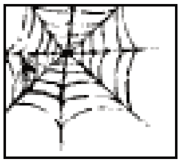

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Maryland Forms Statewide Monitoring Association

by Kathy Ellett

Volunteer water monitoring groups in Maryland have joined together to form a statewide association, the Maryland Volunteer Water Quality Monitoring Association. We believe this is the first such statewide organization of volunteer monitoring groups.

The new organization is an outgrowth of discussions held by Maryland participants at a regional volunteer monitoring workshop in May 1991. A Steering Committee was formed in November 1991 and has (1) drawn up Articles of Incorporation; (2) developed a mission statement, goals, and objectives; (3) written and approved a set of bylaws; and (4) received nonprofit tax-exempt status under IRS code Section 501(c)(3).

Important objectives and activities for the association include:

- foster communication among citizen and governmental monitoring units
- develop a statewide directory of citizen and governmental water quality monitoring groups
- maintain a statewide listing of who is collecting what monitoring data, and where
- act as a liaison between monitoring groups and manufacturers of monitoring equipment, to assure that the equipment is effective and accurate
- offer training and workshops in monitoring techniques
- promote quality assurance
- determine how to best use citizen monitoring data to improve the quality of our waterways

Principal membership in the association will be held by representatives of Maryland organizations that are involved in hands-on volunteer water quality monitoring. Individuals involved in volunteer monitoring projects may be non-voting members. The organization received start-up money from the Chesapeake Bay Trust and will be supported primarily by annual dues ($45 for organizations and $25 for individuals).

For more information, contact Kathy Ellett, Alliance for the Chesapeake Bay, 6600 York Rd., Ste. 100, Baltimore, MD 21212; 410/377-6270.

Watersheds

Revised December 8, 1998
URL: http://www.epa.gov/volunteer/spring93/school01.htm

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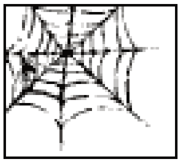

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National Monitoring Association Developments

by Jerry Schoen

As reported in past issues of *The Volunteer Monitor*, representatives from volunteer monitoring groups around the country are working to form a national association to promote volunteer monitoring. The goals and objectives proposed by the goals subcommittee were listed in the Fall 1992 issue of the newsletter.

Survey Now in Progress

Over the past few months, the survey subcommittee (Robert Frease, Abby Markowitz, Al Schmauder, Jerry Schoen, Karen Siletti, David Tessitor, and Joseph Sanders [chair]) has developed a questionnaire, which is being circulated to members of the volunteer monitoring community to help determine the desired priorities for the goals, composition, benefits, and activities of the proposed association. If you would like to participate in the survey , please request a copy of the questionnaire from Joseph Sanders, Marine Stadium Center, Long Beach Schools, P.O. Box 91598, Long Beach, CA 90809 (phone 310/498-2071); or Jerry Schoen, MassWWP, Blaisdell House, UMass, Amherst, MA 01003 (phone 413/545-5532).

In order for your responses to be included in the results, you must request and fill out the survey promptly.[*Note:* This material is dated such that the survey may no longer be available.]

Current Status: An Overview

Volunteer environmental monitors began communicating with one another on a national level in 1988, when the U.S. Environmental Protection Agency (EPA) sponsored the first national volunteer monitoring workshop. Since then, EPA has taken a lead role in facilitating national-level communication among volunteer monitors.

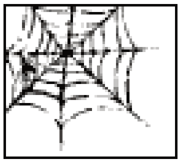
EPA's Office of Water has designated Alice Mayio to serve as Volunteer Monitoring Coordinator in Washington, DC. Each of EPA's 10 regional offices has also designated an employee to help support volunteer monitoring in that region.

In addition, EPA sponsors the following projects: national and regional volunteer monitoring conferences; a national newsletter, *The Volunteer Monitor*; a volunteer monitoring mini-bulletin board on the NPS electronic bulletin board (see article on page 11); a national directory of volunteer programs, the fourth edition of which is currently under way; and several methods manuals and guidance documents.

Questions for the Future

The EPA has expressed its commitment to continue or expand its assistance to volunteer monitors. As a national volunteer monitoring association emerges, we need to consider the following questions: How important is it to establish similar alliances with other federal agencies, corporations, foundations, and interest groups? Who should these other supporters be? How might the association best cooperate with all potential allies, including EPA, to help volunteer monitoring programs thrive today and move into the next generation of environmental decision making?

Please let us know your thoughts on these questions, either by requesting and filling out the survey questionnaire or by discussing your ideas with Jerry Schoen or Joseph Sanders (phone numbers listed above).



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Volunteer Monitoring Electronic Bulletin Board Opens

The U.S. Environmental Protection Agency (EPA) has just set up an electronic mini-bulletin board that will allow volunteer monitors to communicate with each other via computer. Called the Volunteer Monitoring Special Interest Group (SIG) Forum, the bulletin board is a special part of EPA's Nonpoint Source Electronic Bulletin Board System (NPS BBS) dedicated to volunteer monitoring. The Volunteer Monitoring SIG provides users with timely and relevant volunteer monitoring information, a forum for open discussion, and the ability to exchange computer text and program files.

Bulletins on the Volunteer Monitoring SIG include VolMon News, which highlights new developments and activities, and VM Calendar, a regularly updated listing of meetings and conferences of interest to volunteer monitors.

The SIG also contains special files such as an EPA factsheet on how to get started in volunteer monitoring, summary information on volunteer monitoring programs managed or sponsored by state agencies, a list of environmental newsletters, and a bibliography of documents on monitoring and related topics. Back issues of *The Volunteer Monitor* newsletter will also be available on the SIG soon.

The SIG's technical monitor, Alice Mayio of EPA's Office of Wetlands, Oceans, and Watersheds, will continually add new messages, files, and bulletins and encourages online questions, comments, and discussion.

Getting on the SIG

To get on the Volunteer Monitoring SIG, you first need to access the NPS BBS. You'll need a personal computer or terminal, telecommunications software, a modem (1200, 2400, or 9600 baud), and a phone line.

The phone number of the NPS BBS is 301/589-0205, and the telecommunication parameters are no parity, 8 bits, and stop-bit (N-8-1). To get on any of the SIG Forums, type "J" (for "join") and press . You will see a menu of SIGs from which to select.

To get a user's manual for the NPS BBS, write to the EPA, Assessment and Watershed Protection Division (WH-553), NPS Information Exchange, 401 M St., SW, Washington, DC 20460.

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Interdisciplinary School-Based Water Monitoring Programs

by Nancy M. Trautmann

Because comprehensive water monitoring programs are by their very nature interdisciplinary, water monitoring provides an ideal focus for integration of many different school disciplines. This is the philosophy behind Cornell University's Institute on Science, Computing, and the Environment, a week-long residential continuing education program for high school science teachers (See *Note). The science teachers attend the Institute in teams (for example, chemistry, biology, and earth science) so that when they return to their home schools they will be equipped and enabled to carry out water quality projects that span the science disciplines. Together the teachers learn skills in water quality monitoring, remote sensing, land use analysis, and computer modeling. By the end of the week, each participating team has designed a water quality curriculum project to be carried out by cooperating science classes at their school.

Interdisciplinary Program Structure : Two Models

A common way to structure interdisciplinary stream monitoring is to have each class focus on its own subject area, then share results with cooperating classes from other science disciplines. This approach is being used in Corning, New York, for example, where biology and chemistry classes are studying the impact of a major highway construction project on a stream that runs by their school. Because the classes meet at different times of day, they take separate field trips to the same stream site, with biology classes sampling invertebrate populations and chemistry classes collecting chemical data. By pooling their results, the students learn about cross connections between the science disciplines.

A different approach is being taken in Canandaigua, New York, where high school biology, chemistry, and earth science classes have teamed up to monitor a stream that changes character significantly within a stretch of several kilometers. The three classes, ranging from freshmen to Advanced Placement seniors, each sample biological, chemical, and physical parameters at a separate site along the stream. The first time they went out, the students stayed at their class's designated stream site, while the teachers rotated from site to site conducting lessons in their own subject areas. With the biology teacher, the students inventoried macroinvertebrate life. When the chemistry teacher arrived at their site, the students measured dissolved oxygen, pH, nutrients, and other chemical parameters. With the earth science teacher, they conducted stream flow measurements. After the initial sampling day, the teachers have no longer needed to rotate, since each class has become familiar enough with the techniques to perform all the tests.

After field trips, each class characterizes the biological, chemical, and physical parameters of the site they visited, then compares their results with those of the other two classes. Working together, the classes analyze changes in water quality as the stream flows past industrial and residential development.

Linking Science Disciplines

Stream monitoring provides a natural way to link biological, chemical, and physical measurements, allowing students to experience firsthand how science is used in the real world. For example, biology classes learn about the survival requirements and particular adaptations of aquatic organisms, as well as how the organisms can be used as indicators of water quality. They relate the kinds of life found at each stream site to aquatic chemistry, and they learn how changes in habitat affect the types, diversity, and numbers of organisms found.

Chemistry classes learn how dissolved oxygen levels are affected by water temperature and by rates of aquatic photosynthesis and decay. (Students often are surprised to learn that more oxygen dissolves in cold water than warm, since in their experience most substances, such as sugar, dissolve more readily in a warm liquid.) When they relate nutrient concentrations to rates of stream flow, they discover another chemical concept that is not intuitive: lower concentrations of a substance in a stream do not necessarily mean lower amounts of that substance reaching a downstream lake or reservoir. By calculating chemical loads (multiplying the concentration of a chemical by the volume of stream flow), they learn that measuring concentration alone does not tell the full story - the total load of nutrients carried by the stream may peak at times when the concentrations are low but flow volumes are high.

Earth science and physical science classes measure stream flow and turbidity and correlate these with weather patterns. They learn how to interpret a topographic map, including calculating slope and stream gradient and defining watershed boundaries. They study how local geology relates to water hardness, pH, and alkalinity. Using maps, aerial photographs, and field observations, they analyze watershed land uses and predict trends in stream flows, flood levels, and water quality based on land use changes over time.

Beyond the Sciences

The possibilities for interdisciplinary school-based water monitoring reach far beyond the sciences. Students can write letters or articles for local newspapers, make presentations to government agencies, and participate in local politics. They can compose songs about water or sing those written by Pete Seeger and others. Human biology or health classes can explore human needs for water, how water quality standards are set, and what risks are posed by contaminated drinking water. Math classes can use monitoring data to introduce statistics and discuss how to design sampling so that statistically meaningful results will be obtained.

Obstacles to Interdisciplinary Programs

Teachers attempting to conduct interdisciplinary water monitoring programs face a number of possible obstacles. Scheduling is one oft-cited problem. When the classes involved meet at different times of day, joint field trips may be impossible. Moreover, some laboratory class periods are too short to allow for any field sampling. Some schools have solved such scheduling problems by conducting water monitoring as an end-of-year special project, with all classes participating together in a joint field day. Another approach is to conduct field work as an after-school or weekend science club activity, then provide the samples or data to classes for analysis.

Curricular requirements may also present constraints. In New York State, for example, the state-mandated syllabi tightly control the content of high school science classes. Teachers have responded in two ways: either by speeding through the mandated syllabus to save time for water monitoring activities, or by creatively using water monitoring activities in conjunction with more traditional approaches to teach the required concepts. For example, the study of aquatic life can be incorporated into the ecology section of biology curricula and used to demonstrate concepts in population dynamics, habitat requirements, energy flow, and food webs.

Perhaps the most common challenge facing teachers who want to conduct interdisciplinary programs is the need to work together rather than independently. This coordination requires extra effort on the part of the teachers, but it can be facilitated by teacher education opportunities that are aimed at interdisciplinary teacher teams. Such events provide the opportunity for teachers to get to know each other, to discover their common interests and concerns, and to work together in overcoming their own school-specific constraints.

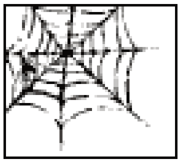
Is The Effort Worthwhile?

Teachers who have overcome the obstacles and are carrying out interdisciplinary water monitoring programs are enthusiastic about the results. Students' motivation is increased when they can share their data with other classes - especially when students in remedial level classes provide data to more advanced classes. Interdisciplinary programs also help students understand how the disciplines they currently are studying fit together with the ones they have studied or will study in other years, and how professionals in all of these fields work together to resolve social problems.

After conducting his first interdisciplinary stream monitoring field trip, Bud Bertino, a biology teacher in Canandaigua, New York, said, "I could not believe the level of enthusiasm that could be generated in all levels of classes, from Advanced Placement down to freshman remedial level students. The hands-on, practical approach made science come alive for all of them."

**Note: The Institute currently is funded with New York State funds and consequently is open only to New York State teachers. Plans are in place, however, to expand the Institute with other funding sources and to admit teachers from other states starting in 1994.*

***Nancy Trautmann** is Youth and Teacher Outreach Coordinator for the Cornell Center for the Environment, NYS Water Resources Institute, 115 Wing Hall, Cornell University, Ithaca, NY 14853.*



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Macroinvertebrates and Math

For the past three years, the Connecticut Department of Environmental Protection's SEARCH River Monitoring Program has been a tremendous success with my Junior Ecology classes. As part of our project, the students collect, sort, and identify macroinvertebrates from the stream bed. Once they discover the variety of these aquatic insects, they never look at a river the same way again.

We use the River Watch Network's *Guide to Macroinvertebrate Sampling*, which offers a clear description of methodology and a "user-friendly" picture key (see Note below). Students analyze their macroinvertebrate data using the various indices described in this manual. They find a practical application for their math skills as they calculate such indices as the Percent Composition of Major Groups, the Modified Family Biotic Index, and Organism Density per Sample. As an example, the Modified Family Biotic Index is calculated from the following formula:

$$[\text{the sum of all } (nT)] \div [\text{the sum of all } N]$$

where:

n = the number of insects in the sample that belong to a given family
N = the total number of organisms found at the site
T = the Tolerance Value for a given family

Analyzing the data also involves graphing. I use this opportunity to introduce my students to the use of computer spreadsheet software for storing and graphing data. Finally, the students need to use critical thinking to interpret the results and determine the overall water quality picture for our river.

**Note: This manual is available for $5 from RWN, 153 State St., Montpelier, VT 05602.*

Linda Charpentier
Xavier High School
Middletown, CT

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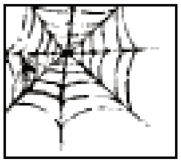

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Putting the Action Into Your Action Plans

by Terrie Cooper

Last spring, high school students from 32 schools in the Milwaukee River Watershed "Testing the Waters" program came together for a daylong Student Congress. After presenting their biological and chemical water quality data, the students worked together to develop "action plans" to address the issues facing the river. Enthusiasm was high as they came up with proposals to:

- Stencil storm sewer drains to prevent careless dumping of pollutants into the river
- Organize a school-wide litter cleanup program along specific sections of the river
- Launch a public awareness campaign to increase concern for water quality in the river
- Present their research findings to the county conservation club to raise funds for farmers who participate in nonpoint pollution abatement programs

There was just one catch: the date was May 24. Only two weeks of school remained. As you might guess, the students' action plans stayed just that . . . plans.

Yet the goals of environmental education-teaching students that they can make a difference, and developing a citizenry skilled in, and committed to, resolving issues-depend on students having opportunities to take action in the "real world." How can we make sure that students have time for "action," not just for plans?

Use Your Existing Database

One solution is to start right at the beginning of the school year taking action based on last year's data (or preferably a longer data base, if you have one). This approach also helps students realize the importance of long-term monitoring in identifying water quality trends.

Involve Several Disciplines

No matter how early in the school year you start, the science classes that are doing the actual data collection and analysis probably won't have time for much action-taking. We have worked to resolve this problem by having the science class present and explain their findings to other classes, which then take action on the data. English classes have conducted letter-writing campaigns and social studies classes have made presentations at public hearings. We are currently working with technical education classes to design and construct interpretative signs to be placed at our testing sites. The signs will increase public awareness about the water quality issues affecting that particular site - for example, one sign will contain information about non-point source pollution and barnyard runoff.

Look Outside the School

One of the most frustrating aspects of student action-taking projects - next to lack of time - is not having the logistical, financial, and human resources available to make the projects a reality. You may be able to find such resources outside the school setting, either in a student after-school club, such as an ecology club, or in a community-based environmental group. The exciting thing about working with such organizations is that they can carry a project through a number of years, rather than having it end at the completion of the school year.

Some groups you might consider working with include your county Land Conservation Department and local chapters of organizations such as Sierra Club, Audubon Society, Izaak Walton League, Lions Club, Jaycees, and League of Women Voters. Your Chamber of Commerce should have a directory listing such organizations in your area.

If your organization has found additional strategies for making the action component of your water monitoring program a reality, please share them with us, so together we can continue to make a difference!

Terrie Cooper *is Project Director for the "Testing the Waters" program of the Milwaukee River Watershed. She may be reached at Riveredge Nature Center, P.O. Box 26, Newburg, WI 53060; 414/675-6888.*

Wisconsin's ***Testing the Waters*** *program, modeled on Project GREEN, is sponsored by a consortium of nature centers, local and state agencies, and UW-Extension. This year, students at 32 participating schools performed water quality testing in the Milwaukee River Watershed*

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The Real Social Studies

Carefully, a group of students collects a stream water sample and measures its dissolved oxygen content. Upstream, another group from the same class wades into the water armed with nets and trays to collect benthic macroinvertebrates.

An ecology class on a field trip? Not at all - these are social studies students on a mission: to assess the quality of a local stream, interpret the implications of their results for the community, and develop and carry out a plan of action to preserve or improve the quality of the stream.

But why are they out of doors, out of books, out of libraries? Because this is the real social studies - doing real research in the real world.

For too long, the social studies have focused on knowledge acquisition. Yet the social studies are intended to develop an informed and involved citizenry. Water quality monitoring offers limitless opportunities to confront students with puzzling, troubling, real problems that they are genuinely interested in learning about.

Many social studies teachers would probably choose to let science classes collect the actual water quality data, then allow their own students to analyze it. But my philosophy is that if you really want to understand the nature of your data you have to collect it yourself - you have to get your hands dirty. If my students were presented with a set of water quality data, they would be inclined to think, "It's on a piece of paper, man - it must be true." When students collect data themselves, they are all too aware of the errors it might contain.

-Al Lewandowski
Port Huron Northern High
Port Huron, MI

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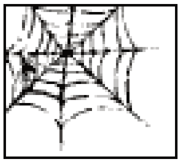

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Research Paper Puts it All Together

For my senior level Environmental Science class, I wanted to come up with a project that would tie together the things the students had learned in earth science, biology, chemistry, English, math, and social studies. I decided the best way to do this was to have the students develop a real and worthwhile research paper based on their involvement in Wisconsin's "Testing the Waters" monitoring program. The students collect quantified data using nine water quality tests. They then use this data to write a research paper that requires them to:

- Identify potential problems with the river and hypothesize why the problems are occurring
- Describe the importance of each of the nine water quality tests
- Present their results in a quantified data chart
- Discuss the significance of their findings
- Propose steps that could be taken to correct the problems found

Jan Jaeger, a student who participated in the program, said, "The paper required me to understand the data and also come up with ways to correct the problems." She added, "The great thing about the program is that even kids who weren't interested in the class became interested in 'Testing the Waters.'"

-Stu Hannam
Grafton High School
Grafton, WI

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Computer Networking

by Eleanor Ely

Telecommunication - the ability to transmit information from computer to computer through a phone line using a modem - is still relatively new. Teachers who are using computer networking in their classrooms are truly pioneers, and like any pioneers they have to overcome barriers and frustrations.

THE VISION:

"Imagine being able to share your water quality data and your environmental concerns with schools throughout your watershed and around the world. . . . Through telecommunications, the world is transformed . . . into a global community."

— Mark Mitchell and William Stapp, *Field Manual for Water Quality Monitoring*

THE REALITY:

"The computer I use is my own from home. Everything I have, I have bought with my own money. The lack of [administrative] support is frustrating."

— high school teacher, Michigan

"After one training session on the computer, one teacher burst out, 'How can you expect us to do this? It's too complicated! If I had known we were going to have to do something this difficult I never would have signed up.'"

— high school teacher, Wisconsin

"It's Worth It"

"There's power there - but we have to get through the roadblocks," says Al Lewandowski, a Port Huron, Michigan, teacher whose classes participate in a Project GREEN water monitoring project. "If I can get my students to communicate with people from the far reaches of the planet, it's worth it."

The unique advantage of telecommunicating, points out EcoNet Environmental Education Coordinator Andy Alm, is that "it expands your network of contact in a way not possible through any other medium. By cutting out the gatekeeper function of the mass media, you can communicate directly with like-minded people. Suddenly, your community is the planet."

Teachers, who traditionally have been isolated from their peers, stand to benefit as much as students. Computer networking offers the opportunity to communicate with other teachers all over the country.

What You Need To Network

To telecommunicate, you need a computer, a phone line, a modem (a device that connects a computer to a phone line and converts signals from the computer into sound frequencies), and telecommunications software. A modem with a baud rate (speed) of at least 2400 bps is recommended; you should be able to find one for $60 - $70. Many telecommunications software packages are available; Alm generally recommends ProComm for IBM-type computers and ZTerm for Macintosh (both of these are available as shareware).

Now that you're equipped, you need to take one more step to enter the world of computer networking: you need to find a "bulletin board" (a relatively small network based in a single computer) or a larger network to join. Some networks are free (though you may have to make a toll telephone call to access them), while others charge sign-up fees, online charges, and/or monthly subscription rates. Once you're connected to a network, you can "talk" to anyone else on the network via public forums, or "conferences." Some networks are "closed," meaning that you can only communicate with other people who are on the same network, while others are linked ("gatewayed") to other networks, allowing you to access those networks as well.

An excellent introduction to computer networking, geared especially to environmentally oriented networks, is *Ecolinking*, by Don Rittner (Peachpit Press, Berkeley, CA, 1992).

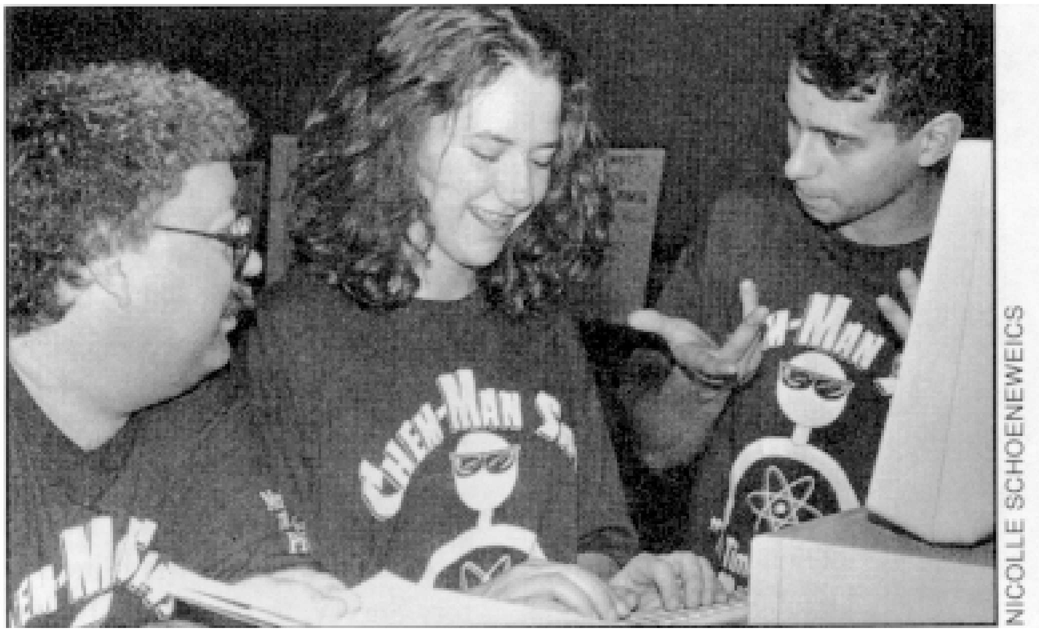
Computer Networking in Schools

Computer networking in the school setting presents its own special set of challenges. The first problem generally is lack of money to buy computers, modems, and software - or to pay phone charges or online charges.

Gaining access to a phone line can be a major hurdle, since classrooms almost never are equipped with a phone. Often the computer has to be wheeled into another room to be hooked up to a phone line.

Even after a teacher has succeeded in obtaining equipment and a phone line, he or she often has to teach a whole roomful of students using just one computer. Lewandowski handles this situation by teaching the telecommunications procedures to five or six students, then having those teach their classmates.

Many teachers are unfamiliar with computers, and few schools provide the luxury of a computer specialist on staff. Fortunately, a ready source of help is at hand. "The best way for teachers to learn how to use computer networking is to ask their students," says Lowell Herr, a physics teacher who developed the computer networking system for the Student Watershed Research Project in Oregon.



For additional tips, see the chapter on "Computer Networking" in the GREEN manual, *Field Manual for Water Quality Monitoring*, by Mark Mitchell and William Stapp (available for $9.95 from William Stapp, 2050 Delaware, Ann Arbor, MI 48103).

Computer Networking and Monitoring

A number of school-based water quality monitoring programs are using computer networking to exchange data, notify participants about upcoming program events, problem-solve, and discuss water quality concerns. Following are three examples, ranging from a local bulletin board to a global network.

SWRP

"If you want teachers to really use the computer network, you have to make it an essential tool," says Steve Andrews, program director with Oregon's Student Watershed Research Project (SWRP). "It can't be just a toy. Once the administration is convinced that computer networking is important, they will find the resources to support it."

Fourteen classes at 13 schools share SWRP water quality data via a bulletin board that is part of K12Net, a free international computer network for teachers. This summer, 14 more classes are expected to go online. To help students enter their data, SWRP has developed custom software that produces a screen display in the same format as the field data sheet the students use. All participating classes receive a free copy of this software.

Illinois Rivers Project

The 180 schools participating in the Illinois Rivers Project are linked through an electronic bulletin board called SOILED NET (for "Southern Illinois Education Network"), which is part of a larger nationwide educational network called FrEdMail. The Project chose FrEdMail because it is free (no online charges) and it also carries many other educational forums.

To make it easy for teachers to participate in SOILED NET, the Illinois Rivers Project provides them with a modem and software, as well as hands-on training. Project staff also work with the school administration to make a phone line available for telecommunications, and on occasion the Project has even paid for the line to be installed.

Participating schools use SOILED NET to send their water quality data to the Project office. There, staff members compile the results from all the schools into one file, which in turn is made available to the schools via SOILED NET. Having access to the complete data set encourages students to analyze the data and to identify geographic and temporal trends.

GREEN

Global communication as a means to cross-cultural understanding is a fundamental goal of the Global Rivers Environmental Education Network (GREEN), and GREEN's computer network provides one important avenue for pursuing this goal.

The GREEN computer network consists of 10 conferences located on EcoNet, a nonprofit environmental network. EcoNet charges users a minimal fee for subscribing as well as for online time. Mare Cromwell, GREEN Acting Executive Director, explains that EcoNet offers (1) the opportunity to interact with a very active international network of people interested in environmental issues, and (2) access to other EcoNet conferences on topics such as global warming, toxics, environmental education, and energy policy. For many GREEN participants, communicating about environmental issues and sharing ideas for action-taking is at least as important as sharing data.

The GREEN computer conferences are open to any school or community in the world and are networked to every continent. In addition to participating in GREEN's international computer conferences, GREEN programs have the option of creating a separate conference for their own watershed.

Don't Give Up!

Admittedly, computer networking takes perseverance - especially in a school environment - but those who have taken up the challenge are sold on the benefits. Above and beyond the tangible benefits, such as data sharing and cross-cultural communication, simply giving students hands-on experience with the technology is valuable preparation for work in the "information age." And when monitoring information is compiled on an electronic database, it is not only easier to share and analyze within a program, but also much more useful to agencies. For example, the Illinois Rivers Project data file is sent electronically to the Illinois EPA and the U.S. Fish and Wildlife Service.

Finally, if you get discouraged, remember that the technology is continually developing, and it's getting easier every day.

For more information about the networking systems described above, contact: Illinois Rivers Project, SIUE, Box 2222, Edwardsville, IL 62026-2222, phone 618/692-3788; SWRP, Saturday Academy, OGI, 19600 NW Von Neumann Drive, Beaverton, OR 97006, phone 503/690-1416; Project GREEN, 216 S. State St., Ste. 4, Ann Arbor, MI 48104, phone 313/761-8142.

Eleanor Ely *is the editor of* The Volunteer Monitor.

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Getting the Word Out

by Robert Williams and Cindy Bidlack

Since its inception in February, 1990, the Illinois Rivers Project has grown phenomenally - from 8 schools in Illinois to 180 schools in eight Midwestern states. Each school in the Project monitors one or more river sites for nine water quality parameters, according to the model developed by Project GREEN. Most schools sample at least four times per year. Through the Rivers Project computer network and our annual Student Congress, results are shared to give a composite picture of the river's health.

Without good outreach and publicity, the Rivers Project would not be where it is today. Publicity provided the avenue for Project expansion.

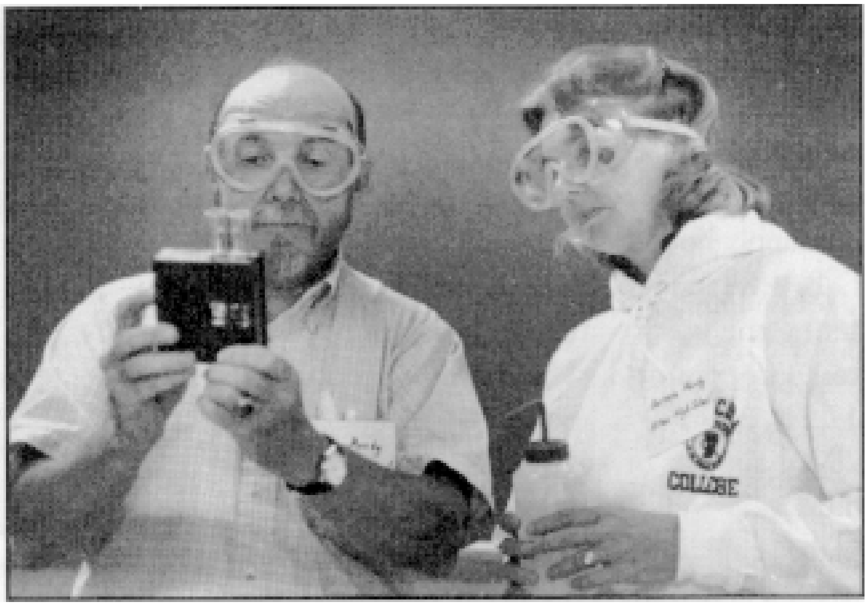
We would like to share with you some of our thoughts about creating a successful image for your project. But first we should warn you: The more exposure your project gets, the more work you will have. So, if you set out to make your project fantastic, just remember that a person can be worked to death loving and nurturing a river!

Reaching Out Through the Media

The Rivers Project places great emphasis on newspaper and magazine articles and TV coverage. This publicity has brought us additional funding and equipment, led new schools to the program, and generated more articles and coverage. It has also enabled us to share our knowledge and concerns about the river. Like an advertiser reaching out to a new purchaser, we reach out to enlarge our audience because everyone impacts rivers in some way.

For the Project's two all-schools monitoring days (in October and April), media alerts are sent out to newspapers and television stations. We always have a good media turnout. Reporters find students monitoring their local river especially photogenic, and often they trust kids more than adults to tell the truth about water quality. Most Rivers Project schools have filled several scrapbooks with articles about them.

One way the Illinois Rivers Project generates media coverage is by sending photographs like this one, taken at a teacher training session, to the teachers' local newspapers. Shown are Marvin and Barbara Mondy.



Teacher training sessions provide another opportunity for publicity. In this case, instead of inviting reporters to attend, we use another strategy that has proved very successful: teachers from the same school are grouped together, and as they learn to conduct the water quality tests, their pictures are snapped. The teachers fill out questionnaires telling us the names of their local papers, and we send the photos to the appropriate newspapers along with a cut-line that identifies the teachers and the school and gives a short description of the project.

Several Rivers Project schools contribute regular weekly or monthly articles, written by the students, to their local papers. If you try this approach, be sure to warn the students of the probability that their article will be changed in some way. Students don't seem to understand this part of the editing process!

Seeing their names and efforts in print is always encouraging to teachers and students. And at least one Illinois Rivers Project teacher we know of received something more tangible than encouragement. After the local paper ran an article on his class's monitoring work, chemistry teacher Allen Burbank in Chester, Illinois, got a call from the local Wal-Mart manager, who told him, "We have an environmental program that your school is eligible for. Please come by and fill out the application." The upshot was that the school received $350 - and another article appeared in the paper.

Good publicity really pays off at proposal-writing time, when you need to document that other people believe in your work. Due in part to all the media coverage of our program, the Rivers Project has received two Illinois State Board of Education Scientific Literacy grants, three Title Two Dwight D. Eisenhower grants awarded through the Illinois Board of Higher Education, and a three-year National Science Foundation grant to develop a rivers curriculum.

Talks and Presentations

Through presentations and exhibits of all kinds, the Rivers Project reaches out to people who do not know about the Project but have a parallel interest in water quality.

We encourage teachers to volunteer themselves and their students to give talks at meetings of local clubs and civic organizations, as well as at other schools that may be interested in joining the Project. Project staff members make presentations and display materials at various conferences, and if a Project school is nearby, we always ask students to help. The school's scrapbook of news clippings and photographs is also displayed at conferences, where it generally attracts a great deal of interest. Rivers Project students have spoken to such varied groups as the Governor's Conference on the Illinois River, the Kansas Rural and Small Schools Conference, and zebra mussel conferences. Adult audiences are always impressed by the effectiveness of the students' presentations.

When students make presentations, they develop valuable skills and at the same time form ties between the school and the community. Some audience members may become sources of funding, others may become volunteers, others may bring new schools into the network - but all will become part of the ever-expanding body of people with an awareness of river issues.

Student-Authored Book

One of our most visible outreach tools is *Meanderings*, a book of students' writings about their river. *Meanderings* contains stories, plays, and poetry about the river; interviews of local people; and writings on river history and ecology. To date, 10 editions, containing a total of over 2,000 pages, have been published. The Illinois Department of Energy and Natural Resources prints the books as part of their support for the Project.

The books are part of all our displays and are available for purchase for $12. Ken Lubinski, a biologist with the U.S. Fish and Wildlife Service in Onalaska, Wisconsin, told us that he went home after a meeting, started reading *Meanderings*, and couldn't put it down. That's when he knew he wanted Wisconsin involved in the Rivers Project.

Everyone Can Shine

Like the volunteers in any organization, high school students represent a mixture of abilities and interests. Outreach efforts give all students a chance to show their strengths.

Some students may not want to get wet, but they will be happy to talk as much as you want to the press, or at conferences. Those who like English better than science can write newspaper articles or letters to the editor, or contribute a story to *Meanderings*. Others may use their talents at cutting, pasting, drawing, or taking photographs to help create exhibits. The computer whizzes can produce banners and graphics for displays. The rivers need everyone's help.

Illinois Rivers Project student testing the water in Piasa Creek, a tributary of the Mississippi River.

It's a Long Way From 8 to 180

The Project's growth has been a reaffirmation of the ideals with which we began. But growth has also brought some problems. For example, knowing each teacher was easy in the beginning. We still believe that the personal touch is vitally important, but now, with almost 500 teachers, maintaining it is much more difficult.

As you expand your outreach efforts, you too will be dealing with growth. Be sure to look into the future and plan where your project wants to go.

Robert Williams *is Project Advisor and* ***Cindy Bidlack*** *is Project Coordinator for the Rivers Curriculum Project, Illinois Rivers Project, Southern Illinois University, Box 2222, Edwardsville, IL 62026; 618/692-3788.*

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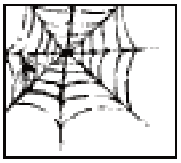

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How to Be Part of GREEN

To be part of GREEN (Global Rivers Environmental Education Network) is to be part of an expanding, proactive international network of people working together for cleaner waters.

Sometimes people assume that to be considered part of GREEN they must meet certain criteria - for example, participate in GREEN's computer conferences, or base their work on the *Field Manual for Water Quality Monitoring*, written by Mark Mitchell and William Stapp (the Honorary Director of GREEN). This is a misconception. In fact, the GREEN network is open to everyone who is concerned about water quality. Different individuals or groups choose different levels of involvement in the network, depending on their needs. Although many people in the GREEN network do follow the Mitchell and Stapp manual, others use a different monitoring approach but still tap GREEN as a resource.

Any individual or group is welcome to participate in GREEN by taking advantage of any or all of the opportunities listed below:

- **Newsletter.** GREEN's quarterly newsletter highlights international and U.S. monitoring activities, especially innovative projects. Teacher activity sheets and students writings are always included. Recent issues feature low-tech monitoring methods. Subscriptions range from $20 to $30 per year.

- **Cross-cultural partners.** The Cross-Cultural Partners Program links students internationally by matching a class or school with a partner class or school in another country. Partner schools exchange water quality information, action plans and strategies, visions for future watershed uses, and information about their respective cultures. Participants receive a handbook of activities and ideas.

- **Computer conferences.** GREEN's conferences on EcoNet offer the opportunity to communicate both within a watershed, via individual watershed-wide conferences, and internationally, through the 10 GREEN international conferences. (For more on GREEN's computer conferences, see "Computer Networking.")

- **Outreach.** GREEN conducts onsite workshops on such topics as water monitoring, action taking, and computer networking, and distributes information and materials out of its Ann Arbor office (see address below).

GREEN's philosophy is that everything we can do to help people create successful monitoring programs brings us closer to the vision of GREEN's founder, Bill Stapp - not only to achieve cleaner waters, but to develop a global citizenry with the knowledge, skills, and motivation to deal with environmental challenges and create a sustainable lifestyle.

For more information, contact GREEN, 216 S. State St., Suite 4, Ann Arbor, MI 48104; 313/761-8142.

Mare Cromwell
Acting Executive Director, GREEN

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Opportunity to Field-Test Rivers Curriculum

The National Science Foundation-funded Rivers Curriculum Project is looking for high school teachers to field-test a new rivers curriculum. The curriculum consists of five month-long units: chemistry, biology, geology, geography, and language arts.

Participating teachers will attend a training session held from August 9 to 13, 1993, in Elsah, Illinois. They will receive meals, lodging, transportation, a $60/day stipend, and curriculum materials to test in their classroom. Five units of graduate credit are available for the training. In return, teachers agree to return to their school and field-test the curriculum during the 1993-1994 school year.

Preference will be given to applications from teachers who can attend the training as part of an interdisciplinary team from the same school (i.e., at least one science teacher and one social science or language arts teacher).

For more information, or to apply, contact Robert Williams, Project Advisor, Rivers Curriculum Project, SIUE, Box 2222, Edwardsville, IL 62026-2222; 618/ 692-3788.

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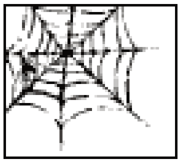

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The School as the Hub of the Community

by Glenn Tremblay

Several years ago, in response to a very high fecal coliform count in the local river estuary, a group of concerned citizens in Newcastle and Damariscotta, Maine, formed a water quality monitoring project known as the Damariscotta River Tidewater Watch Committee. The committee decided to initiate a program to monitor the estuary's temperature, salinity, and fecal coliform levels. Coliforms were of paramount concern because aquaculture and shellfishing are major local industries.

I was involved from the beginning, both as an interested citizen and as an interested teacher. Our committee realized that our monitoring program needed to be (a) ongoing and (b) not too expensive. As a teacher, I felt that involving the high school would be the perfect way to achieve both these objectives - while at the same time teaching science to the students and allowing them to provide a valuable and meaningful service for their community.

It didn't take long to convince the Tidewater Watch Committee that it made sense to work with the school. First, the school tends to be the focal point or hub of a community, and thus it was the perfect place for our committee to hold meetings, training sessions, and public information gatherings. Second, the school laboratory facilities would allow us to perform fecal coliform testing at a low cost. Third, the school provides continuity: once a project becomes part of the curriculum, it is likely to be sustained into future years and generations. And finally, it made a great deal of sense to use the natural resource that I refer to as "teen power": a renewable and enthusiastic source of free energy that was absolutely essential for the long-term project we wanted to establish.

Esperanza Stancioff, from the University of Maine Cooperative Extension, provided our group with training in sampling techniques and laboratory procedures. We decided upon two dozen sampling sites and an every-other-week sampling routine, and we were in business. Sampling began in the spring of 1989 and is ongoing.

The adult volunteers in our group sample all the sites that require boats - about two-thirds of the total sampling. The students and I sample the remainder of the sites from the shore. During the school year, all the laboratory tests are done by the students in the high school science laboratory. In the summer, our committee hires a graduate student to do the sampling and testing.

A Teacher's Point of View

From the point of view of a teacher considering a water quality monitoring program, two questions deserve attention:

- Why is the project good for the students?
- What does the project mean for the teacher?

For students, a water quality monitoring project means the opportunity to actually do relevant research. Most of the work students do in school is done simply for the discipline of doing it; they hand in their report, get a grade, and throw it away. But the monitoring results go into a computer, and students know that in 10 years people will still be using those results. Students feel they are making a real contribution to their community and to the health of the environment.

Students look forward to the water testing days. There are varied tasks for them to do: collect samples, maintain equipment, perform test procedures, record data, and trouble-shoot. The laboratory procedures do tend to be repetitious, but that is also an advantage - through repetition, students have the opportunity to master techniques. Students are willing to make the effort to perfect their technique because they know that their results matter. And they learn that real science often is repetitious.

A water monitoring project can include much more than just science; for example, students can also learn math, history, and social sciences. I feel that this type of project provides an ideal way for educators to incorporate collaborative learning (small groups working together), interdisciplinary teaching, and restructuring - all wrapped into one endeavor.

A teacher contemplating a monitoring program will probably wonder how the project will affect his or her scheduling and curriculum. In my own case, the monitoring project calls for relatively frequent sampling - every other week - which means that I reserve one 50-minute class period every other week for the students to do the laboratory testing. Also, the membrane filtration procedure that we use for fecal coliform testing is somewhat involved. Nevertheless, I soon discovered that I do not have to be glued to the project. As the students gain experience, a team of four or five students can easily be doing the testing in one part of the lab while I work with the remainder of the class on some other project.

On the testing day, I usually use part of my planning period to do the shore sampling with two or three students. (The samples collected by the adult volunteers are delivered directly to the school.) The project requires an additional half hour of my time every other week, and I can honestly say that the extra effort is one of the best investments that I make as a teacher.

Glenn Tremblay *is a science teacher at Boothbay Region High School, Boothbay Harbor, ME 04538.*

Resources for Teachers and Students

The materials listed below are specifically geared toward teachers and students. Monitoring manuals developed for adult monitoring groups can also be very helpful in school programs, especially for older students.

Some districts, states, or regions have developed curricula for water quality monitoring that are available only in that locality. Teachers are encouraged to contact local and state agencies to find out what is available.

Focus on Monitoring

Books

Mitchell, Mark and William Stapp, ***Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools (6th edition)***. 1992. The basic text used by Project GREEN programs worldwide. Instructions for eight chemical and physical water quality tests plus fecal coliforms and macroinvertebrates; also chapters on heavy metals testing, cross-cultural partnerships, and computer networking. Spiral-bound, 240 pages, numerous photographs and illustrations. High-school level. $9.95 (discount available for 10 or more copies). Order from William Stapp, 2050 Delaware, Ann Arbor, MI 48103. Spanish edition (titled ***Manual de Campo del Proyecto del Rio***) also available for $9 from Project GREEN, 216 S. State St., Ste. 4, Ann Arbor, MI 48104; 313/761-8142.

Tennessee Valley Authority, ***Water Quality Sampling Equipment and Homemade Sampling Equipment***. 1988. Two 16-page booklets, designed to be used as a set. The first describes professional sampling equipment and tells how to obtain it; the second contains instructions for making low-cost facsimiles of the same equipment (Secchi disks, plankton samplers, artificial substrates, nets for macroinvertebrate sampling, and more). Order from Carol A. Davis, 311 Broad St., Chattanooga, TN 37402-2801; 615/751-7338. Free (one set only).

Hach Co., ***Water, Water Everywhere*** packet. Instructions for nine experiments (all but two can be conducted in the classroom) and background information on water pollution. For grades 7-12. Complete package includes three spiral-bound books: Teacher's Guide and Experiments, Student Reading Unit, and Water Quality Factors Reference Unit; $24.95. Books are also sold individually. Order from Hach Co., P.O. Box 389, Loveland, CO 80539; 800/227-4224.

The following books, for three different age groups, are available from Adopt-a-Stream, Delta Laboratories, P.O. Box 435, Pittsford, NY 14534-0435; 716/392-6450. Previews are available for $3.

Teacher's Handbook. 1987. Contains an impressive amount of scientific information, such as equations for reactions in water quality tests, a key to plankton identification, EPA criteria, and diversity indices for macroinvertebrates. Unfortunately, print quality is very poor. (*Note:* Print quality is good in the other Delta Laboratories materials, listed below.) Loose-leaf notebook, 241 pages. High-school level. $30.

Middle School Technology Teacher's Guide. 1992. Biological and chemical testing and related classroom activities; instructions for making equipment. Spiral-bound, 100 pages. Packet (one teacher's manual and 10 student workbooks) $65; additional workbooks $4.50.

The Water Detectives. 1993. Spiral-bound, 150 pages. For grades 3-6. Packet (one teacher's manual and 10 student workbooks) $90; additional workbooks $6.50.

Oregon Department of Fish and Wildlife, ***The Stream Scene: Watersheds, Wildlife, and People***. 1992. Numerous classroom and field activities covering watersheds, water quality, aquatic organisms, etc. Slight bias toward Oregon issues and species. Loose-leaf, 300 pages, many drawings. For grades 6-12. $15. Order from Oregon Dept. Fish and Wildlife, Office of Public Affairs, P.O. Box 59, Portland, OR 97207; 503/229-5400, ext. 432.

Video

Oregon Department of Fish and Wildlife, "Macroinverts and the River Continuum." Designed for high school students; also useful for adults. Good introduction to collecting and identifying macroinvertebrates and to the concept of "functional feeding groups." $8. Order from Oregon Dept. Fish and Wildlife, Office of Public Affairs, P.O. Box 59, Portland, OR 97207; 503/229-5400, ext. 433.

Supplemental Materials

EPA, ***Always a River: Supplemental Environmental Education Curriculum on the Ohio River and Water***. 1991. Based on the Ohio River but applicable to any body of water. Instructions for 58 classroom activities on water cycle, wastewater treatment, etc. For grades K- 12. Looseleaf, 284 pages. Available from U.S. EPA, OR&D, Center for Environmental Learning, 26 W. Martin Luther King Dr., Cincinnati, OH 45268; 513/569-7770. Free.

Lewis, Barbara, ***The Kids' Guide to Social Action***. 1991. Ideas for letter-writing, speech-making, campaigning, lobbying, and other kinds of community action for kids 10 and up. 185 pages. $17.95. Order from Free Spirit Publishing, 400 First Ave. North, Ste. 616, Minneapolis, MN 55401; 800/735-7323.

Project GREEN, "Water Curriculum Materials: K-12." A listing of more than 75 water-related classroom materials, including books, videos, and computer programs. $3.60. Order from Project GREEN, 216 S. State St., Ste. 4, Ann Arbor, MI 48104; 313/761-8142.

Project WILD Aquatic Educational Activity Guide. 1992. This 240-page book of activities is provided free of charge to participants in Project WILD Aquatic workshops. It is not sold separately. Project WILD is available in all 50 states and 10 Canadian provinces; workshops are free or low-cost. To find out about workshops in your state, contact Project WILD, P.O. Box 18060, Boulder, CO 80308; 303/444-2390.

All prices include shipping.

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Bicultural Program Monitors Rio Grande

Along the Rio Grande, from Taos, New Mexico, to the Gulf of Mexico, U.S. and Mexican schools are working together in a bicultural monitoring project called Project del Rio.

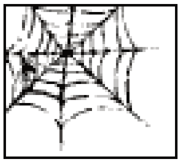
"A watershed is defined by its drainage basin - not political boundaries," says Lisa LaRocque, director of Project del Rio." How do you protect a river that flows through two different countries, with different cultures and histories, different economic situations, different environmental legislation? You have to think more globally."

Project del Rio, which is part of the GREEN network, includes about 15 schools in New Mexico, 20 in Texas, and 20 in Mexico. Students use a bilingual monitoring manual and share data via bilingual computer conferences.

High school students in Juarez, Mexico, study the Project del Rio manual.

LaRocque notes that U.S. and Mexican students have few opportunities to work together, even though they live near each other. Through the project, they are learning that students in both countries are equally capable and equally concerned about the river

For more information, contact Lisa LaRocque, Project del Rio, 3312 Camino Prado Vista, Santa Fe, NM 87505; 505/473-0841.



High Schoolers as Teachers

Out on the San Francisco Bay Delta, on board the RV *Crago*, fifth-graders from Bancroft Elementary School are clustered in small groups at seven stations. At one station, they collect a water sample and test it for chloride, conductivity, and temperature; at another, they collect plankton in a net; at a third - the clear favorite - they take a grab sample of sediment, then sort through the muck to find clams, worms, and other creatures.

The kids' instructors are high school students who have been trained by Richard Thall, a biology teacher who works full-time on the *Crago* program, and *Crago* captain Mike Liston. Thall says that he has about 225 of these trained teaching assistants ("TAs") on his roster at any one time. Together, they take nearly 5,000 fifth-graders out on the boat each year.

"It would be impossible to run this program without the TAs," says Thall. As for the high schoolers, they obviously enjoy working with the younger students. "It's great to have someone listen to us for once," comments sophomore Padmini Parthasarathy.

The *Crago* program is jointly sponsored by the Mount Diablo Unified School District and the Contra Costa Water District. This funding supports not only the activities aboard the boat but also round-trip bus transportation to the *Crago* and pre- and post-trip sessions for each class, during which Thall and Liston visit the school to discuss with students the importance of the measurements done on the boat.

For more information, contact Ivy Morrison, Contra Costa Water District, 1331 Concord Ave., P.O. Box H20, Concord, CA 94524; 510/603-8307.

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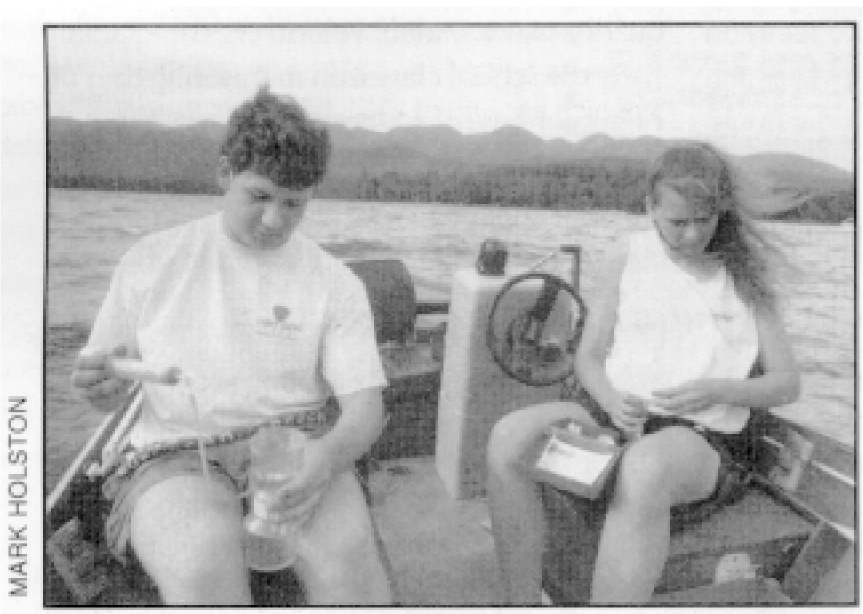
Students Monitor Whitefish Lake

Most students who test water quality do so on a stream or river. But a group of students from Flathead High School in Kalispell, Montana, are monitoring Whitefish Lake for nitrates, phosphates, pH, dissolved oxygen, Secchi depth, coliforms, and plankton.

The students' monitoring project is a spin-off from an Advanced Biology class taught by Linda de Kort. After the students were introduced to water monitoring in class, many were inspired to continue monitoring on their own. Now they sample the lake every other Sunday.

How does lake monitoring differ from stream monitoring? For one thing, a boat is usually needed for sampling a lake. Many of the Flathead students are using their own rowboats, or in some cases motorboats. "Some teachers might be leery of having students go out in boats," says de Kort, "but I trust these. We had safety training in class."



Students from Flathead High School perform water quality tests on Whitefish Lake.

Some of the tests are also different. Instead of collecting aquatic insects, as stream monitors do, the students are collecting plankton. And they are measuring dissolved oxygen at different depths to study thermal stratification.

For more information, contact Linda de Kort, 1290 Lost Creek Dr., Kalispell, MT 59901; 406/755-3704.

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Building Your Own Water Bath Incubator

by James Buratti and Eric Brown

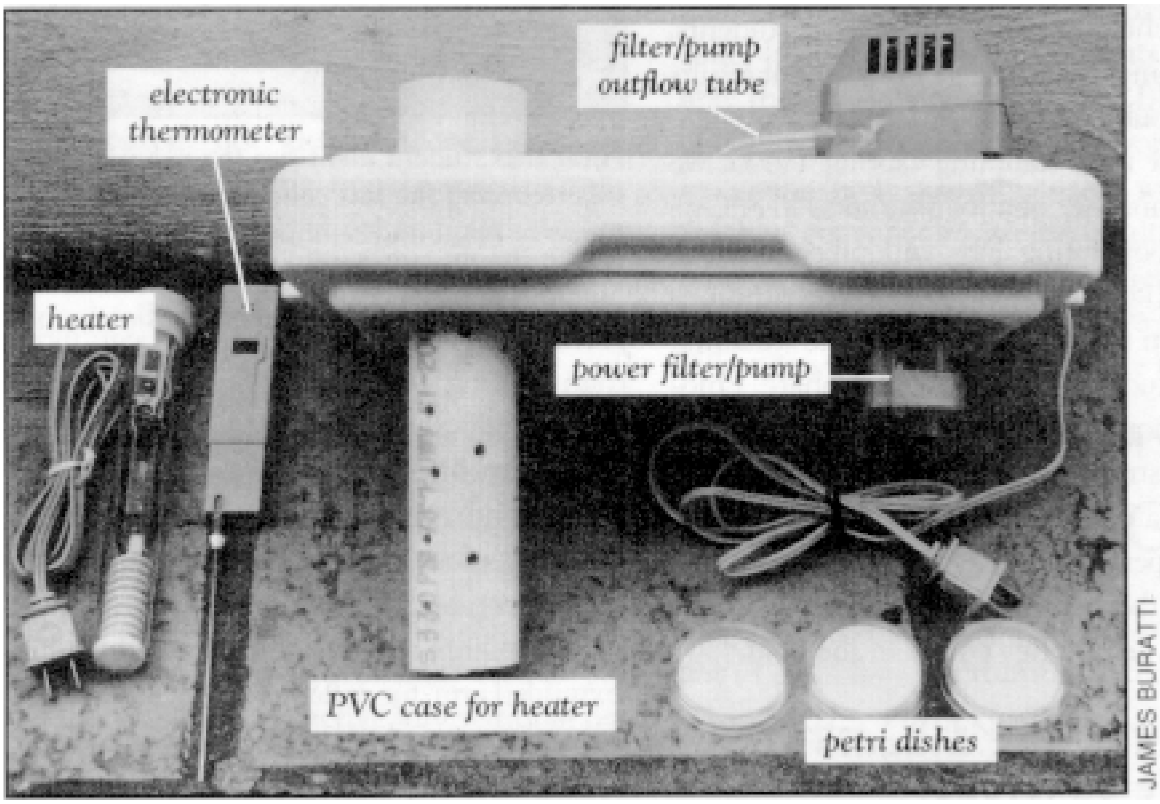
Fecal coliform testing is a powerful water quality indicator that many monitoring programs would love to be able to perform. One thing holds them back - cost. Commercial water bath incubators cost upward of $600.

As the Colorado River Watch Network in Texas expanded to almost 600 volunteers monitoring over 50 sites along hundreds of miles of river, we quickly realized that it simply would not be practical to have just one centrally located incubator. On the other hand, purchasing individual incubators for each site would have burst financial purse strings.

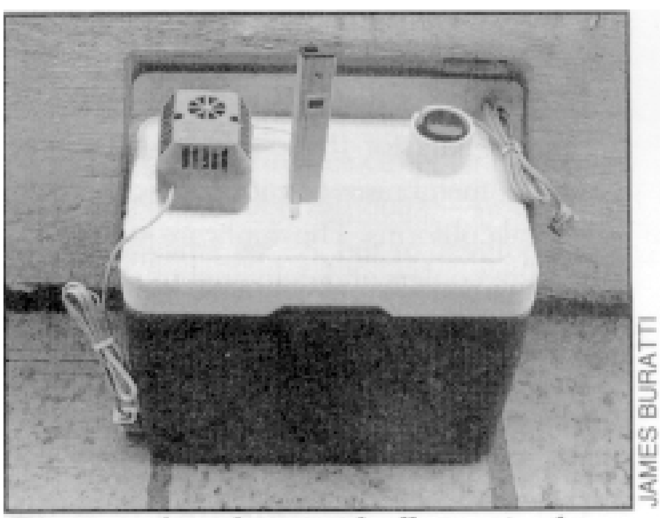
But, as the saying goes, necessity is the mother of invention. So we designed and built our own water bath incubators. Final price tag: $65 per unit.

Currently over 50 of our homemade incubators are in use - one for every monitoring site. More than half of our sites are monitored by students, who keep the incubator at the school lab. The remaining sites are monitored by adult volunteers, who typically use the incubator in their homes.

Basically, the incubator consists of a non-styrofoam ice chest or cooler filled with water. The water is heated by an aquarium heater/thermostat and circulated by an aquarium power filter/pump. Temperature is monitored with a Celsius thermometer. The heater, filter, and thermometer are mounted through holes drilled in the lid.



This incubator was designed, developed, and built by a number of people working with CRWN, including Wes Halverson, James Buratti, and Eric Brown.



Top view of incubator with all parts in place. Left to right: power filter/pump, electronic thermometer, heater (inside PVC case)

Because the heater is contained in a glass housing and thus subject to accidental breakage, we enclose it in a protective case made from a piece of PVC tubing slightly larger than the heater.

Either an electronic thermometer or a standard alcohol thermometer may be used. The electronic thermometer is more accurate and easier to read, but it is more expensive. If you use an alcohol thermometer, be sure it is the armored type so that it will be protected from breakage.

The cooler should be filled with water to within one inch of the top. Once the water temperature has stabilized at 44.5øC (this takes some initial experimentation and patience), the culture plates inoculated with the sample are sealed in zip-lock bags and floated in the water for the desired incubation period, with the cooler lid closed.

Currently a variety of modifications are being experimented with, including horizontal placement of the heater element (through a hole drilled in the side of the cooler), improved circulation systems, and internalization of both the heater and the pump. However, the basic design shown in the accompanying photographs has been widely used by CRWN volunteers and is sound. Following are brief instructions for building the model shown in the photographs.

Tools Needed:

standard hand-held electric drill
jigsaw

Materials:

cooler/ice chest, 12- to 17-quart (non-styrofoam)
75-watt aquarium heater
aquarium power filter/pump
Celsius thermometer, alcohol (armored) or electronic
PVC pipe (diameter large enough to go around heater)
waterproof sealant

Basic Procedure:

Cut a piece of PVC pipe slightly longer than the heater to make a protective case for the heater. Drill 1/4" holes in the pipe to allow water circulation.

Using a hand-held electric drill, drill four holes through the lid (one for the filter/pump, one for the filter/pump outflow tube, one for the thermometer, and one for the heater). Use a jigsaw to enlarge the hole for the oblong-shaped filter/pump.

Seal the power filter and heater case in place with waterproof sealant.

For more detailed instructions, contact Colorado River Watch Network, c/o Lower Colorado River Authority, P.O. Box 220, Austin, TX 78767; 512/469-6883.

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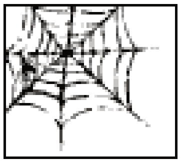

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Kids Use Kits to Measure Salinity in Florida Lagoon

Five fifth-grade classes have adopted sites in the Volunteer Monitoring Network for the Indian River Lagoon. The Indian River Lagoon is a long, narrow estuary with many tributaries, and water quality varies considerably throughout the system.

The volunteers - both adults and students - measure dissolved oxygen, salinity, temperature, and pH. Salinity is a particularly important measurement, because we are using it to track the impacts of stormwater runoff - a significant problem in the lagoon.

The students use the same methods as the adult volunteers. They are subjected to the same quality assurance criteria, and are performing just as well (in some cases, better!).

For testing salinity, we have trained the students in the use of LaMotte salinity titration kits. We chose this method for our program because we like knowing exactly what is being measured - that is, chloride (which is converted to salinity). We feel that hydrometers have a couple of drawbacks: first, they are prone to breakage, which can run up costs; and second, there is confusion regarding hydrometer scales and conversion tables (see "The Problem with Hydrometers").

For the students, the kits offer an added plus: kids love the color change. We get a lot of "oohs" and "aahs" when the titration endpoint is reached.

ELLIOT JONES

Julie Keller, 10, performs a salinity test on Indian River Lagoon water as Jennifer Taylor, 11, watches.

In our estimation, the salinity kits we use have few drawbacks. We know that some people have expressed concern over the disposal of the reagents, which contain silver and chromate. However, the amounts involved are very small. We calculate that our program annually disposes of less than 1/5 pound of silver and only about 1/3 ounce of chromium from salinity kits.

In fact, we feel that more potential toxicity is associated with the disposal of broken hydrometers. Volunteer monitoring groups may be interested to know that the hydrometer counterweight contains the heavy metals lead, tin, and antimony - all three of which exhibit much greater toxicity and are of greater environmental concern than either silver or chromium. The mass of heavy metals contained in just two hydrometers is equal to the mass of silver and chromium in a years' worth of salinity reagents for our program. Ideally, of course, broken hydrometers should be recycled, but our gut feeling is that many are thrown in the trash and eventually wind up in landfills.

--*Robert Frease*

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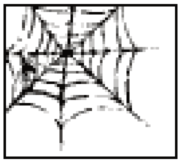

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The Problem With Hydrometers

by Robert Frease and Brian Christman

Hydrometry is a popular method of salinity analysis among estuarine water quality monitoring programs. However, many groups are not aware of a problem concerning the hydrometric method as published in *Standard Methods for the Examination of Water and Wastewater* through 1985. (Later editions of *Standard Methods* do not include hydrometry as a recommended method for determining salinity.) The problem is one of omission: the authors failed to notify readers that not all hydrometers are based on the same specific gravity scale. In fact, most hydrometers manufactured today are based on a different scale than that used to generate the conversion tables published in *Standard Methods*.

Measuring Salinity by Using a Hydrometer

First let's review the basic principles involved in using a hydrometer to measure salinity, starting with the definition of density. Density is defined as mass (or weight) per unit volume. For water, density is usually expressed in grams per cubic centimeter (g/cm^3).

Density is dependent upon temperature. If a sample of water is warmed, the water will expand and occupy a larger volume. However, the mass remains constant, so density decreases. Conversely, as the water is cooled, it contracts and the density increases. For pure water, contraction continues until maximum density is reached at 3.98°C, at which point the water expands slightly until it freezes at 0°C.

Density also changes with the amount of dissolved salts in the water; hence the ability to determine salinity by measuring density. As the amount of dissolved salts (or the salinity) increases, the density of the sample increases. If the sample is diluted, the density decreases.

Specific gravity is the ratio of the densities of two substances. For our purposes here, specific gravity is defined as the ratio of the density of a water sample to the density of some reference substance - in our case, pure water. The temperature of the water sample and the reference pure water are specified. However, it is important to note that the two temperatures (T_1 and T_2 in the equation below) *do not have to be the same*.

$$\text{Specific gravity} = \frac{\text{density } (g/cm^3) \text{ of water sample at } T_1}{\text{density } (g/cm^3) \text{ of pure water at } T_2}$$

Specific gravity has no units, since the units in the numerator and denominator are the same and cancel each other out.

A hydrometer measures specific gravity. In order to convert a hydrometer reading to salinity, you must consult the two tables published in *Standard Methods*. The first table is designed to convert the specific gravity measurement to an equivalent density at 15°C. The second table converts the density value obtained from the first table to an equivalent salinity, also at 15°C. (*Note*: The phrase "equivalent salinity at 15°C" may lead to the mistaken impression that salinity is dependent upon temperature. In fact, salinity is an intrinsic property of a water sample and does not depend on temperature.)

What's the Problem

Now we come to the problem. The tables published in *Standard Methods*, which were devised in 1953 by Zerbe and Taylor, were designed to be used with a hydrometer calibrated on a 15°C/4°C basis. In other words, the tables are based on a definition of specific gravity as the ratio between the density of a water sample at 15°C (T_1) and the density of pure water at 4°C (T_2).

Unfortunately, so far as we are aware no hydrometers are currently manufactured on the 15°C/4°C scale. Instead, hydrometers manufactured today are calibrated on a 60°F/60°F basis. Since 60°F = 15.6°C, the difference in T_1 (the temperature of the water sample) is negligible. But the difference in the temperature of the pure water sample (T_2) is significant. Because pure water expands when warmed from 4°C to 15.6°C, the density of the reference water has decreased from 0.999973 g/cm³ (at 4°C) to 0.999007 (at 15.6°C). The difference between these two densities is 0.000966 g/cm³.

The end result is that if you are using a hydrometer calibrated on the 60°F/60°F basis, the specific gravity reading you obtain will be higher by approximately 0.001 than the reading that would be obtained using a 15°C/4°C hydrometer. If you go directly to the tables without correcting your reading, you will end up with a salinity value that is too high by an average of 1.3 parts per thousand (ppt or o/oo).

This size of error is not insignificant if your data may be used for such purposes as determining saltwater intrusion, determining the effect of stormwater discharges on the salinity of estuaries, calculating salt budgets, or constructing circulation models. And because the error is constant, it becomes even more significant in estuaries. For example, an error of 1.3 ppt at a salinity of 35 ppt is only about a 4% error, but it is a 13% error at a salinity of 10 ppt. Keep this in mind if your quality control protocols call for comparing volunteers' salinity data, measured by hydrometer, against a conductivity meter or standard titration method. You may be unnecessarily rejecting data that actually are of high quality.

The Solution

Fortunately, correcting the error is easy. First check the paper scale inside the neck of your hydrometer. If it says "60°F/60°F," simply subtract 0.001 from your hydrometer reading before you use the tables.

To make things even easier, charts for converting 60°F/60°F hydrometer readings to density and salinity are now available to monitoring groups at no charge from Steve Wildberger at LaMotte Company, P.O. Box 329, Chestertown, MD 21620. If you use these charts, you won't need to subtract the correction factor.

Since the mean positive error of 1.3 ppt is constant across the entire table, old salinity data can be corrected by subtracting this amount from all the old values.

(If you are using a computer, you can use the following equation, developed by Mark Mattson of the Acid Rain Monitoring Project at the University of Massachusetts, to calculate salinity directly from a 60°F/60°F hydro-meter reading (H) and temperature (T):

$$\text{Salinity (at 15°C)} = -1242.39 + 1241.726H - 3.69946T + 0.00771211T^2 + 3.62136HT$$

The standard error is approximately 0.08 ppt. The equation should not be used for dilute freshwater systems.)

Ideally, hydrometers should also be checked against solutions of known salinity.

We urge volunteer groups to make these corrections. Our philosophy at the Volunteer Monitoring Network for the Indian River Lagoon has been to design the program for maximum use of the data. Recognizing that we cannot predict future potential uses of the data, we want our data to be as precise and accurate as possible. We have found that our salinity data have the potential for confirming circulation models of the Indian River - a use that would not have been possible if we had taken the attitude that "an approximate measurement is adequate."

Robert Frease *is Project Director for the Volunteer Monitoring Network for the Indian River Lagoon.* ***Brian Christman*** *is the Quality Assurance Officer for the Project. For further information, please contact Robert Frease at the Marine Resources Council of East Florida, Melbourne, Florida; 407/952-0102.*

References:

Zerbe, W.B., and C.B. Taylor, *Sea Water Temperature and Density Reduction Tables*, U.S. Dept. of Commerce, Spec. Pub. No. 298, Washington, DC 1953.

T.R.S. Wilson, Salinity and the Major Elements of Seawater, pp. 365-409 in *Chemical Oceanography*, 2nd ed., J.P. Riley and G. Skirrow, eds., 1975. (Available at most university libraries.) Although highly technical, this book gives a very interesting historical account of attempts not only to measure salinity, but to define it.

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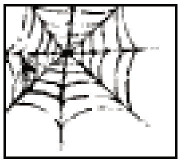

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Quality Control of Students' Data

by Lin Howell

Many school-based water quality monitoring programs would like to be doing more to verify the accuracy of the students' data. What often stops them is the belief that doing so would be too expensive or difficult, or that the time spent on quality control procedures would detract from students' learning time.

For the Student Watershed Research Project (SWRP), producing high-quality, credible data was a major goal from the outset. We never could have achieved that goal without the cooperation of four laboratories (two universities, an agency, and a utility) who donate time, equipment, and expertise to the project. Among other things, these labs perform duplicate testing, at no charge, on the samples collected by the students.

How SWRP's Quality Assurance Program Works

SWRP was developed by Steve Andrews, program director with the Saturday Academy at the Oregon Graduate Institute of Science and Technology in Beaverton, Oregon, with grant support from the National Science Foundation. Now in its second year, the project involves 14 teachers and 500 students in grades 8 through 12. At 29 different stream sites, the students monitor chemical and physical parameters, fecal coliforms, macroinvertebrates, and plants at least twice during the school year (fall and spring).

At each site, students collect two sets of samples for alkalinity, orthophosphate, total phosphate, chloride, ammonia, nitrate, and fecal coliform testing. (Additional tests the students perform, but for which duplicate tests are not run, are pH, temperature, dissolved oxygen, biological oxygen demand, and flow.)

The students analyze one set of samples, using test kits for the chemical parameters and the membrane filtration procedure for the fecal coliforms. The duplicate samples are placed in coolers and delivered to participating labs the same day they are collected. So far, one person - this writer - has picked up and delivered all the samples. This arrangement might have to change as the program expands!

The students' identifications of macroinvertebrates and plants are also verified by the cooperating labs. After recording their own identifications, students preserve the macroinvertebrate specimens in small vials filled with alcohol and preserve the plants by pressing them between newspapers. These specimens are mailed to Pacific University, where Invertebrate Zoology students identify the macroinvertebrates and Plant Systematics students identify the plants. The identifications are confirmed by the instructors.

Of course, quality assurance involves more than just testing duplicate samples. Training is another critical factor. SWRP provides a five-day summer training workshop for participating teachers. Followup is also essential. During the year, SWRP staff members meet with teachers to discuss how their students' results compared with the professional results and to trouble-shoot any problems.

For our next sampling (spring 1993), we will add another quality assurance step: One of the cooperating labs will prepare check samples (i.e., samples whose concentrations are known to the lab but not to the students) for the students to run for phosphate, chloride, ammonia, and nitrate. The check samples will be distributed to schools three weeks before the sampling date, allowing time for students to perform the analyses, compare their results to the known results, and work out any problems before they go out in the field.

Why Labs are Willing to Donate Services

By this time, you may be wondering what kind of arm-twisting we had to do to persuade labs and universities to donate time and equipment to SWRP. Actually, none at all. All our partners agreed to help with no hesitation; in fact, they even gave the impression they would have felt slighted if they had not been asked. One critical factor was that all the cooperating agencies and universities were represented on our steering committee and had helped set up the program. Thus, they already had a stake in the project and were committed to seeing it succeed.

In addition, reaching young people tends to be an important goal for agencies charged with protecting water quality. As Jan Wilson, laboratory supervisor for the water quality lab at the Unified Sewerage Agency (one of our partner labs) says, "We've always been more than willing to help with environmental education."

But altruistic desires to help a worthwhile project and support future stewards weren't the only motivation. The SWRP program also offers tangible benefits to its partners. As Wilson points out, the students "serve as an 'extended arm' for collection, especially since they go to areas that we've never tested."

After this student identifies the macro-invertebrates she has collected, she will preserve them and send them to a university where the identifications will be confirmed.

At present, agencies don't use the students' actual results; the students simply provide the samples for the agencies to analyze. But SWRP's goal is to make the students' numbers usable. Once we reach that goal, students can collect data more frequently than twice a year. Agencies will perform parallel tests once or twice a year, and trust the students' data the rest of the time.

For students at Pacific University, there are other benefits to working with SWRP. Biology Professor Rob Stockhouse says, "With the SWRP samples, my students are put in a real-life situation where they have to identify material they might not have collected. When my students go out themselves, they tend to collect just the plants they think are easier to identify." Some Pacific University students go out in the field with the SWRP classes, to help teach the kids how to collect and identify macroinvertebrates and plants. Again, the benefits are two-way: the SWRP students get expert help, while the university students enjoy the teaching experience and the chance to be the "experts."

How Students' Results Have Measured Up

So far, most of the students' results have correlated well with the professional results for all tests except phosphate, ammonia, and nitrate. The problems are probably due to the difficulty of obtaining accurate results at low concentrations with the color wheel-based kits the students have been using for these tests. We hope to switch to a colorimeter method for these three tests next year.

Why Data Quality is Important

Granted, assuring quality data takes effort. At times, it has taken even more effort than we anticipated. For example, we originally planned only an initial five-day summer training workshop for teachers. But after the first year, we realized that teachers needed additional followup sessions to discuss and solve data-quality problems that had arisen.

Maintaining a high level of quality control is also expensive. This is where local support is absolutely essential. In our case, support from some local agencies has gone well beyond the donation of lab time. Two agencies sponsor teachers by underwriting the costs of the students' equipment, bus transportation to the testing site, and substitute teachers.

So, is all the effort worthwhile? We think so. Jane Blair, lab manager for the Department of Environmental Science and Engineering at Oregon Graduate Institute (which runs duplicate analyses for several of our chemical tests), says, "The emphasis on data quality - trying to get numbers of a quality that agencies can use - is what makes this program unique. Over the years, this program can provide a tremendous amount of data."

But what about the students? We've heard some argue that the time students spend on quality control takes away from their learning time. In our opinion, the students are probably the biggest benefactors. As Blair points out, "Students learn about real-world science by seeing how quality control works. The teachers come back with the results from the labs, and if there are discrepancies, the kids have to think about, What did we do wrong? What can we do differently in the future?"

The importance of quality assurance comes home most forcefully when the students take their data outside the school. Science teacher Richard Petersen, a SWRP participant, has taken his students - and their data - to city planning meetings. Petersen says, "The students really recognize the value of quality control when they see how scientific information is used in the democratic process. In order for data to be used in decision making, that data must be believable."

Our hope is that our students will take enough pride in their data that they will want to make sure it's good - good enough to be used in management decisions.

Lin Howell *is Program Coordinator of the Student Watershed Research Project, Saturday Academy of Oregon Institute of Science and Technology, 19600 NW Von Neumann Drive, Beaverton, OR 97006; 503/690-1416.*

SWRP *is a program of Saturday Academy at the Oregon Institute of Science and Technology. Saturday Academy offers classes, internships, and programs for students and teachers, providing direct access to professionals in science, math, and technology.*

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Salinity Testing Methods

by Steve Wildberger

What is Salinity?

Salinity is defined as the total amount (grams) of solid material dissolved in a kilogram of seawater when all the carbonate has been converted to oxide, all bromine and iodine replaced by chlorine, and all organic matter completely oxidized. It is expressed as g/kg or parts per thousand (ppt or o/oo).

Seawater is a very complex mixture of over 100 different constituents, but six ions account for over 99% of the dissolved material. In the ocean, these six ions are very well mixed and present in nearly constant proportions: chloride (Cl^-), 55.0%; sodium (Na^+), 30.6%; sulfate (SO_4^{-2}), 7.7%; magnesium (Mg^{+2}), 3.7%; calcium (Ca^{+2}), 1.2%; and potassium (K^+), 1.2%.

Standard Seawater

Since 1975, Standard Seawater has been provided by the Institute of Oceanographic Sciences in Wormley, England. It is supplied in sealed 280-cc glass ampoules that cost about $40 each and are labeled with the water's chloride concentration - down to the nearest ten-thousandth of a part per thousand - and its conductivity.

Obviously, few if any volunteer monitoring groups will purchase Standard Seawater. Volunteers can practice their technique using a solution of ordinary table salt in water. Instruments should ideally be checked against another instrument that has been calibrated with a primary standard.

Methods for Testing Salinity

- **Chloride titration**

By measuring the concentration of one major constituent, the salinity of a sample can be calculated. Chloride (Cl^-) is the most abundant ion and the easiest to measure accurately. The chloride concentration expressed in grams of chloride ion (assuming Br^- and I^- are Cl^-) per kilogram of seawater is called *chlorinity*. Since chloride accounts for a constant portion of the dissolved solids in seawater, salinity can be determined from chlorinity by the following formula:

```
chlorinity (ppt) x 1.80655 = salinity (ppt)
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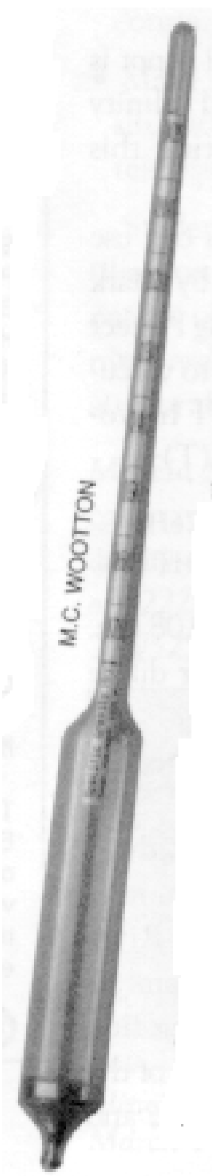
Chlorinity is measured by titration in a fairly simple procedure. First an indicator, potassium chromate, is added to a carefully measured volume of sample. This reagent produces a yellow color. Then silver nitrate solution of a standard concentration is added as the titrant. The silver reacts with chloride in the sample to form a white precipitate, silver chloride. When all the chloride has been precipitated, the next portion of silver nitrate added forms red-colored silver chromate, producing the pinkish-orange endpoint.

Chloride concentration is calculated from the size of the sample and the concentration and amount of the silver nitrate used. Some test kits incorporate the conversion formula into their design so that salinity may be read directly.

Because of the high levels of chloride in most samples, usually the sample is diluted with distilled or deionized water to make the titration easier. The amount of dilution water is not critical, but the measurement of the volume of the original sample is critical.

(*Note*: Another version of this method uses mercuric nitrate as the titrant because it produces a more distinct endpoint. This small benefit must be weighed against the additional challenge of dealing with mercuric chloride waste.)

Salinity (chlorinity) titration test kits are available in the range of $30. Reagent costs per test are approximately 30. Laboratory buret titration outfits, which use a large sample volume to provide more precise measurements, require larger amounts of reagents per test. As in all titration tests, accuracy depends on the precision of sample measurement and titrant measurement, and on accurate endpoint identification.



- **Hydrometer** Objects float higher in salt water than in fresh water because salt water is more dense (heavier per unit of volume). The density of water also changes with temperature. Salinity can be calculated by measuring the specific gravity of a sample of water using a hydrometer, correcting for the effect of temperature, and converting the readings to salinity by means of conversion tables. Because the effect of temperature is slightly different at every concentration, a simple formula for conversion cannot be used; hence the need for the daunting charts familiar to all users of the hydrometric method.

The hydrometric method is simple to perform, but it requires the user to correctly read two scales (thermometer and hydrometer), use two cross-referenced charts, and perform one arithmetic function. Moreover, if the hydrometer uses a 60°F/60°F scale (as most hydrometers manufactured today do), a correction factor must also be applied (see "The Problem with Hydrometers"). All these factors can contribute to errors.

Complete hydrometer outfits cost about the same amount as salinity test kits. Hydrometers are made of glass and are quite fragile; some volunteer programs estimate that the cost of replacing broken hydrometers is equivalent to the cost of reagent refills for kits. (For instructions on making a low-cost protective carrying case for hydrometers, see *The Volunteer Monitor*, Fall 1991, page 9; "Field-Proofing Hydrometers," by Beverly DeAngelis.)

- **Refractometer** When light passes from the air into water it is refracted - that is, its direction changes. The illusion of bending when a straight stick is submerged in water illustrates this principle. The amount of refraction is affected by the temperature and the amount of dissolved solids in the water. A refractometer is an optical device that magnifies this effect in a single drop of water and quantifies it on a scale.

Refractometers are widely used in food processing to measure the concentrations of both sugar and salt. For this reason, many include a "Brix" scale for sugar as well as a salinity scale that ranges up to 100 ppt in 1 ppt increments.

Refractometers are very handy and require no batteries or reagents. However, they are somewhat expensive (over $250), and they sink like stones when dropped overboard. The most convenient units are hand-held and include temperature compensation.

- **Electrical Conductivity** The more salts dissolved in a water sample, and the warmer the temperature, the better the water sample conducts electricity. This simple principle is the basis for the operation of conductivity, salinity, and TDS (total dissolved solids) meters.

The flow of electricity between electrodes in the meter probe is measured and read as "micromhos per centimeter" (mmhos/cm) or "microSiemens/cm" (mS/cm). The concentration of dissolved material in a water sample may be estimated by multiplying the conductivity by a factor that depends on the unique mixture of dissolved material in the water. The conversion factor also varies with concentration and temperature.

To accommodate all these factors, a variety of look-up charts, microprocessors, automatic temperature compensation (ATC) devices, or ingenious manual adjustment knobs are used with conductivity meters to help calculate the salinity of samples. Moreover, in order to cover the full range of conductivity and temperatures that occur in estuaries and oceans a conductivity meter must range up to 75,000 mmhos/cm. Each of these features has a cost associated with it, resulting in meter prices that range widely.

Inexpensive pocket-sized conductivity testers can produce accurate readings (and may include ATC), but the drawback is that they are usually of a limited range. Typical pocket-sized units are capable of displaying only up to 10,000 mmhos/cm. At 25°C, this is equivalent to only 5 or 6 ppt salinity. Dilution of high-salinity samples will extend this range, but dilution also introduces an additional element of variability because in this case the amount of dilution is critical to the accuracy of the test (unlike the sample dilution in a titration test).

Commercially available KCl solutions can be used as a standard to check the calibration of conductivity meters.

Salinity of Coastal and Inland Waters

It is important to note that *all* methods of salinity measurement are based on the assumption that the sample contains the nearly constant proportions of major constituents found in "typical" seawater. In freshwater systems, dissolved solids may be present in high concentration, but in proportions that differ from those found in seawater. Therefore, "salinity" as a unit of measure, although handy, becomes less appropriate as the mixture becomes less "seawater-like."

Thus, the most prudent approach is to record salinity data not only in terms of the final salinity value but also in terms of the *actual factors measured* and used to calculate salinity. For titration, record chloride concentration; for the hydrometric method, record specific gravity and temperature; and for conductivity, record conductivity and temperature. This way, you can always return to your original data if new approaches to calculating salinity for your type of water are developed.

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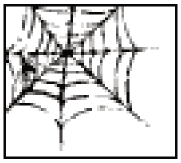

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Students Test for Toxics

by Mark Mitchell

Over the last several years, school-based water quality monitoring has enjoyed tremendous growth. The vast majority of these school programs monitor benthic macroinvertebrates and/or standard physical-chemical parameters. Recently, however, some schools have begun testing for toxic substances, especially metals. In the spring of 1992, four high schools that are part of Project GREEN (Global Rivers Environmental Education Network) participated in a pilot program, testing water samples for toxics. GREEN is also working to develop methods that students could use to test for toxics in sediments.

Toxics monitoring can detect types of pollution not revealed by standard physical and chemical tests. It also creates opportunities for class discussions about the overuse and misuse of toxic products at home and at school (for example, in science labs and art and shop classes).

Toxic substances are compounds or elements that can produce harmful effects in living organisms - including humans, fish, plants, and microscopic life forms. They include inorganic elements such as the metals lead, zinc, mercury, and cadmium as well as organic compounds like PCBs and solvents. Toxic substances can arrive in waterways via urban runoff, agricultural runoff, regulated industrial discharge, discharge from wastewater treatment plants, combined sewer outfalls, leachate from dumps, and mine runoff.

Where to Sample

Before you start testing, it's a good idea to do some research to determine which sites on your river are likely to yield levels of metals or other toxic substances that are measurable with the method you plan to use. Check with the agency responsible for water quality monitoring in your region for historical data that can reveal problem areas along a river. Students can also identify specific industries or other known point sources, then contact the state regulatory agency and look up the discharge permits. These will indicate any regulated toxic substances being discharged as well as daily limits, weekly limits, or monthly averages.

If one of your goals is to uncover toxic pollution at a site that is suspect but not currently monitored by local or state agencies, try sampling at such locations as combined sewer overflows, leachate points from landfills or illegal dumps, drainage ditches that flow through agricultural areas, and slurry ditches coming from mines or mineral processing plants.

Since metals are sometimes found naturally at fairly high levels in streams, you should try to find a reference stream with a similar physical nature that is relatively untouched (perhaps even the headwaters of the same river). This will help determine what the river would be like without significant human impacts.

Methods

Two major approaches can be used for toxics monitoring in schools: bioassay, and analytical measurement using a spectrophotometer.

Bioassay. A bioassay tests the relative toxicity of the water sample for an indicator organism. Unlike analytical procedures, a bioassay does not indicate which toxic substances are present or their exact concentrations. It does not differentiate between metals and organic substances. It can, however, be used to compare relative toxicities over time or distance.

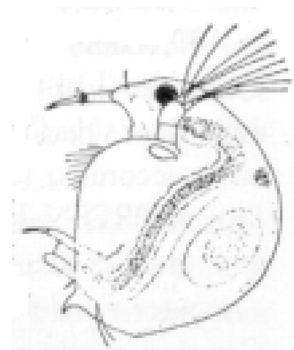
Using the wide end of a Pasteur pipette to pick up Daphnia neonates

WILLIAM STAPP

The bioassay used in the GREEN pilot program employs *Daphnia magna*, a microcrustacean barely visible to the naked eye, as the indicator organism. *Daphnia* may be obtained from a local university or lab that maintains a culture or purchased through biological supply houses.

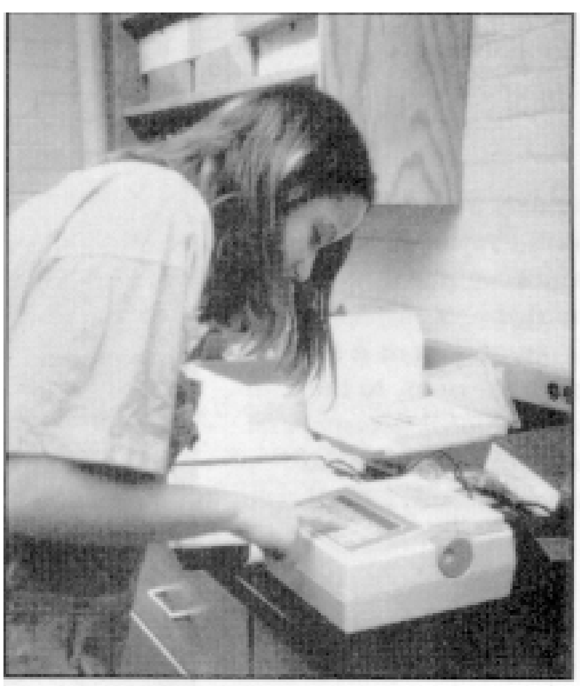
Briefly, the procedure we used involves diluting the water sample to obtain a series of test concentrations (for example, 6.25%, 12.5%, 25%, 50%, and 100%). Five replicate 20-ml aliquots of each concentration are placed in small plastic cups. The cups are seated in a specially designed tray (in which holes have been drilled to hold the cups). Ten *Daphnia* neonates are added to each cup, using the wide-mouthed end of a Pasteur pipette. (Neonates are the very young *Daphnia*, which are more sensitive to toxic substances.)

At specified time intervals, students use dissecting microscopes to count the number of dead or immobile *Daphnia* in each cup. The LC 50 (that is, the concentration that caused 50% mortality) is calculated after 48 hours.



The bioassay procedure is rich with educational potential. It graphically demonstrates, in a way that analytical methods do not, that organisms are killed by toxic substances in many of our rivers and streams. And it confronts students with challenging questions of experimental design, such as: What should we use as the dilution water? (make standard dilution water, or use water from the same stream, upstream from a point source?) Should we use a series of controls? How many replicate dilutions should we use?

Spectrophotometry. In contrast to a bioassay, spectrophotometry yields a precise measurement. That old standby, the Spec 20, which is available in most school labs, can be used. However, in the GREEN pilot program we chose to use a computerized spectrophotometer called the DR 2000. This instrument is capable of detecting very low levels of metals. It is easier to use and more accurate than a Spec 20, and does not require you to construct a standard curve. These advantages must be weighed against the cost of the DR 2000, which is about $3,000.



WILLIAM STAPP

Patty West uses a DR 2000 spectrophotometer to test river water for copper.

The first step in preparing a water sample for spectrophotometric analysis is to digest the sample by adding acid and then heating. This step may take an hour or more. Specific reagents, depending upon which metal is being tested for, are then added. These reagents are quite expensive.

A drawback of the spectrophotometric method is that it requires the use of corrosive acids. Students must be carefully trained, and you will need to use a ventilation hood, heavy rubber gloves, and aprons. You also will need to properly dispose of hazardous chemicals.

Toxics monitoring in schools is still in its early stages, and all of us can benefit from continued dialogue and greater collaboration.

GREEN has developed a manual, the *Toxics Monitoring Sourcebook for Schools*, which will be available in June 1993. Call the number listed below for ordering information.

For more information on methods, see EPA's *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*, available for $44.50 from NTIS, 800/553-NTIS (order publication number PB91-167650).

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So You Want to Work With Schools

by Sharon Behar

The look on a student's face when she sees a macroinvertebrate magnified for the first time; an urban student's realization that the channel of smelly water he walks by daily is actually a river, alive with a multitude of life forms, that connects to other rivers and ultimately the ocean; and students' excitement at discovering the role they can play in their community to protect water quality are all personal reminders of the value of working with schools.

Many citizen monitoring programs consider involving schools at some point. But they may wonder, What is it really like to work with schools? This article is written for monitoring programs currently working only with adult volunteers, who would like to expand their program to include schools.

Challenges

In order to work effectively with schools, you need to understand the school environment and what a teacher's day is like. The school structure can make implementing a monitoring program challenging: class schedules tend to be rigid, especially in high schools, and teachers are required to follow a curriculum. Another ubiquitous problem is that most schools have very limited financial resources to buy books, test kits, or computer equipment, or to pay for substitutes or transportation.

Compared to most professionals, teachers are strikingly isolated from their peers. They have little or no time during the school day that is not spent with students - no time set aside to meet with other teachers to share ideas, plan together, or work as teams. As one teacher who works with River Watch Network put it, "I feel kind of alone in running the show here."

Fortunately, there is a great deal that a citizens water monitoring program can do to help overcome these challenges and support a school-based monitoring program.

RWN and Schools

The River Watch Network (RWN) had its roots in student involvement on the Ottauquechee River in Vermont in 1970. Since then, RWN has grown to a national organization providing support to monitoring programs on 63 rivers in 13 states. Of the approximately 7,000 volunteers in this network, 70 percent are teachers and students.

RWN has no set protocol for school-based monitoring programs. Instead, each program is tailored to a particular class's needs and what they want to know about their river. Teachers we work with choose a particular combination of physical, biological (i.e., coliforms or macroinvertebrates), or chemical parameters to study.

Citizen Group - School Group Partnerships

As RWN's education coordinator, I focus on building strong working partnerships between community monitoring programs and schools. Such collaboration is a great way to get a whole community working together. In addition, both the citizen group and the school group benefit in numerous ways. For example, work can be shared by giving the school program primary responsibility for sampling and/or analyzing data during the school year, then having the adult volunteers take over these tasks during the summer.

Students can help the citizen group by providing people-power for labor-intensive projects such as a thorough physical survey of a watershed (stream walking), surveys of community values and current river uses, and restoration work. School labs are an invaluable resource for analyzing samples. Additionally, students make very powerful advocates. As RWN's New England Coordinator, Geoff Dates, commented, "It's more difficult for an adult to look a student in the eye and say 'There's nothing we can do about this problem' than to say it to another adult."

Opportunities abound for a citizen program to assist its partner school program. To start with, the simple fact that an outside community organization is working with the school can help legitimize the school program and garner administrative support.

In addition, your group can help the teacher and students by sharing your expertise in data analysis, computer networking, and water quality issues. Adult volunteers can accompany the school classes on monitoring days or help coordinate Student Congresses. You can work with the teacher to identify ways in which the monitoring program can fit into the established curriculum.

Following are some additional suggestions for how you can help:

- **Linking teachers.** Teachers are more likely to stay with a monitoring project when they have support from other involved teachers at the same school or in the same watershed. Your group can create opportunities for teachers to meet, plan, and network by encouraging more than one teacher in each school to become involved, training teachers in groups, and bringing teachers together at the end of each school year to evaluate the program and lay the groundwork for the coming year.

  Remember that you can recruit more than just the science teachers. Water monitoring lends itself to interdisciplinary study, including math, language, and social studies - and don't overlook the potential for involving the guidance counselor, the physical education teacher, or the special education teacher.

- **Providing resources.** Teachers are hungry for resources. Much of what they want to teach about water quality and community action is hard to find in a textbook. Providing audiovisual aids, lists of books, and a listing of resource people and agencies in your area can be a big help. A manual with clear written procedures for performing all the tests, as well as background information and equipment lists with ordering information, is essential.

- **Helping teachers obtain equipment or funding.** A citizen monitoring group can lend monitoring equipment to the school program. Alternatively, you can help set up partnerships with local businesses or service clubs who can provide funds for equipment. Groups can also help teachers write funding proposals.

  A simple but often effective tactic is to suggest that teachers check with their principal or superintendent about the availability of Eisenhower funds - federal monies given to each school system for math and science teacher training (which can include training in water monitoring). I have found that often a school does have such funding available, but the teachers are not aware of it.

- **Helping with action projects.** Often, the school schedule provides little time for students to apply what they've learned. The citizens group can help organize activities like restoration projects, student presentations to local boards, or writing articles in a newspaper. But before embarking on action projects, be sure to talk with each teacher about what degree of controversy he or she is comfortable with, then design activities accordingly.

Getting Teachers Involved

Once you've decided that working with schools makes sense for your group, the first critical step is to enlist interested teachers. Administrative support alone cannot sustain a monitoring project if teachers are reluctant to get involved or feel they already have too much to do. You can meet teachers to tell them about the program, assess their interest level, and "flush out" enthusiastic teachers by:

- giving workshops or presentations at school district "inservice days"
- going to staff meetings and giving a 10-minute presentation
- providing in-class programs for students on water quality topics
- talking to the school's science coordinator or science department chairperson

Teacher Meetings and Training

After you've identified interested teachers, hold initial meetings to discuss what the teacher's commitment is, what role your group will play, and how you will work together. Then hold training sessions in monitoring techniques, study design, and aquatic ecology. Some tips for training sessions:

- Wait until equipment is available before training.
- Train groups of teachers together. Good grade clusters are K-3, 4-6, 5-9, 9-12.
- Encourage teachers to bring someone else from their school.
- If possible, arrange for graduate credit for teachers.

What Grade Level Should You Work With?

Involvement with all grades, even the very youngest, helps increase community awareness about the river. For more in-depth monitoring and analysis, it's best to work with middle school and high school classes.

Middle schools usually have more flexible schedules than high schools, allowing classes to go into the field for longer time periods. Also, team-teaching is more common in middle schools, making it easier for teachers to integrate monitoring into many different subject areas.

Working with high school students presents more challenges, since each student has an individual schedule and the day is divided into 50-minute class periods. The high school curriculum also tends to be more rigid. On the other hand, the opportunities are greater, since the teachers and the students are more highly trained in science. At the high school level, monitoring is usually incorporated into individual subject areas, most frequently chemistry, biology, and environmental studies. To avoid the restrictions of working within the school schedule and curriculum, some high school teachers choose to incorporate monitoring into an after-school program or club.

Designing the Program

I have observed that citizen group-school partnerships work most smoothly when teachers have a clear framework to follow in terms of where and when to sample and what to test. The more the school collaborates in designing the study, the better. It's easy for teachers and students to get caught up in the "Doctor Science" appeal of the testing; encourage them instead to first consider basic questions like, What do we want to know? What tests will help us find out? What are the threats to water quality in the river?

In deciding what quality of data you need, it is important to consider how the students' data will be used and what the teacher's goals are. Data quality control is time-consuming, and in some cases a heavy emphasis on data quality could take away from what the teacher is trying to accomplish. We have found that school data are not usually used in a regulatory setting. The most frequent uses have been: (1) general assessment on the state level; (2) identifying problem sites; and (3) public education.

Start Small

For any given teacher or school, start with just a few of the easier tests the first year - perhaps a stream walk and physical survey - then build up. The hardest tests are those requiring a standard curve, such as total phosphorus and nitrates; these should be saved for later. In our experience, it takes about three years for a teacher to become comfortable with all the techniques and to feel confident about data quality.

Timing

Your program will run more smoothly if you take into account the cycles of the school year. Avoid burdening teachers at the busiest times - the first few weeks of school, the time between Thanksgiving and New Year's, and the end of the year. In the fall, contact teachers after the first wave of activity has settled down to get the program running.

Keeping In Touch With Teachers

Because of teachers' isolation, maintaining contact is especially critical. But there are a few tricks to learn. I've found that the communication techniques people usually rely on in the business world - memos, phone calls, phone messages - don't work as well in the school setting.

During class time, teachers are very hard to reach by phone. You may be able to reach them either right before the school day starts or right after school ends. Better still, arrange to call them at home.

If you send mail to the school, don't address it to "science teacher." It probably won't reach the right person. Address mail specifically to teachers by name, then make a follow-up phone call.

But mail and phone are no substitute for actually going to the school and talking to teachers in person. You'll find that teachers who have never responded to your memos will really make use of you once you show up at the school.

Before you embark on a joint monitoring effort with teachers and students, there's just one more thing I should warn you about: you are going to have a tremendous amount of fun!

Sharon Behar *is the Education Coordinator for River Watch Network, 153 State St., Montpelier, VT 05602; 802/223-3840.*

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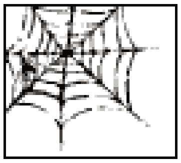

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Students Against Zebra Mussels

by Robert Williams and Cindy Bidlack

Students from 180 high schools throughout the Midwest are hot on the trail of the latest exotic invader of our rivers and lakes. These students are participating in Zebra Mussel Watch, a program coordinated by the Illinois Natural History Survey and the Water Resources Center at the University of Illinois in cooperation with the Illinois Rivers Project.

The students, armed with the latest zebra mussel detection devices, encountered live zebra mussels in both Illinois and Minnesota in the fall of 1992. We expect that by the summer of 1993 the Illinois, Ohio, and Mississippi rivers will be full of these troublesome mollusks.

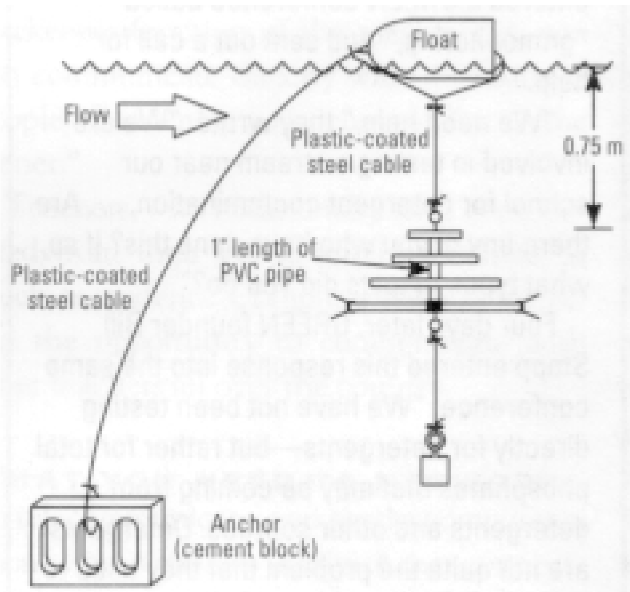
Catching the Critters

With funding from the Illinois-Indiana Sea Grant Program, the Rivers Project constructed zebra mussel monitoring devices, or "samplers," for each school in the Project. The sampler is basically an artificial substrate, similar to a Hester-Dendy sampler, made of PVC plates. Zebra mussels and larvae (called veligers) settle on the PVC plates and on the three glass microscope slides that are clipped to the bottom PVC plate.

Tania Aglikin, a student at Glenbrook South High School, prepares to deploy a zebra mussel sampler into the Des Plaines River. The bottle will be used as a float.

Each school chooses a site for deploying the sampler. We recommend that teachers contact a power or water treatment plant and arrange to place the devices on their property. That way, plant officials can monitor the sampler during the summer months when school is not in session. Also, we have found that the samplers tend to disappear, due to either vandalism or natural causes, when they are not placed on company property.

Every two or three weeks, the students revisit the site and inspect the PVC plates for zebra mussels, which are usually very small and may appear only as bumps. Some classes bring along a dissecting microscope to aid in onsite identification of mussels. The students also remove the glass slides from the bottom PVC plate and take them back to school, where they use a microscope to examine them for small mussels and veligers. New glass slides are put in place, and the device is lowered back into the water.



The samplers have provided an unexpected, but welcome, additional learning opportunity - at certain times of the year, they may be covered with other organisms, such as mayflies, diving beetles, and caddisflies. We have also found *Hydra* and *Planaria*. Students can take these specimens back to lab and identify them with the help of charts.

The students' zebra mussel findings are reported to project advisor Doug Blodgett, a research biologist at the Illinois Natural History Survey. In the future, Blodgett hopes to involve the students in monitoring growth rates and maximum densities of the mussels.

Zebra Mussel Study Unit

The Rivers Project has developed and is currently field-testing a monthlong study unit to accompany the zebra mussel monitoring. Students first learn about other examples of exotic species and their impacts, then zero in on zebra mussels for an in-depth study. They use maps to plot the spread of the mussels and play a decision-making game in which they assume various roles in a hypothetical town that has a zebra mussel problem. Finally, they develop and implement an action plan. Draft copies of the study unit are available from the Rivers Curriculum Project for $12.

Robert Williams *is Project Advisor and* ***Cindy Bidlack*** *is Project Coordinator for the Rivers Curriculum Project, Illinois Rivers Project, Southern Illinois University, Box 2222, Edwardsville, IL 62026; 618/692-3788.*

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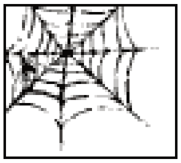

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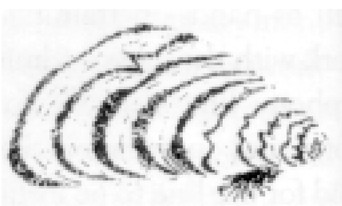
A Silent Invader

The zebra mussel (*Dreissena polymorpha*) was accidently introduced into North America in late 1985 or early 1986, probably in the ballast water of a transatlantic vessel from a European port. It was first spotted in the Great Lakes and has spread rapidly since then. Scientists believe it is only a matter of time before most U.S. rivers and lakes become colonized by this alien invader.

Zebra mussels are cream-colored or yellowish-brown, with zigzag or wavy bands of brown and yellow (hence the name "zebra"). Adults grow to about 3 cm in length and have a life span of 3 to 5 years. The mussels attach themselves in thick clusters to almost anything, and reproduce at incredible rates - a single female can produce up to 40,000 eggs annually.



Utilities and industries that draw cooling water from mussel-infested waters have suffered repeated shutdowns and costly cleanups as a result of the invasion. Layer upon layer of zebra mussels build up inside the intake pipes, clogging them and shutting off the water supply.

-P. Satish Nair
Illinois Rivers Project.

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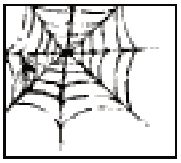

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What's a Student Congress?

by Marcia Siam Wiley

"I enjoyed meeting new friends, seeing that I wasn't the only teenager who wants the river clean, and learning about the ways that I can improve it and help clean the river up."
-- Faith Bryant, student, State of the Cuyahoga River Student Congress, May 1991.

Many water monitoring groups sponsor Student Congresses, events that bring students, teachers, and water resources professionals together to celebrate student monitoring work. These gatherings enable students living throughout a watershed to identify issues of mutual concern and plan actions to resolve them. Teachers and citizen monitoring groups also benefit - they see the fruits of their educational efforts in action and can meet to evaluate program design and plan for the future. By forging connections among participants, Student Congresses inspire and rejuvenate.

Planning a Congress takes time and the ability to coordinate many groups and individuals, both beforehand and at the event. It is best if one person is in charge of arrangements - *not*, however, a busy project teacher or the program coordinator.

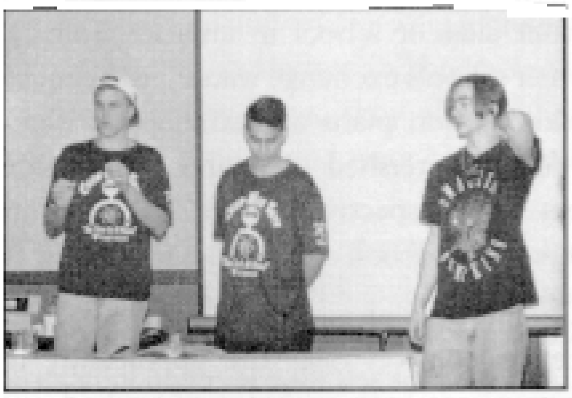
Effective Congresses are those in which:

- Students produce something (a petition, song, poem, rap, silk-screened T-shirt, poster, banner, or video) that can be shared with their school, class, and/or family as a starting point for discussion of what they learned at the Congress and during the project.
- Activities for *all* participants are varied and thought-provoking. General group sessions might include a slide show, keynote speaker, or artistic performance. Small group sessions might include skill-building workshops, such as "Stream Restoration Activities" or "Communicating with Elected Officials," or topical presentations such as "Salmon Ecology and Management."
- Students attend sessions they are interested in, choosing a level (elementary or secondary school) that allows them to meet with peers.
- All participants know what to expect at the Congress and how to prepare for it (e.g., graph water quality data, assemble displays, generate preliminary action-taking strategies, gather informational materials).
- Participants have the opportunity to do something outdoors, ideally on or near the featured water body.
- Students meet in small groups with a facilitator to share their findings and brainstorm action-taking strategies.

Another key ingredient of successful Congresses is that students have the opportunity to summarize their thoughts and concerns in writing. Often their documents become part of media coverage of the event. At the recent Deschutes and Nisqually Project GREEN Student Congress in Olympia, Washington, students produced the "South Sound Watershed Action Declaration." Their ideas for improving water quality included:

- Educate farmers and other landowners about damage caused by animals, fertilizers and herbicide use.
- Keep logging debris out of streams to protect salmon spawning grounds.
- Reduce waste at the source - don't consume as much.
- Make an "infomercial" about our river situation to be broadcast on local television.

Student Congresses promote the cross-fertilization of students' ideas and the dissemination of these ideas to the larger community, resulting in benefits both for citizens and for the water that sustains us.



NICOLLE SCHOENEWEICS

Illinois Rivers Project Student Congress, March 1993.

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