The
Volunteer Monitor
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Angling for data

by Eleanor Ely

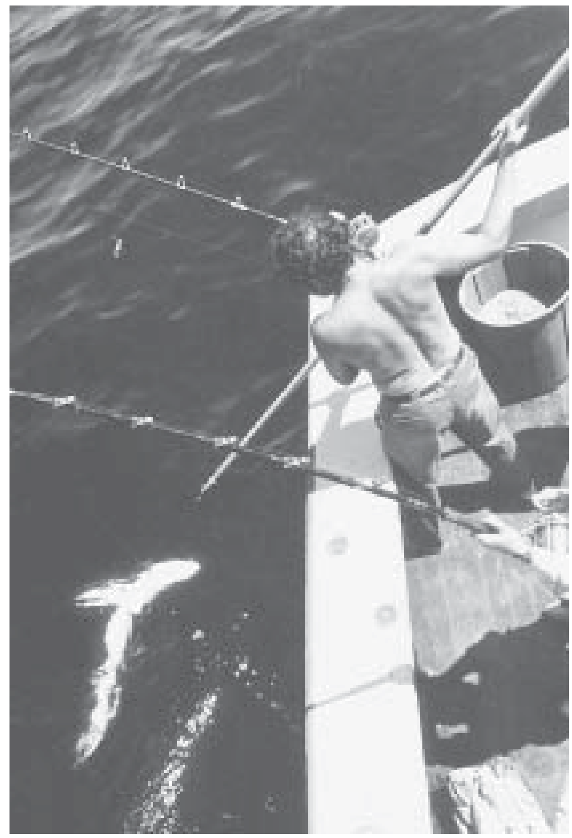
Back in the early 1970s, when the first volunteer stream monitors were wading out with kicknets to catch the tiny creatures that live on stream bottoms, volunteer monitoring of some rather different aquatic animals was already well into its second decade. In this case the target organisms were at the opposite end of the food chain and the size scale—indeed, some were larger than the volunteers themselves. These volunteers were anglers who, instead of killing their catch, inserted tags into the fish and then let them swim away.

Three large "constituent-based" fish tagging programs that are still going strong today were up and running by the early 1960s. The granddaddy of them all is the Cooperative Tagging Center, founded in 1954, which targets tunas and billfish (fish with long thin jaws, or bills, such as marlin, swordfish, and sailfish). The Cooperative Shark Tagging Program was started in 1962 and since that time has tagged 52 species of shark. Both of these programs are run by the National Marine Fisheries Service (NMFS); the Cooperative Tagging Center is based at NMFS's Southeast Fisheries Science Center in Miami while the shark tagging program is located at the Northeast Fisheries Science Center in Narragansett, Rhode Island. Tags and tagging kits are available at no charge to any recreational or commercial fisherman who requests them.

In contrast to the above two programs, which target large, offshore, highly migratory species, the American Littoral Society (ALS) sponsors a program in which recreational anglers tag smaller fish within three miles of shore. ALS, a private membership-based organization, started its tagging program in 1964 as a way for members to gather more information about sportfish such as striped bass, fluke, and bluefish. Participants support the program by purchasing the tagging kits.

Tagging thrills and skills

So, how does one go about tagging a fish that is too large to be brought onto a boat? Descriptions in the scientific literature sound bland enough—"A dart tag is implanted in the muscle near the first dorsal fin." Right, okay, except this happens to be referring to sharks, one of nature's most efficient killing machines. They can weigh hundreds of pounds, and some species can jump right up onto the deck. As for billfish, "You have to treat the bill like a loaded gun, hold it with a gloved hand and keep it pointed away from you," according to Cooperative Tagging Center Director Eric Prince. He adds, "It's called 'cockpit chaos' when a big fish is alongside the boat—everyone gets so excited."



HAROLD WES PRATT, NOAA-NMFS

Tagging a shark from a research vessel.

Successfully tagging a large fish takes two people, plus a lot of experience and good judgment. One person grabs hold of the line and holds the animal close to the boat while the other uses a long tagging pole to push a sharp dart two or three inches into the fish's dorsal (back) muscle. Attached to the dart is a piece of monofilament with a capsule that projects from the fish, and inside the capsule is a rolled-up piece of plastic printed with the unique tag number and

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focus on FISH

The Volunteer Monitor

The Volunteer Monitor is a national newsletter, published twice yearly, that facilitates the exchange of ideas, monitoring methods, and practical advice among volunteer monitoring groups.

Next Issue:
The theme for the next issue is "Agency Partnerships." If you have ideas for topics or articles, please contact Eleanor Ely, Editor, 50 Benton Ave., San Francisco, CA 94112; 415-334-2284; ellieely@earthlink.net.

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Anna Carr's research interests combine social analyses of scientific work, geography, and sociology within an environmental context. Recently she interviewed 45 individuals involved in volunteer monitoring in the United States. The following article is based on a more detailed paper available from the author.

A Social Scientist's Perspective on Community Science

by Anna Carr

In order to address complex environmental issues we need new ways of knowing and new kinds of "knowers." This is the context in which community science has arisen.

Community science (of which volunteer monitoring is an important subcategory) is a rapidly developing field that remains loosely defined. I assert that *community science* is a more inclusive term than the individually oriented *citizen science* on the basis that it (like other branches of science) is a collective, if not always cooperative, undertaking. Citizen science, like citizen soldier, implies an individual doing his or her own thing. I define community science as the interaction between conventional (institutional, professional) and community-based (unaffiliated, "amateur") scientific knowledge systems. Importantly, community science is *not* science conducted in the community (aka fieldwork).

Community science is usually practiced by groups of volunteers in their own localities who sometimes work in partnership with government agencies, museums, or universities on issues typically related to environmental restoration and management. Community scientists are always volunteers, sometimes retired institutional scientists, sometimes students, activists, or naturalists. Invariably they work on issues that are in the public interest.

Although always conducted in a particular place, community science is not always conducted within the framework of monitoring, modeling, or measuring changes in species number and/or behavior or other biophysical states of the environment. Community science projects may also entail discovery, experimentation, or mapping. They can be unique to one individual studying one species in one place or as broadscale as large groups conducting environmental monitoring across nations.

Association with "traditional science" values

Within the public sphere, science is perceived as systematic, rigorous, powerful, and prestigious and is also seen as objective, impartial, and fair. Science is associated with progress, forging ahead, making discoveries. I believe that community scientists feel better equipped than local historians or lay philosophers, for example, to address environmental degradation in their locality. They draw confidence from the well-established standards for conducting scientific research that unite scientific communities worldwide.

> FOR COMMUNITY SCIENCE PROJECTS, IT IS VERY OFTEN THE SAME FEW PEOPLE WHO NOTICE A PROBLEM, DESIGN THE RESEARCH, COLLECT THE DATA, ANALYZE THOSE DATA, AND ACT UPON THE RESULTS.

Like other science traditions, community science techniques and protocols are subject to careful and critical peer review via quality assurance and quality control (QA/QC) procedures. Only through buying into that well-established positivist mindset can community science expect to carry any weight or influence outside a specific community. It is important to recognize that what community science practitioners are doing is valid, legitimate, and honest. In this sense community science follows conventional science in a quest for reliable, credible, accurate, and authoritative

World Water Monitoring Day: October 18, 2003

Building on the energy of last year's National Water Monitoring Day, America's Clean Water Foundation is partnering with the International Water Association to bring the event's messages, goals, and approaches to an international audience this fall. Interest has already been expressed in Australia, the United Kingdom, Eastern Europe, the Middle East, Canada, and Mexico.

Over 75,000 people participated in last year's first-ever National Water Monitoring Day celebrating the 30th anniversary of the Clean Water Act. Data for four key parameters—dissolved oxygen, temperature, pH, and water clarity—were collected at over 3,500 sites nationwide, and a wide range of festivals and educational activities were held in conjunction with the event (for details see www.yearofcleanwater.org). First-time monitors used simple kits from LaMotte Company specially designed for the occasion, while established volunteer monitoring groups and agency staff used their standard equipment and methods.

After July 15, participants will be able to order the same monitoring kits from the new World Water Monitoring Day website (www.worldwatermonitoringday.org). The price of the kits is $18.35 for U.S. orders, with a discount for bulk orders.

In response to comments about the difficulties of monitoring on one day alone, this year we have established a monitoring "window" of September 18 through October 31. Data collected at any time during this window can be entered into the database through December 5. However, organizers are expecting that most activities and press coverage will take place on or around October 18, the actual date on which the first Clean Water Act was signed.

To keep up with developments, please visit www.worldwatermonitoringday.org. For questions, please contact Ed Moyer of America's Clean Water Foundation at e.moyer@acwf.org.

STEVE DELANEY, USEPA

EPA Deputy Administrator Linda Fisher on the Potomac River with Marymount College students in celebration of National Water Monitoring Day, 2002.

Hold the date!

The National Water Monitoring Conference, scheduled for May 17-21, 2004, in Chattanooga, Tennessee, will feature a significant presence from the volunteer monitoring community. We'll be incorporating many opportunities into the agenda for you to present papers and posters, learn about the latest techniques and programs from your volunteer monitoring and water quality agency colleagues, and just have fun. A call for papers will be going out in the next few weeks.

If you have suggestions for the 2004 conference or would like to help out, contact Alice Mayio, USEPA, at mayio.alice@epa.gov, 202-566-1184.

scientific results.

However, there are important differences between conventional and community science. For community science practitioners, there is a basic tension between the pull for local data, detailed knowledge, and recognition of local cultural perspectives and the push toward meaningful comparisons at regional, statewide, national, and international scales. For example, community scientists engaged in water quality monitoring in a specific place may have quite different approaches to, and needs from, the data they collect compared to institutional scientists who collect and/or manage water quality monitoring data on a much bigger scale.

Connection to place

Community science cannot be disentangled from an ethic of care for a specific place. But it goes further than simply being-in-place or even having an emotional connection to that place. Community scientists' observations about the natural world are deeply grounded in and grounded by real world experiences. They know about water quality, for example, from repeated exposures, from direct, lived and breathed, experience of science *in situ*.

Why we need community science

Why do we need community science? The reason most commonly cited by conventional scientists is that more people covering a greater area allows for economies of scale and shortened timespans. The economic feasibility and practical utility of community science are hard to beat.

There is also another issue of scale at work in why we need community science. Within institutional settings, the gap in job description between those who design the research, collect and analyze the data, write up the results, and then implement or operationalize those results is generally larger than for community scientists. For community science projects, it is very often the same few people who notice a problem, design the research, collect the data, analyze those data, and act upon the results. It is in this last stage, of acting upon the results, that the significance of having community scientists undertake the work is most noticeable. We need community science because the ownership of results can lead to more direct, immediate, effective on-the-ground changes, combining an ethic of care with a duty to restore local environments.

We need community science because it is complementary to conventional science. By looking at species or phenomena in the natural world in detail over long periods of time, community scientists come to know about them in profoundly different ways than, for example, scientists engaged in modeling species based on population estimates or testing of DNA material. Moreover, community scientists can conduct science in local contexts in ways which

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ANGLING, continued from front page

tag-return instructions for the person who recaptures the fish.

Some fish spin or turn sideways to the boat, making the tagging target area hard to reach. Both NMFS programs instruct taggers to wait for a fish to settle down before attempting to tag it. And what if the animal moves at the last minute? "Then you might make an air tag," says Nancy Kohler, who coordinates the Cooperative Shark Tagging Program. Worse, the tag could end up in a part of the fish where it could cause harm. The Cooperative Tagging Center's instructions warn, "Tagging doesn't kill fish, but bad tagging can kill fish." Fortunately many participants are charter boat captains or crews who work with these animals every day and are expert taggers. Some of them have even developed innovative tagging techniques that have been adopted by the programs.

Taggers are asked to provide a length estimate for all fish they tag. Some participants make marks on the side of the boat to help with this task. Still, it's often hard to get an accurate estimate. Kohler says, "It's very exciting when you bring up a shark, and they look really big, and some of them are—but some of them aren't quite as big as you think." Some anglers are better at estimating weight, so the shark tagging kit includes a table relating length to weight for common shark species.

Contact information

Cooperative Tagging Center
NOAA/National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, Florida 33149
Website: http://fwie.fw.vt.edu/tagging

Cooperative Shark Tagging Program
NOAA/National Marine Fisheries Service
Northeast Fisheries Science Center
Apex Predators Program
Narragansett Laboratory
28 Tarzwell Drive
Narragansett, RI 02882
Website: http://na.nefsc.noaa.gov/sharks/

American Littoral Society
Sandy Hook
Highlands, NJ 07732
Website: www.littoralsociety.org/tag.htm

ERIC PRINCE

Cooperative Tagging Center participants tag a bluefin tuna.

Because the ALS targets smaller fish, anglers can actually land the fish that they tag, bringing them into the boat or onto the beach where they insert a thin tubular "spaghetti" tag that is threaded onto a needle, pushed through the dorsal area of the fish near the tail, and tied into a knot. The Society provides taggers with information on how to handle fish properly without removing their protective slime layer or knocking off scales. A big advantage to working with smaller fish is that length can be accurately measured.

Volunteers with all three programs send in a card for each fish they tag. The card bears the same identification number as the tag, along with such information as fish species, sex, and length, and the location where the fish was caught.

Who tags fish?

Participants in the ALS tagging programs are all recreational anglers, but the other two programs rely on significant participation from commercial fishermen as well. Prince estimates that about 20 percent of both initial tagging and tag recovery for the Cooperative Tagging Center is done by commercial fishermen. For the Cooperative Shark Tagging Program, initial tagging is about 55 percent by recreational anglers, 25 percent by biologists, and 20 percent by commercial fishermen or observers aboard commercial vessels. But when it comes to tag returns, commercial fishermen and fisheries observers account for 54 percent; recreational anglers, 40 percent; and biologists just 6 percent.

Error and bias

All fish tagging studies, whether conducted by volunteers or professional biologists, have some inherent sources of error. One is tag shedding. The Cooperative Tagging Center recently switched to a new nylon dart tag after a comparison study showed that its retention rate was considerably better than that of the stainless steel dart tag used since 1954. It was the participants themselves who conducted the comparison, by double-tagging fish with the steel dart tag on one side and the new nylon tag on the other.

Another source of error or bias is the possibility that tagged fish will not survive as well as other fish, due either to the trauma of being caught and tagged, or to subsequent problems such as infection at the insertion site.

When taggers are volunteers, some new sources of error are introduced. Volunteer-collected data on species, sex, and length may not be as reliable as professional data. All the tagging programs work hard to minimize errors, both by providing good instructions and educational materials to participants and by carefully screening the data. Kohler explains, "We do a lot of quality control at our end. If something doesn't look right we contact the tagger. We also have quality control programs in our database that send out automatic error messages—for example, if the length is not compatible with the reported species."

The only way to go

But the limitations of volunteer-collected tagging data pale in comparison to its importance. "You can criticize constituent-based tagging programs for a variety of reasons," says Prince. "On the other hand, you can't do this any other way."

Consider the numbers. The Cooperative Tagging Center has tagged about

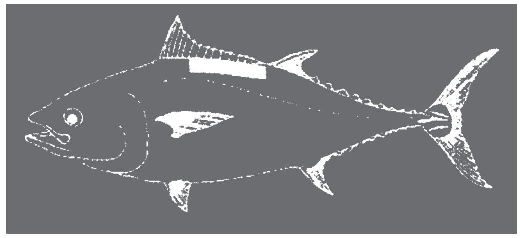
250,000 fish since the program's inception, and about 11,000 tags have been returned. The Cooperative Shark Tagging Program has tagged more than 175,000 sharks, with about 11,000 recaptures; and the ALS has tagged 400,000 fish of 134 species and has had about 21,600 returns. There is simply no way that researchers alone could have captured and tagged all these fish.

Kohler says, "I cannot overemphasize the value of a volunteer-based program. There are hundreds of fishermen out there tagging and recapturing fish. Because they are in the field day after day, they see things that the biologists may never see."

The participation of volunteers is especially crucial for species that range widely, travel alone rather than in schools, and are rare—characteristics that apply to most billfish as well as many shark species. "If you spend a week trying to catch a blue marlin and you catch one, you're doing fabulous,"says Prince. "Cooperative tagging programs are the major source of data on the distribution, migration patterns, stock structure, and biology of billfishes." For example, the Atlantic sailfish was thought to live only three or four years until the Cooperative Tagging Center got back a tag from one that had been at large for 13 years.

What the data show

All the tagging programs track a variety of interesting records. For all three programs combined, the distance record is held by a blue marlin tagged by the Cooperative Tagging Center in Delaware and recaptured over 9,000 miles away in the Indian Ocean. A sandbar shark tagged by the Cooperative Shark Tagging Program holds the record for longest time at liberty: 27.8 years.

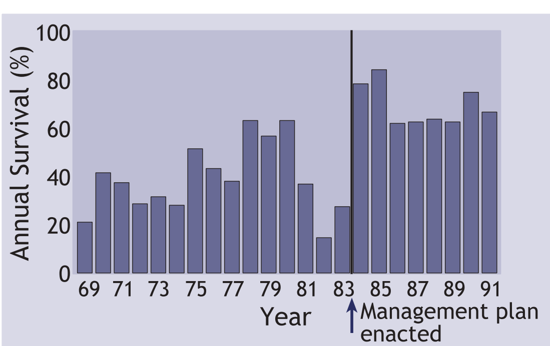


COOPERATIVE TAGGING CENTER

White rectangle shows tagging target area for tuna recommended by the Cooperative Tagging Center.

While the breaking of a record is always an exciting event, the greatest value to science comes from analyzing the whole set of accumulated data points. Migration patterns, including questions about whether certain species migrate across international boundaries, are among the most useful kinds of information that can be derived from tagging data. The data also reveal population characteristics such as sex ratios and age and size distributions. By closely analyzing the data, researchers can gain new insights into fish behavior and biology—for example, a Cooperative Shark Tagging Program study on blue shark migration revealed, among other things, that mature females were largely absent from the continental shelf area, suggesting that they move offshore after mating.

The ratio of tagged fish recovered to total fish caught can be used to estimate population size and to indicate whether a population is increasing, decreasing, or remaining stable. By looking at how this ratio changes over time scientists can also derive an estimate of survival rate within the population. This type of data analysis was applied to ALS striped bass data to demonstrate that restrictions instituted by the Northeast coastal states in 1984 significantly increased striped bass survival (see graph).



ALS tagging data documented that following the 1984 restrictions on striped bass harvest, average survival of adult striped bass increased from an estimated 37% per year to an estimated 68% per year. (Adapted from "Why Tag Fish?" by John Boreman, in *Underwater Naturalist,* Bulletin of the American Littoral Society, Vol. 23, No. 2, 1996.)

Fish that are tagged in their first year and remain at large for a long time before being recaptured provide one of the very few sources of fish of known age. Such fish are indispensable for validating aging techniques (such as counting the rings on the backbone, a method used for aging sharks).

The critical endgame: tag retrieval

Very little of this important scientific information comes from tagging alone; the real payoff comes when a tagged fish is recaptured, and the longer it has been at large and the farther it has traveled, the more valuable the information. Yet recovery has often been the weak link in tagging programs. As Eric Prince says, "It's unfortunate that these programs became known as 'tag and release,' because you've got nothing until you get the tag back. Unless you focus as much attention on the critical endgame as on the tag-and-release part, you're doing a real disservice to the program."

One challenge when dealing with highly migratory species is that they may be caught hundreds or thousands of miles from where they were released, which is why the Cooperative Shark Tagging Program tags are printed in English, Spanish, French, Japanese, and Norwegian.

Intentional non-reporting of recovered tags by commercial fishermen can also be a problem, especially in situations where fishermen are unhappy with regulations on their industry and concerned that tag recapture information may be "used against them." And even the most dedicated and experienced participants can accidentally miss tags. Prince stresses the simple message, "Look on both sides of the fish." He says, "You wouldn't believe how many notes I get from fishermen saying, 'We tagged this fish and then as it swam away it turned over and we saw a tag on the other side, but we couldn't get it.'"

The long haul

Forty or 50 years is a long time to keep a volunteer monitoring program going. But as Pam Carlson, who has run the ALS

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program since 1986, says, "Once you put a tag in a fish you have really made a commitment. You don't want to go around stabbing tags into fish if there's no purpose for it; you have to be prepared to track those fish and manage the data over the long haul." Given the enthusiasm of the volunteer taggers and dedication of the program staff, these programs seem well on track for at least another half-century.

Resources

Prince, Eric, et al. 2002. In-water conventional tagging techniques developed by the Cooperative Tagging Center for large, highly migratory species. *American Fisheries Society Symposium* 30:155-171.

Kohler, Nancy and Patricia Turner. 2001. Shark tagging: A review of conventional methods and studies. *Environmental Biology of Fishes* 60:191-223.

1996. 30 years of fish tagging. *Underwater Naturalist: Bulletin of the American Littoral Society* Vol. 23, No. 2 (special issue).

SOCIAL SCIENTIST, continued from page 3
may extend or refine institutionally based scientific work. Indeed, they may initiate conventional science projects—e.g., by sounding the ecological alarm bells for endangered species.

As government-funded monitoring programs continue to decline, there is an increasing opportunity for volunteer monitoring and other community science projects to "take up the slack." Community science is fundamentally necessary to social and ecological well-being and not just something to be allowed, permitted, or condoned.

In promoting community science, I am not suggesting that we ignore the wealth of lessons derived from conventional science. Community science will not replace academic or agency-based science. However, I am arguing that it is time that the theory and practice of science, heretofore largely contained within the Academy, be inclusive of those who are operating outside it.

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FISH SEINING with Blue Thumb

by Cheryl Cheadle

Like many volunteer stream monitors, participants in Oklahoma's Blue Thumb program perform regular chemical and macroinvertebrate monitoring at their sites. But every three to five years, they do something a little more unusual: wading repeatedly into the stream with a seine, they spend many hours collecting fish along a 400-meter reach (approximately 1/4 mile). It's an exciting, fascinating, and physically demanding job that leaves everyone wet, muddy, and tired.


JENNIFER CAMPBELL

Blue Thumb volunteer fish seiners learn the tricks of the trade at a training session.

Fish collections are an integral component of stream health assessment. The diversity and abundance of fish at a site represent an integration of many variables that would be too costly to assess individually. As with macroinvertebrates, some fish species are pollution-tolerant, and others are very sensitive.

Blue Thumb follows the Oklahoma Conservation Commission's standard operating procedures for fish collection with a few minor differences, the main one being that no electroshocking is done with volunteers present. We usually work in teams of three to six, including at least one Blue Thumb staff member (Jean Lemmon, Jennifer Campbell, or myself).

Before we start catching fish we perform a habitat assessment of the reach, evaluating 50-meter segments at a time. As Jean puts it, "We look at habitat from a fish's perspective." In other words, we observe and record how deep the stream is, how wide, whether it's full of woody debris and has other places for fish to hide, what the bottom is like (e.g., muddy, bedrock, hardpan clay), how much shade covers the stream, and so on.

When the habitat assessment is finished (this typically takes a couple of hours), we go back to the beginning of the reach and begin seining. We use

The Oklahoma Conservation Commission's Water Quality Division is the primary sponsor of the Blue Thumb program, which has been in existence for over 10 years and currently monitors some 40 streams in the state.

1/4-inch-mesh seines that are generally 4 feet high and 12 to 15 feet long, with lead weights along the seine bottom and Styrofoam floats at the top. It takes two people to maneuver the seine: one on each side, holding a pole (called a brail). At least one additional team member is required to carry the fish container and clipboard with data forms.

The basic technique is to quickly scoot the seine through the water—hauls may be as short as 20 seconds—and then bring it up on to the shore, bottom edge first. Ideally, you emerge with a mass of shiny, flopping fish. When practical, hauls are made in the direction of the current, as fish are known to dart upstream when startled. We work each habitat until we stop getting new species of fish, which can take 20 or 30 hauls for a big pool.

Fish that can be identified by the lead collector are recorded and released; those that cannot are preserved for later identification by Oklahoma Conservation Commission staff. For quality control purposes, one example of each species identified and released in the field must also be preserved.

Seining is definitely an art, with different sections of the stream requiring different strategies. Constant communication is needed about how far and how fast to tow the net and where to pull up. The crew leader will say things like, "We're going to walk straight across and go up on that sandy bank," or "There's a real deep hole here, let's go out halfway and then you pivot around me and we'll come back to shore right where we are now."

In very shallow riffles, two people might hold the seine in place (like a kick net) while other team members walk toward them, splashing and disturbing the water to spook fish. In deep pools, we seine as many portions as we can reach but skip the deepest, most inaccessible places.

Those bits and pieces of structure that make such wonderful places for fish to lurk present major challenges for seiners. Many times we helplessly watch large, diverse schools of fish joyously swimming around the poles because the seine has become entrapped in a root wad, snagged on a submerged log, or filled with heavy rocks. Someone has to quickly duck under the water and free the net. (If seining is being accomplished with only a three-member team, the clipboard-holder is the designated diver.)

New volunteers or students from participating schools often have never pulled a seine. When they see a large haul of fish, the party begins! Bit by bit the volunteers learn to expect big catfish and sunfish in pools, stonerollers and shiners in runs, and darters and madtoms in riffles.

Seining a degraded stream often results in the most lasting impression for volunteers. During demonstrations, Oklahoma's Blue Thumb volunteers have sometimes found 12 to 15 different fish species within an hour in a nice rural stream, only to travel 10 miles to a more impacted stream, work just as hard, and find only three different species and far fewer individuals. This type of experience leaves volunteers sadder, wiser, and extremely motivated to tell their neighbors about pollution prevention and the importance of making land use decisions that allow streams to maintain their integrity.

Blue Thumb staff members encourage volunteers to get to know streams other than their own. Then the volunteers who monitor wonderful, clean streams can better appreciate their resources, while those who usually work on impacted streams can enjoy the treat of seeing a healthy stream with a variety of aquatic life.

It isn't just the volunteers who learn and grow from the fish collection experience. This is such a visible activity that crowds often gather, and the excitement is contagious. The folks watching become invested in the outcome of the next seine haul. There is a magical quality to pulling a seine through a stream and finding it full of fish. Pulling a seine time after time and finding nothing is a bitter experience, and one that Oklahoma's Blue Thumb volunteers are working to prevent.

Cheryl Cheadle is Blue Thumb's Program Director. She may be reached at 918-280-1598; CherylC@okcc.state.ok.us.

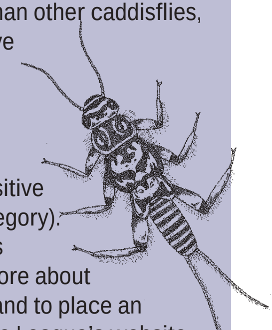
STEPHANIE KROUTTER

Size is relative. Often in Blue Thumb fish collections minnows, shiners, and sunfish prevail, meaning a "big" fish might be 6 inches long.

New IWLA Field Guide

The Izaak Walton League of America (IWLA) has just released an improved macroinvertebrate identification field guide with updated drawings, descriptions, and significance rankings based on current scientific understanding of macroinvertebrate distribution patterns. The "Volunteer Monitor's Field Guide for Aquatic Macroinvertebrates" is a two-sided 11 x 17 laminated card that folds to a 4-1/2 x 11 size to fit conveniently into a bag or monitoring kit. Diagrams of larvae and adults display common features that characterize each type.

A change from the original IWLA "Stream Insects and Crustaceans Identification Card" is that macroinvertebrates are now organized based on biological type rather than sensitivity to water degradation. In addition, sensitivity classifications for a few macroinvertebrates have been modified (common net-spinning caddisflies are now placed in a less sensitive category than other caddisflies, water snipe flies have moved from the less sensitive to the sensitive group, and hellgrammites have moved from the sensitive to less sensitive category).



The cost is $4 plus shipping. To learn more about the new field guide and to place an order, please visit the League's website at www.iwla.org/sos/sostools.html or call toll-free 800-BUG-IWLA.

Fish Counts

"Fish counting"—probably the very simplest type of fish monitoring—can be used to gather data on returning runs of anadromous fish (those that spend part of their lifecycle in the ocean, then swim up rivers to spawn). In the Puget Sound region, volunteers stand next to streams and stare down into the water counting returning salmon, while across the continent their counterparts in Massachusetts station themselves at fishways to monitor returning runs of river herring.

Salmon Watchers: The Eyes and Ears on Salmon

by Katie Sauter and Saffa Bardaro

One of the key responsibilities of the King County Department of Natural Resources and Parks is to be the steward of the county's water, land, and natural resources. Our mission's success is based on our ability to tap into one of the most valuable resources available to us—volunteers!

When Puget Sound chinook salmon became listed as endangered in our region, conservation and recovery became paramount. Educating and engaging the public about this Pacific Northwest treasure was equally as important as the science and policy surrounding the issue.

The experienced Salmon Watcher's secret weapon: polarized sunglasses to help spot fish through glare.

KATY VANDERPOOL

In 1996, multiple local jurisdictions interested in salmon recovery began a jointly coordinated volunteer spawning survey program, which evolved into the current Salmon Watcher program in 1997. The program's purpose is to document the distribution of spawning adult salmon throughout the basin. We now have 200 volunteers watching for salmon on 60 King County streams twice a week from September through December. Policymakers and the public can use the data to improve aquatic resource management, protect salmon, and enhance fish habitat.

Volunteer recruitment

All Salmon Watcher volunteers attend one of several trainings held throughout King County, where they view a slide-show presentation about the salmon life cycle and learn identifying characteristics of the salmon species they may encounter. The fact that spawning salmon are so distinctly, and often brilliantly, colored makes it possible for a complete novice to learn enough in one sitting to be able to identify spawning salmon in the stream.

In conjunction with classroom training, we hold field sessions so volunteers can see fish in action and get identification tips and tricks from fish biologists. In the field you rarely get a classic view of all the identifying field marks that we show in the classroom, but many things besides appearance can help identify salmon. For example, coho are skittish and solitary, while sockeye are very aggressive and travel and spawn in groups. Another challenge faced by volunteers is to avoid counting the same fish twice. This can happen if a volunteer's site is at a spawning area, since spawning fish may spend a week or two at the site before they die. Volunteers learn to identify individual fish by marks such as white patches (from fungal infections, which are very common in spawning salmon), scars, or injuries.

Following training, volunteers visit their site(s) twice a week, at any time of day, and make observations for at least 15 minutes. They complete a data sheet on the species type and number of fish seen, including fish mortalities. If they have any doubts or difficulties with identification, they are encouraged to call one of a number of enthusiastic fish experts for assistance.

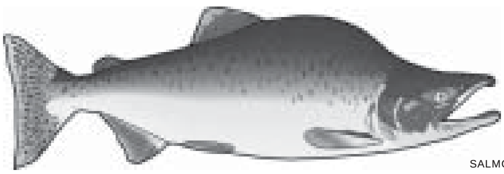
While on site, volunteers also have the opportunity to talk with passersby about salmon and the Salmon Watcher program. So in 2000 volunteers began tracking the number of visitors they spoke with, to measure the program's reach. At the end of each month, or the end of the season, volunteers submit their data sheets to program staff for data entry.

Volunteer appreciation

At the end of each season, participants receive a program evaluation form. Volunteer feedback is highly regarded and volunteer suggestions are frequently instituted. For example, a volunteer suggestion led us to create a Salmon Watcher "business card" for volunteers to give to people they meet at their stream sites.

We recognize our volunteers with Salmon Watcher service pins as well as special achievement awards in the areas of "Most Visits," "Most Sites," "Most Volunteer Hours," and the coveted A-For-Effort award, "Most-Hours-By-A-Stream-Without-Actually-Seeing-A-Fish." Not surprisingly, the same volunteers tend to carry away the first three awards year after year, while we've never had a repeat award winner in the last category!

To ensure a positive experience for our volunteers, we are committed to prompt, thorough, and friendly communication. We also publish a Salmon Watcher Report containing all the data collected, providing volunteers with a source of pride and proof that they are part of a real scientific study that is used by a range of individuals and organizations.



FISH ART FROM SALMON WATCHER WEBSITE

The big picture

The great value of the Salmon Watcher data is its broad reach. Our volunteers cover many sites never visited by agency staff, who generally can only survey critical places such as areas where fish are known to be declining.

Individuals, citizens' groups, nonprofit organizations, and government agencies use Salmon Watcher data for a variety of reasons. In 1999 we conducted an informal survey to identify how the data were being used within government agencies. Staff reported using the data for determining geographic areas of fish and fish migration patterns; for inventories; to educate students, landowners, and county staff; and in biological assessments. Salmon Watcher volunteers also reported using the data themselves in a number of ways, including encouraging continued city council support of water conservation and in court testimony on the daylighting of a creek.

"Eyes and ears"

By virtue of their frequent presence along streams, Salmon Watchers often end up accomplishing more than their charge. For example, volunteers sometimes help identify problem stream blockages, potential restoration sites, and illegal dumping or poor land use practices. They become the "eyes and ears" of the streams where we cannot, reporting on fish and human activities.

Katie Sauter is the Volunteer Coordinator for the Salmon Watcher program at King County Department of Natural Resources and Parks in Seattle, WA, and Saffa Bardaro is a Communications Specialist for the department. For more information contact Katie Sauter at 206-263-5086; katie.sauter@metrokc.gov; or see http://dnr.metrokc.gov/wlr/waterres/salmon/index.htm.

Have You Seen This Fish?

Counting River Herring in Massachusetts

by Karen Pelto

Each year you can practically set your watch by the return of herring to the coastal rivers of Massachusetts. The bright silver flash of alewives and blueback herring is a sure sign of spring. During their spawning runs, which begin in mid-March to mid-April and end in mid-May to mid-June, river herring face an arduous journey up and over, and in some cases around, dams and through fishways to reach their natal waters.

This mad dash to spawn has long been eagerly awaited by local anglers who use river herring as bait for striped bass and lobster. More recently, it is also attended by a growing base of local volunteers who are interested in the health of their local run.

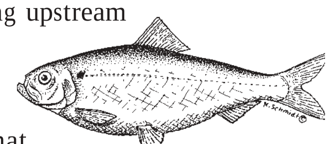
Anadromous fish, including the alewife, blueback herring, and American shad, spend most of their life in ocean waters, ascending coastal rivers and ponds to reproduce. Young spend their first summer in the rivers and ponds, emigrating to the ocean during the fall months.

Anadromous fish in Massachusetts rely primarily on fishways to make their way upstream over dams. The Massachusetts Division of Marine Fisheries has authority and responsibility for making sure the fishways function properly. In some cases, towns have been granted local control for regulating herring fisheries. In either case, state and local human and financial resources are strained in the effort to care for fishways.

Fishway Stewards

Through the Fishway Stewardship Program, local volunteers can lend a hand and observant eyes to help herring. The Riverways Program takes the lead in promoting the program and helping groups get organized and tap into technical and financial resources. Division of Marine Fisheries biologists provide technical oversight and guidance. Currently, 200 volunteers representing six different groups are conducting fish counts on the North Shore of Massachusetts.

During the two-month migration period, volunteers conduct visual counts of fish passing upstream through the fishways. Volunteers sign up for a one-hour timeslot and commit to making observations for 10 minutes during that hour. Equipment includes a notebook for data collection and observations, a thermometer, and polarized sunglasses and/or a hat with a brim to cut down on water glare. In addition to counting fish, volunteers record the air temperature (in the shade), water temperature (upstream of the fishway), and weather conditions (especially cloud cover). Additional volunteers dedicate themselves to data compilation and analysis.



KATHLEEN A. SCHMIDT

Alewife

Fishways in Massachusetts are mainly of two types: pool-weir and Denil. Pool-weir fishways consist of pools arranged

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Monitoring Sea Turtles

by Christopher Swarth

For tens of million of years sea turtles have plied the world's oceans. These marine reptiles spend almost their entire life in the ocean; only the females come to land briefly to lay eggs. Although sea turtles possess adaptations and behavioral traits that have helped them survive for millennia, they are ill-equipped to coexist with the exploding human population growth along our coasts. Today, six of the seven living species are on the endangered species list.

The long-term survival for sea turtles does not look good: nesting beaches have been altered, destroyed, or overrun by people; in many countries, eggs and adult turtles are consumed; and commercial fishing nets, shrimp trawlers, and longlines capture and drown turtles. Collisions with boats and injuries from dredging take their toll. In coastal regions poor water quality degrades the marine environment and leads to a diminished food supply. Dismal though this situation may be, for over two decades volunteer "turtlers" have been working with scientists to save sea turtles from extinction.

Sea turtles range in size from the Kemp's ridley weighing less than 100 pounds to the immense leatherback weighing over 1,000 pounds. Like other turtle species, they are long-lived and take years or decades to reach reproductive age. Sea turtles nest on sandy beaches along the outer coast. Once every two or three years, females migrate from distant foraging grounds and crawl laboriously to suitable sites above the reach of high tide waters, where they excavate a nest and deposit a clutch of 100 or more eggs in an egg chamber. Females deposit several clutches in a season. After she lays the eggs, the female quickly fills the egg chamber opening by dragging sand into it with her hind flippers and packing it with her plastron (lower shell) before she turns her back on the nest and returns to the ocean. The eggs are incubated only by the heat of the sun and the mother knows nothing of the fate of her offspring. In 7 to 8 weeks the eggs hatch, and after several days of digging the hatchlings make their way swiftly from the nest to the ocean. In the United States, sea turtles nest from Texas to Florida and north to North Carolina (rarely to New Jersey), and in Hawaii.

Thousands of volunteers in dozens of coastal communities in the United States and Central America work diligently to protect sea turtle nesting beaches and to monitor and protect nests. Volunteers walk beaches and search for nests, survey beaches for stranded live and dead turtles, mark females with flipper tags to study migration patterns and survivorship, monitor numbers by boat and by scuba diving, and document habitat use in order to establish sea turtle sanctuaries. Volunteers have also mounted extensive education programs to reduce poaching and fishing mortality and have promoted the installation of turtle excluder devices (TEDs) to reduce the accidental take from shrimp fishing. Because all sea turtles are protected, programs exist in every state with beaches where turtles nest. Dozens of organizations—ranging from small grassroots groups to state and federal resource conservation agencies and even military bases—monitor and protect sea turtles. Volunteers play a key role in most of these efforts. Because sea turtles are endangered, all volunteers who handle eggs, hatchlings, or adults (live or dead) are required to possess a state or federal permit.

BARBARA BERGWERF

Volunteers with Isle of Palms Turtle Team in South Carolina move nest to a safer place.

Nest monitoring and protection

Sea turtles are vulnerable to human disturbance at all stages of the reproductive cycle. In the ocean, sea turtles are agile, fast swimmers, but the female is slow and awkward when she ventures on shore to nest. Taking advantage of this, local people in many countries capture and eat the egg-laying females. The eggs are also a rich source of nutrition, and are dug up and consumed by humans, raccoons, and other animals. Curious beachgoers and dogs that encounter a female in the process of nesting can disrupt the egg-laying process, forcing her to abandon the beach and head back to the ocean before she is able to nest. Recreational vehicles crush eggs and hatchlings. Finally, when the tiny hatchling turtles emerge from the sand ready to scamper into the surf their bearings may be thrown off by bright lights along shore. Add to these considerable unnatural threats the many predators—gulls, ghost crabs, and fish—always on hand to make a quick meal of a tasty hatchling, and you begin to understand why sea turtle populations are in such bad shape.

One of the most important ways people can help sea turtles is by protecting their nests. Florida supports more sea turtle nesting than any other state, and 5-mile-long Juno Beach is one of the most densely nested beaches, with 1,000 nests per mile in some areas. Volunteers with the MarineLife Center of Juno Beach search for nests from March through October. To reduce predation on eggs, volunteers place wire mesh over the nests. The wire prevents mammals like

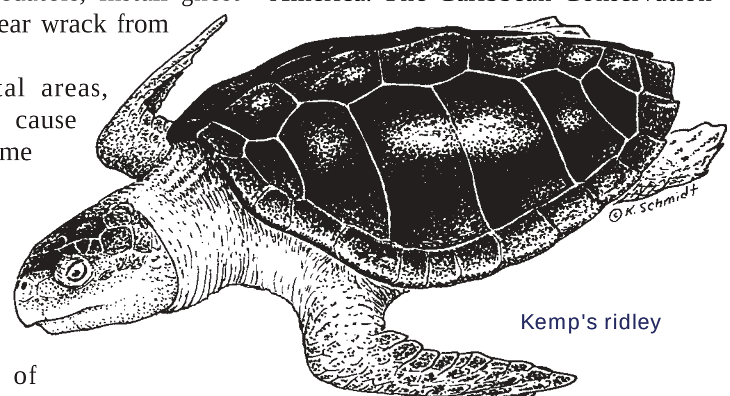
BARBARA BERGWERF

Isle of Palms Turtle Team volunteers probing for a nest. The turtle tracks in the sand show them where to look.

raccoons from digging up the eggs, but allows hatchlings to crawl through when they eventually emerge from the nest. Larry Wood, curator with MarineLife, says, “We have about 100 volunteers who assist us annually. Very detailed nesting surveys are conducted, including GPS mapping and nest productivity for loggerheads, green sea turtles, and leatherbacks. Education probably represents the biggest impact to big-picture turtle conservation, but our research also contributes to an understanding of behavior.”

There are 19 nest-protection projects along the coast of South Carolina. Projects involve a range of individuals and organizations, from paid federal and state employees to all-volunteer efforts. The Marine Turtle Conservation Program of the South Carolina Department of Natural Resources (SC-DNR) coordinates most of the efforts. One management activity involves nest relocation. Some turtles do not excavate their nests high enough above the reach of high spring tide waters. If eggs are inundated, the developing embryos are killed. To reduce this possibility, volunteers search for nests that should be relocated, using a wooden dowel “probe stick” to feel for the soft sand above the eggs. Before they are permitted to probe for real eggs (which could be broken by an inexperienced prober), volunteers are trained using golf balls buried in the sand. Once the egg chamber is located, eggs are carefully dug up and placed in a new egg chamber in a safer location. After the hatchlings emerge, volunteers count the number of hatched eggs and dead or live hatchlings in the nest to calculate the percent of hatchling emergence. Volunteers also screen nests to protect eggs from predators, install ghost crab traps, and clear wrack from on top of nests.

In many coastal areas, bright lights can cause hatchlings to become disoriented when they emerge at night and attempt to navigate from the nest site to the ocean. Instead of crawling toward the water they may attempt to travel inland. In Alabama, “Share the Beach” volunteers protect nests and assist the hatchlings when they emerge to make sure they reach the water safely. They also work to persuade coastal dwellers to turn off unnecessary lights.



Kemp's ridley

Population censuses

Another aspect of sea turtle conservation involves estimating the size of populations. MarineLife volunteers study the leatherback populations on beaches south of Cape Canaveral, Florida, scanning nearshore waters with spotting scopes and tagging females with numbered tags. To track turtle movements in the ocean, they work with researchers at Hubbs SeaWorld and the University of Central Florida using satellite telemetry, a crucial tool for revealing the details and extent of seasonal movements. Several organizations have web pages with up-to-the-minute maps of migrations by turtles tagged with radio transmitters.

In 2001, the Reef Sea Turtle Program initiated a new approach to monitoring sea turtles: instead of working on foot or by boat, volunteers do their monitoring under water. A network of divers watches for turtles and reports sightings made while diving in tropical waters in the West Atlantic and Eastern Pacific.

Sea turtles are global travelers, making immense migrations north to south and east to west. Turtles hatched on tropical beaches may travel to temperate waters to feed. Therefore many conservation efforts are international in scope. Several organizations that are headquartered in the U.S. focus on turtles in Mexico and Central or South America. The Caribbean Conservation Corporation (CCC), the oldest sea turtle conservation organization, started protection and education programs in 1959 with turtle conservation pioneer Archie Carr, and their work today is centered in Florida and Costa Rica. At Costa Rica’s Tortuguero Beach 230 currently registered volunteers help monitor population trends by flipper-tagging and measuring the size of nesting female green sea turtles. Volunteers also discourage poaching and work with local communities to help them shift away from eating turtles to a sustainable revenue source through ecotourism. CCC advocacy coordinator Gary Appelson says, “Our work in Costa Rica has saved the green sea

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The sea turtle drawing on this page, as well as the drawings of *Phragmites* and purple loosestrife on pages 13-14 and the alewife on page 9, were graciously provided by Kathleen A. Schmidt, Natural History Illustrations, 518-325-7265; bobkat@taconic.net.

turtle from extinction."

WildCoast, an organization in northern California, coordinates Mexican and U.S. students, volunteers, and local fishermen who observe, capture, and mark adult turtles along the Pacific coast of Baja, California, with the aim of delineating a new marine sanctuary specifically for sea turtles. According to WildCoast Director Wallace Nichols, "The impact of our program has been tremendous. Most volunteers are fishermen who formerly ate or hunted sea turtles. Preliminary data suggest that turtle numbers have begun to increase."

Monitoring beaches for stranded turtles

In Virginia, where few sea turtles actually nest, monitoring focuses on dead or injured turtles that are discovered on the beach. The Virginia Institute for Marine Science (VIMS), in cooperation with the National Marine Fisheries Service (NMFS), initiated a program in 1979 to monitor sea turtle population trends in the Chesapeake Bay, where turtles appear annually to feed. Volunteers are trained to search for dead or live juvenile loggerheads and Kemp's ridleys. They measure the turtles, collect information on stomach contents (from dead turtles), and inspect for clues as to why a turtle may have died. They also transport sick or injured turtles to rehabilitation centers where the turtles are nursed back to health, then marked with a tag and released. VIMS has a turtle stranding hotline and they receive hundreds of calls annually from volunteers and beachgoers. Sightings of stranded turtles found nationwide are compiled by NMFS, an effort aimed primarily at monitoring the impact of commercial fishing on turtles and the effectiveness of TEDs.

LEE WILSON

Myrtle Beach State Park volunteers measure a stranded leatherback that was hit by a boat at Surfside Beach in South Carolina.

Quantifying volunteers' contributions

All types of environmental monitoring are greatly enhanced by contributions made by volunteers, but the dollar value of volunteer work is rarely calculated. Sally Hopkins-Murphy, a project leader with the SC-DNR, recently documented the monetary value of work carried out by sea turtle volunteers in South Carolina. Assigning an hourly rate of $5.15 for beach patrol volunteers and $10 for volunteers helping with project management and more technical tasks such as moving nests, she calculated that in 2001 alone, the volunteers' work—a total of 15,270 hours—was worth almost $105,000.

Hopkins-Murphy also determined that over the past 25 years volunteer monitoring efforts have increased nest survival by 75-95% on 15 South Carolina beaches, and in the process have helped more than 2.7 million sea turtle hatchlings survive to make it safely to the ocean. Without the volunteer nest protection projects, she concluded, only 235,300 hatchlings would have survived to enter the sea.

Because sea turtles take many years to reach sexual maturity, it may be years or even decades before we are able to witness tangible results from the conservation efforts outlined here. Yet volunteers remain committed to carrying on with the work. Hopkins-Murphy says, "Volunteers care deeply about the plight of the turtles. They are also motivated by the challenge of finding and protecting nests. The work can be fun, too." In the words of J.G. Frazer, writing in a recent issue of the Marine Turtle Newsletter (see www.seaturtle.org), "Clearly, there is adventure and excitement involved in turtle work, spiced with varying amounts of hardship, risk and discomfort. The amount of devotion, dedication, motivation, and yes, passion, that is commonly part and parcel of marine turtle work is remarkable."

Christopher Swarth is the Director of Jug Bay Wetlands Sanctuary in Lothian, Maryland, and a member of The Volunteer Monitor *editorial board. He may be reached at 410-741-9330; jugbay@toad.net.*

For more information about sea turtles and efforts to help them, please get in touch with the following organizations:

Marine Turtle Conservation Program
South Carolina Department of
Natural Resources
Charleston, South Carolina
http://www.dnr.state.sc.us/marine/turtles/
murphys@mrd.dnr.state.sc.us

Caribbean Conservation Corporation
Gainesville, Florida
800-678-7853
ccc@cccturtle.org
http://www.cccturtle.org

"Share the Beach"
U.S. Fish and Wildlife Service and Alabama
Department of Conservation and
Natural Resources
Gulf Shores, Alabama
251-540-7720
jereme_phillip@fws.gov

MarineLife Center of Juno Beach
Juno Beach, Florida
561-627-8280
http://www.marinelife.org

Archie Carr Center for Sea Turtle Research
Gainesville, Florida
http://accstr.ufl.edu

WildCoast International Conservation Team
Davenport, California
888-736-6686
http://www.wildcoast-usa.com

Sea Turtle Stranding Coordinator
Virginia Institute of Marine Science
Gloucester Point, Virginia
804-684-7313
turtles@vims.edu

Folly Beach Turtle Watch
Folly Beach, South Carolina
http://www.follyturtles.com
crew@follyturtles.com

A Second Look at INVASIVES

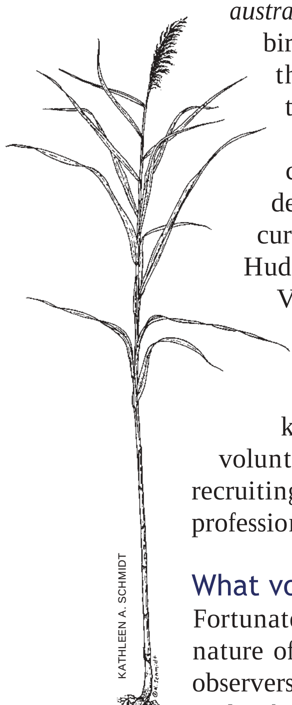
ERIK KIVIAT

Phragmites stand on abandoned commercial pier in Manhattan. In highly degraded environments like this, the only alternative to an invasive species may be no vegetation at all.

by Tanessa Hartwig and Erik Kiviat

When recruiting volunteer monitors, it always helps if your project involves a charismatic species. So imagine the challenges we faced when we set out to enlist participants for our new Volunteer Observer Network (VON), designed to help gather more information on wildlife use of purple loosestrife and *Phragmites*. Not only are these two species locally ubiquitous weeds notably lacking in romantic appeal, they have a "bad reputation" as invasive plants that take over natural wetland areas, in the process displacing native vegetation and destroying habitat for native animals.

How well these plants deserve their reputation is more open to debate than many people realize. Here at Hudsonia Ltd. (a small nonprofit ecological research institute located on the Bard College campus in the Hudson Valley region of New York), we've been studying a variety of invasive plant species for more than 30 years, focusing particularly on purple loosestrife (*Lythrum salicaria*) and *Phragmites australis*. Over the years we have observed a multitude of insects, birds, and other animals using these two plants, contradicting the prevailing idea that invasive plants in general are useless to wildlife.



KATHLEEN A. SCHMIDT

Phragmites australis

However, our small staff size limits the number of sites we can visit and the geographical range we can cover. To help determine whether our observations were local, isolated occurrences or whether they were representative of the larger Hudson Valley and New York City region, we established the VON three years ago with funding from New York City Environmental Fund and Westchester Community Foundation. Although we had previously worked with volunteer monitors at other research sites, the VON was a new kind of venture for us, covering a large area and requiring volunteers to work without close supervision. So we focused on recruiting as many "expert" volunteers as possible—land managers, professional and amateur naturalists, and restorationists.

What volunteers found

Fortunately, not all potential volunteers were scared away by the nature of our project. Over the course of two years, 32 volunteer observers sent us more than 400 observations of biota interacting with *Phragmites* and loosestrife. The volunteers themselves were surprised at the number and variety of interactions they witnessed. We heard comments like, "This project really opened my eyes—I saw creatures using these plants that I wouldn't have believed were there!"

The information collected by the VON greatly enhanced our understanding of the two plant species' ecological interactions and confirmed that many observations made by Hudsonia hold true throughout our region. Our volunteers saw many butterflies nectaring at loosestrife flowers, and birds using loosestrife stands as feeding and singing areas, or as staging areas in the spring. They also observed white-tailed deer browsing loosestrife tops, many insects feeding or pupating on loosestrife, and muskrat runways in mixed stands of loosestrife and other plants. As for *Phragmites*, the volunteers noticed a variety of bird species—including two New York State endangered species, black rail and short-eared owl—using this plant for shelter or as nesting habitat, or feeding on insects in its tassels, stems, or leaves. In addition, many invertebrates, including insects, spiders, and snails, were seen using *Phragmites*. VON observations were not limited to animals; volunteers also noted many species of woody and herbaceous vines, including two rare species of dodder, using *Phragmites* and loosestrife for support.

Some of the relationships discovered by VON participants—for example, several rare plants growing in the edges of

continued on next page

INVASIVES. continued

Phragmites stands, and a rare butterfly visiting loosestrife flowers—had not been documented previously. Without the eyes and ears of our volunteers, these occurrences would have continued to go unnoticed, as they have for years.

Data from the VON are being used in scientific journal articles and in preparing a detailed guide that will help land managers choose optimal management actions for dealing with loosestrife and *Phragmites* in their specific situation (see Resources section).

Dispelling myths

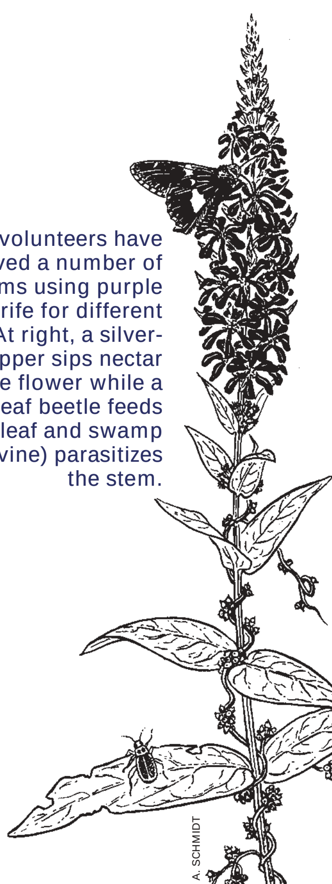
Based on data collected by Hudsonia researchers and the VON, as well as published results from other researchers, we have come to believe that several widely held assumptions about the behavior of invasive plant species are exaggerated or simplistic and not well supported by scientific evidence. Among these are the following ideas:

"No or low value to wildlife." As discussed above, we have found that certain invasive plants can have substantial utility to wildlife for food, cover, nesting substrate, and other uses. There is no reason to believe that native animals can distinguish "introduced" from "native" species per se. Over time, native animals may adapt behaviorally, demographically, or genetically to new plant species.

Admittedly, the presence of wildlife in a stand of an invasive plant species does not necessarily indicate that the stand is increasing or maintaining the fitness of an animal population. Few studies have addressed this question; much more research needs to be conducted. Some studies have indicated that for some species or sites *Phragmites* provides the only habitat, or supports a higher density of an animal species than does another plant community, while in other situations the opposite is true.

"Inevitable and rapid spread." In contrast to the common belief that an invasive plant will inexorably spread and invade available habitats, we have observed a number of instances where stands of loosestrife, *Phragmites*, and other invasive plant species have ceased spreading, or even declined, on their own.

"The pure, persistent stand." Although some stands of invasive plant species do attain a very high dominance and at least approach monoculture, there are many mixed stands of *Phragmites*, purple loosestrife, Eurasian watermilfoil, and others in which the invasive species comprises less than 75%, or even less than 50%, of total cover or biomass.



©KATHLEEN A. SCHMIDT

Hudsonia volunteers have observed a number of organisms using purple loosestrife for different purposes. At right, a silver-spotted skipper sips nectar from the flower while a water-lily leaf beetle feeds on the leaf and swamp dodder (a vine) parasitizes the stem.

A more balanced view

We certainly are not suggesting that invasive plants are harmless or control efforts unnecessary. Clearly invasives are a problem with immense ecological and economic costs. However, our data do call into question the widespread attitude that loosestrife and *Phragmites* should be eradicated under all circumstances. Not only is eradication often impossible, in some cases it may not even be desirable. We propose a more balanced management approach in which decisions are made on a case-specific basis.

Discussions about invasive plants often underemphasize the potential positive impacts of invasive species and negative impacts of control efforts. In some situations, invasive plants perform useful services such as immobilizing excess nutrients or preventing erosion, as well as providing food and other benefits to wildlife as described above. Existing control methods are costly, potentially exhausting limited resources, and can also have harmful ecological consequences. Herbicides, mowing, and burning can damage nontarget plant species, and mowing can also cause soil compaction or erosion. Biological control carries the risk that the introduced insect or pathogen will be able to switch to another host besides the target species. Hand-pulling has fewer unwanted side effects, but is limited to small, recently established stands of invasive plants.

ANGELA STEWARD

Swan nesting in *Phragmites.*

Before undertaking expensive eradication efforts, managers should think carefully about whether the end result will really be an improvement. An important question to consider is, What will replace the offending species? Spread of the invasive plant may have been promoted in the first place by stresses such as physical disturbances to soil, eutrophication, siltation, or pollutants. Removal of the invasive will not necessarily produce a high-quality native plant community; instead the area may be reinvaded by the same or another undesirable plant species, or may remain bare for a long time.

Several strategies are available for dealing with invasive species. For a small patch of an invasive occurring in an area with many native plants, eradication—preferably by hand-pulling—would be indicated. On the other hand, a narrow belt of *Phragmites* that is stabilizing the soil along the edge of an eroding tidal marsh would be a good candidate for "watchful waiting." In other cases managers might opt for inhibiting the spread of the invasive (e.g., by competitive planting), or thinning it (by repeated cutting or prescribed grazing) to encourage an admixture of non-invasive species.

Influencing land management decisions

The benefits of the VON go far beyond the value of the data collected. We initially targeted land managers and restoration ecologists for VON training workshops not only because their expertise would make them good observers but also because they are in a position to put the information to greatest use. Fifteen land managers attended our workshops and 13 participated as observers. We recently spoke to 12 of the most active, including representatives from the New York State Department of Transportation, Westchester County Planning Department, Westchester County Parks Department, and New York City Parks Department, to find out how their involvement had influenced their attitudes and actions. Nine expressed an enhanced appreciation for the possible benefits of *Phragmites* and loosestrife and an increased awareness of the need to evaluate management practices on a site-by-site basis, and three stated that they had been happy to find other people who "don't hate these plants." On the other hand, two told us they remained unconvinced that these plants have benefits.

The director of education at a Westchester County preserve reported that as a result of her participation in VON workshops, the preserve greatly scaled back its loosestrife control efforts. Formerly the practice was to eradicate loosestrife in the preserve with herbicides and hand-pulling, but now they allow it to grow freely except in a rare plant habitat. Many of the managers we worked with are also educators who will be able to incorporate their new ideas into their interactions with the public. In fact, one specifically mentioned bringing these viewpoints into public talks and walks.

Our volunteers not only provided us with a large amount of information that we were able to integrate into our work, they are now equipped to act as knowledgeable citizens in their communities, contributing to better-informed and more constructive management.

Tanessa Hartwig is a Research Assistant and Erik Kiviat is Executive Director of Hudsonia Ltd. in Annandale, New York. For more information: 845-758-7053; hartwig@bard.edu; kiviat@bard.edu.

Resources

"Loosestrife: Purple Peril or Purple Prose?" and "Reed, Sometimes a Weed," short articles from Hudsonia's newsletter, available at no charge from Hudsonia, P.O. Box 5000, Annandale, NY 12504-5000.

Kiviat, E. In press. Impact of invasive wetland plants on wildlife in the New York City region. Metropolitan Conservation Alliance of the Wildlife Conservation Society (68 Purchase St., 3rd Floor, Rye, NY 10580, 914-925-9175).

HERRING, continued from page 9

in a stepped pattern separated by concrete or wooden weirs. Denil fishways are typically rectangular chutes with wooden, plastic, or aluminum baffles set at an angle and closely spaced. Pool-weir fishways provide unobstructed views of migrating fish, but Denil fishways do not. Therefore, rectangular "counting boards" fabricated from white enameled metal are installed under water at the top of Denil fishways so that volunteers can observe herring as they exit the fishway to continue their upstream migration.

The Parker River experience

The oldest and most active group of fish count volunteers is led by the Parker River Clean Water Association, which has organized successful annual fish counts since 1997. These citizens got involved to get a handle on the status of their local alewife population. The project has not only yielded valuable information about fishery health and dynamics—it has turned out to be the Association's most successful public relations effort to date, as curious passersby engage in conversation with the volunteers about what they're doing and why.

Coordinating more than 50 volunteers over a short but intense period involves a good deal of preparation and leadership on the part of the Association. A publicity coordinator helps recruit volunteers by means of flyers, mailings to members of local nonprofits, and announcements in local newspapers. A training session is held a couple of weeks prior to the start of the count. A volunteer coordinator assigned to each fishway is responsible for making sure the counting site is accessible, calibrating and distributing the necessary equipment, and finding alternates for people unable to make their assignments.

Standardizing procedures

The Massachusetts Audubon Society's North Shore office, which has provided technical and organizational assistance to launch fish counts on several rivers, is now working to standardize the procedures for observing fish and recording and analyzing volunteer fish count data. Challenges that fish count coordinators are trying to meet in order to improve confidence in the data include ensuring

A pool-weir fishway.

that the pool of volunteers is large enough to cover each sampling hour during the run (increasing sample frequency), determining error among volunteer observers (computing confidence intervals), and predicting relative population size (extrapolating from the raw data). Improving data interpretation is of particular interest to the Division of Marine Fisheries, which is interested in using the data to look at trends in the runs over time.

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Detecting Sewage Leaks with Optical Brightener Monitoring

by Don Waye

Got D's in chemistry? Spent more time partying than in the college library? Sounds like you're perfectly qualified to perform optical brightener (OB) monitoring.

This simple test operates under the same principle that makes partygoers' clothing glow brightly under a blacklight. Special optical brightener dyes that are added to the vast majority of laundry detergents sold in the U.S. (look for the words "brightening agent" or "whitener" in the fine print on your detergent container) are adsorbed onto natural fibers, like cotton, causing them to appear whiter under natural sunlight and to fluoresce under ultraviolet light.

What is OB monitoring and why do it?

In most buildings, laundry effluent goes out through the same drains that carry sewage waste. Thus, testing streams or storm drains for optical brighteners is a good way to screen for the presence of wastewater from human sources. The ploy is simple: place OB "traps" containing fabric untainted with optical brighteners in watershed inputs. If the fabric subsequently fluoresces under UV light, it's a good indication that sewage may be present.

Currently, no method for OB testing is officially EPA-approved. Nevertheless, OB monitoring is an effective and inexpensive tool for anyone who would like to determine the extent and locations of illicit discharges. It is especially relevant to communities that are subject to new Phase 2 Storm Water Regulations, which require illicit discharge detection and elimination in storm drain systems.

OB monitoring offers several advantages over alternative methods for detecting sewage contamination, which include bacteria testing, testing for surfactants (another laundry detergent ingredient), and testing for caffeine (associated with human waste, though not uniquely so since there are also natural sources of caffeine).

Unlike bacteria testing, OB monitoring is meant to pinpoint human waste (that is, fecal bacteria from waterfowl produce the same reactions on culture plates as fecal bacteria from human sources, but ducks don't do laundry). Genetic techniques can also be used to determine whether bacteria are from animal or human sources, but the methodology is sophisticated and too expensive for surveying all watershed inputs.

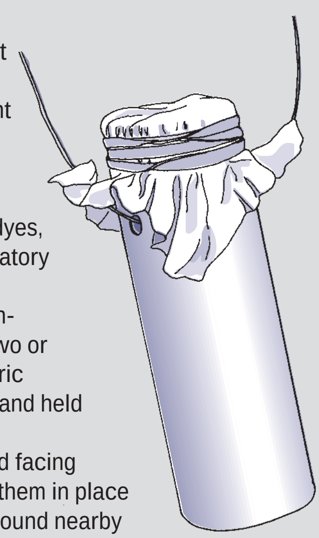
Most illicit connections are not running 24/7, meaning that they could be missed by the grab samples that are collected for bacteria, surfactants, and caffeine. Because the OB traps are typically left in the field for days at a time, they collect an integrated sample, allowing the detection of intermittent contamination. And because OB monitoring is the cheapest and simplest of the available methods, it lends itself to wholesale surveys of storm drain outfalls, feeder streams, or rivulets within a given study area.

As useful as OB monitoring is for screening watersheds for sewage inputs, it has its limitations. For instance, it is not likely to detect sewage from most commercial buildings—those that have toilets but no laundry facilities.

OB monitoring is ideally suited for composite sampling during baseflow conditions. Wet weather sampling is not usually recommended because the traps can be lost as the stormwater pulse rips through the sampling area, and also the sediment load, especially from clay, tends to coat the cotton swatches and mask any OB dye that has been adsorbed onto the fibers.

Although OB monitoring is considered a qualitative measure, some information on the severity of contamination can be gleaned by making note of the relative intensity of each sample's reaction with UV light. Control samples can be made up by diluting laundry detergent in water to various known concentrations. Verified positive results can

Low-Cost Homemade OB Trap



The key component in the OB trap is the material that will adsorb any OB dye that may be released into a waterway. The trick is not so much in finding the right material (cotton is ideally suited), but in finding a supply that has not already been processed with OB dye. We used 6-inch-square unbleached fabric swatches used by the garment industry to test new dyes, which we purchased from Ozark Underground Laboratory ($1 apiece in bulk order).

To make the traps, we cut 10-foot lengths of 2-inch-diameter PVC pipe into 6-inch sections, and drilled two or four holes (for holding wire) in each section. The fabric swatches were stretched over the end of the tubing and held snugly in place with thick, strong rubber bands.

In the field, we placed the traps with the fabric end facing upstream against the direction of flow, and secured them in place by running wire through the holes and wrapping it around nearby tree roots or anything handy at the site. We used 17 gauge spooled aluminum wire, which proved malleable enough to be twisted easily by hand or with needle-nosed pliers.

be obtained by sending samples to a laboratory that can analyze precise intensities of OB dyes by scanning them under a spectrofluorophotometer (the instrument should be set to detect fluorescence in the range of 415.0 to 422.0 nanometers). Some universities have this equipment, usually in their physics departments. I paid $25 per sample analysis to the Ozark Underground Laboratory (OUL) in Protem, Missouri (phone number 417-785-4289). OUL's director, Tom Aley, specializes in environmental dye-tracing studies and helped pioneer OB monitoring in his efforts to protect sensitive cave habitat in the Ozark karst region from septic effluent.

Case study and lessons learned

I used OB monitoring while working for the Northern Virginia Regional Commission (NVRC) in the summers of 1999, 2000, and 2001. For the first summer I hired two college interns to monitor the upper half of the 20-square-mile ultra-urban Four Mile Run watershed at a total cost of $6,800, most of which was the $10/hour that my agency paid each intern. It took the interns six weeks to survey about 150 sites. The following summer I hired two interns for 10 weeks to monitor every known storm drain outfall in the watershed (299 outfalls in all).

After the first season, we made some important changes to our methodology:

1. The first summer, the traps were made by enclosing pieces of fluffy medical cotton in "cages" made from poultry fencing. Constructing these traps proved to be labor-intensive. Moreover, we found that the fluffy cotton contained trace amounts of optical brighteners and also had a tendency to disintegrate in the field. For the second summer, we designed a new trap (see box) using unbleached fabric swatches and PVC pipe. These traps were easy and quick to make, held up well in the field, and could be reused many times simply by replacing the fabric square. The difference in efficiency between the summers of 1999 and 2000 was largely attributable to the new trap design.

2. During the second summer, each OB trap was left out in the field between 4 and 72 hours instead of the 7-10 day sampling period used the first summer. The objective was to strike a balance between maximizing the composite nature of OB monitoring and minimizing interference from wet weather events.

3. We switched from using hot incandescent UV bulbs (party bulbs) the first summer to a blacklight fluorescent lamp with its own built-in base housing and cord. The self-contained fluorescent lamp, which we purchased for $24 from Home Depot, yielded more easily interpretable results and was not hot to the touch.

The surveys revealed potential problems with several storm drain outfalls, the most significant being the discovery that two industrial-sized washing machines were discharging into a storm drain within Four Mile Run's Long Branch tributary in Fairfax County. The investigation was turned over to the county, which confirmed the illicit connection with its own surfactants tests and then used remote TV inspection (a robotic TV camera designed to snake through the sewer network) to trace the discharge to a hotel, where the problem was promptly fixed. (For additional information on this project see www.novaregion.org/4MileRun/obmslides.)

How to do OB monitoring

There are many possibilities for applying OB monitoring. Here's what we did.

Because we were sampling in a highly urbanized watershed, we placed traps at or near every outfall, whether or not the outfall was flowing. This allowed us to sort out which outfalls experienced intermittent flows, and several sporadic illicit discharges were detected in otherwise dry outfalls.

When we went into the field, we carried a supply of PVC pipe sections and a Ziploc-style baggie containing the fabric swatches. We assembled the traps using jumbo rubber bands wrapped twice around the pipe to hold the fabric tightly, then used pliers to cut and secure the wire. With a Sharpie marker, we tagged each OB trap with a unique ID and keyed it to a specific location in the field (e.g., an outfall or rivulet).

After recording the ID, location, and pertinent site characteristics (e.g., outfall size) in a field book, we left the trap in the field as long as baseflow conditions prevailed. We kept close tabs on the weather and retrieved the traps when rains threatened.

Traps collected from the field were placed in large sturdy plastic baggies and brought back to our agency for blacklight analysis. All samples flagged as "potential positive" from the quick-and-dirty blacklight testing were sent to OUL for spectrofluorophotometric analysis, and in every case the presence of OBs was confirmed. For quality control, 5 percent of negative samples were also sent to OUL for confirmation.

Tips

- Work with a partner in the field if possible.
- To avoid false positives, handle swatches minimally and only close to the edges. Monitors should have clean hands and avoid excessive touching of their clothing.
- When labeling traps, write small to allow for multiple reuses of the PVC pipe.
- Attach "Do Not Disturb" signs to traps (ours read: "Please Do Not Disturb! This device is being used as part of a study of the outfalls in Four Mile Run," and included a website and phone number for further information).
- In the field, carry a letter of explanation on official letterhead; this comes in handy when people wonder what you're up to, or when you're seeking permission to sample on private property.
- To preserve samples, store them in a freezer (best) or refrigerator to retain any fluorescent signature for many months.

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[*Editor's note:* An earlier article on monitoring optical brighteners, using slightly different methodology, appeared in the Fall 1999 issue of *The Volunteer Monitor* (pp. 21-23).]

Measuring Streamflow: How Much, How Fast

by Eleanor Ely

In common usage, the word *flow* often refers to how fast water is moving—for example, we might speak of a "swiftly flowing" stream. But to a hydrologist, that's *velocity*, while flow incorporates both velocity and quantity. Technically, stream flow (also called discharge) is defined as the volume of water passing a cross-section per unit time. Flow may be described as high or low, but not fast or slow. A wide, deep stream that is moving slowly can easily have a higher flow than a faster-moving but smaller stream.

Sometimes discharge can be measured directly. If you are monitoring a small stream that has a naturally occurring waterfall, or that flows through a pipe or culvert, you may be able to simply catch the water in a bucket, using a stopwatch to measure the time required to collect a given volume.

But in most cases this simple direct measurement is not possible. Instead, flow is calculated by the "velocity-area" method, which calls for measuring two physical attributes, channel cross-sectional area and stream velocity, then combining them to obtain flow. Many methodological variations exist, as discussed below.

First, though, let's take a quick look at the fundamental question of why a volunteer monitoring program would be interested in measuring flow.

Why monitor flow?

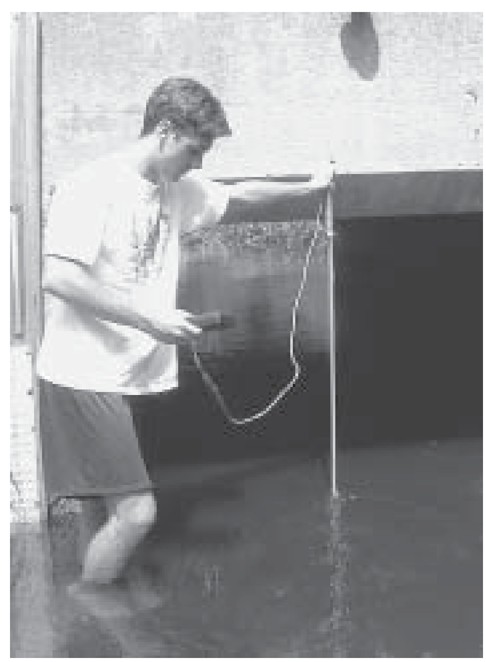
Conversations with volunteer monitoring programs around the country reveal that they are monitoring flow for a variety of reasons. In some cases water quantity itself is the fundamental concern. A group may be trying to determine whether a stream has enough water to support particular fish species—for example, migrating fish like salmon or trout, which require seasonal high flows. Or they might be interested in documenting the effects of urbanization on stream flows, or in providing water-quantity data to assist agencies in making decisions about diversions, interbasin transfers, or water supply permits.

Another important reason for monitoring discharge is to help interpret water quality data. Often information about flow conditions at the time a measurement was taken provides critical clues to help volunteer monitors answer their bottom-line question: "What do these results mean?" Lyn Hartman of Indiana's Hoosier Riverwatch says, "In the summer, some of our streams have almost no water. When we look at volunteers' data and see that a measurement was made under very low flow conditions, we ask, What was the source of the water? Was it all sewage treatment plant discharge? Was all of it coming from agricultural irrigation runoff?" In the spring, Hartman adds, the volunteers often observe increases in turbidity and conductivity in conjunction with higher flows, indicating that streams are swollen with snowmelt runoff carrying sediment and road salt.

Sue Mauger, stream ecologist for Cook Inlet Keeper in Homer, Alaska, recently decided that the organization's volunteer monitors should begin measuring flow, in part to help interpret turbidity results. Mauger explains that as water levels rise, turbidity generally increases because the stream has more contact with its banks and floodplain, and also has more energy to erode the banks and scour the bottom. She says, "If you begin seeing higher turbidity at a site even when discharge is low, you could be picking up a new source of sediment, such as construction-induced erosion."

Several groups use flow measurements to study loading (i.e., inputs to a receiving body such as a lake, wetland, or larger stream) of nutrients, suspended sediment, or pollutants. As New Hampshire Lakes Lay Monitoring Program coordinator Jeff Schloss points out, "You could have a very high nutrient concentration in the stream, but if flow is a trickle, the impact on the receiving water could be infinitesimal. On the other hand, moderate nutrient levels in a stream with high flow could have a large impact on the receiving body."

Interpreting flow data can be tricky. Schloss notes that a given parameter might either increase or decrease with increased flow, depending on the situation. He says, "If levels of a particular pollutant increase at higher flow then we would suspect a nonpoint



ELIZABETH HERRON

Rhode Island Watershed Watch volunteer using a top setting rod with a current meter (the meter is under water) to measure streamflow. Flow is read from the hand-held digital readout device.

source, because the concentration goes up when there is more runoff. But if we see the pollutant decreasing as flows increase we might be looking at a point source that contributes a consistent level of pollutant, which is diluted when flows increase."

Methods

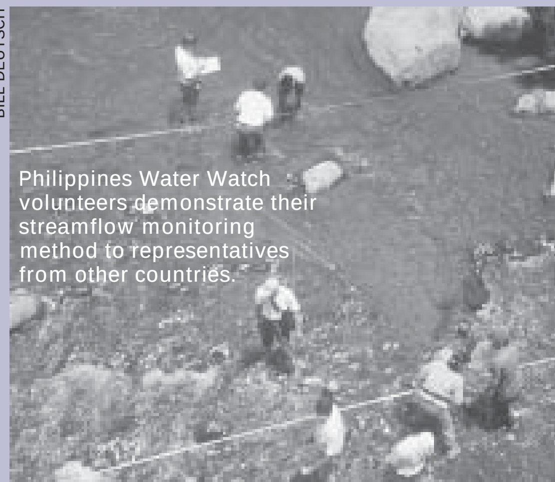
Volunteer monitoring groups around the country are using a variety of approaches for measuring flow. The usual method-selection "mantra" applies—namely, "The choice of method depends on your resources and the intended uses of the data."

At the high end are methods based on the use of meters (generally costing $1,000-$3,000) to measure water velocity. These methods provide the highest degree of accuracy and reliability. A low-cost alternative that's popular with volunteer monitoring groups is to measure velocity with a floating object such as an orange. And even very rough observational data about flow conditions can be extremely useful, especially for helping interpret results of water quality testing. Ken Cooke reports that the Kentucky Water Watch Program, which involves hundreds of adult volunteers and thousands of students across Kentucky, used to include flow monitoring as part of their routine suite of monitoring parameters. But many volunteers balked at the procedure, especially the mathematical calculations, so the program switched to an easier alternative—an observational estimate based on the following 6-point scale:

0 = Dry
1 = Ponded
2 = Low
3 = Normal
4 = Bank full
5 = Flood

Another option—what might be termed the "armchair" approach to measuring flow—is to simply use stream height and flow data from a U.S. Geological Survey (USGS) or state agency discharge monitoring station, if you are fortunate enough to have one at or near your monitoring site. Real-time and historical USGS streamgaging data are available at http://water.usgs.gov/. However, caution must be used in extrapolating from one location to another. It's advisable to make some actual measurements over different flow magnitudes and compare these to the USGS results.

Case Studies



BILL DEUTSCH

Philippines Water Watch volunteers demonstrate their streamflow monitoring method to representatives from other countries.

Topsoil loss in the Philippines

Soil erosion is a serious economic, social, and ecological problem in the Philippines. Not only does it remove valuable topsoil and reduce farm productivity, but the siltation of irrigation canals greatly reduces their efficiency. To get a handle on the extent of the soil erosion problem, volunteers with the Philippines Water Watch* program (PWW) monitor streams for total suspended solids (TSS) and also measure flow, using oranges as floats. TSS only measures *concentration*—that is, milligrams of sediment per liter of water. If the TSS measurement is coupled with an estimate of flow, then sediment *yield* or *load*—that is, total tons of soil that the watershed is losing to the stream—may also be estimated.

*PWW is partially supported by Auburn University, which also runs Alabama Water Watch (AWW). PWW was initially modeled on AWW. For more on both programs see *The Volunteer Monitor,* Winter 2003, pp. 14-15.

Restoring salmonid habitat in California

Low flow is an important consideration for salmonid habitat restoration. Salmonids require fast-moving water with a depth at least twice their body height, as they have higher oxygen requirements than less active fish. Volunteers with the Coastal Watershed Council in Santa Cruz, California, use current meters to collect flow data which are then used to help the California Department of Fish and Game make recommendations for enhancing salmonid habitat. For example, if flows are too low in a certain area, Fish and Game might recommend stopping diversions or changing diversion patterns.

The gold standard

Professionals with the USGS, Forest Service, and other agencies usually measure flow by methods similar to those described in the Forest Service publication *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*. Please note that the following brief summary does not include all the details.

In the United States, English units of measure are typically used for flow measurements. Stream depth is reported as feet and tenths of feet; velocity as feet/second; and flow or discharge as cubic feet/second (cfs).

A number of different styles of current meter are available for measuring velocity. One commonly used model is the Price type AA, a so-called "bucket wheel" meter that measures velocity mechanically (moving water rotates the wheel at a rate proportional to the water's velocity). The Price pygmy is a 2/5 scale model, suitable for use in shallow streams. Both the Price AA and Price pygmy can be attached to a headset; the operator then determines velocity by counting clicks (each rotation produces a click). A more expensive but convenient alternative is to attach the meter to a digital readout device.

Another type are the electronic sensor models (such as those made by Marsh McBirney, Sigma, or SonTek), which have no mechanically moving parts,

continued on next page

Resources

Harrelson, Cheryl C., C. L. Rawlins, and John P. Potyondy. 1994. *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*. General Technical Report RM-245. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 pages. Detailed instructions for measuring flow using a meter, and brief description of float method. This very useful manual also covers many techniques for measuring physical characteristics of stream channels, including installation of staff and crest gauges and measurement of channel cross-section and longitudinal profile. Free. Order from Publications, USDA Forest Service, Rocky Mountain Station, 240 W. Prospect Road, Fort Collins, CO 80524; 970-498-1392; rschneider@fs.fed.us. PDF version at www.stream.fs.fed.us/publications/documents.html.

Murdoch, Tom and Martha Cheo. 1996. *Streamkeeper's Field Guide*. The Adopt-A-Stream Foundation. 300 pages. Includes 13-page section on measuring stream flow using the float method, plus comprehensive guidance on water quality testing, macroinvertebrate monitoring, etc., and lots of illustrations. $29.95 + shipping. Order from Adopt-A-Stream Foundation, 600 128th Street SE, Everett, WA 98208; 206-316-8592; aasf@streamkeeper.org; or see the online catalog at www.streamkeeper.org.

U.S. EPA Office of Water. 1997. *Volunteer Stream Monitoring: A Methods Manual*. EPA 841-B-97-003. 210 pages. Short section on stream flow monitoring; instructions for float method. Both HTML and PDF versions are available online at www.epa.gov/owow/monitoring/volunteer/stream/.

Clean Water Team (California State Water Resources Control Board). "Information paper" on stream flow (22 pages) plus protocols for both meter and float methods are available at www.swrcb.ca.gov/nps/flow.html. (For other Clean Water Team online publications, visit www.swrcb.ca.gov/nps/availdoc.html.)

Missouri Stream Teams Stream Discharge Worksheet. www.mostreamteam.org/forms.html. Brief instructions, worksheet, and sample calculations for float method.

USGS website. http://water.usgs.gov/. Stream height and flow data from USGS streamgaging stations at thousands of sites throughout the nation, updated every four hours.

FLOW, continued

instead measuring current velocity by detecting the movement of very small particles either electromagnetically or acoustically. They are always used with a digital readout.

Several less expensive propeller-style devices are also available (Swoffler, Global Water). Depending upon conditions they may or may not perform as well as the more expensive meters, so it is advisable to do comparisons.

Because the flow will be different at different points along the cross-section, multiple measurements are made. A measuring tape is stretched across the stream and the operator wades alongside the tape, measuring depth and velocity at regular intervals while being careful to stand downstream and to the side of the meter. The meter needs to be properly positioned within the water column to obtain a representative reading because water velocity varies with depth, generally being highest at the surface and lowest at the bottom. The recommended depth for streams less than 2.5 feet deep is at 6/10 of the total water depth, as measured from the surface. For deeper streams, velocity is measured at two points: 2/10 and 8/10 total depth. A handy device called a "top setting rod" makes the job easier, but adds several hundred dollars to the total cost of the equipment. The top setting rod actually consists of two rods: a support rod that is used to measure water depth, and a smaller sliding rod that holds the meter. By sliding the smaller rod, the operator can quickly position the meter at the correct depth for the velocity reading.

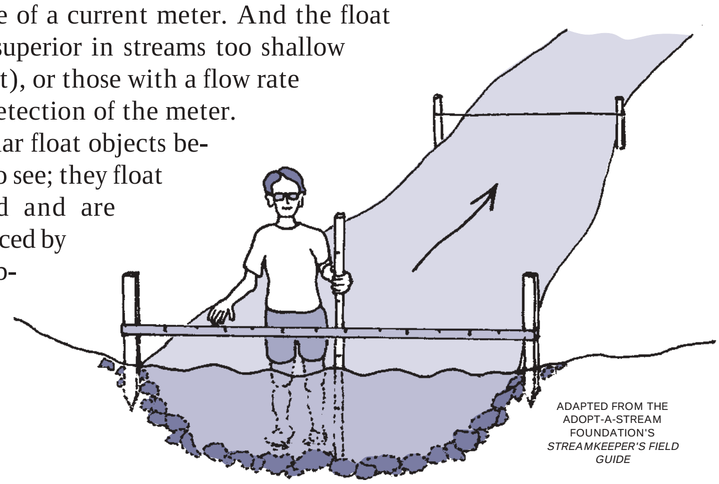
For most streams, measurements are made at 25 to 30 intervals across the stream. Smaller intervals are recommended for the deeper parts of the channel. Each interval defines a rectangle whose area is the width (read from the measuring tape) times the depth. The flow (cfs) for each rectangular subsection is calculated by multiplying its area (square feet) times the velocity (feet/second) measured at that point. Finally, the flows for the individual subsections are summed to obtain the flow for the whole cross-section.

Some volunteer monitoring programs use current meters to measure flow, sometimes getting around the high cost factor by sharing one or a few meters among several groups of volunteers. Often the method is simplified somewhat—for example, by taking measurements at 1-foot intervals across the stream. It's even possible to measure the length of your wading boot and use one or two boot lengths as the measurement interval.

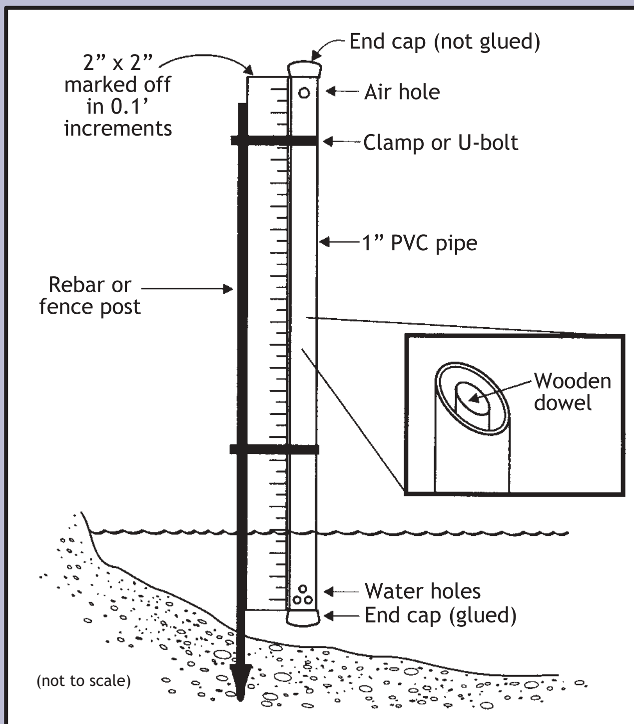
Float method

The majority of volunteer groups opt to measure stream flow by floating an orange or other object for a specified distance, which generally gives less accurate results than the method described above. On the other hand, you can buy an awful lot of oranges for the price of a current meter. And the float method is actually superior in streams too shallow for meters (< 0.2 feet), or those with a flow rate below the level of detection of the meter.

Oranges are popular float objects because they are easy to see; they float partially submerged and are therefore less influenced by wind than lighter objects; and if you lose one there's no worry because



Measuring water depth at intervals to determine cross-sectional area is the first step in the float method. In step 2, an object such as an orange will be floated between the "start line" and "finish line."



Combination Staff Gauge/Crest Gauge

A staff gauge measures stream height, or stage, at the time of inspection, while a crest gauge preserves a record of the highest level reached since the last inspection. In this combination gauge, the wood 2 x 2 serves as a staff gauge.

The crest gauge part of the apparatus is based on the "bathtub ring" principle. It consists of a PVC pipe containing a wooden dowel and a supply of granulated cork. As the water rises, so does the powdered cork. When the water goes down, the cork granules remain stuck to the wooden dowel at the level of highest water.

To read the crest gauge, remove the top end cap and take out the dowel. Measure the level of the cork powder ring, then wipe the powder off and replace the dowel.

Materials needed:
6-ft fence post or rebar
PVC pipe, 1" diameter (or wider), 4-5 ft long
2 end caps for PVC pipe
2 or 3 metal clamps or U-bolts
2 x 2 wood board, approx. same length as PVC pipe
Wooden dowel, 1/4" to 1/2" diameter, cut to same length as PVC pipe
Granulated cork

[Adapted from an article by Ken Pritchard in *The Volunteer Monitor*, Fall 1995, p. 18.]

it's biodegradable. Volunteer monitoring groups have also used apples and, in at least one case, cucumbers. (Elizabeth Herron of Rhode Island Watershed Watch reports, "We found that oranges gave results closer to the meter values than did apples ... so you actually *can* compare apples and oranges!") Several programs, including Missouri Stream Teams, prefer to use practice golf balls (a small plastic ball like a Wiffle ball) in shallow streams because oranges can get caught on the bottom. Tim Rielly of Missouri Stream Teams reports that the program has had no problems with volunteers losing the balls.

Like the current-meter method described above, the float method is based on the velocity-area approach. The protocols currently in use by volunteer monitoring programs are all quite similar, though they vary in details such as the distance the object is floated and the number of float trials that are performed. A typical protocol is briefly described below; consult the references listed in the Resources box for more detailed instructions.

Choose a site. Essentially you will set up a mini "racecourse," usually at least 20 feet long, where you will float the object. Look for a stretch that is as straight as possible, with an even width, a smooth bottom, and few obstructions or eddies. As Tim Rielly observes, "Finding an area like this can be tough in a stream with good habitat and a natural meander. The ideal place would be a box culvert, though of course we hope our streams aren't like that."

Measure cross-sectional area. Next, determine the area of the stream cross-section at the beginning (start line) of the stretch. Extend a measuring tape across the stream, then wade across, measuring depth at regular intervals (generally one or two feet) with a stadia rod or yardstick, preferably marked in tenths of feet. [Note: Some protocols call for determining the cross-sectional area at the

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Storm Flow Monitoring: Too Much to Ask?

How fast a stream rises in response to a storm, and how high the water gets at its peak, are interesting and important pieces of information. But is it realistic to expect volunteer monitors to measure stream height at hourly intervals, or even more frequently, during a storm?

Volunteers with Napa County Resource Conservation District (RCD) used wire weight gauges to collect stream height data that could be used to compare the behavior of Napa River tributaries in different subwatersheds during a storm. "The volunteers were excited about the project," reports RCD's Kathleen Edson, "but storms have a way of happening in the middle of the night, or while people are at work. During any given storm, typically only some of our volunteers would be able to make the measurements, so we had a difficult time getting consistent enough datasets to make the kinds of comparisons we wanted to make."

As Edson points out, the RCD's experience demonstrates that volunteers are indeed capable of collecting storm flow data. For other programs that may want to try this type of monitoring, she suggests that it is more realistic to plan on getting data from some sites for some storms, rather than expecting to get data at all sites for all storms; and she adds that the ideal volunteer for storm flow monitoring would be a retired person who lives right near the stream.

FLOW, continued
end of the stretch (finish line) as well, then averaging the two values.]

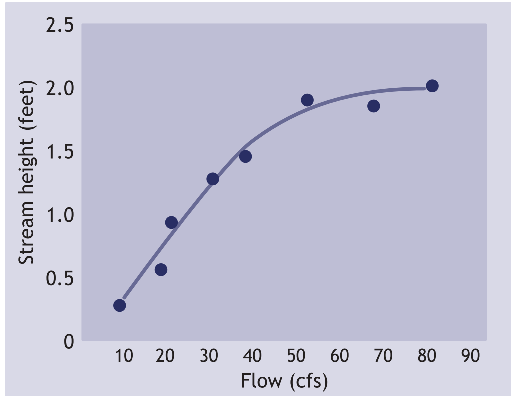
Measure velocity. One person releases the float object above the start line so that it attains stream velocity by the time it crosses the line. A second person stands at the finish line and uses a stopwatch to measure the travel time from start to finish.

In theory you could float the object at 1-foot intervals, to approximate the current-meter method. However, in practice the floating object rarely stays in its lane but rather tends to drift right or left. Most volunteer monitoring groups perform three or four float trials, spaced more or less evenly across the stream. To compute average velocity, average the travel times (in seconds), then divide that number by the length of the "racecourse" (in feet).

Calculate flow. Multiply the cross-sectional area by the average velocity. Because the float travels along the water surface, rather than being submerged at the 6/10-depth point like a meter, the number you obtain is actually average *surface* flow, which is higher than the overall average flow. Therefore you need to multiply your result by a correction factor to get a closer approximation of average flow. Most protocols suggest a correction factor of 0.8 for rocky-bottom streams and 0.9 for smooth-bottom streams.

How accurate is the float method?

While the float method is less accurate than methods using meters, under favorable conditions it produces a fairly close estimate of flow. Tim Rielly has used a Marsh McBirney electronic current meter to conduct over 50 side-by-side accuracy checks of Missouri Stream Teams volunteers' flow measurements. He reports that when flow is under 10 cfs, the volunteers are usually within 15% of the meter. Agreement is better if the stream section is straight and smooth-bottomed; naturally, rocks and eddies make it harder to get accurate velocity readings with the float method.



A rating curve, or stage-discharge curve, plots stream height (stage) against flow (discharge) under different flow conditions. Once established, the rating curve can be used to convert stream height to flow without the need for measuring velocity.

Stream height as a proxy for flow

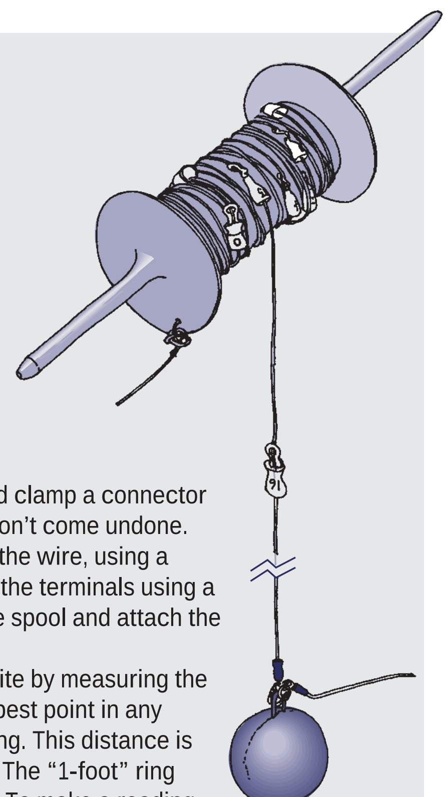
As is probably clear by now, measuring flow can be fairly time-consuming. Fortunately a convenient shortcut is available. The catch is that before you can use the shortcut you need to make a number of flow determinations under different conditions—some when the stream is very full, others at low flow, etc. Once you have this data you can construct a "rating curve" relating flow to stream height (see figure above). Now you can simply measure stream height (or water depth), then look at the curve and read off the corresponding value for flow. (The rating curve is often called a *stage-discharge* curve, *stage* being another term for stream height.)

If you plan to use this method, you'll want to install a permanent staff gauge,

Wire Weight Gauge

Materials:
Large plastic kite-string spool
Nylon-coated wire fishing line
1-pound lead fishing weight
Electrical ring terminals

This hand-held wire weight gauge is used to measure stream height from a bridge or overpass. It is especially useful in situations where wading into the stream would be difficult or dangerous.



Instructions:
Tie the weight to the end of the fishing line and clamp a connector sleeve on both sides of the knot to ensure it won't come undone. Attach ring terminals at 1-foot intervals along the wire, using a crimping tool to clamp them in place. Number the terminals using a permanent marker. Drill a small hole in the kite spool and attach the end of the line, using connector sleeves.

The gauge may be calibrated to a specific site by measuring the distance from the thalweg (*thalweg* = the deepest point in any given stream cross-section) to the bridge railing. This distance is marked with the "0" ring terminal on the wire. The "1-foot" ring terminal is attached 1 foot below it, and so on. To make a reading, the volunteer lowers the weight until it just touches the water. Stream height is read as the point where the wire crosses the bridge railing. A ruler (preferably marked in tenths of feet) is used to measure the distance from the nearest foot mark.

[Wire weight gauge designed by Luna Leopold, Emeritus Professor of Geology, University of California, Berkeley.]

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which can be as simple as a meter stick or yardstick affixed to a permanent post or a structure such as a bridge piling. This way you can be sure that you're always measuring stream height at the same place.

The combination staff gauge/crest gauge shown on page 21 not only serves as a staff gauge but also preserves a record of maximum stream height (crest). Rather than visiting your site in a downpour to check water height on the staff gauge, you can wait until the storm is over and make your reading in comfort.

Trout Unlimited (TU) volunteers in Rhode Island have developed rating curves for several sites, using a Price pygmy meter to make the flow measurements. The group has only one meter, so being able to monitor established sites with a staff gauge frees up the meter for constructing rating curves for new sites. About four times a year, the volunteers reconfirm the rating curves by measuring flow with the meter. Elizabeth Herron of Rhode Island Watershed Watch (which provided assistance to the TU volunteers) offers the following words of advice: "Streams change! At one site, grass growing in the stream channel in summer and fall really altered the flow, wreaking havoc with our calculations. At another place spring flooding ripped out the gauge."

Wire weight gauge

An alternative way to determine stage is to measure the distance from a fixed point above the stream, such as a bridge or overpass, down to the water surface. Some groups use a Secchi disk to make this measurement. At the Sonoma Ecology Center in northern California, volunteers use a homemade wire weight gauge (see figure at left). "A stadia rod would not be a practical way for us to measure water depth,"explains the Center's Wendy Losee. "The water gets very high; at peak flow it can be carrying huge logs downstream, so it would be very dangerous to have the monitors down at the level of the creek. The wire weight gauges have worked really well and are easy for the citizens to use."

Directory Updates Needed!

The EPA's online National Directory of Volunteer Environmental Monitoring Programs includes 834 programs nationwide. The usefulness of this valuable networking tool depends upon having up-to-date information. Please help by visiting http://yosemite.epa.gov/water/volmon.nsf/ to make sure your program information is current, or to add your program if it's not already listed.