THE Volunteer Monitor

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CATHERINE McEVER

Issue Topic:
Doing Science, Taking Action

INSIDE

Notes from the Citizen Science Conference

Volunteer Monitoring & the Democratization of Science

by Eleanor Ely

It's said that traveling to other countries teaches you what your own country is like. Last June, I had the opportunity to spend a few days in the larger citizen science universe, in the form of the Citizen Science Toolkit conference convened by the Cornell Lab of Ornithology in Ithaca, New York. I came away from that visit with new insights into what's special about volunteer water monitoring. I was especially struck by the realization that water monitoring, perhaps more than any other scientific activity that citizen volunteers engage in, opens the door to full participation by volunteers in the scientific process.

The conference was the first major meeting to bring citizen science practitioners of every stripe together under the same roof. Our goals were to discover what we had in common and what we could learn from each other, and in the process generate ideas for an online "Citizen Science Toolkit" being developed by the Lab of Ornithology (see www.birds.cornell.edu/citscitoolkit/).

Above: Citizen Science Toolkit conference, Cornell Lab of Ornithology, June 2007.

Worms to stars

For purposes of the Citizen Science Toolkit initiative, "citizen science" was defined as "projects in which volunteers partner with scientists to answer real-world questions." Almost everyone at the conference was affiliated with a project that could be broadly categorized as environmental monitoring — weather observing, physical/chemical water quality monitoring, and an amazing variety of projects that survey, study, or monitor living organisms of some kind, from birds and butterflies to frogs, fish, worms, and plants. There were also several attendees representing astronomy projects.

Of the 70 or so conference participants, only about 10 represented programs you'd be likely to read about in this newsletter — i.e., programs with some connection to aquatic environments — and only about half of those water-related programs included a water quality monitoring component (the others focused on monitoring some type of aquatic animal or plant). Note that the makeup of the conference should not be taken as an indication of the relative proportions of different types of citizen science activities in the real world. Because of the conference location, about one-third of attendees were staff and faculty from Cornell Lab of Ornithology and Cornell University, most of whom represented large-scale surveys of birds or other wildlife.

Commonalities, with twists

Participants quickly recognized many shared activities and interests, such as training volunteers, rewarding volunteers, ensuring data quality, and getting volunteer-collected data accepted and used by various audiences. Sometimes

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THE Volunteer Monitor

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From the Editor

For various reasons, especially funding delays, *The Volunteer Monitor* has not been published since the Fall 2006 issue. With this issue the regular biannual publication schedule resumes.

Current issue

This issue explores two great strengths of community-based volunteer water monitoring projects — the opportunities such programs offer for participants to (a) engage in all steps of the scientific process and (b) take action based on their findings.

Next issue

The topic of monitoring invasive species, originally planned for Spring 2007, will be the theme of the Winter 2009 issue. Please contact the editor if you have an idea for an article on this topic.

Letter to the Editor

MI Method for Bacteria Testing

In the excellent review of bacteria methods in the Winter 2006 issue ("Bacteria Methods for Recreational Waters: A Short History and Guide"), it was noted that "the MI method has been little used by volunteer monitoring programs." Our certified lab at the Community Science Institute (CSI) in Ithaca, New York, has used the MI agar membrane filtration method (EPA approved method 1604) to enumerate *E. coli* and total coliform in lake and stream water since 2003. We also use it as a New York State-certified presence/absence test for total coliform and *E. coli* in drinking water. Based on hundreds of samples I can report that the MI agar method works very well. Stream profiles of *E. coli* and total coliform bacteria, which CSI has obtained in partnership with several local groups of volunteers, may be viewed at www.communityscience.org.

Our lab has noticed that the MI agar method tolerates small temperature fluctuations around 35°C, and this suggests that inexpensive equipment such as a chick egg incubator, while not appropriate for a certified lab, should nevertheless give accurate results. Moreover, *E. coli* enumeration tolerates colony crowding reasonably well. We have observed that 200 to 300 *E. coli* colonies may be counted accurately on a 47 mm filter, as indicated by dilutions that yield similar counts.

MI agar plates are available commercially, obviating the need for an autoclave and extensive sterility controls and potentially facilitating use of the method by volunteer groups.

One caveat is false positives for total coliform. Only colonies that fluoresce blue-white (or blue-green in the case of *E. coli*) under long-wave UV light should be counted. Exclude colonies that do not fluoresce, or that fluoresce colors other than blue-white or blue-green, such as pale yellow or pale green.

In summary, MI agar is a robust, accurate, and convenient membrane filtration method for simultaneously monitoring *E. coli* and total coliform concentrations in streams and lakes as well as in drinking water. For more information see www.epa.gov/microbes.

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DEMOCRATIZATION, continued from page 1

there were interesting twists on common themes. For example, certification of volunteers is widely practiced, but nonetheless attendees were impressed to hear from Louis Liebenberg, a Master Tracker from South Africa, that to get a level 3 certification as a tracker you have to track and find a lion without the lion noticing you.

Top-down vs. bottom-up

Some of the most provocative discussions centered around the difference between a "top-down," scientist-directed model and a "bottom-up," community-based approach. Candie Wilderman, founder of the Alliance for Aquatic Resource Monitoring (ALLARM), presented a scheme for categorizing programs along a continuum of increasing community involvement and control. Classification is based on a series of "who does what" questions (see graphic below) that represent steps in the scientific process.

The top-down model, referred to at the conference as the "Cornell model," is exemplified by several large-scale Cornell Lab of Ornithology bird-monitoring projects. A team of scientists and educators determines the scientific question(s) to be answered and decides what segment of the public will be targeted as participants. (Perhaps tellingly, the Cornell model terms potential participants the "audience" for the project.) The team also designs and tests the protocols, analyzes the data that the volunteers send in, and sometimes publishes the results.

The strength of top-down programs is their ability to coordinate large numbers of volunteers, span a wide geographic area, and collect and manage a large amount of data. Such programs can answer important scientific questions that would be difficult or impossible to answer any other way. The downside is that the role of volunteers is usually limited to data collection.

The bottom-up, community-based model has the potential to involve participants in every step, from defining the problem through communicating the results and taking action. Wilderman stressed that the bottom-up or community-based model doesn't dispense with scientists; their involvement is critical to producing valid, credible data. But the role of scientists is to advise and guide community groups rather than to set the agenda for them.

Size matters

Most of the programs represented at the Citizen Science Toolkit conference were in the top-down camp. The main examples of the bottom-up model came from the water quality monitoring corner of the citizen science world — ALLARM, University of Rhode Island Watershed Watch, and Pacific Streamkeepers Federation (a Canadian program).

The prevalence of top-down, scientist-driven projects was surprising to some of the volunteer monitoring folks at the conference. We wondered why we weren't hearing much about topics that figure prominently at volunteer monitoring conferences — such as how to involve volunteers in roles other than data collection, or how to use volunteer-collected data to fix local problems and inform policy decisions.

At first we assumed that the differences in approach stemmed mainly from philosophical differences. But over the course of the conference it became increasingly clear how much the choice of model is determined by characteristics of the project itself. In particular, size matters.

Think of a volunteer recording observations about a wide-ranging species — say a migratory bird —and sending the data to a centralized location, where it will be combined with observations from thousands of other volunteers scattered across the geographic range of the species. Ultimately, sophisticated data-crunching by project scientists will generate information about population distribution and trends. A project of this scope seems to demand a top-down, scientist-driven approach.

Now think about members of a watershed association testing a local swimming beach for bacteria, or lake residents taking Secchi disk readings on their lake, or volunteers with a "Friends of" group measuring stream temperature and dissolved oxygen. What's different about this picture?

continued on next page

WHO
- Defines the problem?
- Designs the study?
- Collects data?
- Interprets data?
- Communicates results?
- Takes action?

Top-down model:
Volunteers collect data; professional scientists or managers do the rest. Good for large-scale projects.

Project FeederWatch
Cornell Lab of Ornithology

Volunteers: 16,000
Scope: All U.S. states plus Canada

Bottom-up model:
Volunteers can potentially participate in every step. Works well with local, community-level projects.

STEVE LANDRY

Upper Merrimack Monitoring Program
Boscawen, NH

Volunteers: 55
Scope: 32 river miles

DEMOCRATIZATION, continued

The specialness of volunteer monitoring

This is where we come to the specialness of volunteer water monitoring. Water quality problems often have local causes. Mud from a construction site may be reaching a stream. Bacteria from failing septic systems may be getting into a lake. Trout may be dying because streamside vegetation has been removed, raising the water temperature. Problems like these can be — in fact, need to be — addressed at the community level.

The local nature of water quality problems means that volunteer water monitoring is tailor-made for the community-based approach. You don't need thousands of far-flung volunteers to collect the needed data. What you want is a small group of local citizens.

Democratizing science

Because the group is small and local, participant involvement in all steps of the scientific process becomes a realistic possibility. Science can be democratized in a way that simply isn't possible with a big top-down program. Participants can physically get together to talk about what water quality problems they want to investigate and what methods they will use. They can attend workshops to learn about study design and data interpretation. A volunteer with expertise in databases might set up a system to manage the monitoring data. One who is handy with tools might design and build low-cost monitoring equipment.

Certainly, not all volunteer water monitoring programs involve participants in all the steps. Some water-related projects are large in scope and follow a more top-down, scientist-driven approach. Examples include the Secchi Dip-In, the Reef Environmental Education Foundation (REEF), the North American Amphibian Monitoring Program, several large programs for tagging oceangoing fish, and the International Coastal Cleanup.

Even among local, community-based volunteer monitoring programs, empowering participants to really "do science" is often more of a potential than a reality. But the point is that the potential is there.

Terminology and Controversy

One thing the Citizen Science Toolkit conference proved is that the terms *citizen science* and *citizen scientist* have the ability to spark debate and controversy. Not only do these phrases mean different things to different people, but the individual words — *citizen, science, scientist* — all carry their own baggage.

The word *citizen* is troubling to some people because it has legal/political meanings that can make it sound exclusionary. In addition, citizen implies nonprofessional, which raises the question of whether a professional scientist can also be a citizen scientist. But the term also has its fans. Terrie Miller, creator of the blog "Citizen Science Projects" (http://citizensci.com/), writes that "the citizen in citizen science is a person who recognizes and studies the local ecology that they themselves are part of . . . The citizen science projects that I participate in are . . . inquiries into *my* world, the world that I'm a citizen of."

The words *science* and *scientist* can raise as many hackles as *citizen*. In defense of the scientist in "citizen scientist," Miller cites historical examples of individuals without formal training who performed science, and points out that "a 'scientist' has become someone with a doctorate degree from an accredited university . . . But it didn't used to be like that . . . [W]e need to take science back."

But while the idea of "taking science back" is appealing, many people are wary of defining science too broadly. Secchi Dip-In founder Bob Carlson says, "Surely there must be more to being a scientist than knowing that we mix A with B before adding C." At the citizen science conference, Rick Bonney, one of the conference organizers, commented, "I don't think we call somebody a 'citizen scientist' until and unless they are asking and answering their own questions."

Those of us in the water monitoring world have traditionally used the terms *volunteer environmental monitoring* and *volunteer monitoring*. Carlson put his finger on one big advantage of these terms when he pointed out that they "describe without interpreting." Carlson himself is a professional limnologist who also participates in a volunteer monitoring group. "*Volunteer monitor* really does explain what we are," he says. "We are of varied careers, yet freely donate our time to monitor."

Taking action

If water quality problems have local causes, they also have local solutions. The information volunteers collect is information they can directly use to protect and improve the same waters they are testing. Volunteer monitors use their data in all kinds of ways, such as planning restoration projects, cleaning up pollution sources, upgrading the protection status of waterbodies, and advocating for sound local land-use planning.

Water quality issues have another attribute — social relevance —that facilitates action-taking. Communities care about having clean water for drinking, fishing, and swimming, among other things. Water is connected to public policy — to laws, regulations, permits, and planning decisions — in ways that birds, butterflies, worms, and stars are not. This opens up many opportunities for volunteer water monitors to use their data to bring about change.

Best of both worlds?

At the conference, people from both camps were intrigued by the opportunity to look over the fence and see what other programs were doing. The tantalizing question is whether programs can have it both ways by combining the advantages of the top-down and bottom-up models. Some specific questions to think about:

For top-down projects:

- Can projects that compile data collected over a large geographic area also provide opportunities for volunteers to use their data locally?
- Can the "Cornell model" make room for volunteers to participate in other steps besides data collection?
- Can scientist-driven projects move beyond research and make more use of their findings to guide and inform public policy?

For local water monitoring projects:

- Can there be more collaborations in which local groups pool their data to help answer larger questions?

- Can volunteer water monitoring programs make a greater effort to get their data used in scientific studies and published in scientific journals?

A number of volunteer monitoring programs have found ways to incorporate the strengths of both models. One example is Florida LAKEWATCH. Participating lake associations use their own data to manage their individual lake, and at the same time University of Florida researchers use the comprehensive statewide LAKEWATCH database to answer a variety of scientific questions. Often these researchers publish their findings in science journals (for a list of such articles, see page 9).

Future directions

My experience at the citizen science conference left me with a couple of thoughts about future directions and opportunities for the volunteer monitoring movement. First, community-based programs could move further toward realizing the potential they have for democratizing science. Second, volunteer monitoring programs could strengthen their connections with the world of professional science through increased collaboration with researchers and publication of findings in science journals.

Further reading

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McEver, C., R. Bonney, J. Dickinson, S. Kelling, K. Rosenberg, and J. Shirk (Editors). 2007. *Proceedings of the Citizen Science Toolkit Conference.* Cornell Laboratory of Ornithology, Ithaca, NY, June 20-23, 2007. www.birds.cornell.edu/citscitoolkit/conference/presentations.

Wilderman, C. 2006. The taxonomy of community-based monitoring. Presentation at the 5th National Monitoring Conference, Atlantic City, NJ, May 18-22, 2006. http://alpha.dickinson.edu/storg/allarm/publications/presentations.htm.

Wilderman, C., A. Barron, and L. Imgrund. 2003. The ALLARM program: Growth, change, and lessons learned. *The Volunteer Monitor* Winter 2003.

Wilderman, C., A. Barron, and L. Imgrund. 2004. Top down or bottom up? ALLARM's experience with two operational models for community science. *Proceedings of the 4th National Monitoring Conference,* Chattanooga, TN. National Water Quality Monitoring Council. http://water.usgs.gov/wicp/acwi/monitoring/conference/2004/proceedings_contents/13_titlepages/posters/poster_235.pdf.

High Tech, Low Tech

There was a lot of talk at the Citizen Science Toolkit conference about how technology is facilitating and expanding citizen participation in the scientific endeavor. David Witzel, managing director for Backyard Jungle (a website that encourages kids to explore nature in their backyards), commented that the Internet is transforming science in the same way it has transformed other fields, such as medicine or journalism. "In some sense," he said, "scientists are going to lose their role as the high priests of science and increasingly become partners in the scientific process."

At the other end of the technology spectrum was a demonstration by Cindy Hale, director of Great Lakes Worm Watch. Hale mixed powdered mustard with water in a gallon jug, then poured the contents onto the ground. Almost instantly worms of all sizes came wriggling out. Even more surprising than the sudden emergence of the worms was the revelation that none of them were native to the region. During the last glaciation, Hale explained, native worms disappeared from all parts of the United States and Canada that were covered by glaciers. Worms that currently live in those areas are exotic species introduced in the past few centuries.

CATHERINE McEVER

Conference Sound Bite

Why monitoring matters

"Research in the broadest sense is answering a question — a question that can, in most cases, be answered at any point. The issue with monitoring is that if we don't collect monitoring data this year, that data can never be collected again.

"Once monitoring data are in, they are always there and will be used over and over again. Monitoring information gets better with age because you're able to detect more trends the more years you have in. You're in a difficult place in the first few years because people want quick results. Once you have 10 years in, it starts getting to be gravy."

— Sam Droege, USGS Patuxent Wildlife Research Center

Recommended Resources from Citizen Science Conference

Citizen Science Central • Proceedings of Citizen Science Toolkit conference, directory of citizen science programs, list of articles about citizen science, and more. www.birds.cornell.edu/citscitoolkit/

Volunteer monitoring fact sheets • The Cooperative State Research, Education, and Extension Service (CSREES) Volunteer Water Quality Monitoring website has fact sheets on program design, training, building credibility, and other topics plus many other resources and links for volunteer monitoring. www.usawaterquality.org/volunteer/

Citizen science blog • Terrie Miller's blog, Citizen Science Projects, is eclectic, lively, and informative. www.citizensci.com/

Do-it-yourself field guides • Electronic Field Guide project from UMASS-Boston. http://efg.cs.umb.edu/

Online data entry: CyberTracker • Free software for field data collection; can be used on GPS-enabled smart phones and PDAs. www.cybertracker.org

Study design guidance • U.S. Geological Survey (USGS) Patuxent Wildlife Research Center's online "Managers' Monitoring Manual: How to Design a Wildlife Monitoring Program." www.pwrc.usgs.gov/monmanual/

Virtual Nest Watch • A citizen science project conducted completely in cyberspace. http://watch.birds.cornell.edu/nestcams/home/index

WordPress • Templates for creating a weblog. www.wordpress.com

Flickr • For organizing and sharing photos. www.flickr.com

volunteer research SYMPOSIUM

by Chris Swarth

When volunteers are asked why they enjoy monitoring the environment, they often say that they like "being in the field" or "helping to improve the environment."

Fieldwork is fun. But making sense of the raw data is often considered plain hard work. It requires gathering, summarizing, analyzing, and interpreting the accumulated data, and, finally, communicating the results with others. These tasks usually fall on the shoulders of the project leader. But volunteers can play an important role in bringing a project to completion — if you give them a chance. If volunteers are to advance to the point of becoming "citizen scientists" they need the chance to apply science to their data and observations. If you give them this opportunity by working side by side with them at desk and computer you may be pleasantly surprised to see volunteers rise to the occasion.

Since 1987 we've trained hundreds of volunteers at the Jug Bay Wetlands Sanctuary, a 1,500-acre field station on the edge of the Patuxent River in central Maryland. We generally coordinate about 10 studies at any one time, and trained volunteers help with each one. They measure dissolved oxygen levels in the wetlands, count flocks of canvasbacks, band migratory songbirds, and identify amphibian tadpoles in vernal pools.

Our work over two decades had convinced us that some of our 100-plus volunteers would enjoy the challenge of participating in the reporting phase of a project. While Sanctuary staff members often give papers at conferences, most of our volunteers do not. Why not add this dimension to our volunteer program by organizing our own symposium?

Speaking at conferences — sharing results with peers, getting critical feedback, and networking with other scientists — is an important part of the scientific process. Conferences are also a great source of stimulation and inspiration. Importantly, a conference looming in the near future imposes deadlines, reduces procrastination, and forces one to analyze collected data.

Preparing for our volunteer symposium

We approached eight confident and dedicated volunteers with our new idea. Some had worked with us for 12 or more years, while others were relative newcomers. Each was a key participant in the study they would speak about. Several had played roles in designing the studies and adjusting methodology. Four were retired and four were working full-time. Five had a background in science. Four had Ph.D.s and two had master's degrees. Two were college professors.

To our delight each accepted our invitation. There was initial trepidation about speaking in public: would there be experts in the audience who might ask tough questions they couldn't answer? I assured them that this was not likely.

With our team assembled, we picked a date five months out, booked a conference site in Annapolis, and began promoting the event, which we called the Jug Bay Wetlands Research Symposium. We wanted to attract resource management professionals from county, state, and federal agencies that are headquartered in Annapolis. We also wanted our larger volunteer corps to learn more about our research program, and we wanted to attract new volunteers.

> A conference looming in the near future imposes deadlines, reduces procrastination, and forces one to analyze collected data.

Each volunteer presenter was paired with a Sanctuary staff member to prepare the presentations. Many hours were spent making graphs and tables, talking about the data, and finally creating a polished slide presentation—all things that professional scientists do when going to a scientific conference. Volunteers read papers and reports to gain background knowledge. Since much of our data was already on the computer, the main tasks involved examining the database, deciding which aspects of each study to highlight and which data to summarize, and finally making the presentations clear and compelling.

The first steps involved double-checking the data to make sure it was "clean." We showed volunteers how to use Excel to sort and graph data and perform basic statistical analyses to examine trends and look for data outliers. These simple techniques can reveal mistakes in data entry or a suspect measurement.

Once the data were proofed, we delved into the intricacies of using the

CHRIS SWARTH

These eight volunteers gave presentations at the volunteer research symposium.

spreadsheet program to prepare presentation-quality graphs and charts. From here, the data were imported into PowerPoint. About half the volunteers had some experience with PowerPoint, but for others it was a crash course.

Finally we set deadlines for abstracts (just like at a professional conference) and for practice presentations to work on timing and delivery. Practice was crucial in helping the speakers develop key points to make when each slide appeared. One mental hurdle we faced was convincing everyone that 20 minutes was enough time to deliver their talk.

CHRIS SWARTH

CHRIS SWARTH

Research presented at the symposium included studies of marbled salamander migration, songbird breeding productivity, and Eastern box turtle home range (measured with radio transmitters).

CHRIS SWARTH

A bonus outcome of the data summarization process was that we met and talked with other researchers in the Chesapeake Bay region about their related studies. As a result we learned much that helped us to better interpret our own results, and collaborations were spawned that are giving new direction to some projects.

At the symposium

On the day of the symposium (March 29, 2008), more than 60 people gathered at 8:30 in the morning at a conference center. They had registered in advance and had paid a $10 registration fee. Continental breakfast and lunch were provided by the Friends of Jug Bay.

The volunteer speakers kept on schedule and gave excellent and animated talks about their research. The presentations were filled with colorful photos, graphs, and charts which described the local ecosystem in fascinating detail: when salamanders move to breeding places; how much habitat space a box turtle requires to find food and reproduce; how invertebrates in Patuxent estuary mud affect the distribution of the waterbirds that prey on them; and how some songbird species thrive at Jug Bay while their populations are declining elsewhere.

There were sighs of relief when their talks were over, and a great sense of pride for a job well done. And the volunteers actually enjoyed tackling the questions from the audience. Comments we heard later from those in the audience were along the lines of "Wow, I had no idea you were doing such sophisticated and interesting work. Your volunteers are awesome!"

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Volunteer Presentations at Jug Bay Wetlands Research Symposium

Measuring Eastern box turtle home ranges with radio telemetry – Sandra Barnett, retired senior herpetologist at the National Aquarium.

Environmental informatics: Building a data warehouse at Jug Bay – Jeff Campbell, research scientist at the Center for Urban Environmental Research and Education, University of Maryland.

Water quality trends in Jug Bay wetlands – Dave Davis, astronomer with NASA.

Assessing population density and site fidelity in Eastern box turtles – Mike Quinlan, retired U.S. Army colonel.

Comparing the distribution of diving ducks and their benthic invertebrate prey in winter on the Patuxent River estuary – Sue Ricciardi, retired college math professor.

Patterns of tree diversity across sanctuary habitats – Lisa Siciliano, former astronomer, now a landscape designer.

Using constant-effort mist-netting to study songbird survivorship and breeding productivity – Sandy Teliak, retired from the National Security Agency.

Effect of weather on fall migrating marbled salamanders – Pete Uimonen, economist with the U.S. Department of Labor, Bureau of Labor Statistics.

Getting Volunteer Data Into SCIENCE JOURNALS

by Eleanor Ely

It's still rare for volunteer water-monitoring programs to publish their data in the peer-reviewed scientific literature. Yet most volunteer monitoring programs are continually on the lookout for additional ways to put their volunteers' data to use, and publication in a science journal offers such advantages as enhancing the data's credibility and value, disseminating the findings to a wider audience, and contributing to the advancement of scientific understanding.

"If you want to reach scientists, if you want your data respected and used by scientists, you need to publish in scientific journals," says Catherine Corbett, senior scientist at the Charlotte Harbor National Estuary Program. Corbett adds that having your data published through the peer-review process is also helpful "when you ask people to make regulations or fund restoration projects based on the findings."

"If you want to reach scientists, if you want your data respected and used by scientists, you need to publish in scientific journals."

Volunteer bird monitoring programs provide an inspiring example — they've been publishing their studies in scientific journals for decades. This is especially true of large-scale, scientist-driven studies such as the North American Breeding Bird Survey (BBS), jointly coordinated by the U.S. Geological Survey and the Canadian Wildlife Service, and various bird studies run by the Cornell Lab of Ornithology. The BBS bibliography (www.pwrc.usgs.gov/infobase/bbsbib/bbsbib.pdf) includes nearly 300 entries, about one-third of which are peer-reviewed research articles that rely heavily on volunteer-generated data.

Granted, publishing in science journals isn't for everyone. It does require significant time and effort, and some program leaders and participants will feel that their goals are best served by communicating their findings through other channels, such as reports to volunteers, newspaper articles, postings on the program's website, presentations at conferences or to local decision makers, or agency reports. But for those who are considering scientific publication, this article offers some introductory information and advice.

The gold standard

A peer-reviewed journal is the "gold standard" for publication of a scientific research paper. This is because of the rigorous — or, as one volunteer monitoring program coordinator termed it, "excruciating" — review process. Manuscripts submitted to a peer-reviewed journal (also called a refereed journal) are sent out to reviewers (typically two or three) to be vetted and critiqued. The reviewers are scientists with expertise in the research topic, and they are often anonymous—that is, the manuscript author does not know their identities. If the article is accepted, the author(s) are generally required to make revisions, sometimes substantial revisions, based on the reviewers' comments.

Academics have many incentives to publish (e.g., tenure, promotions, salary increases, prestige, and the desire to get information out to colleagues and advance scientific knowledge). The fact that the Florida LAKEWATCH program was founded by Dan Canfield, a research professor at the University of Florida, helps explain why nearly half the articles in the list on pages 9 and 10 are from the LAKEWATCH program. "LAKEWATCH was set up to answer research questions," Canfield says. Canfield and his colleagues have mined the LAKEWATCH database, which dates back to 1988 and includes data on over 700 lakes, to answer a variety of research questions.

But you don't have to be a university professor to publish. Judy Ott, the lead author of an article recently published in *Florida Scientist*, was a Florida Department of Environmental Protection employee when she wrote the article. Neither she nor any of paper's five co-authors has a Ph.D., and Ott had no previous experience with publishing in a peer-reviewed journal.

You don't have to be a university professor to publish.

Perhaps surprisingly, most of the people contacted for this article did not feel that the inclusion of volunteer data had been, in and of itself, a major barrier to getting their papers published in scientific journals. They reported that reviewers' criticisms usually focused on other issues, such as the statistical analysis of the data.

Validation studies

Performing a validation study can reassure journal editors and reviewers about the reliability of the volunteers' data. For example, every paper using LAKEWATCH data cites a validation study (Canfield 2002) which demonstrated that data collected by

LAKEWATCH volunteers were comparable to data collected by professionals. Elsewhere in this issue, David Delaney states that, in his view, "a validation study is a prerequisite for publishing volunteer-collected data in a peer-reviewed journal" (see page 21). But not everyone agrees. Catherine Corbett feels that if a program has a state or federally approved quality assurance plan and is

using standard, accepted methods, a validation study could actually undermine respect for the data by implying that people are questioning its validity.

Conducting a validation study is most important if volunteers are deviating from standard methods. This is quite often the case, and many of the published validation studies listed on page 11 were designed to evaluate modified or novel equipment or methods used by volunteers, such as transparency tubes (Anderson and Davic 2004), freezing of

continued on next page

Examples of Journal Articles Using Volunteer Data

The aim in assembling the list below was to identify those articles that make the very strongest case for the acceptance and use of volunteer-collected data in the scientific literature. Accordingly, all articles on this list met the following rather stringent criteria:

1. They are research articles (not abstracts).
2. They were published in peer-reviewed journals (no book chapters, conference proceedings, agency reports, etc.).
3. Volunteers generated actual data (i.e., they measured or identified something) as opposed to simply collecting water samples.
4. The volunteer-generated data made a significant contribution to the research.
5. The use of volunteer-collected data was explicitly acknowledged and described in the article.

This list does not include validation studies, which are listed separately on page 11. It also does not include social science studies.

The list contains 19 articles, of which 9 are from Florida LAKEWATCH and 10 were published in the North American Lake Management Society (NALMS) journal *Lake and Reservoir Management*. There are only five examples of volunteer data other than Secchi depth being used in a peer-reviewed research paper. Many types of data commonly collected by volunteers, such as bacteria counts, macroinvertebrate data, and dissolved oxygen, to name just a few, are not represented at all in the listed examples.

I found articles for the list through a combination of listserv postings, Internet searches (Google Scholar), visits to volunteer monitoring websites, and direct communication with volunteer monitoring representatives. I hope that readers will submit additional examples, which may be published in a future issue.

Volunteer monitoring data in peer-reviewed research papers

Type of data volunteers collected	Published research papers
Water temperature and salinity	Zhang, Y., F.X. Fu, E. Whereat, K.J. Coyne, and D.A. Hutchins. 2006. Bottom-up controls on a mixed-species HAB assemblage: A comparison of sympatric *Chattonella subsalsa* and *Heterosigma akashiwo* (Raphidophyceae) isolates from the Delaware Inland Bays, USA. *Harmful Algae* 5(3):310-320. Field data collected by the Delaware Inland Bays Volunteer Phytoplankton Monitoring Program during blooms of two phytoplankton species were used to supplement professional scientists' data obtained in lab cultures.
Identification or characterization of aquatic organisms	Delaney, D.G., C.D. Sperling, C. Adams, and B. Leung. 2008. Marine invasive species: Validation of citizen science and implications for national monitoring networks. *Biological Invasions* 10:117-128. The crab distribution and abundance findings reported in this article are all based on volunteer data. Ellis, S.L., and D.F. Cowan. 2001. Volunteer-based monitoring of juvenile American lobster, *Homarus americanus. Marine and Freshwater Research* 52(8):1103-1112. Article reports volunteer-collected density, size, and abundance data on juvenile lobsters in Maine. Hodgson, G. 1999. A global assessment of human effects on coral reefs. *Marine Pollution Bulletin* 38(5):345-355. All data for this research study were collected by teams of trained recreational divers with the Reef Check program. Participants identified indicator organisms (fish and invertebrates) and substrate types. www.reefcheck.org/about_RC_Reef/Publications.php.

continued on next page

Volunteer monitoring data in peer-reviewed research papers, *continued*

Secchi depth; non-Florida LAKEWATCH studies

Note: For some of these studies volunteers also collected and processed (including filtering for chlorophyll) water samples that were later analyzed by professionals.

Bruhn, L.C., and P.A. Soranno. 2005. Long term (1974-2001) volunteer monitoring of water clarity trends in Michigan lakes and their relation to ecoregion and land-use/cover. *Lake and Reservoir Management* 21(1):10-23. This study uses Secchi data from Minnesota's Citizen Lake Monitoring Program to analyze trends on 71 lakes.

Heiskary, S.A., and C.B. Wilson. 1989. The regional nature of lake water quality across Minnesota: An analysis for improving resource management. *Journal of the Minnesota Academy of Science* 55(1):71-77. This analysis of hundreds of Minnesota lakes uses Secchi data collected between 1977 and 1987 by Minnesota's Citizen Lake Monitoring Program.

Macdonald, R.H., G.A. Lawrence, and T.P. Murphy. 2004. Operation and evaluation of hypolimnetic withdrawal in a shallow eutrophic lake. *Lake and Reservoir Management* 20(1):39-53. A 9-year Secchi depth dataset collected by volunteer monitors was used in evaluating the effects of a drawdown on a Canadian lake.

Smeltzer, E., and S.A. Heiskary. 1990. Analysis and applications of lake user survey data. *Lake and Reservoir Management* 6(1):109-118. Secchi disk readings by the Vermont Lay Monitoring Program and Minnesota's Citizen Lake Monitoring Program were used in a study of user perceptions of lake quality. www.pca.state.mn.us/publications/reports/lqr-lakeusersurvey.pdf.

Smeltzer, E., R.A. Kirn, and S. Fiske. 1999. Long-term water quality and biological effects of alum treatment of Lake Morey, Vermont. *Lake and Reservoir Management* 15:173-184. The study used Secchi data from the Vermont Lay Monitoring Program. www.anr.state.vt.us/dec/waterq/lakes/docs/lp_morey-alum-jlrm1999.pdf.

Secchi depth; Florida LAKEWATCH studies

All these papers rely heavily or exclusively on Florida LAKEWATCH data. To view PDFs, go to http://fishweb.ifas.ufl.edu/Faculty.htm and click on Dan Canfield or Roger Bachmann.

Note: In most cases volunteers also collected and processed water samples, including filtering samples for chlorophyll.

Bachmann, R.W., C.A. Horsburgh, M.V. Hoyer, L.K. Mataraza, and D.E. Canfield, Jr. 2002. Relations between trophic state indicators and plant biomass in Florida lakes. *Hydrobiologia* 470:219-234.

Bachmann, R.W., M.V. Hoyer, and D.E. Canfield, Jr. 2003. Predicting the frequencies of high chlorophyll levels in Florida lakes from average chlorophyll or nutrient data. *Lake and Reservoir Management* 19(3):229-241.

Brown, C.D., M.V. Hoyer, R.W. Bachmann, and D.E. Canfield, Jr. 2000. Nutrient-chlorophyll relationships: An evaluation of empirical nutrient-chlorophyll models using Florida and north-temperate lake data. *Canadian Journal of Fisheries and Aquatic Sciences* 57:1574-1583.

Caffrey, A.J., M.V. Hoyer, and D.E. Canfield, Jr. 2007. Factors affecting the maximum depth of colonization by submersed macrophytes in Florida lakes. *Lake and Reservoir Management* 23:287-297.

Hoyer, M.V., J. Winn, and D.E. Canfield, Jr. 2001. Citizen monitoring of aquatic bird populations using a Florida lake. *Lake and Reservoir Management* 17(2):82-89. *Note:* The second author is a volunteer monitor! According to lead author Mark Hoyer, the volunteer made many significant contributions to the manuscript.

Hoyer, M.V., C.D. Brown, and D.E. Canfield, Jr. 2004. Relations between water chemistry and water quality as defined by lake users in Florida. *Lake and Reservoir Management* 20(3):240-248.

Hoyer, M.V., C.A. Horsburgh, Daniel E. Canfield, Jr., and Roger W. Bachmann. 2005. Lake level and trophic state variables among a population of shallow Florida lakes and within individual lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 62:2760-2769.

Hoyer, M.V, J.L. Donze, E.J. Schulz, D.J. Willis, and D.E. Canfield, Jr. 2006. Total coliform and *Escherichia coli* counts in 99 Florida lakes with relations to some common limnological factors. *Lake and Reservoir Management* 22(2):141-150.

Terrell, J.B., D.L. Watson, M.V. Hoyer, M.S. Allen, and D.E. Canfield, Jr. 2000. Temporal water chemistry trends (1967-1997) for a sample (127) of Florida waterbodies. *Lake and Reservoir Management* 16(3):177-194.

water samples prior to chemical analysis (Canfield et al. 2002), or modified macroinvertebrate methods (several studies).

Helpful tips

For people outside of academia, the process of getting published in a peer-reviewed journal may seem mystifying and intimidating. Here is some advice from folks who've been successful:

1. Ask experts you know to review the paper before you submit it to a journal.
2. Be prepared for a long process of review and revisions.
3. Don't be too discouraged if the reviewers' comments seem very negative. Dan Canfield advises: "First put the comments aside for a few days. Then analyze them and decide which ones are valid. If they are valid, address them. If they are not valid, defend what you did. Respond to all the comments in a detailed letter to the journal editor." The aim of peer review is to improve

the manuscript, so even though addressing reviewers' comments can take a lot of work, the end result should be a stronger and more useful paper.

4. Don't assume that your findings are "too local" — a local journal might be interested. Or you may be able to analyze your data in a way that addresses questions of broader interest. According to Canfield, "Not everything is publishable, but a lot is."

Note: Cooperative Extension's Volunteer Water Quality Monitoring site, www.usawaterquality.org/volunteer/, describes a number of volunteer monitoring-related studies, including some that do not meet all the criteria for the lists published here. Click on "Researching Volunteer Monitoring."

Volunteer Monitoring Validation Studies in Science Journals

The following studies evaluate the validity of methods or equipment used by volunteer monitors and/or the volunteers' performance. Most are side-by-side studies comparing volunteer and professional results. Although the list includes only studies that have been published in peer-reviewed journals, numerous other volunteer monitoring validation studies have been conducted. For some examples see *The Volunteer Monitor* Spring 1997, pages 16-18; Summer 2005, pages 18-19; and Winter 2006, page 7.

Published validation studies

Method or equipment	Published article
Transparency tubes	Anderson, P., and R.D. Davic. 2004. Use of transparency tubes for rapid assessment of total suspended solids and turbidity in streams. *Lake and Reservoir Management* 20(2):110-120.
Macroinvertebrate bioassessment (various modifications)	Engel, S., and J.R. Voshell. 2002. Volunteer biological monitoring: Can it accurately assess the ecological condition of streams? *American Entomologist* 48(3):164-177. www.usawaterquality.org/volunteer/RelatedResearch/Engel&VoshellAmerEnto20021.pdf. Fore, L.S., K. Paulsen, and K. O'Laughlin. 2001. Assessing the performance of volunteers in monitoring streams. *Freshwater Biology* 46:109-123. www.seanet.com/~leska/publications/Fore_Paulsen_OLaughlin_2001.pdf. Frost Nerbonne, J., and B. Vondracek. 2003. Volunteer macroinvertebrate monitoring: Assessing training needs through examining error and bias in untrained volunteers. *Journal of the North American Benthological Society* 22(1):152-163. www.fw.umn.edu/Research/nerbonne&vondracek03.pdf. Gowan, C., M. Ruby, R. Knisley, and L. Grimmer. 2007. Stream monitoring methods suitable for citizen volunteers working in the Coastal Plain and Lower Piedmont regions of Virginia. *American Entomologist* 53(1):48-57. Penrose, D., and S.M. Call. 1995. Volunteer monitoring of benthic macroinvertebrates: Regulatory biologists' perspectives. *Journal of the North American Benthological Society* 14(1):203-209.
Lake water quality parameters (Secchi reading, chlorophyll filtration, freezing of water samples, etc.)	Canfield, D.E., Jr., C.D. Brown, R.W. Bachmann, and M.V. Hoyer. 2002. Volunteer lake monitoring: Testing the reliability of data collected by the Florida LAKEWATCH program. *Lake and Reservoir Management* 18(1):1-9. Obrecht, D.V., M. Milanik, B.D. Perkins, D. Ready, and J.R. Jones. 1998. Evaluation of data generated from lake samples collected by volunteers. *Journal of Lake and Reservoir Management* 14(1):21-27. www.lmvp.org/documents/HTML/Obrecht1998.htm.
Crab identification	Delaney, D.G., C.D. Sperling, C. Adams, and B. Leung. 2008. Marine invasive species: Validation of citizen science and implications for national monitoring networks. *Biological Invasions* 10:117-128.
Vernal pool assessment (egg mass counts, tadpole identification)	Oscarson, D.B., and A.J.K. Calhoun. 2007. Developing vernal pool conservation plans at the local level using citizen-scientists. *Wetlands* 27(1):80-95.
Reef fish length estimates	Harvey, E., D. Fletcher, and M. Shortis. 2001. A comparison of the precision and accuracy of estimates of reef-fish lengths determined visually by divers with estimates produced by a stereo-video system. *Fishery Bulletin* 99:63-71.

Recipe for Success:
Free Technical Assistance

by Julie Vastine

On a rainy November evening in 2003, seven Antietam Watershed Association volunteers gathered around Hugh McNeil's dining room table in Waynesboro, Pennsylvania. Though they came to the table with different histories and backgrounds, they were all interested in the health of Antietam Creek—but they lacked the tools and a starting point for monitoring the stream.

As the meeting time approached, I knocked on the door excited about the meeting and equipped with a monitoring "road map" just waiting to be fleshed out. Throughout the evening I asked the Antietam volunteers about their ties to the creek and watershed, and intertwined their stories into the water quality monitoring journey we were all embarking upon. The volunteers started to relax as they realized that they were not on their own—they had access to free technical assistance from the Alliance for Aquatic Resource Monitoring (ALLARM).

That evening was the first of six Antietam Creek study design meetings, which in turn led to three chemical monitoring workshops, a physical assessment workshop, two macroinvertebrate trainings, two guided grant proposals, a database management meeting, two data interpretation workshops, and endless amounts of coffee, tea, and snacks consumed (the refreshments being the only things that the Watershed Association had to pay for). Looking back on the start of our partnership, Melodie Anderson-Smith, Antietam Watershed Association monitoring coordinator, says, "I do not know where we would be without the assistance of ALLARM. We either would not have been able to develop a monitoring program or if we did, it would have been a weak one."

How is free assistance possible?

ALLARM, a Dickinson College-based program that has been assisting community groups with water monitoring for more than 20 years, is fortunate to be part of a team of service providers called the Consortium for Scientific Assistance to Watersheds (C-SAW). Since 2001 C-SAW has applied for and received a series of grants through the Pennsylvania Department of Environmental Protection's Growing Greener program. The Growing Greener funding has allowed C-SAW partners to provide free technical support for water monitoring to over 200 watershed organizations throughout Pennsylvania.

The service providers participating in C-SAW represent a broad geographical reach and bring different areas of expertise to the program. Some partners specialize in topical assistance, such as the Pennsylvania Lake Management Society and the Western Pennsylvania Coalition for Abandoned Mine Drainage, which focus, respectively, on lakes and acid mine drainage. For short-term technical assistance the Consortium has the U.S. Geological Survey (USGS),

CANDIE WILDERMAN

ALISSA BARRON

KRISTEN TRAVERS

C-SAW partners at work. Clockwise from top: Julie Vastine (right) helps Antietam Watershed Association members identify macroinvertebrates; volunteers sort macroinvertebrates at Stroud Water Research Center workshop; USGS's Drew Reid demonstrates use of a flow meter.

USDA-Natural Resources Conservation Service, and Wilkes University. For long-term mentoring assistance there is ALLARM, Delaware Riverkeeper Network, and Stroud Water Research Center. Administration is handled by Pennsylvania's Resource Conservation and Development Councils.

Consortium assistance gets started in a variety of ways. For example, with the Antietam group, the group's president contacted the state for assistance and was referred to C-SAW. Some watershed organizations hear about C-SAW's free technical support and contact the service providers directly. The Consortium also receives recommendations from the state or county on potential candidates for assistance. That was the case for one of ALLARM's newest watershed partners, the Middle Spring Watershed Association. The county watershed specialist informed ALLARM that Middle Spring could benefit from technical assistance. As a result I contacted the group's president and secretary and started attending their monthly meetings. It took four meetings to build trust and rapport with the group.

Three kinds of assistance

Consortium assistance takes three forms. Watershed-Specific Technical Assistance consists of targeted short-term skills development designed to answer questions on particular topics. For example, a group might contact the USGS for instruction on installing stream bank pins, or the USDA-Natural Resources Conservation Service for GIS mapping assistance.

Mentoring Assistance is intensive, long-term capacity-building assistance, ranging from study design development to data interpretation training to grant-writing assistance. Middle Spring Watershed Association's secretary Robin Dolbin says, "Working with a service provider that has a good understanding of the types of projects that can be implemented at this stage in our program development is very helpful. This field has its own terminology and lingo, and having someone who can help incorporate that language into our grants I think has significantly helped with our success rate."

Training workshops are key elements in both Mentoring Assistance and Watershed-Specific Technical Assistance. When asked about training experiences, Anderson-Smith said, "ALLARM chemical trainings are strict with procedures but are implemented in a warm, volunteer-friendly way. The trainings make the science matter and help volunteers to perform at a high level."

We promote community ownership at every stage of the scientific process, from defining the questions to collecting and analyzing the data to finding the story in the data and communicating that story.

The third type of assistance is external Quality Control. ALLARM, USGS, and the Stroud Water Research Center perform validation testing at their own certified laboratories to check the accuracy of volunteers' chemical analyses and macroinvertebrate identification. Anderson-Smith says, "Antietam monitors are out there three to four hours a month—it's a significant time commitment. The quality control process holds us to a standard but also makes us feel that our effort is worthwhile—it really enhances the importance of the work we are doing."

C-SAW's recipe

So, what are the special strengths of the C-SAW model? I believe there are three critical ingredients in our recipe. First, the Consortium provides tailored, customized assistance. We do not come to a watershed organization with a standard monitoring program to prescribe; instead we help groups create a study design to address their specific watershed concerns. Second, we promote community ownership at every stage of the scientific process, from defining the questions to collecting and analyzing the data to finding the story in the data and communicating that story. Finally, having a consortium of eight partners allows volunteer monitoring organizations to tap into the expertise of a diverse group of professional organizations with different strengths and niches.

We are very grateful that the state of Pennsylvania supports the work of C-SAW. Grants allocated from the Growing Greener program to C-SAW totaled $1.65 million from 2001 to 2009. This state grant support has greatly expanded the C-SAW service providers' ability to work intensively with multiple watershed groups around the state, and has made it possible for citizen groups on shoestring budgets to take full advantage of the services the Consortium offers. C-SAW's record illustrates the magnitude and scope of this program. Over the past seven years C-SAW has assisted over 200 monitoring organizations, provided over 2,000 consultations, and implemented close to 400 training workshops.

Our experience in Pennsylvania has shown that when volunteer monitoring organizations have access to customized, free technical support, they are more likely to maintain successful long-term monitoring programs in which they can be fully engaged in every step of the process. Anderson-Smith says, "We feel like we have a constant resource. Not only is it helpful in carrying out our program but it makes volunteer recruitment easier because I can let people know that Antietam has equipment to give them and water quality professionals to provide training."

Julie Vastine is the Director of the Alliance for Aquatic Resource Monitoring (ALLARM), Dickinson College, Carlisle, PA. For more information: 717-245-1565; vastine@dickinson.edu; www.dickinson.edu/allarm/.

Integrating Science Into Monitoring — Without Burdening Volunteers

by Joan Martin

In 1991 the Huron River Watershed Council (HRWC) hired me to design a scientific program of volunteer monitoring for the Huron River and its tributary streams. The goals of the program were to build public awareness of the river and public support for actions that would protect it, while generating reliable data that would be useful in evaluating the quality of the river and the watershed. In other words, to combine public education with rigorous science.

In designing our program, I received invaluable help from Michael Wiley, an aquatic ecologist on the faculty of the University of Michigan. Unless your monitoring program is run by an aquatic ecologist, you need to find an expert to help guide the design of the program and the interpretation of the results. The procedures we developed are based on those used by state biologists, adapted for volunteers who have little or no experience in habitat evaluation or invertebrate collection. Several aspects of our monitoring program have been essential to its success:

1. We structure monitoring to encourage new participants.

HRWC makes it easy for anyone to try monitoring. We organize a one-day monitoring event each January, April, and September, when 120 to 180 people meet together for a brief orientation and then, in teams of five to seven, fan out across the watershed to collect samples of the benthic community. There is a buzz of excitement in the room as people meet their team members and begin to learn what they are about to do. New participants are curious about the day ahead since they have received no prior training. We make it clear that new volunteers don't have to make a future commitment or spend time preparing before coming to their first participation. The point is to encourage someone who has never poked around in a stream or been part of a research project to try something new.

HRWC makes it easy for anyone to try monitoring.

2. We make monitoring events fun while still adhering to rigorous scientific methods.

People enjoy making new friends, sharing an experience in the outdoors with their family, and learning something new if it can happen without being overwhelmed by technical details. Many volunteers will return to receive further training and become key members of the program if they enjoy the event and know that the work is important.

We separate collection and identification into two different events that occur on different days, which allows volunteers interested only in the outdoor experience to participate without committing themselves to the more technical indoor activity of insect identification. At the identification event, volunteers separate macroinvertebrates into "look-alike" piles. They don't have to learn bug identification because HRWC recruits local aquatic entomologists to work with the volunteers to identify the bugs to family level (see *The Volunteer Monitor* Summer 2005 for details).

When volunteers know what they need to do and that doing it right will provide useful data, they tend to work hard and complete the task well.

3. We train volunteer leaders to take responsibility for quality assurance.

Volunteers who demonstrate their interest by returning for a second monitoring event are encouraged to undergo training to serve as one of the two team leaders in subsequent events. We keep the leadership training brief (one afternoon), which includes two hours in a stream learning to collect in all different habitats. The leaders are vital in making

JOHN CRAMER

Monitoring day starts with orientation, including a refresher session for team leaders.

JOHN CRAMER

After orientation, teams set out for their stream sites.

JOHN CRAMER

Huron River Watershed Council volunteers pick macroinvertebrates from debris in the collected sample.

the collecting event run smoothly and reliably, following quality assurance procedures.

During monitoring events, only the trained leaders do the actual macroinvertebrate collection from the stream. The other volunteers work on sorting and picking the bugs, under the guidance of the leaders.

Monitoring all sites on a single day gives us the opportunity to meet with all the leaders and remind them about their most important responsibilities just before they set off. Any point we forget is very likely to be brought up by one of the leaders. While the leaders are having their reminder session, the new team members are convened separately for an orientation about the purpose of the activity and the importance of following their leader's instructions.

4. Our data sheet reinforces quality assurance procedures.

The HRWC field data sheet is the guide for streamside activities. It reflects all the steps volunteers take to assure quality, so that participants are constantly reminded to follow the prescribed procedures. The data sheet includes questions such as: "Was the jar rinsed three times with river water before the water sample was collected?" and "Did someone make sure that the net had no creatures clinging to it before you left the site?"

Since HRWC measures the diversity of benthic macroinvertebrates, it is crucial for volunteers to collect from all habitats present at each study site. Rather than depend on people's memory, we list and describe on the data sheet all habitats to be sampled (example: "Undercut Bank: where the water is cutting into the side of the bank").

The last item on our data sheet reads: "Please describe any ways this site, or the team's work on it, is different from other sites you have experienced, or from your training." Since such information is very important, we also ask the team members, especially the leaders, about their experience when they return from the activity. Such conversations occasionally reveal errors. In one case we were told that the site map must be wrong since none of the landmarks were seen. That conversation revealed that the team had collected from the wrong place.

Space is left for volunteers to document what they actually did, which is especially important for quality assurance purposes in determining if they may have done something wrong or unusual.

5. We ask for feedback.

We always ask participants to fill out an evaluation form. The most valuable insights into shortcomings in the program come from those who experience it.

Data interpretation: Think like a scientist

When it comes to interpreting data, the volunteers' enthusiasm and desire to solve problems must be tempered with reminders to "think like a scientist" and avoid jumping to conclusions. Here are three concepts that are especially hard for nonscientists when interpreting data:

• *Distinguishing a trend from natural variability – Are the differences real?* What does it mean when the monitoring results at a site show less diversity than last year? It could be just natural variability. Two different teams that collect bugs at the same site will probably get different results. Even the same team is likely to obtain different results in a second collection, since rivers are dynamic and many factors affect the composition of the benthic community. The more data you have at a site, the easier it is to separate trends from variability. A good rule is to collect data for three years before drawing conclusions.

• *Demonstrating absence.* Repeated failure to find an organism in a stream can provide evidence that it is probably not present, but can never prove definitively that it is absent. However, when a team finds a decrease in diversity at a frequently monitored site, the next step is to send another team to collect at that site within a couple of weeks. If the apparent decline is confirmed, there probably has been some change.

• *Proving causality.* Monitoring data alone does not prove the cause of changing conditions. If sites upstream and downstream of an effluent from a pipe have different benthic communities, there are many possible causes for the difference. It may be reasonable to suspect the effluent, but it takes additional investigation and information to confirm the cause.

Joan Martin is the Huron River Watershed Council's Adopt-a-Stream Program Director. For more information: 734-769-5971; jmartin@hrwc.org; http://hrwc.org/.

The Long, Winding Road to "Outstanding Alabama Water" Status

by Bill Deutsch

There's an old saying that "success has many mothers, but failure is an orphan." The hard-fought and protracted quest of the Wolf Bay Watershed Watch citizen group to see their bay upgraded to "Outstanding Alabama Water" had plenty of "mothers" — but though many groups and individuals could take credit for achieving this milestone, one thing was clear in the end: citizen data was crucial to the final ruling to give greater protection to the bay.

There are eight use classifications of Alabama waters, ranging from the federally designated "Outstanding Natural Resource Water," which is reserved mostly for state parks and wildlife refuges, to "Agricultural and Industrial Water Supply," with low water quality standards. "Outstanding Alabama Water" (OAW) is the second highest of the eight, and the highest classification that the state can designate.

Wolf Bay Watershed Watch

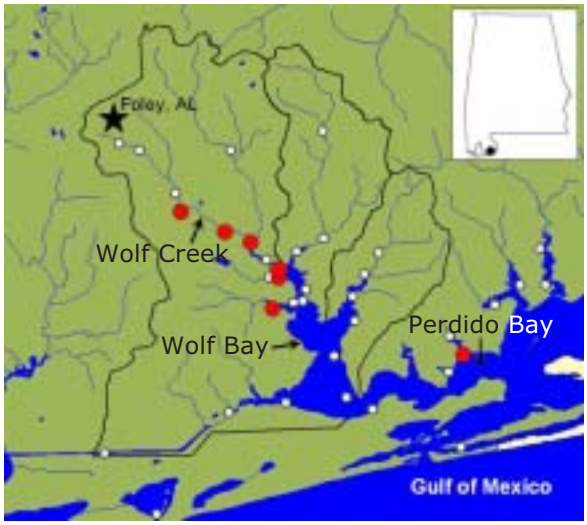
Wolf Bay Watershed Watch is composed largely of retirees — a mix of locals and "damn Yankees" who moved to the area to enjoy a laid-back lifestyle, mild winters, and water recreation. Many of its members have homes on canals or streams that give them direct water access to Wolf Bay and greater Perdido Bay that opens to the Gulf of Mexico.

One of the first things Wolf Bay Watershed Watch did was to affiliate with Alabama Water Watch (AWW), a statewide volunteer monitoring program headquartered at Auburn University. Several members became AWW-certified to measure various physical, chemical, and biological variables of water. They also took the extra steps required to get veteran monitors certified as AWW volunteer trainers and to learn how to enter, analyze, share, and retrieve data using the AWW online database. This gave them relative autonomy to expand their monitoring network, with minimal backstopping from the AWW program office.

Worth protecting

Tucked away from the highly commercialized and condo-lined beaches on the Gulf, Wolf Bay remains relatively pristine and tastefully residential, with amazing wetland and estuarine habitats. Dolphins periodically foray from the Gulf into the upper parts of the bay to hunt for mullet and other fish. Ospreys are often seen overhead and much of the shoreline is covered with natural vegetation including native azaleas and carnivorous plants.

The citizens increasingly realized that without official measures to protect it, Wolf Bay would be ripe for the picking by developers and other forces that would forever change the ecosystem they loved. OAW designation would restrict new or expanding point-source pollution discharges, require higher oxygen levels, and set the stage for low-impact development in the future. But achieving that designation looked at first like a long shot, since at the time this coveted status had been conferred on just a handful of Alabama streams, and no bays or lakes.



ERIC REUTEBUCH

Wolf Bay Watershed Watch members selected monitoring sites according to a strategic and comprehensive sampling design. Sites in color had high *E. coli* counts.

Gathering data to make the case

Because the OAW classification cannot be used as a way to restore a degraded waterbody, the citizens knew they would need strong evidence of the good health of the bay. Developing a monitoring plan was largely the responsibility of the Wolf Bay volunteers. At all AWW monitoring certification workshops, five criteria of sampling site selection are presented: safe, legal, convenient, accessible, and strategic. Applying these criteria, the Wolf Bay group had to consider the appropriate number and distribution of sites that the pool of volunteers could handle and that would give important information from the main tributaries, the brackish water of the smaller embayments, and the open water of Wolf Bay.

Volunteers tested the sites for *E. coli* using the simple AWW protocols described in the Winter 2006 issue of this newsletter, measured dissolved oxygen and other water quality parameters using field kits, and took Secchi depth readings. The monitoring results revealed a generally healthy bay, with a gradient of decreasing contamination moving down Wolf Creek from its urban source. All this information would be "money in the bank" when it came time to make the case for OAW.

The quest begins

The process of approaching the Alabama Department of Environmental Management (ADEM) for OAW was intentionally slow. Through an informal conversation with an ADEM official, the Wolf Bay volunteers learned that a formal pe-

POLLY SIMPSON

Liz Langston (center), Wolf Bay Watershed Watch water quality monitoring chair, trains other group members.

tition to the Department in the late 1990s would have been denied because ADEM did not yet have enough data to support it. So it was better to start with the "prodding and coaxing" approach.

By 2001 the citizens had five years of water quality data to support OAW, but even then they were cautious about pushing their case aggressively. They wanted to avoid alienating several large landowners and the local wastewater utility, which uses Wolf Creek for its effluent discharge.

Gathering momentum

A few years passed, and then the group's Community Action Committee Chairperson, Stan Mahoney, decided it was time to crank up the pressure. Mahoney led a revived campaign and attended virtually any town meeting that would give him the chance to make a case for OAW. This led to letters of support from city councils, the Mobile Bay National Estuary Program, many Wolf Bay Watershed Watch members, the AWW program office, the Alabama Rivers Alliance, and the local delegation to the state legislature. Things were definitely heating up.

Even Mother Nature had a role to play in the OAW process. Devastating hurricanes in 2004 (Ivan) and 2005 (Katrina) caused some developers to envision moving inland, and that had strong implications for greatly accelerated development in Wolf Bay. It seemed like now or never for protecting the bay with OAW, and this sense of urgency pressed the cause even harder.

Wolf Bay Watershed Watch members made more trips to the state capital, Montgomery, with lots of glad-handing in ADEM Coastal Section meetings. According to Mahoney, ADEM Water Quality Branch Chief Lynn Sisk "certainly began to know what our members looked like face-to-face." The citizens used a strategy of balancing economic and environmental considerations so they didn't come across as "frog kissers" and "tree huggers." They emphasized how the OAW classification would help the tourism and water recreation industries and increase property values. They pushed the idea that the beloved dolphins and other wildlife depended on clean water, and now was the time to ensure the sustainability of their environment.

Victory

Finally, the tide turned and ADEM began to lean toward OAW for Wolf Bay. A variety of criteria developed by ADEM for OAW candidacy had to be objectively scored, including the uniqueness of the habitat, recreational value, presence of threatened or endangered species, exceptional biodiversity, and at least five years of water quality data.

This is where the citizen data began to shine. After almost a decade of active monitoring by the volunteers, the Wolf Bay Watershed Watch water quality data sets were the most comprehensive collection of key information for the watershed. Though ADEM had conducted periodic trend station monitoring in the Wolf Bay watershed, the citizen data added more than ten times the amount of information for consideration. The citizen data also helped ADEM focus on sites needing additional monitoring to make the case for OAW rock solid.

In the spring of 2007, the forces for OAW finally prevailed and Wolf Bay became the first estuary to receive OAW designation. The upper portion of the bay, near the mouth of Wolf Creek, was not included in the classification, primarily because of high bacteria counts. Sisk noted the importance of the citizen data in finally resolving the issue and helping the agency to know which portions of the watershed met the OAW criteria.

Wolf Bay Watershed Watch now has a well-deserved reputation among local residents as the protector of the bay. Mahoney notes that the group has been consulted by developers and tourism-related business owners who want to make sure their activities are in compliance with OAW standards.

The Wolf Bay victory has inspired other Alabama lake, stream, and bay groups to shoot for higher use classifications of their waterbodies. The Wolf Bay Watershed Watch leadership attributes the achievement to a combination of reasonable requests, patience, persistence, savvy political maneuvers, and a great set of water quality data. (As it turned out, a formal petition for OAW status was never required.)

Wolf Bay Watershed Watch members also know that the OAW status is just one step to long-term protection of the bay, and they need to guard against complacency which, as Mahoney notes, "can be deadly for volunteers." According to Wolf Bay Watershed Watch President Wanda Ramos, "Increasing stakeholder interest and awareness is our best chance of maintaining and improving the water quality of the bay." Maybe that, and a little victory pride, is why people coming into the watershed are greeted with new signs in white, blue, and black that read, "Entering Wolf BayWatershed, An Outstanding Alabama Water."

STAN MAHONEY

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The Power of One The Clear Creek Story

by Brian Soenen

What motivates volunteers to action? While the answer to this question may be as diverse as the volunteers themselves, one thing is certain—when volunteers are involved, things get done. The Clear Creek story is as much a story about a man as it is about a stream. And like a stone tossed into calm waters, this story cast waves that rippled across Iowa.

September 20, 2003

Say cheese!

The story starts with a monitoring "snapshot" of a couple of Iowa creeks. The effort was spearheaded by Dave Ratliff, a longtime volunteer with IOWATER—a volunteer monitoring program run by the Iowa Department of Natural Resources (DNR). Dave recruited nearly 50 volunteers for the event. With support from IOWATER staff, the volunteers collected chemical, bacteria, and physical data from multiple sites along the creeks at the same time on the same day.

The biggest surprise came from the most upstream site tested on Clear Creek. Here volunteers found chloride values of over 600 mg/L (the highest value ever recorded by an IOWATER volunteer).

March 27, 2004

Where the tiles end and the stream begins

Hoping to track down the source of the chloride, Dave set out to find the headwaters of Clear Creek. By reviewing topographic maps and aerial photographs, and driving the watershed, he was able to trace the headwaters to a lonely gravel road in what many might consider to be the middle of nowhere. On this road, two open concrete structures, or junction boxes, can be found a mile apart. In each of these junction boxes, pipes or "tile outlets" discharge water. The water discharged by the tile outlets is the outflow from a network of underground perforated pipes called drainage tiles.

In a state with nearly a million miles of subsurface drainage pipes, tile outlets are the start of many streams. The five tile outlets that discharge into the two junction boxes are where Clear Creek begins.

May 15, 2004

Something smells worse than fishy...

And now the story takes a turn in a new direction. During a later snapshot event, a volunteer noticed a smell coming from one of the tile outlets that make up the headwaters of Clear Creek. The volunteer called Dave. Dave immediately saw what might be causing the smell. Small strands of a white, fibrous material could be found wrapped around vegetation and accumulating in the shallow pools. For Clear Creek, the truth was in the toilet paper . . . if only it were known where it was coming from.

The chloride that had originally brought the focus of the study to Clear Creek was traced to a different source which was later addressed, but the presence of toilet paper and concern about contamination from human sewage kept a spotlight on the headwaters of Clear Creek.

May – August, 2004

Not new news; not good news

Through observing the tile outlets, sometimes for hours at a time and even through the night, and recording what came out of them, Dave and other volunteers were able to ascertain that only one of the five outlets was discharging toilet paper and sewage waste. But where did the water in that tile line originate?

"We must have driven thousands of miles around the watershed and knocked on hundreds of doors, but no one gave us any definitive answers," says Dave. "Our big break was when we finally tracked down the guy who put the tiles in over 40 years ago." This man pulled out handwritten notes and maps showing that the outlet carrying the toilet paper started in a small, unincorporated, unsewered community of about 72 homes. Some of the older

DAVE RATLIFF

IOWATER volunteer Don Lund retrieves the trap he made to capture toilet paper and sewage material from a tile line at the headwaters of Clear Creek.

houses in the town had no septic system and other houses had nonfunctional systems, so that household wastewater was washing into the underground tiles that surfaced in the headwaters of Clear Creek.

Now that the volunteers knew the source of the toilet paper, they began contacting officials in the regulatory community. Unfortunately, they got responses like, "That's great information, but I'm afraid there's not much we can do," or "We've known about this situation for years," or "You think that's bad, you should see some other places." At one point an official who had never been to the stream insisted that the white, fibrous material in Clear Creek was not toilet paper but "more likely some type of bacteria." When Dave heard about this, his response was: "What kind of bacteria has perforations?"

January 2, 2005

The pictures that will live in infamy

"I knew that toilet paper and other stuff was coming out of that pipe," Dave recalls, "but I just couldn't prove it without a trap." And since toilet paper traps are not something sold commercially, the volunteers had to improvise.

Don Lund, a volunteer working with Dave, fashioned a wire mesh trap and placed it right in front of the tile outlet where the volunteers were regularly observing toilet paper. Twenty-four hours later, the trap had become 100 percent occluded with toilet paper and fecal solids and had begun to collapse on itself.

Two weeks later, Dave showed photographs of the clogged trap in his presentation at the Iowa DNR's 5th Annual Water Monitoring Conference (an event for both volunteer and professional monitors). The visual evidence had a powerful effect. "Dave's presentation had a huge impact on me," says Susan Heathcote, water program director for the Iowa Environmental Council, a coalition of 80 environmental organizations. "I was disturbed that he wasn't getting an appropriate response from government officials." Heathcote subsequently spearheaded a campaign by the Council to promote statewide legislation requiring septic system inspections prior to property sales. "The Council made the problem of failing septic systems our top legislative priority for 2006," says Heathcote.

January 2005 – September 2007

Water quality monitoring is not just the study of water; it's also the study of people

As the Clear Creek scenario unfolded, it revealed some political, social, cultural, and economic issues that all seemed to work against clean water in Clear Creek. Thus, while the study of the water continued, it also quickly morphed into a study of people.

There were the governmental officials who were faced with archaic rules and regulations that were written for large cities and could not be feasibly adapted to an unincorporated community with no management entity, no local government, no wastewater infrastructure, and no money. Their inability to act wasn't necessarily the fault of any individual or entity, but rather that of a flawed system. These officials simply lacked the mechanisms to solve the problem efficiently.

As the Clear Creek scenario unfolded, it revealed some political, social, cultural, and economic issues that all seemed to work against clean water.

Then there were those who would be financially impacted by the solution. Providing sewage services to an unsewered community can boost monthly sewage fees from $0 to upwards of $100 per month. Needless to say, these folks were not too excited about this prospect, or about the volunteers who wanted to push it forward.

Those who lived downstream, however, hoped for change. Their children had spent many lazy days on Clear Creek, trapping minnows and hunting frogs, and catching creek chub to eat. Then their parents learned of the sewage, and the children were no longer

continued on next page

What We Learned

(The reflections below, excerpted from an essay by Dave Ratliff in the Winter 2004 IOWATER newsletter, were inspired by IOWATER's first snapshot sampling event.)

In four hours that stretched to six, we met many and learned much. We met new friends, learned new skills, and many of us learned the difference between north and east. We learned that 14-inch boots can fill in 15 inches of water. We learned it takes a team of three to remove the leg of one member from a foot of mud.

We learned that car interiors are able to remove the mud from shirts, pants, and boots. We learned there is no difference between the terms "discharge" and "flow" because they will both get your butt wet when too high.

We learned from the staff of IOWATER, USGS, and EPA; and from Scout leaders, school teachers, and so many volunteers, without whose time and talents none of this would have been possible.

To Old Mans Creek, Clear Creek, Ralston Creek, Snyder Creek, Muddy Creek, and those other watersheds we waded into 24 short hours ago: We learned more about you. Your veil of secrecy has been removed. We have started to learn how the water moves into and through your watersheds. We have learned about the little bugs that live in your water and call it home. We have seen the beauty of your water and the trees, flowers, and grasses that grace your shorelines.

We learned how our neglect has eroded your banks, silted your bottom, and polluted your waters. We learned that people's desire for more land has straightened your meandering channels. We learned that the loss of buffers has created more silt to choke your streambeds. We learned that all of us are responsible for your future.

But we are learning. Next spring we will once again invade your waters with our students, teachers, children, and other volunteers. We will return with improved skills, with more volunteers and more questions.

We will be returning with a quest of more knowledge.

– Dave Ratliff, IOWATER volunteer

allowed to dream down by the stream.

Finally, and most importantly, there were the volunteers. And while there were hundreds of volunteers who contributed to this project, Dave was the one who made it all happen, and it was he who faced the most adversity. When he discovered the problem, it was he who was asked, "So what are you going to do?" It was he who felt caught in the middle when the regulatory world said,

> "Now we are talking in Iowa about unsewered communities, and Clear Creek has become the poster child for them."

"There's not much that can be done" and the downstream residents asked, "What about our children?" It was he who was labeled an "environmentalist" by governmental officials as they apologized to the community for having to take action. And it was he who led data collection efforts that put Clear Creek on Iowa's 303(d) list. (The 303(d) list is a statewide list of impaired waters mandated by the Clean Water Act. Water bodies on the list are prioritized for restoration efforts.)

September 20, 2007 - Present

New hope for Clear Creek . . . New hope for Iowa

Four years to the day from when the first samples were taken from Clear Creek, Dave returned to its headwaters. As he carefully navigated his way down to the water, he thought of the years gone by—about the hopelessness he felt when the world seemed to turn its back on Clear Creek, and about the hopeful future that now lies ahead. You see, after four long years of learning about Clear Creek and working to protect it, people were starting to listen—and things were beginning to get done.

First of all, there were the benefits to Clear Creek. As a result of being listed on Iowa's 303(d) list, the stream was eligible for a new grant program, from which funds were then used to leverage money from other grant programs. When it was all said and done, Clear Creek and its watershed received $1.5 million in grant money. And with this money, the prospect of building a sewage treatment infrastructure to help protect the creek's headwaters transformed from a dreaded necessity into a welcome reality.

Secondly, the Clear Creek story got people talking—not just about Clear Creek, but about the problem itself, how prevalent it is across Iowa (according to DNR estimates, 550 unincorporated communities are classified as unsewered and therefore may face problems with failing and illegal septic systems discharging raw sewage directly into surface waters), and what can be done to fix this problem statewide.

"Starting with his presentation at the conference, Dave took the unsewered communities issue to another level," Heathcote says. "DNR knew about it, the county sanitarians knew about it, but nobody talked about it. Now we are talking in Iowa about unsewered communities, and Clear Creek has become the poster child for them." During Iowa's 2007 General Assembly, legislators talked about it, too.

"What happened in Clear Creek was much bigger than simply identifying and fixing the problem in the stream," Heathcote says. "It led to Iowa legislators figuring out a plan to address this problem statewide." Early this March, the Iowa Legislature passed a bill that requires septic tank inspections at the time of sale or transfer of property. As these inspections identify and bring into compliance the illegal septic systems currently existing across the state, the quality of Iowa's aquatic resources should begin to improve.

"It helps a lot to have real stories of real creeks and to be able to show pictures of toilet paper and feces," says Heathcote. "It's hard for legislators to walk away from that." It also helps to have talented, dedicated, and determined volunteers who ask for little more than clean water.

Brian Soenen works for the Iowa DNR's IOWATER program. For more information: Brian.Soenen@dnr.iowa.gov; 515-205-8587; www.iowater.net.

Volunteer Monitoring Events and Resources

Secchi Dip-In No. 15

The Secchi Dip-In marks its 15th year with the 2008 event, scheduled for June 28 - July 20. The Dip-In now has 1,876 waterbodies with five or more years of data. http://dipin.kent.edu.

World Water Monitoring Day

This month-long event kicks off on September 18. See www.worldwatermonitoringday. org/ for event-planning resources and to order simple monitoring kits or register a site.

Macroinvertebrate ID Certification

The North American Benthological Society's new Taxonomic Certification Program includes a family-level Taxonomic Certification that may be of interest to volunteer monitors. www.nabstcp.com.

Resources from EPA

The U.S. Environmental Protection Agency's volunteer monitoring website, www.epa.gov/volunteer/, includes monitoring manuals, a national directory of volunteer monitoring programs, conference proceedings, quality assurance plan guidance, back issues of this newsletter, and more.

Volunteer Monitoring Listserv

EPA's volunteer monitoring listserv is an open forum for announcements, questions, and discussion. To join, send a blank message to volmonitor-subscribe@lists.epa.gov.

Verifying the Validity of Volunteer Monitoring

by David Delaney

Currently I am a Ph.D. student at McGill University in Montreal. One problem I have with academia is that the findings made by academics mainly stay within academia. This is frustrating since it decreases the utility of the work. In order to rapidly disseminate my research results to the widest audience possible, I have written articles for newsletters, helped prepare newspaper articles, produced a free educational video, given presentations at conferences and workshops, and had many impromptu interactions with the public while sampling.

The lack of communication between scientists and the public is a two-way problem. Just as scientific information often doesn't reach a broad audience, a lot of the data collected by volunteer environmental monitors isn't getting to scientists. So I also strive to publish data by citizen scientists in peer-reviewed science journals. Recently a paper that I coauthored, reporting on a project in which citizen volunteers collected data on invasive crab species, was published by the journal *Biological Invasions* (see reference at end of article).

I believe that the validity testing we conducted on the volunteers' data was critical to the acceptance of our results in a peer-reviewed scientific journal. One of the two anonymous reviewers wrote that the "approach taken to validating the data is excellent and answers many of the concerns that many scientists have about using such data." Our *Biological Invasions* paper includes an extensive discussion of this validity testing. Only after presenting the results of the validity testing does the paper present and discuss the volunteers' data on invasive crab abundance and distribution.

Our success doesn't mean that validity testing is a guarantee that volunteer monitoring data will be published in science journals. However, in my view, a validation study is a prerequisite for publishing volunteer-collected data in a peer-reviewed journal.

LINDA HURT

Volunteers search for crabs inside a randomly selected quadrat, then measure the carapace width of a specimen.

LINDA HURT

One factor that helped in getting our paper published is that the field of invasion ecology is particularly receptive to, and appreciative of, volunteer data. Many important invasive species discoveries have been made by laypeople. For example, one of the species my research focuses on is the Asian shore crab, whose first sighting in North America was by an undergraduate student. The first time this species was reported in Massachusetts was at Woods Hole — but, oddly enough, it was not found by the great researchers who work in that town, but by a group of young campers.

The invasive crab study

The study was designed to collect data on the abundance and distribution of native and invasive species of crabs, with a particular focus on two invasives—the Asian shore crab (*Hemigrapsus sanguineus*) and the European green crab (*Carcinus maenas*)—that are the dominant species on the coast of the northeastern United States. The study also examined how accurately volunteers collected this data, as this was an important starting step for the establishment and authentication of a new regional volunteer network called the Citizen Science Initiative: Marine Invasive Species Monitoring Organization (CSI MISMO).

During the summer of 2005, my field assistant and I led free workshops at over 50 sites in seven states from New Jersey to Maine. Approximately 1,000 people of various ages, education levels, and professions participated.

After an hour-long training session on methodology, volunteers collected and recorded data during the hour before and the hour after the extreme low tide. During this period, volunteers randomly placed quadrats in the study area and searched the rocks and seaweed within the quadrat for all the crabs they could find. For each specimen, they

continued on next page

identified the species and gender and measured the width of the carapace (hard exoskeleton). The carapace width of the Asian shore crab ranges in size from 1 to 50 millimeters (mm), and that of the European green crab from 2 to 100 mm.

Gender and species can be determined fairly easily by examining external features on the carapace. For example, the European green crab has five anterolateral teeth (commonly known as notches or spines) on each side of its eyes, while the Asian shore crab has three. Surprisingly, color is useless for determining species. The European green crab can even be red! To learn how to properly measure the size of a crab or determine its gender, please see www.salemsound.org/mis/miskids.htm.

Asian shore crab (*Hemigrapsus sanguineus*)

European green crab (*Carcinus maenas*)

BOTH PHOTOS: DAVID DELANEY

The validation study

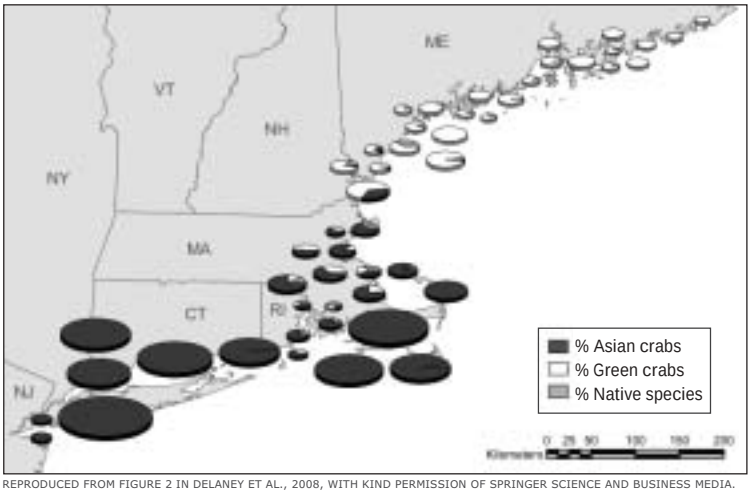
To have scientists accept and use the data collected by volunteers, I had to conduct a validation study to determine how accurately volunteers would determine crab species, gender, and size. The factors affecting the quality of data fall into two categories: factors related to the people conducting the sampling, and attributes of the thing being sampled. For my study, the people-related factors we evaluated were age, education, and the size of the group volunteers were working in. The volunteers' education level ranged from pre-kindergarten to doctorate degrees, and group size ranged from 1 to 10. For factors relating to the thing being sampled, we thought the size of the crabs would matter—larger crabs would probably be easier to correctly count and identify.

To gather the validation data, we checked every crab found by all 1,000 volunteers. Although this sounds excessive, and maybe it was (since we could have just checked a random subsample of the crabs collected by each volunteer), I feel it is always better to have too much data than not enough. It may mean the difference between a statistically significant result and an experiment that lacks sufficient statistical power to find a relationship that may actually be present.

We found that the size of the crab and the size of the volunteer group did not matter, but the education and age of the volunteers were highly significant. The great news was that even young volunteers could collect species data with high levels of accuracy. Volunteers in the third grade and above were 80 percent accurate in identifying species, and those in seventh grade and above were 95 percent accurate. Determination of the crab's gender was more challenging, requiring at least seventh grade for 80 percent accuracy and at least two years of university education for 95 percent accuracy.

We can maintain data quality assurance by enforcing eligibility criteria as a guideline for whose data can be used in peer-reviewed publications. For example, the data used in the figure at left below are data from people with a seventh grade education or greater, which ensures at least a 95% level of accuracy. Although we only used data from volunteers that met a certain level of education, everyone was allowed to participate in data collection. I feel it is important that young kids be involved in the monitoring since it raises awareness of the topic and of science as a whole.

The invasive crab species we studied are relatively easy to identify. Monitoring a different set of crab species in another region would require further validation. When in doubt, it is always best to hedge on the side of caution and do a validation study!



Graphic depiction of the volunteers' crab monitoring data. Pie chart size is proportional to average crab density at the site; the largest pie represents an average density of 43.83 crabs/square meter.

REPRODUCED FROM FIGURE 2 IN DELANEY ET AL., 2008, WITH KIND PERMISSION OF SPRINGER SCIENCE AND BUSINESS MEDIA.

Science literacy

Validation of volunteer-collected data is one important goal that can be achieved by collaboration between volunteer monitoring programs and the scientific community. Another important outcome of such collaborations is increasing the science literacy of the public. In our training workshops, we talk about scientific concepts like hypothesis testing, randomization (i.e., why quadrats must be randomly placed), and replication. Most important, participating together in monitoring allows the volunteers and trained scientists to exchange perspectives, information, and

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questions. This direct interaction rarely occurs, which I feel is a great shame.

The volunteers' findings

After discussing the validation study, our *Biological Invasions* paper presents and analyzes the volunteers' data. The figure on page 22, reproduced from the paper, shows how the volunteer data were used to map the distribution and abundance of the two introduced species as well as native crab species. This dataset is one of the largest standardized datasets that currently exists for native and invasive crabs in New England and New York. It clearly shows two southward-to-northward patterns — a decrease in crab density, and a species shift from the Asian shore crab to the European green crab. The most novel piece of information from our study was the finding of an Asian shore crab at a location 60 km northeast of the previous most northeastern observation.

Is publishing worth the effort?

Should volunteer monitoring groups work to have their data published in peer-reviewed journals? My answer is yes, for multiple reasons. If volunteer data is not contained within scientific journals, it may never be seen or used by scientists and managers. Publication greatly increases the data's accessibility and utility. By publishing in peer-reviewed journals, volunteer programs will receive feedback in the form of reviewers' comments as well as responses from others in the scientific community.

If you have data, it is worth contacting an academic to form a collaboration that could end in publication — a positive result for both the monitoring group and the scientist. Some scientists, such as ecological modellers, are limited mainly by a lack of data and may welcome the opportunity to work with volunteer-collected information.

David Delaney is a marine biology Ph.D. candidate at McGill University and the Director of CSI MISMO. He may be contacted at david.delaney@mail.mcgill.ca.

For more information:

Delaney, D.G., C.D. Sperling, C. Adams, and B. Leung. 2008. Marine invasive species: Validation of citizen science and implications for national monitoring networks. *Biological Invasions* 10:117-128.

CSI MISMO website: www.InvasiveTracers.com

LINDA HURT

David Delaney trains a group of students.

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Report from National Monitoring Conference

Volunteer monitors from around the country came out in force for the 2008 National Monitoring Conference in Atlantic City, New Jersey, May 19-22. The biennial meeting, sponsored by the National Water Quality Monitoring Council, was attended by about 600 people from state, federal, local, and tribal agencies, academia, watershed organizations, and the private sector.

Presentations by volunteer monitoring program representatives were integrated into sessions and special workshops on a wide range of topics including beach monitoring, data management and sharing, bacteria monitoring, innovative approaches to education and training, communicating results, macroinvertebrate monitoring, program evaluation, and much more. The Environmental Protection Agency sponsored a volunteer monitoring booth in the exhibit hall, providing a gathering place for folks to network, compare notes, and learn more about volunteer monitoring.

A conference highlight was the presentation of a $60,000 grant from YSI Foundation to the Columbia Riverkeeper. This special anniversary grant from the philanthropic arm of YSI Inc. was awarded to recognize the important work volunteer monitoring organizations are doing to improve the quality of the nation's water. Over 200 volunteer monitoring and watershed organizations applied. Congratulations to the Columbia Riverkeeper, which will use the grant to monitor 100 sites in backwaters and mainstem eddies in the Columbia River watershed to identify restoration sites for the protection of juvenile salmonids and other native species.

About 50 people participated in an after-hours volunteer monitoring coordinators meeting chaired by Danielle Donkersloot of the New Jersey Department of Environmental Protection and Linda Green of University of Rhode Island Watershed Watch. The group discussed problems with data acceptance; recommendations included getting your Quality Assurance Plan approved by the state or EPA; forming formal and informal partnerships with agencies who might use your data; and, above all, taking local ownership of your data (using it yourself!). Data interpretation—i.e., learning the "story" in the data—was also cited as a hurdle for many groups.

REVITAL KATZNELSON

The conference included an evening field trip to survey horseshoe crabs.

Many at the meeting felt that volunteer monitoring groups need to move beyond monitoring toward restoration and cited the need for more training on monitoring the effects of restoration activities. The Delaware Riverkeeper Network's "Adopt-a-Buffer" toolkit (available at www.delawareriverkeeper.org/) was recommended as a tool for planning and monitoring restoration efforts.

The National Monitoring Conference is a unique networking forum for the volunteer monitoring community, offering participants the opportunity to meet and interact with leaders in the field. We look forward to seeing even more volunteer monitoring representatives at the 2010 conference in Denver.

— Alice Mayio, National Volunteer Monitoring Coordinator
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